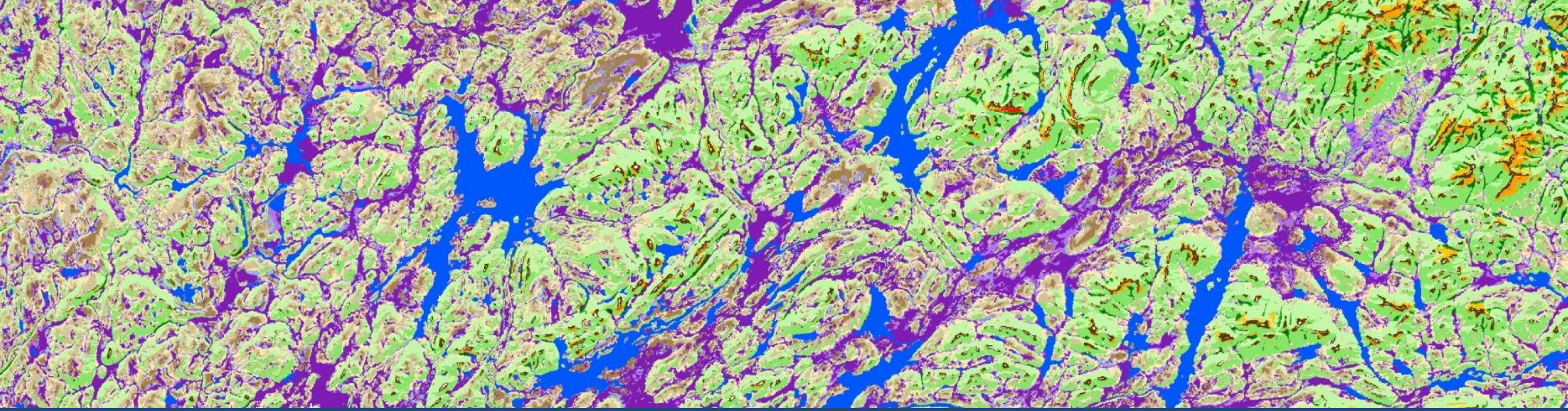


Northeast Lake and Pond Classification

The Nature Conservancy Eastern Conservation Science

Arlene Olivero Sheldon and Mark G. Anderson

Arlene Olivero Sheldon and Mark G. Anderson

The Nature Conservancy
Eastern Conservation Science
Eastern Regional Office
99 Bedford St, 5th Floor
Boston, MA 02111

Please cite as:

Olivero-Sheldon, A. and M.G. Anderson. 2016. Northeast Lake and Pond Classification. The Nature Conservancy, Eastern Conservation Science, Eastern Regional Office. Boston, MA.

Revised January 6, 2016

Funding for this project was supported by a grant from the U.S. Department of the Interior, Fish and Wildlife Service

North Atlantic LCC
North Atlantic Landscape Conservation Cooperative

Cover photo credits

Top Left: Beginning fall color on a beaver pond situated on Conservancy property in New York's Adirondack Mountains. PHOTO CREDIT: © Mark Godfrey/TNC

Top Right: Fisherman in fog on Stonewall Jackson Lake, West Virginia. PHOTO CREDIT: © Kent Mason

Bottom Left: Loon on Ossipee Lake, New Hampshire. PHOTO CREDIT: © John Mitchell and the Mount Washington Observatory

Small Middle Top: Snow geese at Middle Creek Wildlife Management Area, Pennsylvania. PHOTO CREDIT: © Melissa Lenker

Small Middle Bottom: Fall color at Pickwacket Pond in the Adirondack Park, New York. PHOTO CREDIT: © Mark Godfrey/TNC

Bottom Right: Alewife Brook Reservation in Cambridge, Massachusetts. PHOTO CREDIT: © Tim Pierce

Acknowledgements

This project reflects decades of work by many organizations and dedicated individuals. Without their hard work and willingness to share their knowledge this classification could not have been produced.

We would like to thank Matt Carpenter and the Northeast Association of Fish and Wildlife Agencies for envisioning and guiding this project, and Andrew Milliken and Scott Schwenk for support in making it a reality. We also thank Scott Schwenk for his detailed comments and edits to the draft report.

We are deeply indebted to the many people organizations that provided input data to help develop and calibrate our models of alkalinity, trophic state, and temperature. We would like to particularly thank Dr. Jeffrey W. Hollister, Research Ecologist with the Environmental Protection Agency, for sharing his models and data related to lake depth, morphometry, and chlorophyll-a. We also thank Pat Sorrano of the LAGOS project at Michigan State University for sharing the chlorophyll-a and maximum depth data from their multistate database. We also thank all the individual state departments of Fish and Wildlife, Environmental Management, and Natural Resources for sharing their data on water chemistry, temperature, dissolved oxygen, and other attributes. We also thank TNC volunteer, Melissa Lenker for her review and assistance with the current report, and extend a large thank you to Alex Jospe for her assistance with the 2014 version of this Northeast lake classification report. Without their dedication and hard work, the results of this project would not have been possible.

Finally, we would like to thank the members of the lake and pond aquatic habitat classification workgroup who provided feedback on our calls, sent us relevant reports, coordinated data sharing, and reviewed our products. Thank you to Dave Halliwell, Linda Bacon, Dave Coutemanch, and Douglas Suitor (ME Dept. of Environmental Protection), Matt Carpenter (NH Fish and Game Commission, Dept. of Inland Fisheries), Kellie Merrell (VT Department of Environmental Conservation), Richard Hartley (MA Department of Fish and Game), Mark Mattson (MA Department of Environmental Protection), Brian Eltz (CT DEEP Inland Fisheries Division), Greg Edinger (NY Natural Heritage Program), David Newman (NY Department of Environmental Conservation), Dave Arnold (PA Fish and Boat Commission), Barbara Lathrop (PA Department of Environmental Protection), Sherm Garrison (MD Department of Natural Resources), Christopher Smith (NJ Department of Environmental Protection), Elizabeth Herron (URI Watershed Watch), Kevin Kalasz (DE Department of Natural Resources and Conservation), Brett Preston (WV Department of Natural Resources), and Brad Fink (VA Department of Game and Inland Fisheries).

Abstract

We developed a mapped classification of lakes and ponds based on facors that structure lacustrine ecosystems and that could be mapped consistently across Northeastern US. The classification was based upon four key variables: water temperature, alkalinity, trophic state, and depth. Water temperature was mapped into three classes (very cold, cold, and cool-warm) to reflect the requirements and limits of aquatic organisms. Alkalinity was grouped into three classes (high, medium, low) to reflect how well the lake system was buffered from acidification. Trophic states, representing the productivity of a lake, were mapped into two classes (oligotrophic-mesotrophic and eutrophic-hypereutrophic). Depth was divided into two classes (lake, pond) using maximum depth and trophic status to estimate whether light penetrates to the bottom of the waterbody. A steering committee of state and regional experts contributed sampled data with measured values of these and other variables for waterbodies in their states. To create the mapped classification, we compiled the location of every waterbody in the region (n = 36,675), and for each waterbody we generated over 300 descriptive attributes including: morphology, dams, climate, soils, geology, conservation lands, landforms, and land cover in the watershed. We to develop a predictive model for each variable class based on the sampled data points, and we then extrapolated the model to the unsampled waterbodies used Random Forest software to estimate their class based on their descriptive attributes. All waterbodies were assigned to one of 18 classification types based on the combination of three variables: temperature class, trophic state class, alkalinity class. These types can be further subdivided into lake or pond categories to yield mapped occurrences of 36 waterbody types, for example: cold, oligotrophic-mesotrophic, low alkalinity, lake.

Table of Contents

1. Introduction

Objective

The objective of this project was to create a mapped classification of lakes and ponds in the Northeast US. The classification will allow users to study the variation in the ecological character of lakes and ponds in the Northeast and Mid-Atlantic, and we hope will lead to improved conservation and management of these ecosystems. The results can be used to focus field surveys and assessments, or allocate management budgets to certain types of lakes and ponds. The simple "habitat guide pages" produced for each of the final lake and pond types will also will introduce a lay audience to the characteristics of these important habitats by describing the habitat with pictures and text, a distribution map, list of associated species, and description of the current condition of each type.

We based the classification on variables that structure lacustrine ecosystems and that could be mapped consistently across all lakes and ponds in the region. The variables and variable classes were identified and agreed upon by a steering committee of experts representing the 13 states in the Northeast and Mid-Atlantic region. The resulting classification of waterbodies will be added to the existing Northeast Aquatic Habitat Classification of streams (Olivero and Anderson 2008).

Background

In 2008, The Nature Conservancy in conjunction with the Northeast Association of Fish and Wildlife Agencies developed the Northeastern Aquatic Habitat Classification System (NAHCS) and GIS dataset for 13 northeastern states (Olivero and Anderson 2008). The classification was designed to consistently identify and map the natural aquatic habitats of the region and facilitate the conservation of these features across the participating states. It is being used in a number of state and regional projects, and as a model for other regional stream classification efforts.

The NAHCS focused primarily on streams and rivers. Although the dataset included useful attributes on waterbodies such as size, elevation, geology, shoreline sinuosity, and network position, there was no classification of waterbodies into ecologically meaningful types. Information on the depth of each waterbody was unavailable at the time, and because depth is a critical variable related to the presence of permanent coldwater habitats, the steering committee thought that no ecologically meaningful lake classification could be developed without this variable. In 2011, Dr. Jeff Hollister of EPA's Narragansett lab developed a method to predict maximum lake depth from the slope of the surrounding topography for all lakes in the National Hydrography Dataset Plus (NHD-Plus, Hollister 2011), and these data became available in the spring of 2013. The predicted lake depth dataset in combination with other newly available geospatial and field inventory data made it possible to develop a mapped classification of Northeast lakes and ponds in 2014.

In 2015, a small grant from the North Atlantic LCC was obtained to for expanded modeling of the classification attributes based on new information. The scope of work included compiling new state datasets of sampled lake depth and additional GIS landscape attributes such as climate, soils, landforms, and upstream watershed characteristics. The classification variables and thresholds remain the same as the 2014 report, but the models to predict these variables for every waterbody were rerun using the improved depth data and additional attributes. In addition, we revised this report, obtained review of the new products, and compiled a description, photo, and list of associated fauna for each waterbody type, and we summarized their conservation and condition characteristics in a two-page "habitat guide."

Classification Process

A steering committee of 13 aquatic biologists representing ten states and one federal agency guided the classification development (Table 1). The guidance of the steering committee was critical to ensure we developed a useful product that reflected an understanding of lake ecosystems and their management. Additional contacts who helped fill specific data requests and gave advice on the use of the information are listed in the text.

Table 1. Lake classification steering committee and data contacts

State/Federal	Name	Agency
EPA	Jeff Hollister	Environmental Protection Agency
ME	Dave Halliwell	Department of Environmental Protection
	Douglas Suitor	Department of Environmental Protection
	Linda Bacon	Department of Environmental Protection
	Dave Coutemanch	The Nature Conservancy
NH	Matt Carpenter	Division of Fish and Game
VT	Kellie Merrell	Department of Environmental Conservation
MA	Richard Hartley	Department of Fish and Game
	Mark Mattson	Department of Environmental Protection
CT	Brian Eltz	DEEP Inland Fisheries Division
NY	Greg Edinger	Natural Heritage Program
	David Newman*	Department of Environmental Conservation
PA	Dave Arnold	Fish and Boat Commission
	Barbara Lathrop	Department of Environmental Protection
MD	Sherm Garrison*	Department of Natural Resources
NJ	Christopher Smith	Department of Environmental Protection
RI	Elizabeth Herron*	URI Watershed Watch
DE	Kevin Kalasz*	Department of Natural Resources and Conservation
WV	Brett Preston	Department of Natural Resources
VA	Brad Fink*	Department of Game and Inland Fisheries

* unable to be on steering committee but advised and provided data as possible

Classification Variables

We hosted web-based discussion in the early stages of the project to solicit feedback on the variables and classification approach needed to develop a product useful across the whole 13-state study region. During these calls, we examined and discussed 15 existing lake classifications and assessments from nine states (CT, ME, NH, NJ, NY, MA, PA, VA, VT) as well as the National Lake Assessment and our previous work on the Northeast Aquatic Classification. From these, we identified potential classification attributes that we reviewed and discussed with the team: water chemistry, physiography, stratification, temperature, groundwater linkage, morphometry, genesis, trophic state, connectivity to streams, retention time, color, and clarity.

Through the discussions we honed in on variables that the majority of states currently use, or would like to use, for a regional classification. There was a high level of agreement among the team on four key variables that structure lacustrine ecosystems: temperature, alkalinity, trophic state, and depth. From the existing classifications we adopted (or generalized) classes for each variable that appeared to have ecological significance. These were presented to the team and discussed until we reached agreement on the classes and thresholds (Table 2). The definition and significance of each variable and variable class we were ultimately able to successfully model are discussed in subsequent chapters.

Table 2. Summary of key classification variables and threshold definitions

Class	Definition	Direct Measures Used
Temperature Class	Presence of greater than 1 meter of following habitat throughout the summer 1. VERY COLD: <12.8°C and >=5 mg/l DO or indicator fish = lake trout 2. COLD: 12.8°C <=18°C and >=5 mg/l DO or indicator fish = wild brook trout 3. COOL: >18°C <=21°C and >=4 mg/l DO or indicator fish = non-reproducing brook trout, holdover or reproduction of brown trout, kokanee, smelt 4. WARM >21°C	Temperature-dissolved oxygen depth profiles from July-Aug, Indicator fish
Alkalinity Class	1. High Alkalinity >=50 mg/L CaCO3 2. Medium Alkalinity >=12.5 & < 50 mg/L CaCO3 3. Low Alkalinity <12.5 mg/L CaCO3	Milligrams per liter of calcium carbonate < 2m depth or surface
Trophic State Class	National Lake Assessment breaks in Chlorophyll-a. 1. Oligotrophic: <= 2 ug/l 2. Mesotrophic >2 -7 ug/l 3. Eutrophic >7 - 30 ug/l 4. Hypereutrophic >30 ug/l	Chlorophyll-a (July-Aug)
Depth	Pond vs. Lake threshold varies by trophic state class 1 Oligotrophic : 9.14 m (30 ft.) 2 Mesotrophic : 6.10 m (20 ft.) 3 Eutrophic/Hypereutrophic: 3.05 m (10 ft.) These were simplified to 20 ft. in Oligo-Mesotrophic waterbodies and 10 ft. in Eutrophic-Hypereutrophic waterbodies.	Depth of light penetration in meters

2. Data Compilation

GIS Hydrography

We compiled 36,675 lake and pond waterbody polygons as our base dataset. This included 32,652 waterbodies from the National Hydrography Dataset V2 (hereinafter “NHD”)(USEPA 2013, 1:100,000 scale), plus 4,023 waterbodies over 10 acres in size from the high resolution NHD+ dataset (USEPA 2013, 1:24,00) and the National Wetlands Inventory (USFW 2013). The latter datasets were compiled by J. Grand at University of Massachusetts, and were non-overlapping additions to our 2014 lake classification.

State and Federal Database Attributes

We compiled sample attributes on chlorophyll-a, alkalinity, temperature-dissolved oxygen profile, indicator fish, and maximum depth, for as many waterbodies as possible (Appendix I: Data Sources). The sample databases included regional and national survey information from the National Lake Assessment (hereinafter NLA [USEPA 2009]), the New England Lake and Pond Survey (hereinafter NELP [USEPA 2010]), and the Lake Multi-scaled Geospatial and Temporal Database (hereinafter LAGOS [Soranno et al. 2015]), as well as data from the individual states. We worked with EPA to obtain their chlorophyll-a model estimates (Milstead et al. 2013) for waterbodies in the Atlantic drainage basin and to obtain their modeled lake depth data (Hollister 2014).

Data Standardization

The state and federal lake monitoring datasets required extensive processing before we could compile them into a standard form. Databases were provided in multiple forms with various related tables. There was wide variation in collected attributes across state and national datasets, and even within a state there was often data from multiple agencies. Some states provided entire sampling databases with information throughout all years of surveying, although we were primarily interested in recent years (1990 to present), or certain months for some attributes. Substantial thought and effort was required to clean up the information, query relevant data, summarize data, and get the data into a consistent form.

Revised Data on Depth and other Variables in 2015

In 2015, we gave particular attention to compiling known samples of maximum depth from as many lakes and ponds as possible in the hope that using confirmed samples would improve the accuracy of our predictive models which were previously based on estimated maximum depth from an EPA model. We were able to compile depth samples for 5,594 waterbodies in our region. These samples came from state databases, national databases, and from review of each state’s paper or scanned bathymetry maps (Table 3). When conflicting depths were present for a given water body, we integrated the deepest recorded depth for the waterbody. Depth data included in temperature/dissolved oxygen profile databases were sometimes limited to the depth that equipment could be lowered, but if we had another sample confirming the lake was deeper, we used the deeper depth. If depths were identical in the national or regional databases to what was in the state databases, we assigned the source to the state survey. Please see the summary below for the sources of these depths and more information in Appendix I.

Table 3. Sources of maximum depth samples

Source of Maximum Depth Data	Total
Adirondack Lake Survey	1061
CT CAES IAPP 2014	104
CT DEP lake and pond electrofishing survey 1988-95	69
CT DEP scanned bathymetry maps	10
LAGOS 2015	379
MA DEP temp/DO 2014	43
MA DNR website, scanned bathymetry	235
Mary Thill 2015	96
MD database 1991	12
ME DEP 2014 Database	1444
New England Lake and Pond Survey 2010	5
NH DES 2014 & 2004	735
NJ DEP scanned bathymetry maps	64
NJ DEP 2014	101
National Lake Assessment 2009	85
NY DEC profile database 2014	177
NY DEC scanned maps	221
PA BFC 2014, temp/DO profile dataset	9
PA BFC 2015, max depth database	251
RI DEM scanned bathymetry maps	26
RI URI 2014	86
VT DEC Lake Info 2014	329
VT DEC Temp/Do profile 2014	26
WV DNR 2014 temp/do profile database	32
WV DNR scanned bathymetry maps	14

Revisions to other variables in 2015

Revisions to the temperature, alkalinity, trophic state class and depth model are provided in the individual chapters below.

Spatial Joining of Sample Data

After summarizing tabular databases, the data was linked to the appropriate GIS waterbody polygon in our datasets. Using ArcGIS 10.1, we ran a spatial join from state sample points, created from the provided latitude and longitude points, to the NHD waterbody polygons. For all state points that had a distance > 0 from a polygon, we visually checked whether the point should have joined, or whether it was for a lake that was not in our dataset. Points were assigned the appropriate ID from our dataset as needed. For datasets without lat/long coordinates, sample data could only be linked using name-to-name joins or searches in the relevant state, county or town.

GIS Landscape Attribution

For each waterbody we calculated 315 attributes for use in our predictive models (Table 4). These landscape attributes were chosen with input from our review team following previous research on the effect of surrounding land use and imperviousness on lake nutrient level and trophic state (Milstead et al. 2013, Moore et al. 2011, Liu et al. 2011, Wetzel, 2001), the effect of bedrock geology on water alkalinity and trophic state (Norton 1980, Dillon and Kirchner 1975, Milstead et al 2013), and the effect of elevation, latitude, depth, and air temperature on lake water temperatures (Tcherepanov et al. 2005, Becker et al. 2004, Alofs et al. 2014, Stefan et al. 1996, Fang and Stefan 2009, Wetzel, 2001). We joined the Northeast Connectivity Dam dataset (Martin and Apse 2011) to each waterbody to identify which ones were impounded and by what types of dams. Dams may affect the water temperature and stratification patterns of a lake, and the the team was also interested in knowing the impoundment status for their evaluation of management options.

All variables are documented in Appendix III. The variables were sampled and summarized in GIS by acres and percent for one of four extents: 1) the waterbody, 2) a nearshore 100m buffer area to represent nearshore conditions, 3) a larger 1000m buffer area to represent the local area around the lake, 4) the entire upstream watershed of a waterbody. Summaries for the entire upstream watershed were only available for non-headwater and non-isolated waterbodies which had a NHD centerline through the waterbody (20,952 waterbodies; 57% of all) because total upstream accumulations of variables had been done using the NHD stream and centerline network (methods summarized in Olivero-Sheldon and Anderson, 2014). When entire upstream watershed attributes were not available for given waterbodies, we filled the blanks with the 1000m buffer attributes which approximates the direct watershed of smaller headwater and isolated waterbodies.

Table 4. GIS landscape attributes summarized by area and percent of total area for the lake, 100m buffer, 1000m buffer, and watershed

Topic	Source	Area Sampled	Attributes
Morphology/Location	max depth from multiple state/fed databases, elevation and slope from USGS 30m DEM, TNC Terrestrial Ecoregions, other attributes calculated from base hydrography polygon geometry	waterbody	maximum depth, area, elevation, latitude, longitude, shoreline complexity shape compared to circle, ecoregion
Dams	Northeast Connectivity Dam dataset (Martin and Apse 2011)	waterbody	# dams, primary purpose of largest dam, total NID storage of dams on the lake, total NID storage of all dams upstream of the lake
Climate	PRISM 30yr normals, 1981-2010. 800m pixel grids. Oregon State University	waterbody	annual and monthly values for mean temperature, minimum temperature, maximum temperature, precipitation
Land Cover	NLCD Land Cover 2011, NLCD Impervious 2011; 30m grids	100m buffer, 1000m buffer, total upstream watershed	total percent impervious surfaces, Land cover categories: developed open space, developed low intensity, developed medium intensity, developed high intensity, barren land, deciduous forest, evergreen forest, mixed forest, dwarf scrub, shrub/shrub, grassland/herbaceous, pasture/hay, cultivated crops, woody wetlands, emergent wetlands. Summary land cover categories: developed, agriculture, forested, wetland, natural
Landforms	TNC Landforms 6/2015; 30m grids	1000m buffer, total upstream watershed	steep slope cool aspect, steep slope warm aspect, cliff, summit, slope crest, hilltop flat, hill gentle slope, sideslope cool aspect, sideslope warm aspect, dry flats, wet flats, valley toeslopes, moist flats, flat at a bottom of steep slope, cover cool aspect, cover warm aspect
Conservation Lands	TNC Secured Lands Database 2013	100m buffer	GAP status 1, 2, and 3
Bedrock Geology	TNC Bedrock Geology 2015	1000m buffer, total upstream watershed	acidic sedimentary, acidic shale, calcareous sedimentary/metasedimentary, moderately calcareous sedimentary/metasedimentary, acidic granitic, intermediate granitic, mafic, ultramafic, deep coarse sediment, deep fine sediment

Table 4 continued. GIS Landscape Attributes

Regional Soils	STATSGO (1:250,000 map units)	waterbody	cat ion exchange capacity, % calcium carbonate, depth to seasonally high water table, soil thickness, hydrologic soils group A, B, C D, AB, BD, CD, AC, BC, soil erodibility k-factor, permeability, available water capacity, bulk density, organic matter content, clay content, average silt, average sand, % soil material less than 3 inches that passes a No. 4 sieve (5mm), % of soil material less than 3 inches that passes a No. 200 sieve (0.74mm), % of soil material less than3 inches that passes a No. 10 (2mm) sieve
Local Soils	SSURGO (1:24,000 map units)	1000m buffer, total upstream watershed	% sand, % loam, % silt, % clay, mean root zone depth
Base Flow Index	Wolock, D.M., 2003, Base-flow index 1km grid for the conterminous United States: U.S. Geological Survey Open-File Report 03–263	1000m buffer, total upstream watershed	mean base flow index

Statistical Approach

We used the sample data to attribute and classify waterbodies whenever possible. The data also served as input and validation for predictive models used to classify the unsampled waterbodies in combination with the 300 landscape variables.

To build predictive models for alkalinity, trophic state, and temperature class we used the *RandomForest* software package (Liaw & Wiener 2002) in R (R Core Team 2014). Random Forest (RF) is a machine learning technique that builds hundreds of decision trees to assess the relationship between a response variable and potential predictor variables. A classification tree is used when the response variable is categorical. RF has been shown to be a powerful technique that can handle large datasets, complex data distributions, and correlated variables without a decrease in prediction accuracy and it has built-in approaches that prevent overfitting (Breiman 2001). The algorithm works by first randomly selecting many observations from the data with replacement, a technique known as bootstrapping. The bootstrap samples serve as the training data, and a classification or regression tree is fit to each sample. In each bootstrap sample, approximately 33% of the observations are not used and are referred to as out-of-bag (OOB) data. The OOB data is used for calibration and validation of the trees, and to estimate predictor variable importance. Predictor variable importance is calculated by determining how much predictive accuracy decreases when a particular variable is randomly permuted. For classification trees, the predicted classification of an observation is determined by the majority of OOB votes in the forest, with ties split randomly. Classification accuracies are calculated for each observation using the OOB predictions, and are then averaged over all observations (Cutler et al. 2007).

We intentionally used a categorical approach to this project because it allowed for greater confidence in the results. For example, in our model predicting trophic status, the RF classification tree correctly predicted the class membership of 1859 Oligotrophic-Mesotrophic lakes 80% of the time, and of Eutrophic-Hypereutrophic lakes 70% of the time, even though the quanitative regression model of trophic status only explains a quarter of the variation (R^2= 0.23) in chlorophyll-a. Thus we were more confident in the accuracy of class membership than we were in the quantitative estimate of chlorophyll-a.

To determine acceptable models, we systematically expored each variable. For each, we ran 10-20 exploratory runs where we altered RF parameters including the number of trees, input source class sample sizes, and number of predictor variables used at each split. We began with an initial run using all 315 possible predictor variables and subsequent runs with the top 50, 25, 20, 15, and 10 variables from the initial variable importance ranking table. We also experimented with using the top 15 or top 10 variables that occurred in any of the sub class models (e.g. top 10 variables for predicting Very Cold class vs. top 10 variables for predicting all temperature classes) and also used ecological knowledge to select particular variables to include or exclude. Our ultimate decisions were informed by how the class error and variable importance scores changed with these varying parameters. For each variable we settled on the simplest model, e.g. the model with the lowest number of predictor variables, that gave the lowest error rates and was comparable in error rates to more complex models.

Confidence Class

The outputs of a RF model include an estimated probability that a variable falls into each of the possible classes. For example, a lake's estimated water temperature class might have a 75% probability of being Very Cold, a 25% probability of being Cold and a 1% probability of being Warm, so the the temperature class had a 50% higher probability of being Very Cold than Cold, and almost no chance of being Warm. Our confidence is high that it was correctly classified. In contrast if it had had a 50% probability of being Very Cold, and a 49% probability of being Cold, we would be less confident in our classification. Our "confidence" code was thus based on the difference between the maximum probability and second highest probability of class membership within each model. The confidence code was use to evaluate the predictions for a given waterbody and also understand the geographic distribution of possible errors in the model predictions. The five confidence classes were:

1. High: Difference greater than >= 25%
2. Medium: Difference >= 10 and <25%
3. Low: Difference between >=5 and < 10%
4. Very Low: Difference less than 5%

Known: Variable class based on sample data

Details on the final RF model for alkalinity, trophic state, and temperature are described in the subsequent chapters that focus on each variable individually.

3. Temperature Class

Ecological Significance

The temperature and concentration of dissolved oxygen in a waterbody influences the types of fish, amphibians, reptiles, invertebrates, and plants that can live and reproduce within it. Water temperature sets the physiological limits where most aquatic ectotherms can persist and many fish species are commonly described as by their temperature preferences. Cold water lake species include: brook trout, lake trout, rainbow smelt, cisco, burbot, arctic char, and lake whitefish. Cool water lake species include: smallmouth bass, yellow perch, trout-perch, white perch, walleye, muskellunge, striped bass and others. Warm water lake species include: largemouth bass, golden shiner, brown bullhead, chain pickerel, and many species of sunfish (Halliwell et al. 1999). Seasonal changes in water temperature cue reproduction, influence growth rates of eggs and juveniles, and affect the body size and fecundity of adults. Although exact temperature thresholds needed for the presence and reproduction of many species are not known with specificity, species such as lake trout only survive and reproduce in lakes that contain permanent cold water less than 12.8°C with at least 5 mg/l dissolved oxygen (Thill 2014). Another key cold water species, brook trout, has varying reported upper temperature limits for adults between 17-24°C, however temperatures greater than 18°C for fry are considered detrimental and an impediment to successful natural reproduction. Wild reproducing brook trout are not usually found in waterbodies warmer than 18°C or with less than 5mg/l dissolved oxygen (Raleigh, 1982). Brown trout are also considered a cold water species but have a higher upper tolerance and optimal growth temperature range than brook trout. Reproducing brown trout and stocked non-reproducing brook trout are not usually found in waterbodies warmer than 21°C or with less than 4 mg/l dissolved oxygen (NJDFW, 2005).

Model and Results

To reflect the range of ecologically meaningful temperatures found across the region, we grouped the waterbodies into four temperature classes based on the thresholds for temperature and dissolved oxygen (DO = presence of at least 1 m of oxygenated water) discussed above.

1. VERY COLD: <12.8°C and >=5 mg/l DO or indicator fish = lake trout

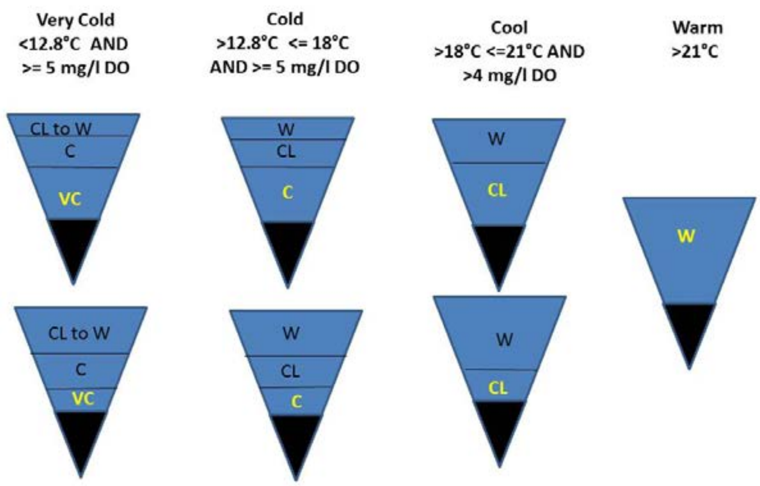
2. COLD: 12.8°C <=18°C and >=5 mg/l DO or indicator fish = wild brook trout

3. COOL: >18°C <=21°C and >=4 mg/l DO or indicator fish = non-reproducing brook trout, holdover or reproduction of brown trout, kokanee, smelt

4. WARM >21°C

We used both temperature and DO profile data and fish indicator information to place sampled lakes into our four categories. In many waterbodies, more than one temperature class was present, but the waterbody was assigned to the "coldest" class present as this was the most limiting habitat type (Figure 1).

Figure 1. Temperature class conceptual diagram. This diagram shows variation in how waterbodies volume could be distributed between anoxic (black) , Very Cold, Cold, Cool, and Warm habitats and how the lake would be placed into one of the four primary temperature classes.



We compiled temperature/DO profile data for each state's waterbodies using values from 1990-present and taken in the months of July and August. Data were cleaned to ensure only paired temperature/DO samples were used, that the profile included more than just the surface and bottom measures (e.g. it represented a full vertical profile at multiple intervals), and included only data from July and August from 1990 to the present. Our query looked at the paired temperature/DO samples at each sampled depth along a vertical depth profile for a given date. Lakes were coded with the coldest temperature/DO pair occurring for a given date and assigned to a class as per Table 2. When the same lake was sampled on multiple years and the estimated temperature class of the lake differed between years, the lake was assigned to the coldest temperature class consistently present in every year.

A few states were missing temperature/DO data but had extensive fish surveys that could be used to indicate cold water habitat. For example, a study of lakes supporting lake trout in NY was used to assign lakes to the Very Cold temperature category because lake trout require permanent cold habitat. Other fish databases such as NH Fish and Game and published fish community information on bathymetry maps were also used to assigned lakes to temperature classes:

Very Cold: presence of lake trout throughout the summer
Cold: presence of brook trout throughout the summer
Cool: presence of brown or other species of trout throughout the summer
Warm: lack of trout or other cold water indicator species.

In total, lake samples with temperature/DO profiles or indicator fish information included 2,634 waterbodies (see Appendix I for more information on our source datasets). This included samples of 423 Very Cold, 646 Cold, 401 Cool, and 1164 Warm waterbodies (Map 1).

We suspect that some of these samples may be assigned to the incorrect category because, in spite of our best efforts to correctly classify these sampled waterbodies, there were factors out of our control. For example, over 80% of our waterbodies were classified based on a single year and many were from a single month. Additionally, large lakes can be heterogenous in temperature and may have regions where cold ground water seeps occur and maintain cold habitat throughout the summer (e.g. trout found huddled near incoming cold water seeps nearshore in hot summer months). These fine-scale refuges may be better classed as Cold, than the Cool class they were likely assigned. When we used fish community data instead of temperature/DO profiles to determine temperature class we may have misclassified Cold waterbodies as Cool because the absence of brook trout throughout the summer might reflect other habitat or competition factors instead of water temperature. We also noted some very deep lakes with cool to very cold water were without oxygen or were below our threshold of 4 mg/L. We classified these lakes as Warm because our criterian was based on layers of water that had enough oxygen to also support aquatic life. In these waterbodies, only the surface warmer waters had enough oxygen to support life even though there was colder water present. These waterbodies often appeared to be large and deep reservoirs with eutrophication problems. Finally, our criteria of at least one meter of a temperature class being present may have been too narrow or low amount of habitat.

We used RF and the methods described previously to estimate the temperature of unsampled waterbodies. The method produced good results for three temperature classes (Very Cold, Cold, and Cool-Warm), but we had to run a second separate model to subdivide the Cool-Warm class. Although the second model does not have the accuracy of the first model, we expect users will find it useful to know the most likely subclass. We developed the two step approach because we could not find an acceptable single model that separated all four classes. Specifically, the class error for the Cool category was greater than 50% and study of the confusion matrix for these runs showed the Cool class was confused most heavily with the Warm class.

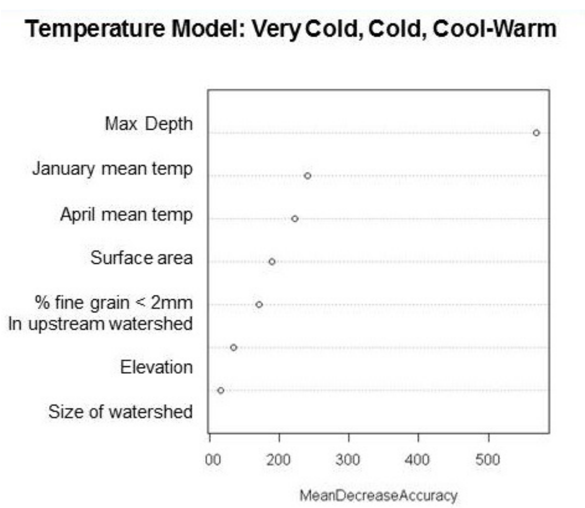
Three Class Temperature Model: Very Cold, Cold, Cool-Warm

To create the three class temperature model (Very Cold, Cold, Cool-Warm) we began with an initial run using all 315 possible predictor variables and subsequent runs with the top 50, 25, 20, 15, and 10 variables that emerged from the overall model variable importance ranking table and the sub type variable importance ranking table. We settled on a seven variable model that produced low overall error and low within class error. This model included 10,000 iterations with 3 variables tried at each split and resulted in overall 18.8% error rate with all sub class error rates also below the accepted threshold of 30% (Table 5). The predictor variables in order of decreasing importance in the model were maximum depth (MAXFT) which dominated the importance, followed by mean January temperature (TMEAN1), mean April temperature (TMEAN4), surface area of the waterbody (ACRES), percent of fine grained soil in the upstream watershed (no10_avgN), elevation (ELV_M), and size of the upstream network watershed (DIVDASQKM) which represents both the total watershed size and also the influence of inflow and outflow rivers from a waterbody (Figure 2). We applied the model to all 36,675 waterbodies, and each unsampled waterbody was assigned to the class it had the highest probability of being within (Map 2).

Table 5. Three class temperature model confusion matrix. Showing number of known occurrences of each class by their placement by the RF model.
OOB estimate of error rate: 18.79%

	Very Cold	Cold	Cool-Warm	Class Error
Very Cold	347	34	42	0.18
Cold	73	458	115	0.29
Cool-Warm	134	97	1334	0.14

Figure 2. Variable importance plot for the three class temperature model. The plot shows each variable on the y-axis ordered from most- to least-important. The x-axis shows the mean decrease in classification accuracy when that particular variable is randomly permuted.



The classification confidence codes measures how strongly an individual waterbody fit into one class versus the other possible classes (see Statistical Models section) and shows the geographic distribution of possible errors in the prediction (Map 4). For the 3 class temperature model, the results show that 79% of the waterbodies were in the high confidence class, and 5% were in the low confidence or very low confidence class (Table 6).

Table 6. Confidence classes for the three class temperature model

	Very Cold	Cold	Cool to Warm	Total
1. High : >= 25%	32.3%	61.0%	83.4%	78.6%
2. Medium: >= 10 and <25%	15.5%	15.1%	8.3%	9.5%
3. Low >=5 and < 10%	7.0%	5.7%	1.9%	2.6%
4. Very Low: < 5%	8.1%	5.8%	1.3%	2.1%
Known	37.1%	12.5%	5.2%	7.2%
# Waterbodies	1,140	5,169	30,366	36,675

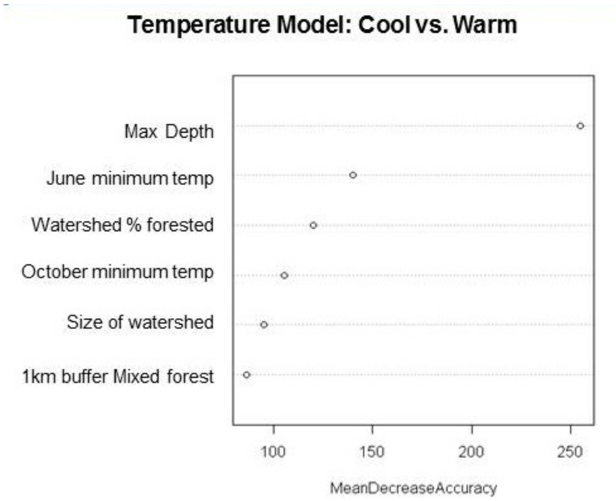
Additional Two Class Temperature Model: Cool vs. Warm

We have high confidence in the three class temperature model. However, in order to distinguish Warm from the Cool waterbodies we ran an additional RF model that separates the two classes but has lower accuracy. We suspected that different variables might drive the Cool vs. Warm split and that we might be more successful distinguishing these two types if we examined them alone. We began with an initial run using all 315 possible predictor variables and subsequent runs with the top 50, 25, 20, 15, and 10 variables that emerged from the overall model variable importance ranking table and the sub type variable importance ranking table. We settled on a simple model using 6 variables that produced lowest overall and within class error. This model included 10,000 iterations with 3 variables tried at each split and resulted in overall 24.5% error rate with all sub class error rates also below the accepted threshold of 30% (Table 7). The predictor variables in order of decreasing importance in the model were maximum depth (MAXFT) followed by minimum June temperature (TMIN6), percent of the upstream network that is forests (NLCD11_ForN), minimum October temperature (TMIN10), size of the upstream network watershed (DIVDASQKM), and percent of the 1km buffer in mixed forest cover (LC1kV43, Figure 3). We applied the model to all waterbodies that were within the Cool to Warm category from the previous model, and each was thus assigned a category based on the model output highest probability. These classes were added to the dataset to produce a provisional 4 Class Temperature Map (Map 3)

Table 7. Two class temperature model confusion matrix. Showing number of known occurrences of each class by their placement by the RF model.
OOB estimate of error rate: 24.54%

	Cool	Warm	Class Error
Cool	**283**	**118**	**0.29**
Warm	266	898	0.22

Figure 3. Variable importance plot for the cool vs. warm model. The plot shows each variable on the y-axis ordered from most- to least-important. The x-axis shows the mean decrease in classification accuracy when that particular variable is randomly permuted.

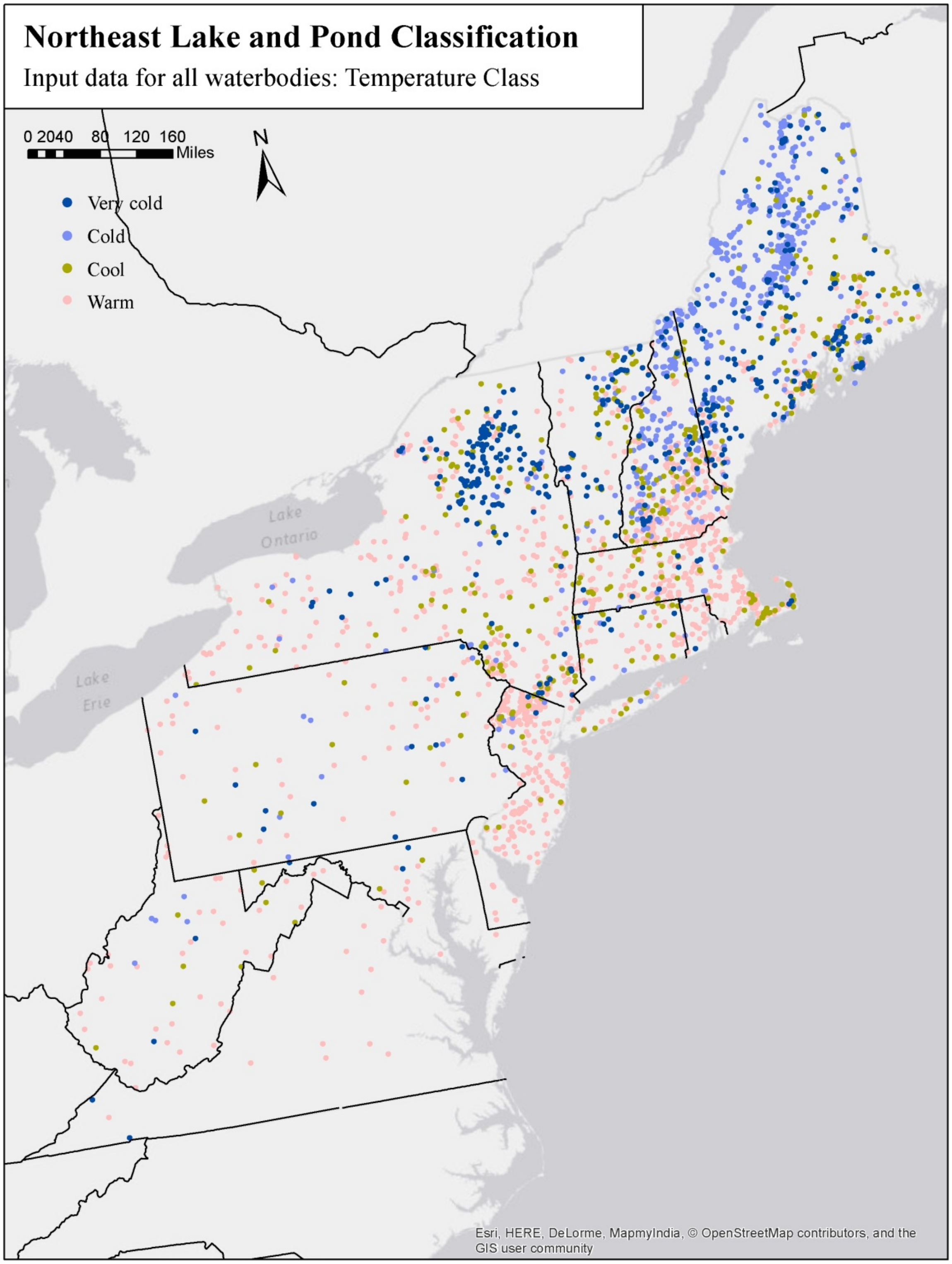


The classification confidence codes based on the model output probabilities for each waterbody were used to evaluate the predictions for a given waterbody and also understand the geographic distribution of possible errors in the prediction (Map 5). For the Cool vs. Warm temperature model, the results show that 87% of the waterbodies were in the high confidence, and 3% were in the low confidence or very low confidence class (Table 5).

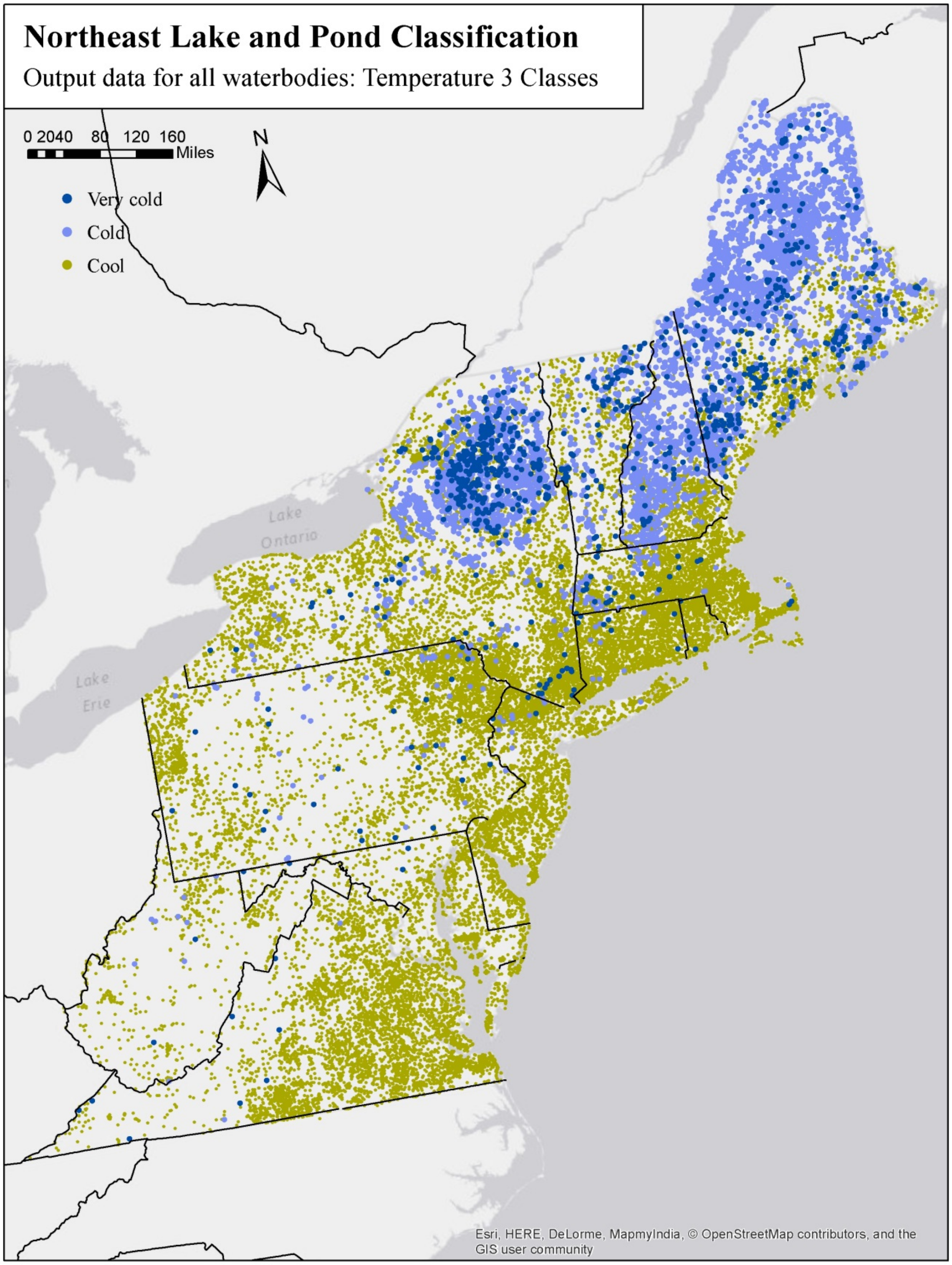
Table 8. Confidence classes for the two class temperature model

	Cool	**Warm**	**Total**
1. High : >= 25%	34.0%	90.3%	86.8%
2. Medium: >= 10 and <25%	22.0%	3.7%	4.8%
3. Low >=5 and < 10%	11.1%	1.0%	1.6%
4. Very Low: < 5%	11.5%	1.0%	1.6%
Known	21.4%	4.1%	5.3%
# Waterbodies	1,871	28,495	30,366

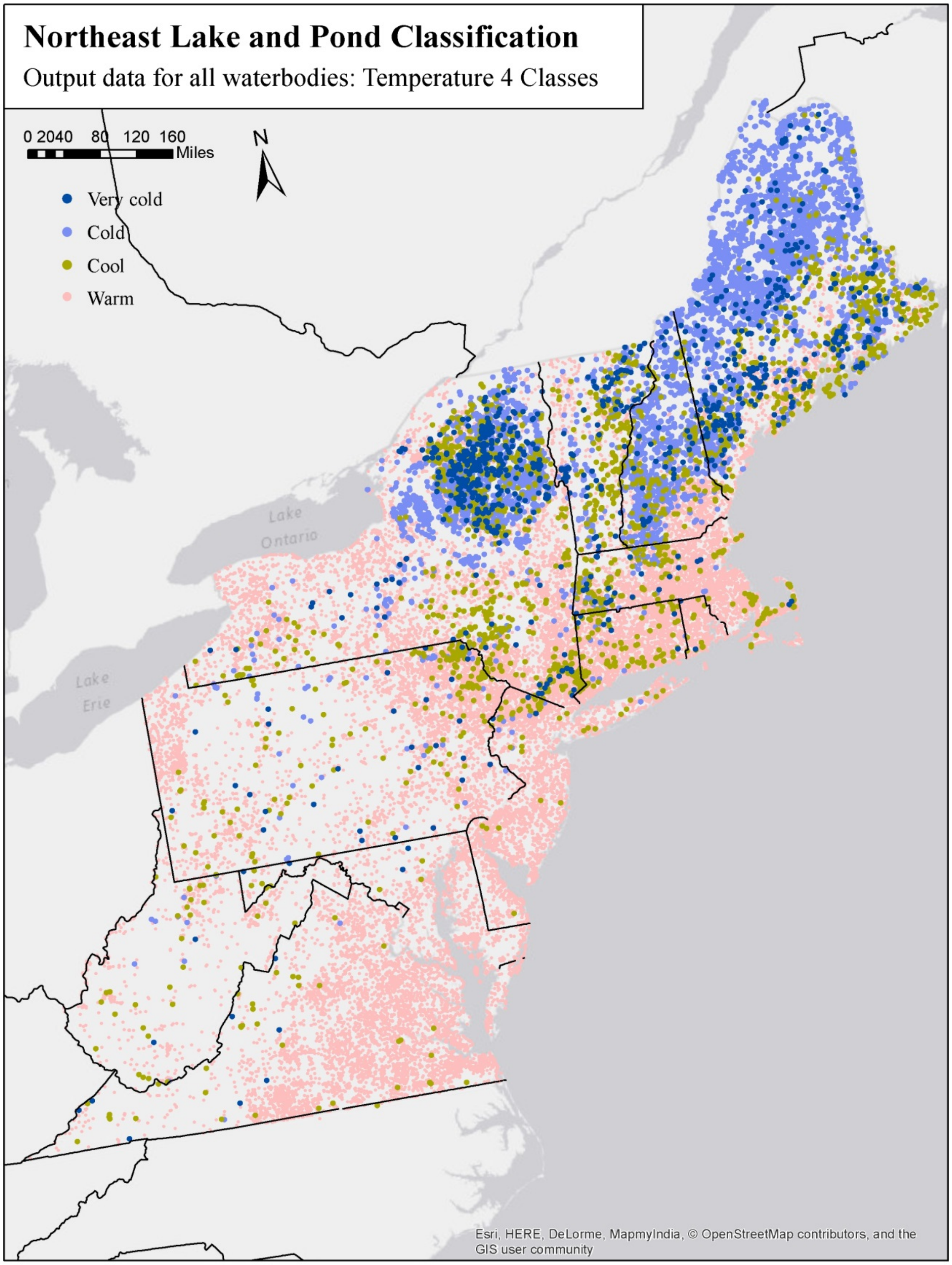
Map 1. Input temperature class for sampled waterbodies



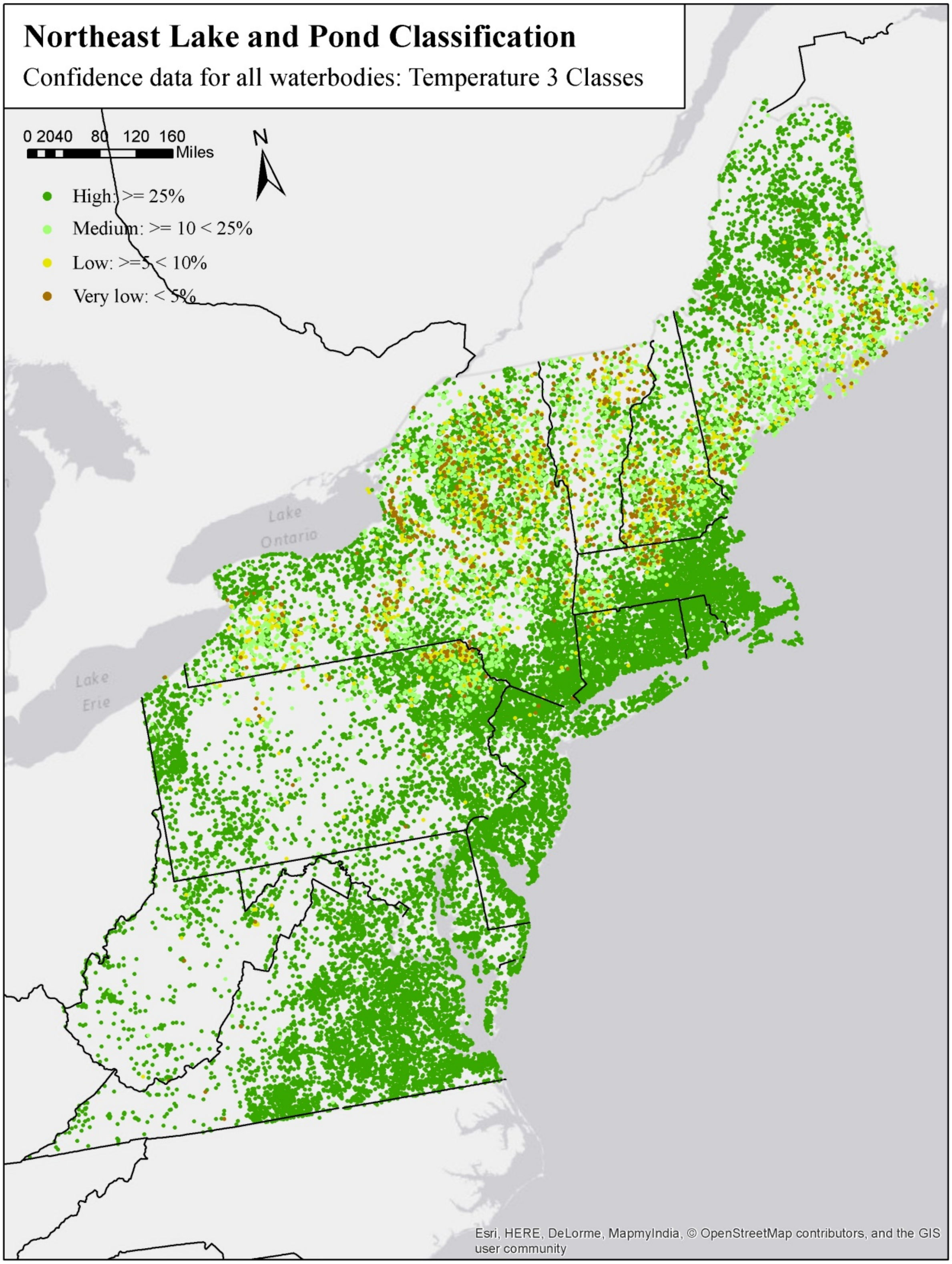
Map 2. Three temperature classes. Estimates for three temperature classes for all waterbodies based on the predictive model and sampled data.



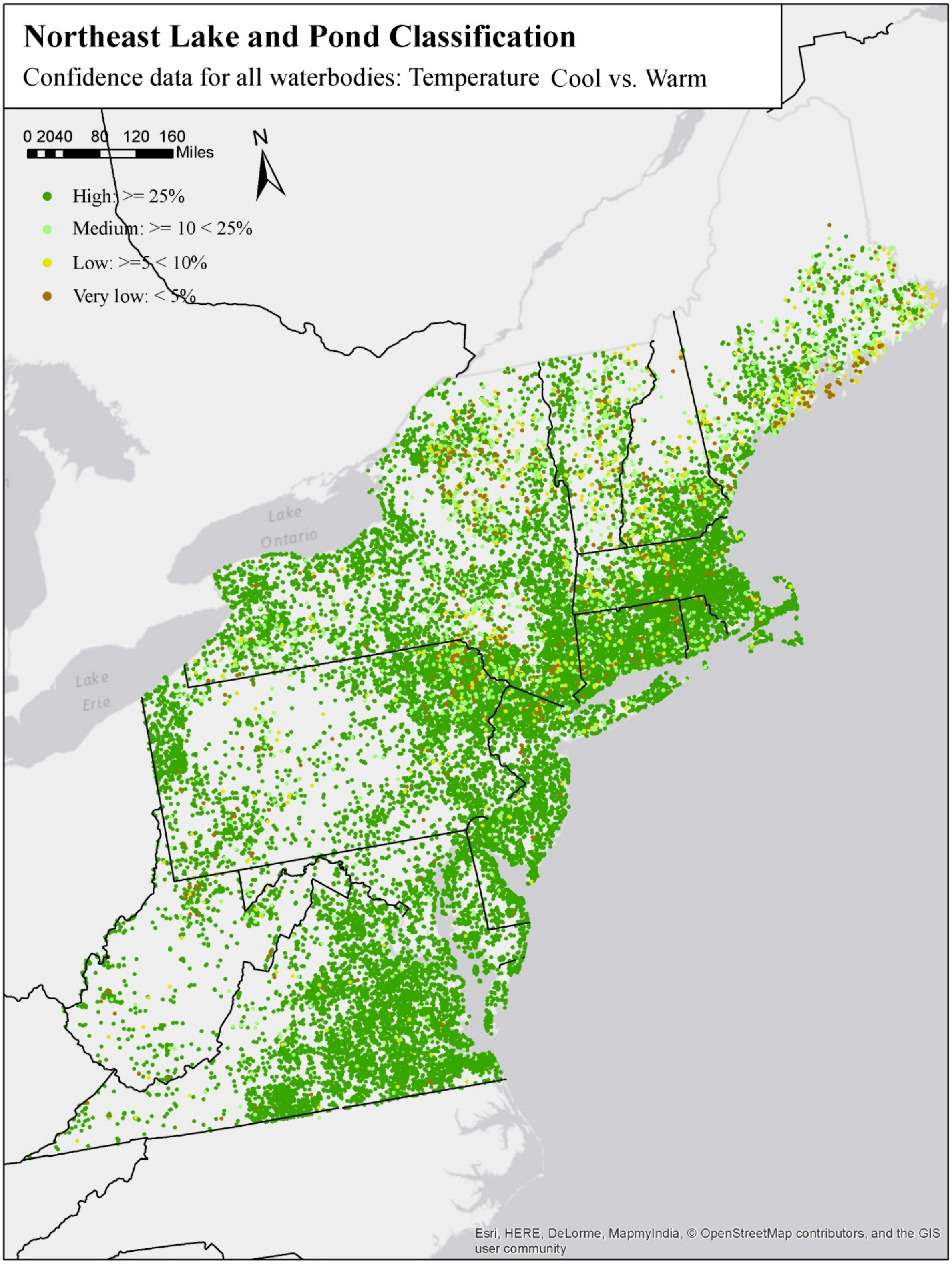
Map 3. Four temperature classes. Estimates for four temperature classes for all waterbodies based on the predictive models and sampled data.



Map 4. Confidence class for three temperature classes



Map 5. Confidence class for all cool vs. warm waterbodies



4. Alkalinity Class

Ecological Significance

Alkalinity and acid neutralizing capability (ANC) are measures of how available bicarbonate ions (CACO3) are to buffer the waterbody from acidification. Lakes with high ANC are able to neutralize incoming acid deposition and buffer the effects of acid rain. These lakes are often found naturally in limestone watersheds, and in some cases are created unnaturally by large inputs of lime onto the land in agriculturally dominated watersheds. In general, lakes with higher ANC also have a higher pH, and these waterbodies support a unique set of aquatic plants and insects (Edinger et al. 2002). Conversely, granite and sandstone dominated watersheds contain fewer acid neutralizing ions, have low ANC, and lower pH, and this combination leads to a predisposition to acidification. Acidification in poorly buffered systems has the potential to disrupt the life cycles of fish and other organisms as it intensifies the mobilization and bioaccumulation of toxic mercury compounds in the food web. Most aquatic organisms need water pH to be within 6.5-8.0 for optimal growth, reproduction, and survival. Lakes with pH levels below 5, or alkalinity concentrations less than 2 mg/L CaCO3, no longer support fish (Allan 1995). Fish that can tolerate some acid conditions include yellow perch, brown bullhead, and brook trout, although brook trout will not spawn if waters are too acidic. In the Northeast, acid intolerant fish that cannot tolerate a pH of less than 5.5-6.0 include the blacknose dace and creek chub.

Model and Results

We used three alkalinity classes based on ANC thresholds recognized by many of the states, and agreed upon by the steering committee, as capturing the thresholds where the biota was most likely to change (Table2). The thresholds used to separate the three classes have been used in a number of northeastern states and represent breaks that correspond roughly to pH:

- Low (<12.5 mg/L CaCO3), ~ acidic
- Medium (12.5-50 mg/l CaCO3), ~ neutral
- High (>=50 mg/L CaCo3) (Table 2),~ alkaline

We obtained sampled alkalinity databases from a variety of state and federal sources (Appendix I). We queried data from 1990-present for alkalinity that were taken at less than 2m in depth (or listed as surface readings) from any month of the year. Most alkalinity data came in mg CaCO3 per L water, however if data were provided as ANC it was converted to Alkalinity using the formula:

1mg/L Alk (as CaCO3) = 20 ueq/L ANC (Brezonik and Arnold, 2011).

If multiple samples were available for a given waterbody in a source database, the data was averaged across years to yield an overall mean value. We separately summarized alkalinity data from the National Lake Assessment (NLA), New England Lake and Pond Survey (NELP), and State sources, and we compared overall alkalinity class assignments for lakes. This was necessary because it was often unclear if state sampling duplicated records found in NLA or NELP and we did not want to double count samples.

We also thought it was useful to compare results given the slightly different methods used in some state vs. national or regional sampling efforts. Ultimately, we found that no waterbodies had differing alkalinity class assignments between our sources.

Our sample dataset included 3,305 waterbodies (ee Appendix I for more information on our source datasets) assigned to the following alkalinity classes: 430 high, 980 medium, and 1895 low (Map 6).

We began the RF modeling with an initial run using all 315 possible predictor variables and subsequent runs with the top 50, 25, 20, 15, and 10 variables that emerged from the variable importance ranking tables. We settled on a model of 6 variables that had low overall and within class error. This model included 10,000 iterations with 3 variables tried at each split and resulted in overall 20.9% error rate with all sub class error rates also below the accepted threshold of 30% (Table 9). The predictor variables in order of decreasing importance were percent natural land cover in 1km buffer (LC1kNAT), longitude (LONG), soil erodibility in the upstream watershed (Kfactup_avgN), latitude (LAT), percent of upstream network watershed in calcareous bedrock (geol_300N), and percent of 1km buffer in calcareous bedrock (geol_300) (Figure 4).

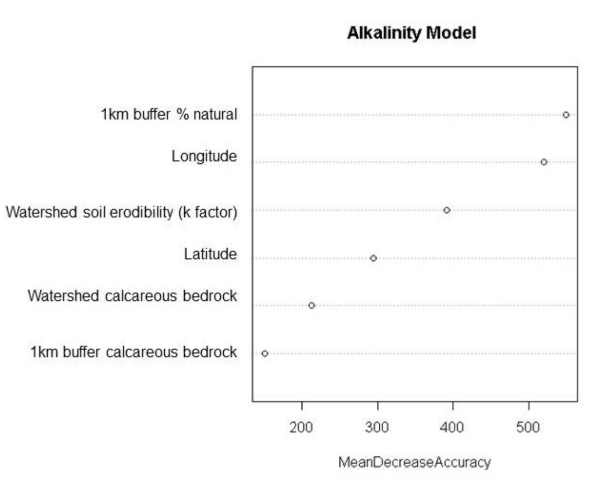
Table 9. Alkalinity model confusion matrix. Showing number of known occurrences of each class by their placement by the RF model.

OOB estimate of error rate: 20.88%

	High	Medium	Low	Class Error
High	323	100	7	0.24
Medium	112	706	162	0.28
Low	10	299	1586	0.16

The "confusion matrix" shows how the model correctly or incorrectly classified the samples (Table 4). Errors in the high and low classes resulted mainly in misclassification to the medium class. Errors in the medium class were split between the high or low class, with slightly more going into the low class. We applied the model to all 36,675 waterbodies, and each unsampled waterbody was assigned to the class it had the highest probability of being based on its landscape variables (Map 7).

Figure 4. Variable importance plot for the alkalinity model. The plot shows each variable on the y-axis ordered from most- to least-important. The x-axis shows the mean decrease in classification accuracy when that particular variable is randomly permuted.

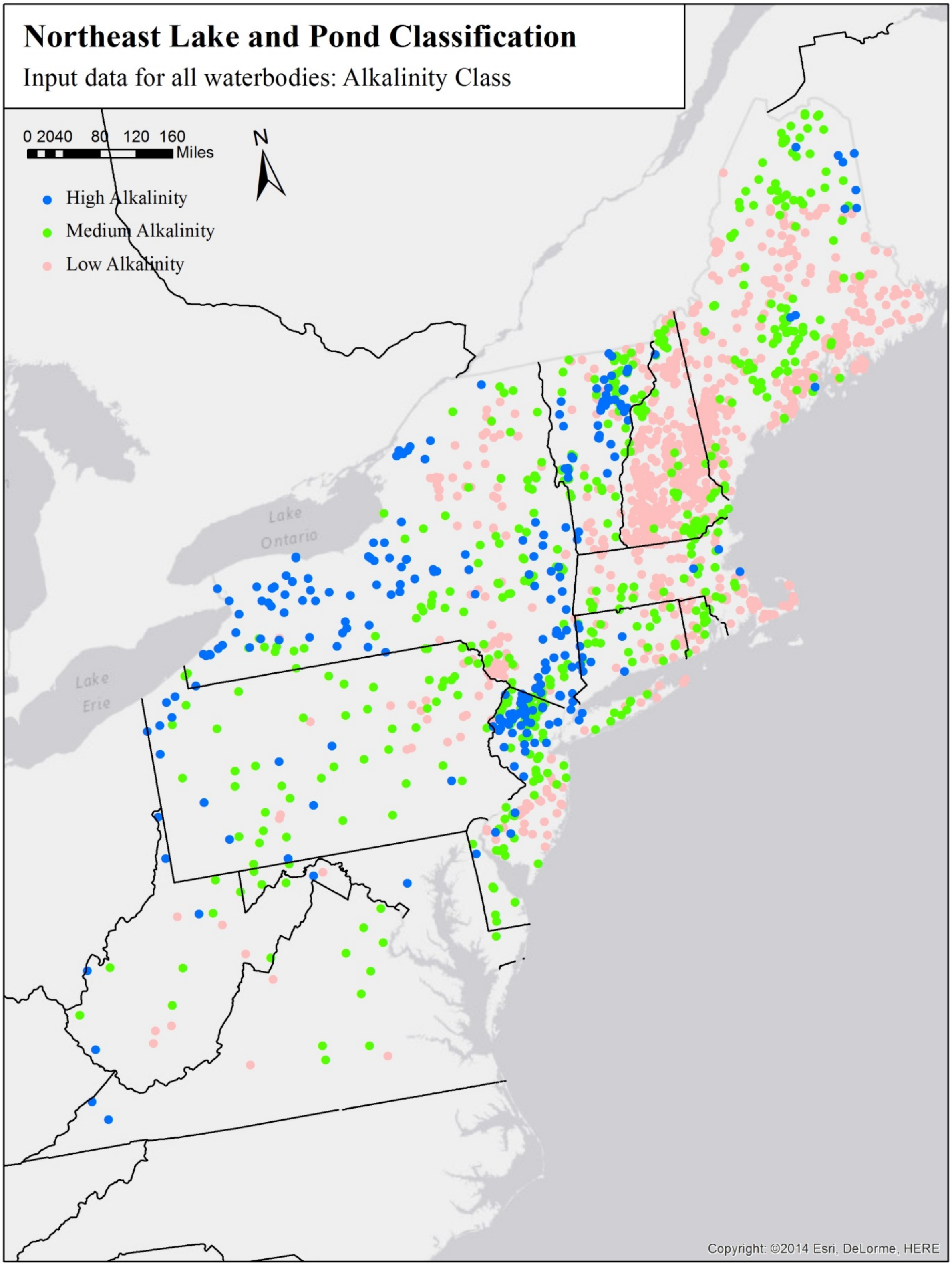


The classification confidence codes (see Statistical Methods section) for each waterbody were used to evaluate the predictions for a given waterbody and also understand the geographic distribution of possible errors in the prediction (Map 8). For alkalinity, the results show that 70% of the waterbodies were in the high confidence, and 8% were in the low confidence or very low confidence class (Table 10).

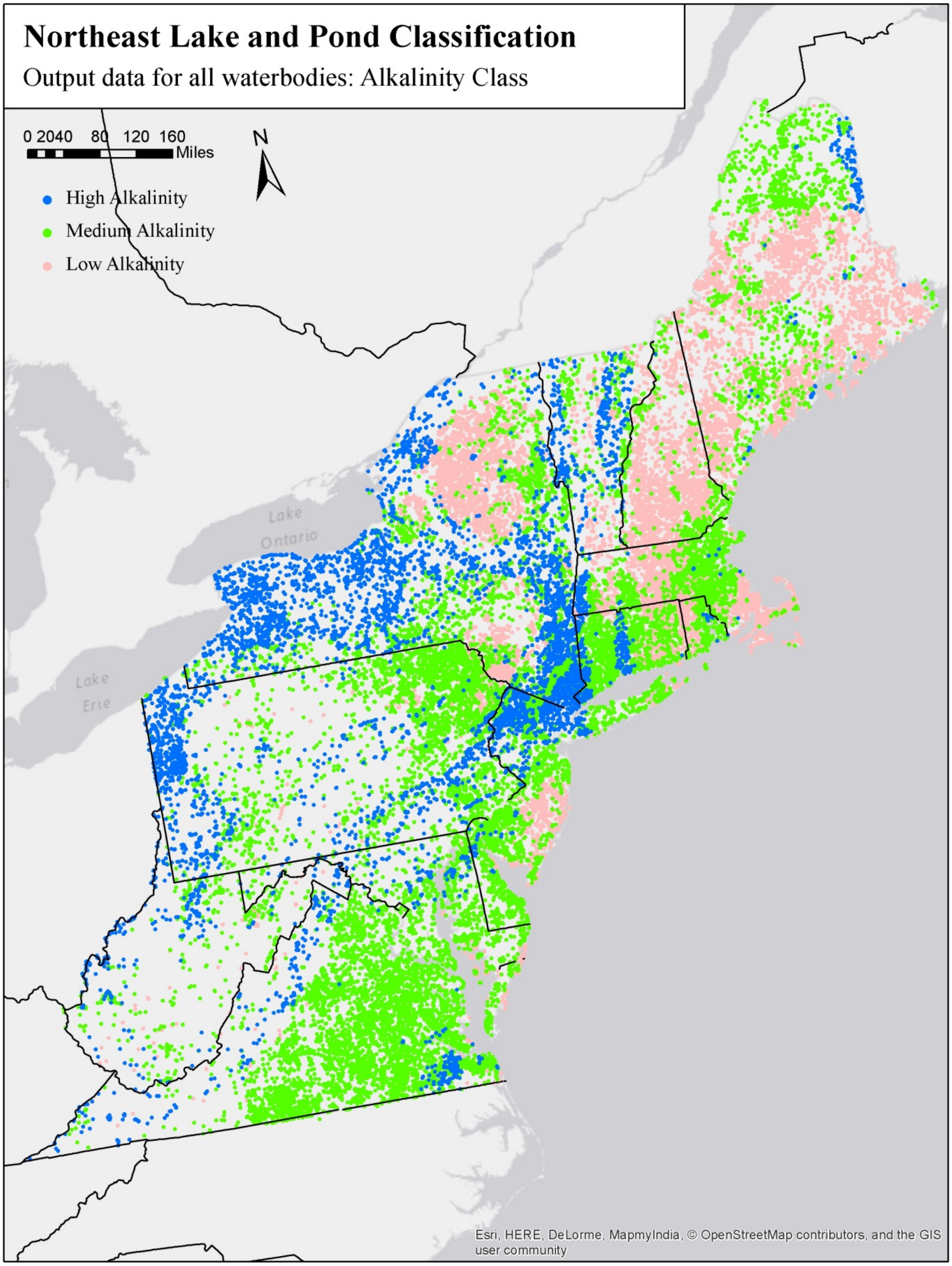
Table 10. Class confidence for alkalinity class

Alkalinity Model Confidence	High Alkalinity	Medium Alkalinity	Low Alkalinity	Total
1. High : >= 25%	73.1%	71.1%	67.0%	70.3%
2. Medium: >= 10 and <25%	12.3%	14.5%	9.7%	12.5%
3. Low >=5 and < 10%	4.1%	4.4%	3.8%	4.1%
4. Very Low: < 5%	4.2%	4.5%	3.8%	4.2%
Known	6.3%	5.5%	15.8%	9.0%
# Waterbodies	6,863	17,780	12,032	36,675

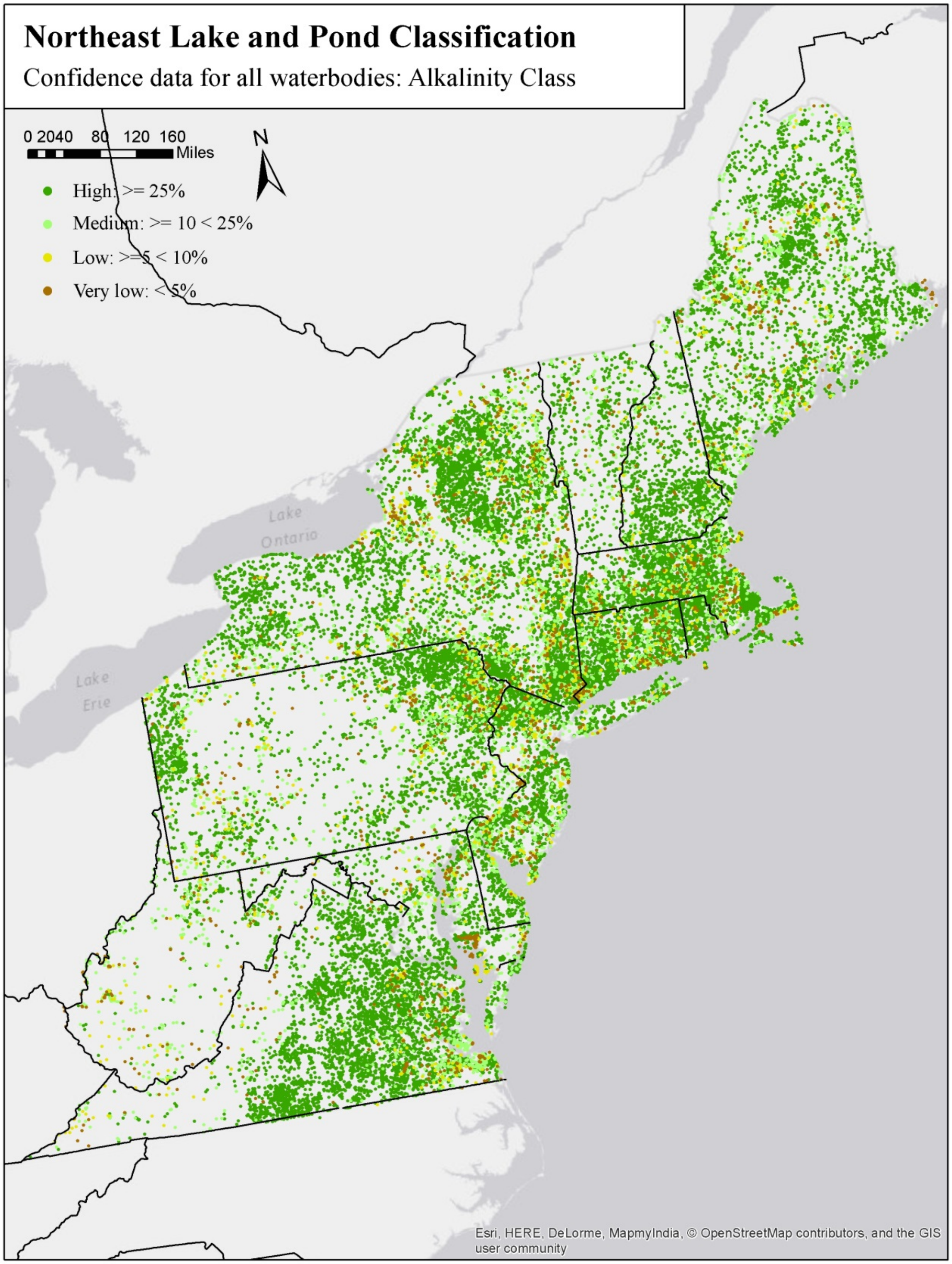
Map 6. Input alkalinity class for sampled waterbodies



Map 7. Alkalinity class. Estimates for all waterbodies based on the predictive model and sampled data.



Map 8. Confidence for alkalinity class



5. Trophic State Class

Ecological Significance

Trophic state, meaning "nourishment," was used to characterize the productivity of a waterbody by placing it into one of four classes. Oligotrophic lakes are nutrient poor, with low biological productivity and high transparency or clarity. Mesotrophic lakes have moderate levels of nutrients and biological productivity. Eutrophic lakes are well-nourished, highly productive systems that support a diverse array of organisms, and usually have low transparency due to high algae and chlorophyll content. Hypereutrophic lakes have an excess of nutrients giving rises to algal blooms, vegetative overgrowth, and low biodiversity. The trophic state of a waterbody can be determined by sampling chlorophyll-a concentrations, total phosphorus, or Secchi transparency, which are surrogates for actually measuring algae biomass (USEPA 2009). We used chlorophyll-a, the predominant type of chlorophyll found in green plants and algae, as the standard metric because it was widely available for many waterbodies and it is the most direct measure of trophic state. The cutoffs we used for the trophic state classeswere adopted from the NLA standards and expressed in micrograms of chlorophyll-a per liter of water (Table2):

- Oligotrophic: <= 2 ug/l
- Mesotrophic >2 -7 ug/l
- Eutrophic >7 - 30 ug/l
- Hypereutrophic >30 ug/l

Model and Results

We obtained waterbody data from state and federal sources (Appendix I), and we queried it for chlorophyll-a samples from 1990-present taken from less than 2m in depth (or listed as surface readings) in the months of July and August. If multiple samples were available for a given waterbody in a source database, the data was averaged across years to yield an overall mean value. We also separately summarized input chlorophyll-a data from the LAGOS project, NLA, NELP, and State sources, and we compared overall chlorophyll-a class assignments for lakes. This was necessary because it was often unclear if state sampling duplicated records found in LAGOS, NLA, and/or NELP and we did not want to double count samples. It was also useful to compare results given the slightly different methods used in some state vs. national or regional sampling efforts. Waterbodies were assigned a final chlorophyll-a class based on the majority of the input source class results (e.g. Oligotrophic in LAGOS, Oligotrophic in NLA, Mesotrophic in State = Oligotrophic final class).

Our sample dataset included an assigned chlorophyll-a class for 2,828 waterbodies. This included 200 hypereutrophic, 769 eutrophic, 1465 mesotrophic, and 394 oligotrophic (Map 9).

In contrast to our 2014 report, we did not include any EPA modeled chlorophyll-a data as sample data (Milstead et al. 2013). We omitted the EPA values because of concerns of the team given the low R-squared of their model (.499). We also tested the results of the EPA model against our collection of known samples, calculating the misclassification rate and finding it to be higher that the classification error rate we could get with our final RF model when it was built using only known sampled chlorophyll-a data as input.

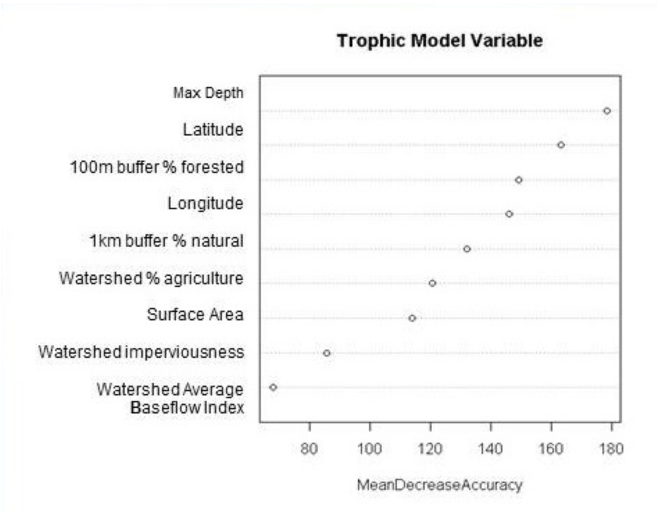
We began the RF modeling with an initial run using all 315 possible predictor variables and subsequent runs with the top 50, 25, 20, 15, and 10 variables that emerged from the variable importance ranking tables. However, we could not produce an acceptable model that accurately separated all four trophic state classes and had an overall and class error rate under 30%. For example, a run including all possible predictor variables with 5,000 iterations and 50 variables tried at each split had an overall OOB estimate of error rate of 45.6% with eutrophic state class error 44.6%, hypereutrophic error at 52.5%, mesotrophic error at 45.1% and Oligotrophic error of 46.3%. Because the model had poor success separating the eutrophic and hypereutrophic classes, we combined these classes together to create a 3 class model. Using the 3 classes, we were still unable to produce an acceptable model with class error under 30%, although the model was able to separate the combined eutrophic-hypereutropic class from the other two classes with accuracy. For example a full run including all 315 possible predictor variables with 5,000 iterations and 50 variables tried at each split had an overall OOB estimate of error rate of 35.7% with eutrophic-hypereutrophic state class error 24.7%, mesotrophic error at 39.4% and oligotrophic error of 51.8%.

Based on the above results, we combined the oligotrophic and mesotrophic classes together and tried a 2 class model. We began RF modeling with an initial run using all 315 possible predictor variables and obtained promising results and a model with overall OOB estimate of error rate 22% and both subclass models with <30% error. We explored subsequent runs with the top 50, 25, 20, 15, and 10 variables that emerged from the overall model variable importance ranking table and the sub type variable importance ranking table. We settled on a model using 9 variables that produced low overall and within class error (Map 10). This model included 10,000 iterations with 3 variables tested at each split and resulted in overall 23.6% error rate with all sub class error rates also below the accepted threshold of 30% (Table 11).   The predictor variables in order of decreasing importance were maximum depth (MAXFT), latitude (LAT), percent forested land cover in 100m shoreline buffer (LC100for), Longitude (Long), percent natural land cover in 1km buffer (LC1kNAt), percent agriculture in the total upstream network watershed (NLCD11_agN), surface area of the waterbody (ACRES), percent impervious surfaces in the total upstream network watershed (imp11_perN), and the average baseflow index in the total upstream network watershed (bfi_avgN) (Figure 5). We applied the model to all 36,675 waterbodies, and assigned each unsampled waterbody to its highest probability class (Map 11).

Table 11. Trophic model confusion matrix. Showing number of known occurrences of each class by their placement by the RF model. EH= Eutrophic-Hypereutrophic, OM = Oligotophic-Mesotrophic.
OOB estimate of error rate: 23.59%.

	EH	OM	Class Error
EH	**682**	**287**	**0.29**
OM	380	1479	0.20

Figure 5. Variable importance plot for the trophic model. The plot shows each variable on the y-axis ordered from most- to least-important. The x-axis shows the mean decrease in classification accuracy when that particular variable is randomly permuted.

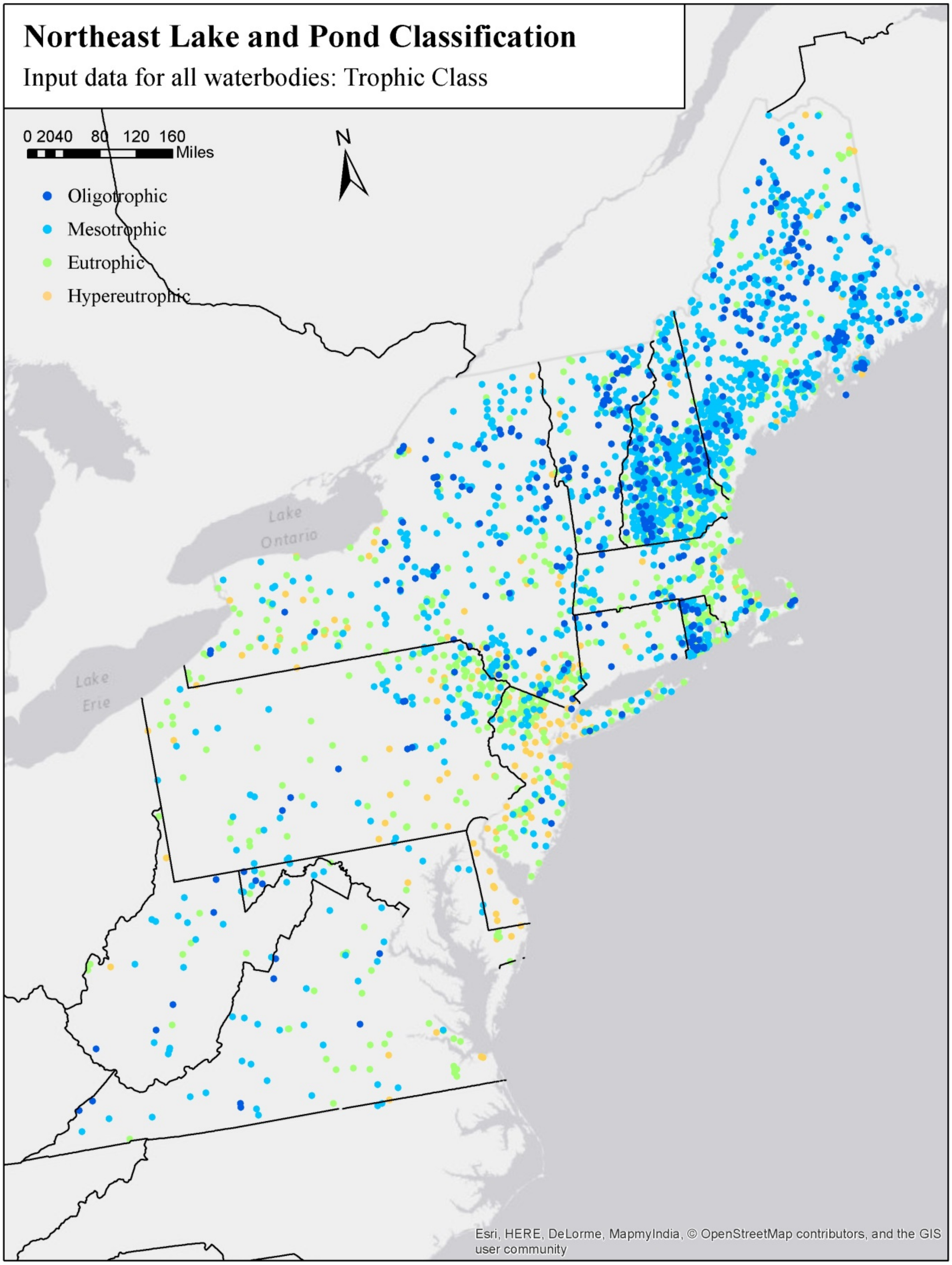


The classification confidence codes (see Statistical Methods section) for each waterbody were used to evaluate the predictions for a given waterbody and also understand the geographic distribution of possible errors in the prediction (Map 12). For trophic class, the results show that 60% of the waterbodies were in the high confidence, and 13% were in the low confidence or very low confidence class (Table 12).

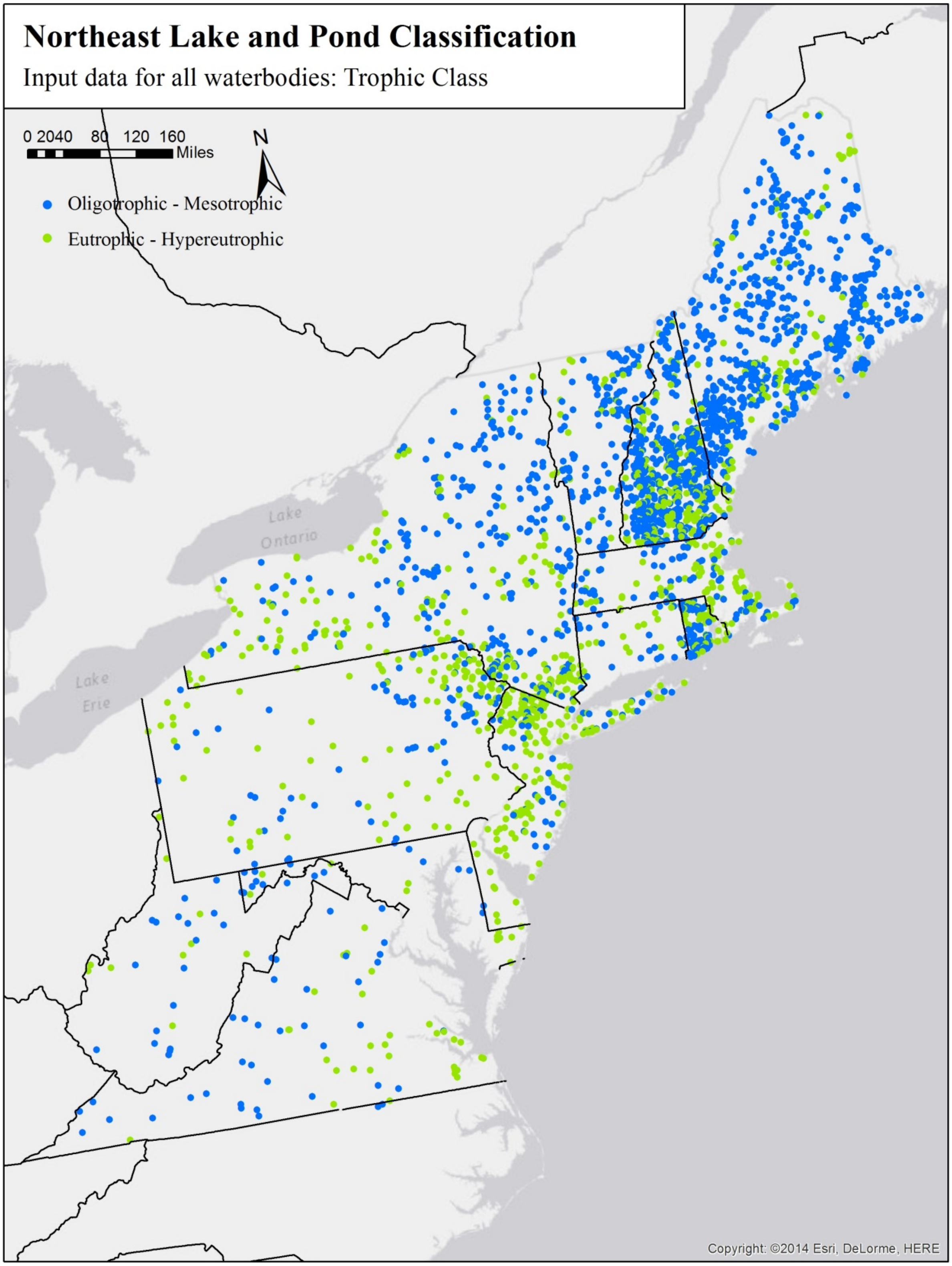
Table 12. Confidence Classes for Trophic State

Trophic Model Confidence	**Eutrophic-Hypereutrophic**	**Oligotrophic-Mesotrophic**	**Total**
1. High : >= 25%	69.6%	39.6%	60.1%
2. Medium: >= 10 and <25%	16.6%	25.7%	19.6%
3. Low >=5 and < 10%	5.0%	9.2%	6.4%
4. Very Low: < 5%	4.6%	9.7%	6.3%
Known	3.9%	15.9%	7.7%
# Waterbodies	24,951	11,724	36,675

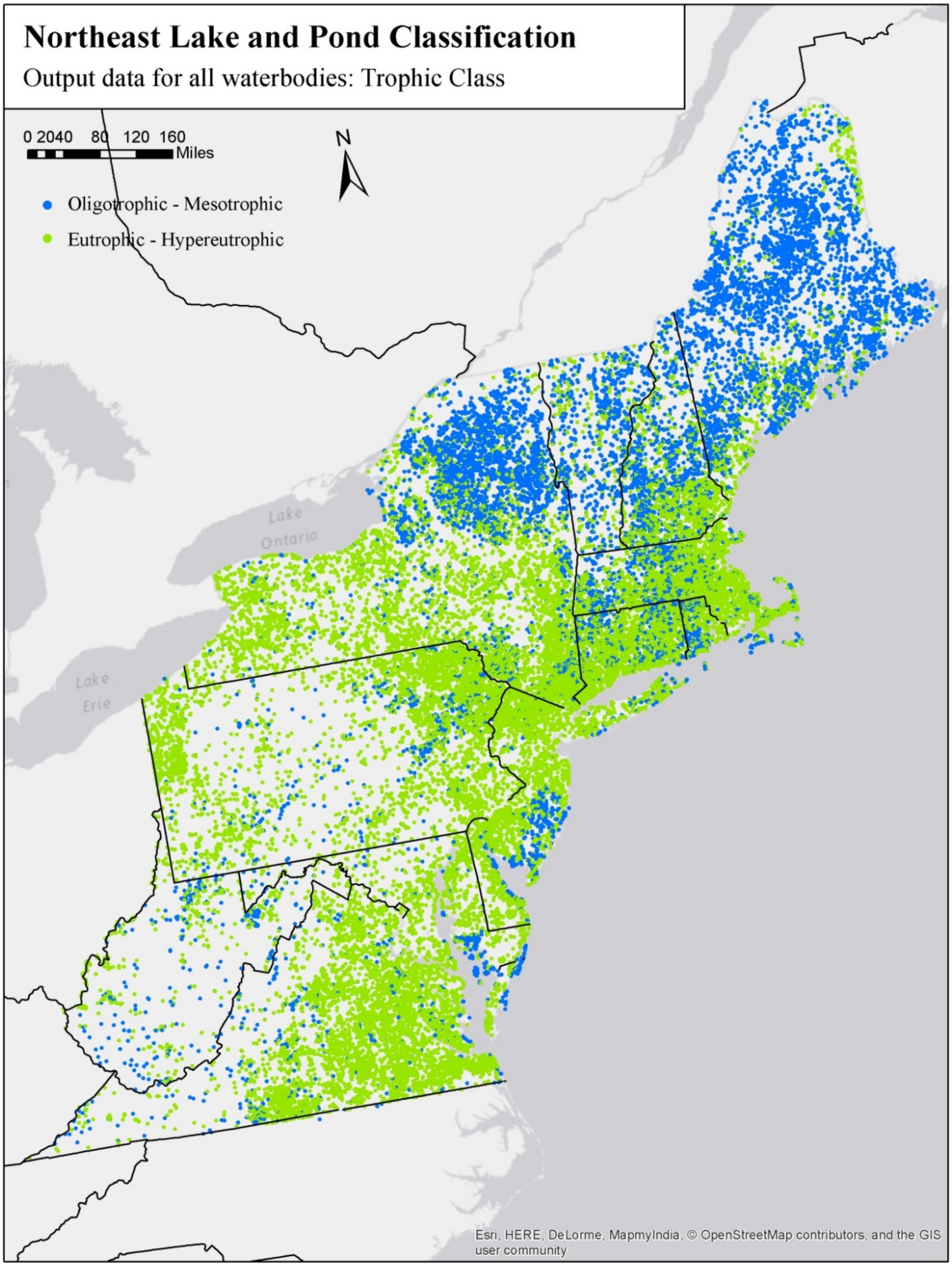
Map 9. Input trophic state class for sampled waterbodies, four classes



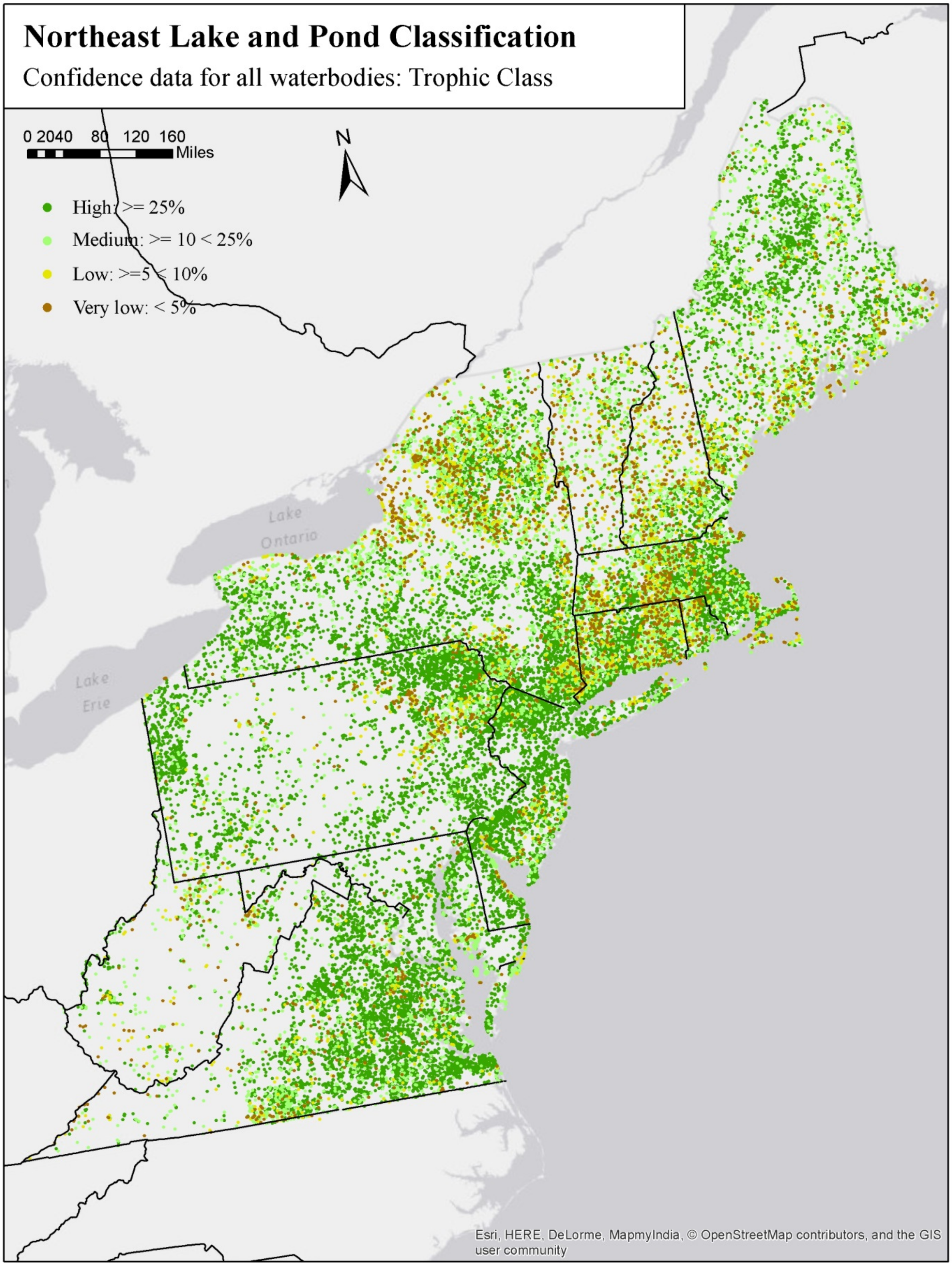
Map 10. Input trophic state class for sampled waterbodies, two classes



Map 11. Trophic state class. Estimates for all waterbodies based on the predictive model and sampled data



Map 12. Confidence for trophic state class



6. Depth Class

Ecological Significance

The distinction between a between a lake and a pond is based on depth, and specifically on the degree light penetrates the waterbody. In ponds, light penetrates to the bottom of the waterbody allowing photosynthesis throughout. Lakes have deeper regions where light does not penetrate, creating a profundal zone with no photosynthesis because algae and macrophytes cannot survive. Light penetration depends on the clarity of water as light will infiltrate deeper in waterbodies with clearer water. Water clarity decreases as a waterbody becomes more eutrophic due to excess nitrates, sediment, and algae blooms which cloud the water. Thus the split between ponds and lakes varies depending on the trophic state. Research has determined that light can penetrate to a depth of about two to three times the Secchi disk depth, a standard measure of water clarity (Michaud, 1991, Moore 1989). In clear nutrient-poor (oligotrophic) waterbodies the depth of light penetration is about 30 ft, whereas in enriched or polluted (eutrophic) waterbodies it is only about 10 ft.

Model and Results

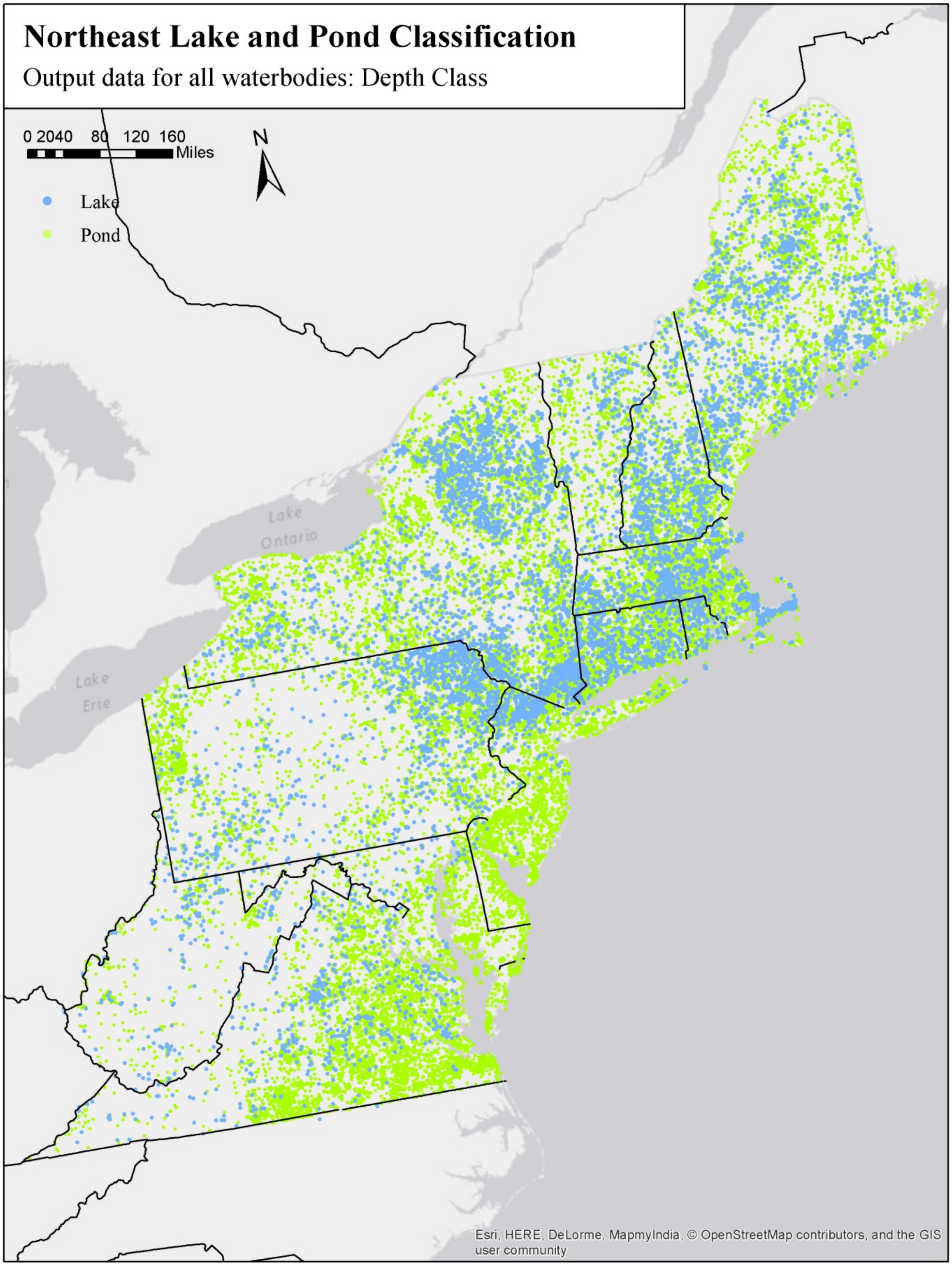
Many eastern states use the conventional rule that light penetrates to a depth of about 2-3 times the Secchi disk depth. This rule was being used particularly for oligotrophic lakes, and 30 ft is an accepted thresholds between lakes and ponds given the mean secchi depth and light penetration in VT and ME. Using data from the NLA (EPA 2009), we calculated the mean Secchi depth of lakes in the oligotrophic (11.04 ft.), mesotrophic (7.74 ft), and eutrophic (2.83 ft) class within our study area. Next, guided by the "rule of thumb" that the light penetration zone was equal to as 2-3 times the mean Secchi depth, we set the following thresholds: For eutrophic-hypereutrophic waterbodies we used a 10 ft threshold to distinguish lakes from ponds, and for the mesotrophic-oligotrophic waterbodies we used a more conservative threshold of 20 ft to distinguish lakes from ponds (Table 13).

Table 13. Depth class criteria

	Oligotrophic-Mesotrophic	**Eutrophic-Hypereutrophic**
Pond	**0-20ft**	**0-10ft**
Lake	>20ft	>10ft

Information on the maximum depth of each waterbody was available from compiled surveys for 5,594 waterbodies from 25 sources (see the Revised Data on Depth section above). For the remainin 26,960 waterbodies that touched NDH 1:100,000 stream lines, we used an EPA model (Hollister 2011) of waterbody depth. This left 4,121 waterbodies where we had no sample depth and we could not apply the EPA model. We assumed these 4,121 waterbodies were ponds because most were very small polygons that had been compiled from the 1:24,000 hydrography, or they were disconnected isolated waterbodies not modeled in the EPA 1:100,000 network analysis. Users can identify these waterbodies in the database by a “0” in the maximum depth in feet column (MAXFT) or by a “none” in the source of maximum depth in feet column (SRCMAXFT). Depth estimates for these waterbodies should be considered low- confidence until confirmed. Application of the depth classification criteria to the waterbodies resulted in 7,843 lakes and 28,832 ponds in the whole regional database (Map 13).

Map 13. Lake or pond depth class. Estimates for all waterbodies based on the depth and trophic state class



7. Combining Variables into Waterbody Types

Each waterbody was assigned to one of 18 primary types by combining their estimated:

Temperature class (Very Cold, Cold, Cool-Warm),

Trophic state class (Eutrophic-hypereutrophic, Oligotrophic-mesotrophic)

Alkalinity class (Low: Acidic, Medium: Circumneutral, High: Alkaline)

These types were further subdivided into based on depth within their trophic class

Depth Class (Lake, Pond)

This yielded 36 mapped types such as: *"cold, oligo-mesotrophic, low alkalinity, lake."*

Temperature class may be further separated using the secondary model which separates Cool from Warm waterbodies (Table 14, Map 14, Map 15). The final output classes and combined lake or pond "type" for each waterbody are found in the output distributed shapefile. The summary attributes distributed in this shapefile are described in Appendix II.

Review

The results of this study were circulated for review by the steering committee who checked the results against waterbodies they were familiar with in their respective states. Initial review highlighted two issues: 1) some types did not seem to be ecologically meaningful or were very unlikely. For example, very cold, olio-mesotrophic, high alkalinity ponds, and 2) some waterbodies looked correct in general except for one variable.

Very Cold Waterbodies

Based on the review and study of the attributes and classification probabilities we made several changes to waterbodies in the Very Cold class. First, we reclassed the modeled Very Cold ponds to Cold ponds (n=147) after we observed that all 18 types and subtypes had known confirmed examples *except* for the very cold ponds. The lack of confirmed examples, the few numbers of mapped examples of very cold ponds, and our knowledge that very cold habitat is usually found only in abundance in deep waterbodies, suggested that Cold was likely the correct class. Second, we moved all Very Cold lakes that had a "very low" or "low" confidence code associated with their temperature class into the Cold lake category (n=93). This restricted the Very Cold lakes to those with with "medium" or "high" confidence in their temperature class. Third, we similarly moved all Very Cold Eutrophic lakes that had "very low" or "low" confidence in their trophic state class assignment to Oligo-Mesotrophic (n = 15) because Very Cold

Eutrophic lakes are a rare or artificial category and there was a relatively high probability that these waterbodies were actually Oligo-mesotrophic most of the year. Lastly we applied an additional depth criteria to the remaining modeled Very Cold Eutrophic lakes, requiring them to be more than 20 ft deep, instead of using the more than 10 ft eutrophic waterbody threshold, because we really wanted to ensure the Very Cold lake category contained waterbodies with a substantial amount of very cold habitat which seemed unlikely in a lake less than 10 ft deep. This resulted in an additional 17 waterbodies being moved out of Very Cold and into the Cold eutrophic lake category. These modifications to the Very Cold class restricted this category to those lakes most likely to contain substantial very cold water habitats.

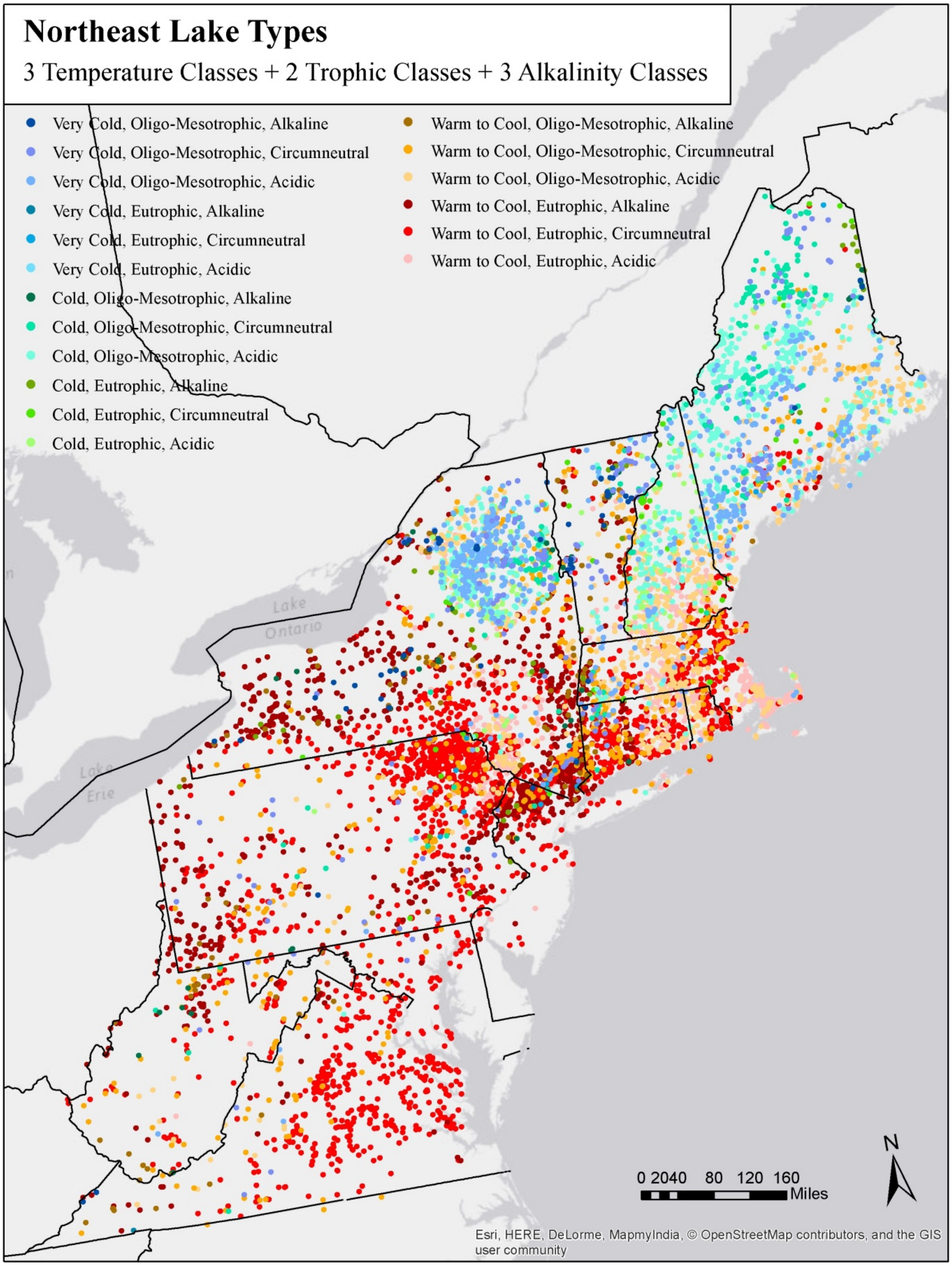
Disagreement between Trophic and Alkalinity Classes
Review also highlighted the unusual situation of a waterbody being both oligotrophic-mesotrophic and highly alkaline. High alkalinity leads to higher available nutrients in most settings and alkaline waterbodies tend to be more eutrophic, not oligo-mesotrophic. Because alkaline lakes can be biologically significant we wanted to keep the high alkalinity class tightly mapped to identify waterbodies with interesting ecological character such as marl ponds. In the RF alkalinity model most waterbodies with high alkalinity had calcareous bedrock in their watershed but some waterbodies were placed in the high alkalinity class due to the landuse in their buffer zone or their soil erodabiilty (k-factor) not because of calcareous bedrock. This suggested temperorary enrichment, and we adjust for this it by moving 123 oligotrophic-mesotrophic waterbodies from the high alkaline class into the circumneutral alkalinity clas. We use the criteria of oligotrophic-mesotrophic waterbodies that had less than 5% total calcareous or moderately calcareous bedrock in their buffer or watershed and less than 10% soil $CaCO_3$ in their watersheds. These revisions corrected specific waterbodies that had been noted by reviewers as incorrectly mapped and it tightened the high alkaline class to a more reasonable representation in the region.

Finally 25 other specific waterbodies had their class “overridden” by state expert review. Changes in Vermont primarily placed waterbodies into a colder class than the model would have predicted, while changes in Connecticut primarily moved waterbodies to warmer temperature classes than the model would have predicted. A few other specific lakes and ponds were altered in New York, West Virginia, Massachusetts, and Maine (Table 14).

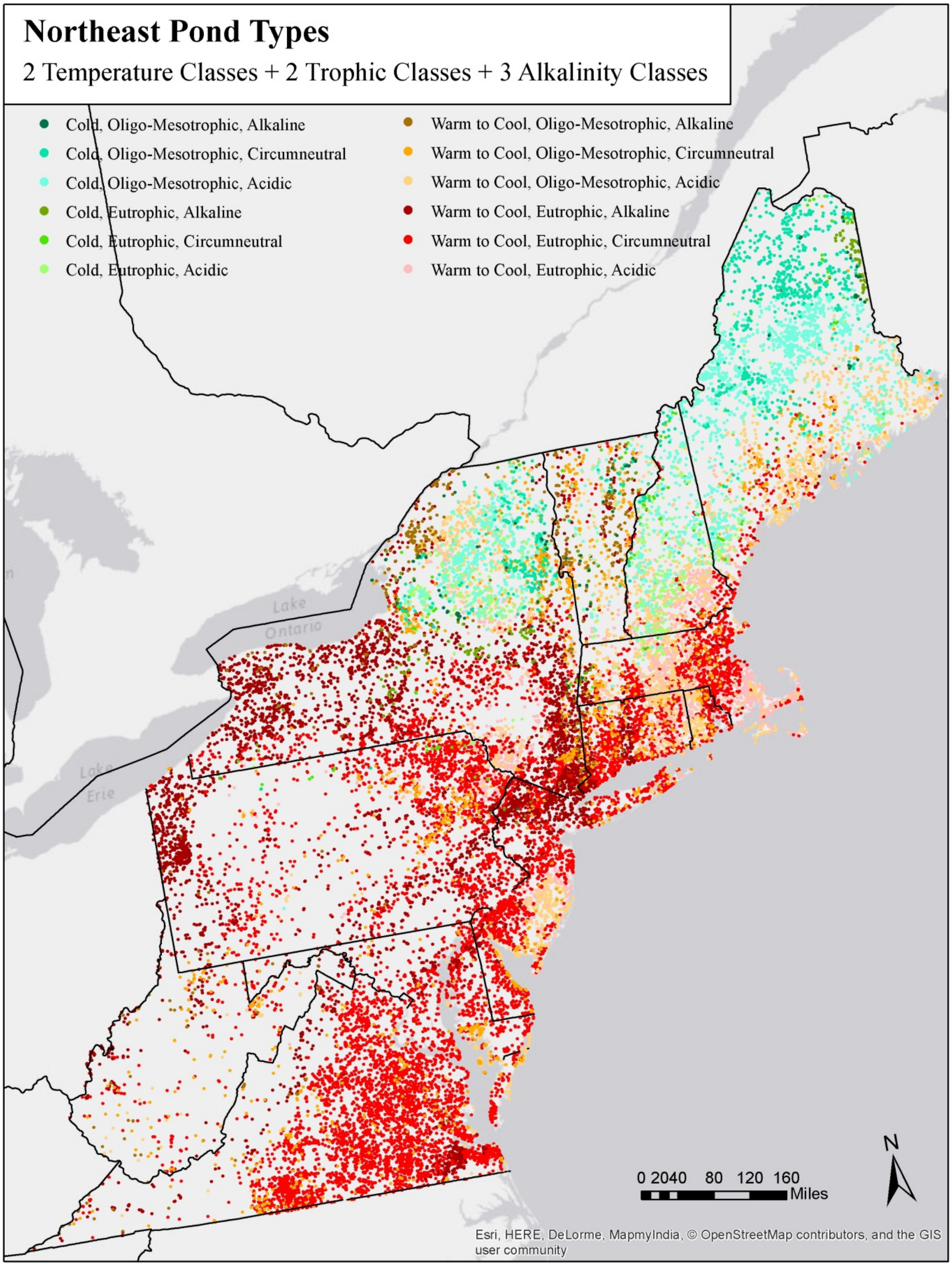
Table 14. Lake and pond types. Numbered rows show the primary types. Further splits from the cool-warm secondary model are shown in the unnumbered rows with the subtype colume.

Type	Subtype	Lake	Pond	Total
1. Very Cold, Oligo-Mesotrophic, Alkaline		60		60
2. Very Cold, Oligo-Mesotrophic, Circumneutral		188		188
3. Very Cold, Oligo-Mesotrophic, Acidic		583		583
4. Very Cold, Eutrophic, Alkaline		4		4
5. Very Cold, Eutrophic, Circumneutral		14		14
6. Very Cold, Eutrophic, Acidic		17		17
7. Cold, Oligo-Mesotrophic, Alkaline		34	88	122
8. Cold, Oligo-Mesotrophic, Circumneutral		232	945	1,177
9. Cold, Oligo-Mesotrophic, Acidic		737	2,093	2,830
10. Cold, Eutrophic, Alkaline		37	188	225
11. Cold, Eutrophic, Circumneutral		50	155	205
12. Cold, Eutrophic, Acidic		208	664	872
13. Warm to Cool, Oligo-Mesotrophic, Alkaline	Warm	61	400	461
	Cool	60	36	96
14. Warm to Cool, Oligo-Mesotrophic, Circumneutral	Warm	275	1,581	1,856
	Cool	267	111	378
15. Warm to Cool, Oligo-Mesotrophic, Acidic	Warm	398	2,713	3,111
	Cool	541	320	861
16. Warm to Cool, Eutrophic, Alkaline	Warm	888	4,776	5,664
	Cool	72	36	108
17. Warm to Cool, Eutrophic, Circumneutral	Warm	2,111	11,688	13,799
	Cool	200	86	286
18. Warm to Cool, Eutrophic, Acidic	Warm	707	2,905	3,612
	Cool	99	47	146
Grand Total		7,843	28,832	36,675

Map 14. Eighteen major lake types



Map 15. Eighteen major pond types



8. Habitat Guides

Two-page habitat guides for each of the eighteen lake and pond types were completed to provide lay users with a concise description of these habitats. These pages also complete the lacustrine section of the Northeast Habitat Guide: A Companion to the Terrestrial and Aquatic Habitat Maps (Anderson et al 2013).

The lake and pond habitats are organized by temperature, trophic level, and alkalinity. The guide pages provide users with compact 2-page fact sheets describing the ecology and conservation status of the eighteen major lake and pond types, including:

- Map of the regional distribution
- Photos of example habitat
- Description and ecological setting
- State distribution and acres of riparian buffer conserved
- Places to visit this habitat
- Associated fish, and species of concern
- Distribution of securement
- Land cover classes in riparian buffer
- Dam type distribution
- Cumulative upstream impervious surfaces

Please see Appendix IV for the lake and pond habitat guide pages and a description of the elements on each page.

9. Summary

In the project we classified all waterbodies in the Northeast and Mid-Atlantic based on four key variables: temperature, alkalinity, trophic state, and depth. The integration of the classification variables yielded a flexible classification scheme that can be used in an expanded or simplified format. The classification allows users to study the variation in the ecological character of lakes and ponds in the Northeast and Mid-Atlantic, and we hope will lead to improved conservation and management of these ecosystems. The results can be used to focus field surveys and assessments, or allocate management budgets to certain types of lakes and ponds.

Prior to this classification, 90% of waterbodies in the region were unclassified due to lack of field survey measures of alkalinity, chlorophyll-a, depth, and temperature profiles. Using known sample locations for the above variables, we developed models that predicted the classification variables for the thousands of unsampled waterbodies based on descriptive attributes and landscape variables that we compiled for each waterbody. All models had error rates below the standard of 30%.

We hope that in the future additional field survey information will be integrated into this classification to further verify the model predictions. We would also like to see biological community descriptions for these lake and pond types developed so managers can more readily identify the likely fish, amphibians, reptiles, invertebrates, plants, and other biota commonly found in these lake and pond ecosystems. Although the resultant classification provides the user with the ability to find and distinguish lakes and ponds sharing similar characteristics in terms of temperature, trophic, alkalinity, and light penetration, we do not suggest that all waterbodies in the same classification type are identical or necessarily contain suitable habitat for a given species. For example, some "very cold" lakes mapped in this study are outside the range of lake trout, or they do not have suitable spawning habitat for lake trout due to poor condition or lack of suitable forage fish. Thus, although the lake may contain very cold water, further information will be need to confirm that the lake contains lake trout.

In addition to the classification, other attributes included with the lake/pond dataset may be of interest to users. The 300+ descriptive attributes available for each waterbody such as: morphology, dams, climate, soils, geology, conservation lands, landforms and land cover, may prove useful covariates for further study of lake conditions. In addition, the statistical probability attributes of class placement provided for each variable can help users understand the how well a lake or pond fits within its class. All in all, we hope the classification and the dataset stimulate new questions and improved conservation of our region's waterbodies and their inhabitants.

10. References

Alofs, K. M., Jackson, D. A., & Lester, N. P. 2014. Ontario freshwater fishes demonstrate differing range-boundary shifts in a warming climate. Diversity and Distributions, 20(2), 123-136.

Allan, J. D. 1995. Stream Ecology: Structure and function of running waters. Kluwer Academic Publishers. Dordrecht, The Netherlands.

Anderson, M.G. M. Clark, C.E. Ferree, A. Jospe, A. Olivero Sheldon and K.J. Weaver. 2013. Northeast Habitat Guides: A companion to the terrestrial and aquatic habitat maps. The Nature Conservancy, Eastern Conservation Science, Eastern Regional Office. Boston, MA. http://nature.ly/HabitatGuide.

Becker, M.; Georgian, T.; Ambrose, H.; Siniscalchi, J.; Fredrick,K. 2004. Estimating flow and flux of ground water discharge using water temperature and velocity. J. Hydrol. 296, 221-233.

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

Brezonik, P. and Arnold, W. 2011. Water chemistry: an introduction to the chemistry of natural and engineered aquatic systems. Oxford University Press.

Dillon, P. J., & Kirchner, W. B. 1975. The effects of geology and land use on the export of phosphorus from watersheds. Water Research, 9(2), 135-148.

Edinger, G.J., D.J. Evans, S. Gebauer, T.G. Howard, D.M. Hunt, and A.M. Olivero (editors). 2002. Ecological Communities of New York State. Second Edition. A revised and expanded edition of Carol Reschke's Ecological Communities of New York State. (Draft for review). New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY. http://www.dec.ny.gov/animals/29392.html.

Fang, X., & Stefan, H. G. 2009. Simulations of climate effects on water temperature, dissolved oxygen, and ice and snow covers in lakes of the contiguous United States under past and future climate scenarios. *Limnology and Oceanography*, *54*, 2359-2370.

Frink C.R. and Norvell W.A. 2010. Chemical and Physical Properties of Connecticut Lakes. The Connecticut Agricultural Experiment Station.

Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, *PE&RS*, Vol. 77(9):858-864.

Halliwell, D.B, Langdon, W.W., Daniels, R.A, Kurtenbach, J.P, and Jacobson, R.A. 1999. Classification of Freshwater Fish Species of the Northeastern United States for Use in the Development of Indices of Biological Integrity, with Regional Applications. Chpater 12, p301-333. Simon, T. 1999 edition. Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities", CRC Press, Boca Raton/New York.

Higgins, J.V., M. Bryer, M. Khoury, and T. Fitzhugh. 2005. A Freshwater Classification Approach for Biodiversity Conservation Planning. Conservation Biology 9:432-445.

Hollister, J.W., Milstead W.B., Urrutia M.A. 2011. Predicting Maximum Lake Depth from Surrounding Topography. PLoS ONE 6(9): e25764. doi:10.1371/journal.pone.0025764

Hollister, J.W., and W.B. Milstead. 2010. Using GIS to Estimate Lake Volume from Limited Data. Lake and Reservoir Management. North American Lake Management Society, Madison, WI, 26(3):194-199, (2010).

Hollister, J.W., 2014. lakemorpho: Lake morphometry in R. R package version 1.0. http://CRAN.R-project.org/package=lakemorpho

Kling, G.W., Kipphut, G.W. et al. 2000. Integration of lakes and streams in a landscape perspective: the importance of material processing on spatial patterns and temporal coherence. Freshwater Biology 43:3, 477-497.

Kratz, T.K., Webster, K.E., et al. 1997. The influence of landscape position on lakes in northern Wisconsin. Freshwater Biology 37. 209-217.

Liu, W., Zhang, Q, and Liu, G. 2011. Effects of Watershed Land Use and Lake Morphometry on the Trophic State of Chinese Lakes: Implications for Eutrophication Control. Clean – Soil, Air, Water 2011, 39 (1), 35–42.

Martin, E. H. and C. D. Apse. 2011. Northeast Aquatic Connectivity: An Assessment of Dams on Northeastern Rivers. The Nature Conservancy, Eastern Freshwater Program.

Martin, S.L., Soranno, P.A., Bremigan, M.T., and Cheruvelil, K.S. 2011. Comparing Hydrogeomorphic Approaches to Lake classification. Environmental Management 48:957-974.

Maxwell, J.R., C.J. Edwards, M.E. Jensen, S.J. Paustian, H. Parrott, and D.M. Hill. 1995. A Hierarchical Framework of Aquatic Ecological Units in North America (Neararctic Zone). General Technical Report NC-176. St. Paul, MN: U.S. Department of Agriculture Forest Service.

Michaud, J.P. 1991. A citizen's guide to understanding and monitoring lakes and streams. Publ. #94-149. Washington State Dept. of Ecology, Publications Office, Olympia, WA, USA (360) 407-7472.

Milstead W.B., Hollister J.W., Moore R.B., Walker H.A. 2013. Estimating Summer Nutrient Concentrations in Northeastern Lakes from SPARROW Load Predictions and Modeled Lake Depth and Volume. PLoS ONE 8(11): e81457. doi:10.1371/journal.pone.0081457

Minns, C.K. 1989. Factors Affecting Fish Species Richness in Ontario Lakes. Transactions of the American Fisheries Society: V. 118, No. 5, pp.533-545.

Minns, C.K. Shuter, B.J. and J.L. McDermid. 2009. Regional Projections of Climate Change Effects on Ontario Lake Trout Populations. Climate Change Research Report CCRR-14. Ministry of Natural Resources. Ontario. 11p.

Moore, M.L. 1989. NALMS Management Guide for Lakes and Reservoirs. North American Lake Management Society, P.O. Box 5443, Madison, WI, 53705-5443, USA (http://www.nalms.org).

Moore R.B., Johnston C.M., Smith R.A., and Milstead B. 2011. Source and delivery of nutrients to receiving waters in the Northeastern and Mid- Atlantic regions of the United States. J Am Water Resour Assoc 47: 965-990. doi:10.1111/j.1752-1688.2011.00582.x. PubMed: 22457578.

The Nature Conservancy, Eastern Conservation Science. 2008. Bedrock and Deep Surficial Geology. The Nature Conservancy Eastern Regional Office. Boston, MA. Compilation of State and Federal Sources.

The Nature Conservancy, Eastern Conservation Science. 2012. Secured Lands. The Nature Conservancy Eastern Regional Office. Boston, MA. Compilation of State, Municipal, NGO, and Federal Sources.

NatureServe. 2013. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: May 30, 2013).

New Jersery Division of Fish and Wildlife. 2005. Coldwater Fisheries Management Plan. Classification of NJ Trout Waters. http://www.state.nj.us/dep/fgw/pdf/cwfmp/33-52.pdf

New Jersey Division of Fish and Wildlife. 2014. Assessment and Classification of New Jersey's Fresh Waters. http://www.njfishandwildlife.com/fshresmgt_waterclass.htm

Norton, S.A. 1980. Distribution of Surface Waters Sensitive to Acidic Precipitation: A State-Level Atlas. National Atmospheric Deposition Program. 65p.

Olivero, A. and Anderson, M. 2008. Northeast Aquatic Habitat Classification. The Nature Conservancy. 88p. http://rcngrants.org/spatialData

Olivero A. and Bechtel, D. 2005. Lake Classification and Condition Assessment for New Hampshire's Lakes. The Nature Conservancy. 96p.

Olivero, A. and Vaux, P. 2006. Maine Lake Classification, Condition Assessment, and Initial Portfolio Prioritization. The Nature Conservancy. 4p.

PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu, created Sept. 2013

Quinlan, R., ., A.M., et al. 2003 A landscape approach to examining spatial patterns of limnological variables and long-term environmental change in a southern Canadian lake district. Freshwater Biology. 48:9, 1676-1697.

Raleigh, R. F. 1982. Habitat suitability index models: brook trout. U.S. Department of the Interior, Fish and Wildlife Service, FWS/OBS-82/10.24. 42p. http://www.nwrc.usgs.gov/wdb/pub/hsi/hsi-024.pdf

R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Soranno, P. A., Webster, K. E., Cheruvelil, K.S., and M.T. Bremigan. 2009. The lake landscape-context framework: linking aquatic connections, terrestrial features, and human effects at multiple spatial scales. Verh. Internat. Verein. Limnol. V.30 (5) 695-700.

Soranno, P.A., E.G. Bissell, K.S. Cheruvelil, S.T. Christel, S.M. Collins, C.E. Fergus, C.T. Filstrup, J.F. Lapierre, N.R. Lottig, S.K. Oliver, C.E. Scott, N.J. Smith, S. Stopyak, S. Yuan, M.T. Bremigan, J.A. Downing, C. Gries, E.N. Henry, N.K. Skaff, E.H. Stanley, C.A. Stow, P.-N. Tan, T. Wagner, K.E. Webster. 2015. Building a multi-scaled geospatial temporal ecology database from disparate data sources: Fostering open science and data reuse. GigaScience 4:28 doi:10.1186/s13742-015-0067-4

Stefan, H.G., Hondzo, M., Fang, X., Eaton, J.G., McCormic, J.H., 1996. Simulated long-term temperature and dissolved oxygen characteristics of lakes in the north-central United States and associated fish habitats limits. Limnol. Oceanogr. 41(5) 1124-1135.

Stuart, C. et al. 2003. Living Waters Technical Report. Massachusetts Natural Heritage and Endangered Species Program. 103p.

Tcherepanov, E. N., Zlotnik, V. A., & Henebry, G. M. (2005). Using Landsat thermal imagery and GIS for identification of groundwater discharge into shallow groundwater-dominated lakes. International Journal of Remote Sensing, 26(17), 3649-3661.

Thill, M. 2014. Lake Trout and Climate Change in the Adirondacks Status and long-term viability. A synthesis report for the Adirondack Chapter of The Nature Conervancy. 27p.

Tonn, W.M., J.J. Magnuson, M. Rask, and J. Toivonen. 1990. Intercontinental comparison of small-lake fish assemblages: The balance between local and regional processes. American Naturalist 136: 345-375.

U.S. Environmental Protection Agency. 2009. National Lakes Assessment: A Collaborative Survey of the Nation's Lakes. EPA 841-R-09-001. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, D.C.

U.S. Environmental Protection Agency. 2010. Gauging the Health of New EnEnglands Lakes and Ponds: A Survey Report and Decision Marking Resource. Cooperative Agreement No. RM83158201 awarded by the U.S. Environmental Protection Agency to the New England Interstate Water Pollution Control Commission. 78p.

U.S. Environmental Protection Agency Office of Water. 2013. National Hydrography Dataset Plus 2: Data Model Version 2.1. http://www.horizon-systems.com/NHDPlus/NHDPlusV2_data.php

U. S. Fish and Wildlife Service. Acessessed 2013. National Wetlands Inventory website. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. http://www.fws.gov/wetlands/

Vermont Department of Environmental Conservation. 2013. Gauging the Health of Vermont Lakes. Results of the 2007 National Lake Assessment. 59p.

Virginia Water Resources Research Center. 2005. January 2005 Report of the Academic Advisory Committee to Virginia Department of Environmental Quality: Freshwater Nutrient Criteria. 120p.

Webster, K.E., P.A. Soranno, S.B. Baines, T.K. Kratz, C.J. Bowser, P.J. Dillon, P. Campbell, E.J. Fee, and R.E. Hecky. 2000. Structuring features of lake districts: landscape controls on lake chemical responses to drought. Freshwater Biology 43:499-416.

Wang,T., Hamann, A., Spittlehouse, A.L., and Aitken, S. 2006. Development of Scale-Free Climate Data for Western Canada for Use in Resource Management. Int. J. Climatol. 26: 383–397 DOI: 10.1002/joc.1247

Wehrly, K.E., Wang, L, and Mitro, M. 2007. Field-Based Estimates of Thermal Tolerance Limits for Trout: Incorporating Exposure Time and Temperature Fluctuation. Transactions of the American Fisheries Society 136:365-374.

Wetzel, R.G. 1983. Limnology. Second Edition. W.B. Saunders Company, Philadelphia. 753 p.

Wetzel, R. G. 2001. Limnology: Lake and River Ecosystems. Academic, San Diego, Calif. 1006 p.

Whittier, T., Paulsen, S. Larson D. Peterson, S., Herlihy, A., and Kaufmann, P. 2002. Indicators of Ecological Stress and Their Etent in the Population of Northeastern Lakes: A Regional-Scale Assessment. BioScience, 52(3), 235-247.

Wolock, D.M., 2003, Base-flow index grid for the conterminous United States: U.S. Geological Survey Open-File Report 03–263, digital data set, http://water.usgs.gov/lookup/getspatial?bfi48grd

11. Appendices

Appendix I: Input sampled lake and pond data sources

State or Region	Source Num.	Data	Reference and/or Contact
CT	1	Alkalinity and depth (2004-2013)	Connecticut Agricultural Experiment Station, Invasive Aquatic Plant Program Contact: Gregory J. Bugbee, Associate Scientist Department of Environmental Sciences, Soil Testing New Haven, CT 06504 Phone: (203) 974-8512 Email: gregory.bugbee@ct.gov
	2	Temp	Coldwater Lakes Categorization. DRAFT Appendix 3. Categorization of Trout Management Lakes and important coldwater Lakes in Connecticut. Contact: Brian Eltz, Primary Staff Department of Energy and Environmental Protection, Inland Fisheries Division, Western District Litchfield, CT 06759 Phone: (860) 567-8998
	3	Depth (1988-1995)	Canavan, R. W. and P. A. Silver. 1995. Connecticut Lakes: A study of the chemical and physical properties of fifty-six Connecticut lakes. Conn. College Arboretum. New London, CT. 299p. Maximum Depth from Appendix 1. Physical parameters of lakes and ponds sampled during the statewide lake and pond electrofishing survey (1988-1995). Within 88 lakes Contact: Brian Eltz, Primary Staff (see CT Source 2)
	4	Depth	Department of Energy and Environmental Protection bathymetry maps http://www.ct.gov/deep/lib/deep/fishing/general_information/lakebathymetrymaps.pdf 74 lakes from Appendix I joined; 114 from CAESIAPP
MA	1	Alkalinity	Alkalinity from Water Resources Research Center at University of Massachusetts Amherst Acid Rain Monitoring Project and its funding sources: MA Division of Fisheries, Wildlife, MA Department of Environmental Protection, Trout Unlimited and the USGS Water Resources Institute Program
	2	Chlorophyll-a, temp, and DO (1994-2011)	Chlorophyll-a and Temp/DO from 1994-2011 Massachusetts Department of Environmental Protection Water Quality Database Contact: Thomas R. Dallaire - MassDEP, DWM Worcester, MA 01608 Phone: (508) 767-2740 Email: thomas.dallaire@state.ma.us
	3	Depth and fish distribution	Created from fishery descriptions and paper bathymetry maps for 271 lakes/ponds from http://www.mass.gov/eea/agencies/dfg/dfw/maps-destinations/pond-maps-northeast-district.html
MD	1	Chlorophyll-a, depth,	MD Department of the Environment. 1995. Maryland lake water quality assessment. 1993 Final report. Water Quality Monitoring Program,

		temp, and DO	Annapolis. 79p. MD_TrophicAssessment.xls - Field and lab data from a "Statewide" assessment of trophic conditions (1991; 1993)
ME	1	Alkalinity, Chlorophyll-a, depth, and temp class query from temp and DO profile	Maine Department of Environmental Protection Databases 2014 Contact: Doug Suitor, Biologist Division of Environmental Assessment, Lake Assessment Section Maine Department of Environmental Protection SHS 17, Augusta, ME 04333 Email: douglas.suitor@maine.gov Phone: (207) 441-6616
	2		Self-Sustaining BRK-CHR Waters 2014. Contact: Dana DeGraaf, Fisheries Biologist ME Department of Inland Fisheries and Wildlife Augusta, ME 04333-0041 Phone: 207.287.5265 Email: dana.degraaf@maine.gov
NH	1	Alkalinity, depth, and chlorophyll-a (2014)	Lake and Pond Database with Coordinates.xls Contact: Amy P. Smagula, Limnologist/Exotic Species Program Coordinator NH Department of Environmental Services Concord, NH 03301 Phone: (603) 271-2248 Email: amy.smagula@des.nh.gov
	2	Fish distributions	NH freshwater fishing guide database Matt Carpenter, Fisheries Biologist NH Fish and Game Dept. Concord, NH 03301 Phone: (603) 271-2612 Email: matthew.carpenter@wildlife.nh.gov
	3	Depths (max, mean)	2004 Lake and Pond Database.xls compiled for NH state lake classification Contact: Ken Edwardson Water Quality Assessment Program NH Department of Environmental Services Concord, NH 03302 Phone: (603) 271-8864
NJ	1	Alkalinity, Chlorophyll-a, max depth, temp, and DO	NJ Department of Environmental Protection: database export 2014 Contact: Victor Poretti, Section Chief Bureau of Freshwater and Biological Monitoring Ewing, NJ 08625 Phone: (609) 292-0427 Email: victor.poretti@dep.state.nj.us
	2		Scanned bathymetry maps http://www.state.nj.us/dep/fgw/lakemaps.htm
	3	Fish distribution	NJ Freshwater Fish Digest (1/2014)
NY	1	Fish distribution	Lake Trout and Climate Change in the Adirondacks. Status and long-term viability: A synthesis report for the Adirondack Chapter of The Nature Conservancy (2014).

			Contact: Mary Thill, Philanthropy Writer and Editor Saranac Lake, NY 12983 Phone: (518) 891-1080 Email: mthill@TNC.ORG
	2	Chlorophyll-a, alkalinity, temp, and DO	Lake Monitoring Program Database 2014 Contact: David J. Newman, Environmental Program Specialist I Lake Monitoring & Assessment Section NYS Department of Environmental Conservation Albany, NY 12233-3502 Phone: (518) 402-8201
	3	Depth	Bathymetry maps http://www.dec.ny.gov/outdoor/9920.html
	4	Depth (max and mean)	Adirondack Lake Survey : Adirondack_lake_locations.gdb Contact: Craig Cheeseman, GIS Specialist/Information Systems Manager The Nature Conservancy, Adirondack Chapter Email: ccheeseman@tnc.org
PA	1	Alkalinity, depth temp, and DO	PA Fish and Boat Commission PFBC Main Resource SQL database export 5/2014 Contact: David Miko Email: dmiko@pa.gov Contact: Russell Burman PFBC-IT Phone: (814) 359-5123 Email: rburman@pa.gov
	2	Chlorophyll-a	Lake Monitoring (2014 sublist) Contact: Barbara F Lathrop PA DEP Clean Lakes, Watershed Support Bureau of Conservation & Restoration Harrisburg, PA 17101-2301 Phone: (717) 772-5651 blathrop@pa.gov
RI	1	Alkalinity, Chlorophyll-a, temp, and DO	Contact: Elizabeth Herron, Program Coordinator URI Watershed Watch Kingston, RI 02881 Phone: 401-874-4552
	2	Depth	Bathymetry maps http://www.dem.ri.gov/maps/mapfile/pondbath.pdf
VA	1	Chlorophyll-a	January 2005 Report of the Academic Advisory Committee To VA Department of Environmental Quality: Freshwater Nutrient Criteria Submitted to: Division of Water Quality Programs VA Department of Environmental Quality
VT	1	Alkalinity, Chlorophyll-a, depth (max), temp, and DO	Contact: Dr. Leslie J. Matthews, Environmental Scientist VT Department of Environmental Conservation Watershed Management Division. Lakes and Ponds Program Montpelier, VT 05620-3522 Email: leslie.matthews@state.vt.us Phone: (802) 490-6193
WV	1	Alkalinity, Chlorophyll-a, temp, DO	Contact: John Wirts, Watershed Assessment Program Manager WV Department of Environmental Protection

	2	Depth	Scanned Bathymetry maps http://www.wvdnr.gov/Fishing/public_access.asp?county=all&type=Lakes
USEPA	1	Alkalinity	http://www.waterqualitydata.us/portal.jsp Query for Lake, Reservoir, Impoundment: Physical Characteristics as of 5/2/2014 The Water Quality Portal (WQP) is a cooperative service sponsored by the United States Geological Survey (USGS), the Environmental Protection Agency (EPA) and the National Water Quality Monitoring Council (NWQMC) that integrates publicly available water quality data from the USGS National Water Information System (NWIS) the EPA STOrage and RETrieval (STORET) Data Warehouse, and the USDA ARS Sustaining The Earth's Watersheds - Agricultural Research Database System (STEWARDS).
New England NELP	1	Alkalinity, Chlorophyll-a, temp, and DO	"Gauging the Health of New England's Lakes and Ponds A Survey Report and Decision-Making Resource" October 2010. United States Environmental Protection Agency. Contact: John Kiddon, Data Steward Phone: (401) 782-3044 Email: kiddon.john@epa.gov
LAGOS LAke multi-scaled GeOSpatial & temporal database	1	Chlorophyll-a and maximum depth (2015)	http://csilimno.cse.msu.edu/lagos_overview.php Contact: Patricia Soranno, Professor Department of Fisheries and Wildlife Michigan State University East Lansing, MI 48824 Phone: 517-432-4330 Email: soranno@anr.msu.edu

Appendix II: Final lake and pond shapefile summary attributes

NUMID	**Definition**
COMID	unique numeric ID for each waterbody
PERMANENT_	NHD V2 USGS 1:100,000 COMID
GNIS_NAME	NHD High Resolution Permanent ID for those polygons added from Umass
STATE_ABBR	Name of the waterbody
ACRES	State waterbody centroid is within
MAXFT	surface area in acres
DEPTHSRC	maximum depth in feet
TYPENUM	source of depth information
TYPE	Descriptive name for the 18 types, based on field T3_TR2_A3
T3_TR2_A3	Abbreviation for the 18 types based on unique combinations of 3 temperature classes + 2 trophic classes + 3 alkalnity classes: 1st value is temperature class (VC = Very Cold, C = Cold, CCW = Cool-Warm), 2nd value is trophic class (OM = oligotrophic to mesotrophic, EH = eutrophic to hypereutrophic), 3rd value is alkalinity class (H= high, M = medium, L = low)
T3TR2A3D2	Abbreviation for unique combinations of 3 temperature classes + 2 trophic classes + 3 alkalnity classes + 2 depth classes: 1st value is temperature class (VC = Very Cold, C = Cold, CCW = Cool-Warm), 2nd value is trophic class (OM = oligotrophic to mesotrophic, EH = eutrophic to hypereutrophic), 3rd value is alkalinity class (H= high, M = medium, L = low), the 4th value is depth class (pond, lake)
T4_TR2_A3	Abbreviation for unique combinations based on 4 temperature classes + 2 trophic classes + 3 alkalnity classes: 1st value is temperature class (VC = Very Cold, C = Cold, CC = Cool, W =Warm), 2nd value is trophic class (OM = oligotrophic to mesotrophic, EH = eutrophic to hypereutrophic), 3rd value is alkalinity class (H= high, M = medium, L = low)
T4TR2A3D2	Abbreviation for unique combinations based on 4 temperature classes + 2 trophic classes + 3 alkalnity classes + 2 depth classes: 1st value is temperature class (VC = Very Cold, C = Cold, CC = Cool, W =Warm), 2nd value is trophic class (OM = oligotrophic to mesotrophic, EH = eutrophic to hypereutrophic), 3rd value is alkalinity class (H= high, M = medium, L = low), 4th value is depth class (pond, lake)
OUT_TEMP3	output 3 temperature class code: VC = Very Cold, C = Cold, CCW =Cool to Warm VC = VERY COLD: <12.8°C and >=5 mg/l DO or indicator fish = lake trout C = COLD: 12.8°C <=18°C and >=5 mg/l DO or indicator fish = wild brook trout reproduction CCW = COOL TO WARM: >18°C
OUT_TEMP4	output 4 temperature class code: VC = Very Cold, C = Cold, CC =Cool, W = Warm VC = VERY COLD: <12.8°C and >=5 mg/l DO or indicator fish = lake trout C = COLD: 12.8°C <=18°C and >=5 mg/l DO or indicator fish = wild brook trout reproduction CC = COOL: >18°C <=21°C and >=4 mg/l DO or indicator fish = non-reproducing brook trout, holdover or reproduction of brown trout, kokanee, smelt W =WARM >21°C
CONF_TEMP3	Confidence in the output temperature 3 class code: Known: Variable class based on sample data; others based on difference in maximum probability and second highest probability of class membership output from the model as 1. High Confidence: Difference in greater than >= 25%, 2. Medium Confidence: Difference >= 10 and <25%, 3. Low Confidence: Difference between >=5 and < 10%, 4. Very Low Confidence: Difference less than 5%
CONF_CC_W	Confidence in the output temperature Cool (CC) vs. Warm (W) class code: Known: Variable class based on sample data, then based on difference in maximum probability and second highest probability of class membership output from the model as 1. High Confidence: Difference in greater than >= 25%, 2. Medium Confidence: Difference >= 10 and <25%, 3. Low Confidence: Difference between >=5 and < 10%, 4. Very Low Confidence: Difference less than 5%
OUT_TROPCL	Output trophic class: OM = oligotrophic to mesotrophic, <7 ug/l, EH = eutrophic to hypereutrophic, >7 ug/l

CONF_TROP	Confidence in the output trophic class code: Known: Variable class based on sample data; others based on difference in maximum probability and second highest probability of class membership output from the model as 1. High Confidence: Difference in greater than >= 25%, 2. Medium Confidence: Difference >= 10 and <25%, 3. Low Confidence: Difference between >=5 and < 10%, 4. Very Low Confidence: Difference less than 5%
OUT_ALKCL	output alkalinity class : H = High Alkalinity >=50 mg/L CaCO3, M= Medium Alkalinity >=12.5 & < 50 mg/L CaCO3, L = Low Alkalinity <12.5 mg/L CaCO3
CONF_ALKCL	Confidence in the output trophic class code: Known: Variable class based on sample data; others based on difference in maximum probability and second highest probability of class membership output from the model as 1. High Confidence: Difference in greater than >= 25%, 2. Medium Confidence: Difference >= 10 and <25%, 3. Low Confidence: Difference between >=5 and < 10%, 4. Very Low Confidence: Difference less than 5%
DEPTH_CL	output depth class, pond or lake; based on rules regarding depth of light penetration for waterbodies of a given trophic class: Oligo-Mesotrophic ponds = 0-20ft, lakes >20ft; Eutrophic-hypereutrophic ponds 0-10ft, lakes >10ft.
override	holds detailed comments regarding why some waterbodies had their model type "overriden" by state experts during the review period

Appendix III: All descriptive atttributes for each waterbody

	Field	Description	Source Dataset
1	NUMID	Unique identification number	calculated in GIS
2	MAXFT	Maximum depth in feet	multiple state and federal sources; see GIS shapefile for additional Depth Source information for each record
3	Long	Latitude	calculated in GIS
4	Lat	Longitude	calculated in GIS
5	ELV_M	Elevation in meters	USGS NED 30m
6	NUM_DAMS	Number of dams on lake	Northeast Aquatic Connectivity Project: http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/freshwater/stream/Pages/default.aspx
7	NIDSTOR	Volume of water stored by dams on this lake: 2012 National Anthropogenic Barrier Dataset (NABD) calculated field based on the maximum value of Maximum Storage and Normal storage, providing a single storage value (acre/ft) to facilitate database queries. (Source: National Inventory of Dams Data Dictionary).	https://nccwsc.usgs.gov/display-project/51014e04e4b033b1feeb2c26/512cf142e4b0855fde669828
8	ACRES	Waterbody surface area, in acres	calculated in GIS
9	CIRCLE	Shoreline sinuosity is calculated as the ratio of the length of the shoreline [L] to the circumference of a circle of area [A] equal to that of the lake using the formula: perimeter of lake / (2 sqrt pie * area of lake) (Weitzell et al. 2003)	calculated in GIS
10	PPT	Thiry year average precipitation	http://www.prism.oregonstate.edu/normals/
11	TMAX	Thirty year average maximum air temperature	http://www.prism.oregonstate.edu/normals/
12	TMIN	Thirty year average minimum air temperature	http://www.prism.oregonstate.edu/normals/
13	TMEAN	Thirty year average air temperature	http://www.prism.oregonstate.edu/normals/
14	TMIN1	Thiry year average minimum air temperature in January	http://www.prism.oregonstate.edu/normals/
15	TMIN2	Thiry year average minimum air temperature in February	http://www.prism.oregonstate.edu/normals/
16	TMIN3	Thiry year average minimum air temperature in March	http://www.prism.oregonstate.edu/normals/
17	TMIN4	Thiry year average minimum air temperature in April	http://www.prism.oregonstate.edu/normals/
18	TMIN5	Thiry year average minimum air temperature in May	http://www.prism.oregonstate.edu/normals/
19	TMIN6	Thiry year average minimum air temperature in June	http://www.prism.oregonstate.edu/normals/
20	TMIN7	Thiry year average minimum air temperature in July	http://www.prism.oregonstate.edu/normals/
21	TMIN8	Thiry year average minimum air temperature in August	http://www.prism.oregonstate.edu/normals/
22	TMIN9	Thiry year average minimum air temperature in September	http://www.prism.oregonstate.edu/normals/

23	TMIN10	Thiry year average minimum air temperature in October	http://www.prism.oregonstate.edu/normals/
24	TMIN11	Thiry year average minimum air temperature in November	http://www.prism.oregonstate.edu/normals/
25	TMIN12	Thiry year average minimum air temperature in December	http://www.prism.oregonstate.edu/normals/
26	TMEAN1	Thiry year average air temperature in January	http://www.prism.oregonstate.edu/normals/
27	TMEAN2	Thiry year average air temperature in February	http://www.prism.oregonstate.edu/normals/
28	TMEAN3	Thiry year average air temperature in March	http://www.prism.oregonstate.edu/normals/
29	TMEAN4	Thiry year average air temperature in April	http://www.prism.oregonstate.edu/normals/
30	TMEAN5	Thiry year average air temperature in May	http://www.prism.oregonstate.edu/normals/
31	TMEAN6	Thiry year average air temperature in June	http://www.prism.oregonstate.edu/normals/
32	TMEAN7	Thiry year average air temperature in July	http://www.prism.oregonstate.edu/normals/
33	TMEAN8	Thiry year average air temperature in August	http://www.prism.oregonstate.edu/normals/
34	TMEAN9	Thiry year average air temperature in September	http://www.prism.oregonstate.edu/normals/
35	TMEAN10	Thiry year average air temperature in October	http://www.prism.oregonstate.edu/normals/
36	TMEAN11	Thiry year average air temperature in November	http://www.prism.oregonstate.edu/normals/
37	TMEAN12	Thiry year average air temperature in December	http://www.prism.oregonstate.edu/normals/
38	TMAX1	Thiry year average maximum air temperature in January	http://www.prism.oregonstate.edu/normals/
39	TMAX2	Thiry year average maximum air temperature in February	http://www.prism.oregonstate.edu/normals/
40	TMAX3	Thiry year average maximum air temperature in March	http://www.prism.oregonstate.edu/normals/
41	TMAX4	Thiry year average maximum air temperature in April	http://www.prism.oregonstate.edu/normals/
42	TMAX5	Thiry year average maximum air temperature in May	http://www.prism.oregonstate.edu/normals/
43	TMAX6	Thiry year average maximum air temperature in June	http://www.prism.oregonstate.edu/normals/
44	TMAX7	Thiry year average maximum air temperature in July	http://www.prism.oregonstate.edu/normals/
45	TMAX8	Thiry year average maximum air temperature in August	http://www.prism.oregonstate.edu/normals/
46	TMAX9	Thiry year average maximum air temperature in September	http://www.prism.oregonstate.edu/normals/
47	TMAX10	Thiry year average maximum air temperature in October	http://www.prism.oregonstate.edu/normals/
48	TMAX11	Thiry year average maximum air temperature in November	http://www.prism.oregonstate.edu/normals/
49	TMAX12	Thiry year average maximum air temperature in December	http://www.prism.oregonstate.edu/normals/
50	PPT1	Thiry year average total precipitation in January	http://www.prism.oregonstate.edu/normals/

51	PPT2	Thiry year average total precipitation in February	http://www.prism.oregonstate.edu/normals/
52	PPT3	Thiry year average total precipitation in March	http://www.prism.oregonstate.edu/normals/
53	PPT4	Thiry year average total precipitation in April	http://www.prism.oregonstate.edu/normals/
54	PPT5	Thiry year average total precipitation in May	http://www.prism.oregonstate.edu/normals/
55	PPT6	Thiry year average total precipitation in June	http://www.prism.oregonstate.edu/normals/
56	PPTM7	Thiry year average total precipitation in July	http://www.prism.oregonstate.edu/normals/
57	PPT8	Thiry year average total precipitation in August	http://www.prism.oregonstate.edu/normals/
58	PPT9	Thiry year average total precipitation in September	http://www.prism.oregonstate.edu/normals/
59	PPT10	Thiry year average total precipitation in October	http://www.prism.oregonstate.edu/normals/
60	PPT11	Thiry year average total precipitation in November	http://www.prism.oregonstate.edu/normals/
61	PPT12	Thiry year average total precipitation in December	http://www.prism.oregonstate.edu/normals/
62	CACO3L	USGS STATSGO % calcium carbonate low value for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
63	CACO3H	USGS STATSGO % calcium carbonate high value for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
64	CECL	USGS STATSGO cation exchange capacity low value for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
65	CECH	USGS STATSGO cation exchange capacity high value for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
66	SLOPEL	USGS STATSGO slope (%), low value for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
67	SLOPEH	USGS STATSGO slope (%), high value for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
68	WTDEPL	USGS STATSGO value for the range in depth to the seasonally high water table (feet), low value for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
69	WTDEPH	USGS STATSGO value for the range in depth to the seasonally high water table (feet), high value for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
70	ROCKDEPL	USGS STATSGO soil thickness (inches) low value for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
71	ROCKDEPH	USGS STATSGO soil thickness (inches) high value for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
72	HGA	USGS STATSGO Hydrologic soil group A (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
73	HGB	USGS STATSGO Hydrologic soil group B (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
74	HGC	USGS STATSGO Hydrologic soil group C (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
75	HGD	USGS STATSGO Hydrologic soil group D (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
76	HGAD	USGS STATSGO Hydrologic soil group AD (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
77	HGBD	USGS STATSGO Hydrologic soil group BD (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml

78	HGCD	USGS STATSGO Hydrologic soil group CD (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
79	HGAC	USGS STATSGO Hydrologic soil group AC (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
80	HGBC	USGS STATSGO Hydrologic soil group BC (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
81	HGVAR	USGS STATSGO Hydrologic soil group var (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
82	KFACT	USGS STATSGO soil erodibility (k-factor; dimensionless) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
83	KFACT_UP	USGS STATSGO soil erodibility factor of uppermost soil horizon (includes rock fragments, dimensionless):for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
84	PERML	USGS STATSGO Low value for the range in permeability (inches per hour) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
85	PERMH	USGS STATSGO High value for the range in permeability (inches per hour) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
86	AWCL	USGS STATSGO Low value for the range in available water capacity (fraction) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
87	AWCH	USGS STATSGO High value for the range in available water capacity (fraction) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
88	BDL	USGS STATSGO Low value for the range in bulk density (grams per cubic centimeter) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
89	BDH	USGS STATSGO High value for the range in bulk density (grams per cubic centimeter) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
90	OML	USGS STATSGO Low value for the range in organic matter content (percent by weight) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
91	OMH	USGS STATSGO High value for the range in organic matter content (percent by weight) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
92	CLAYL	USGS STATSGO Low value of clay content (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
93	CLAYH	USGS STATSGO High value of clay content (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
94	NO4L	USGS STATSGO Low value percent by weight of soil material less than 3 inches in size that passes through a No. 4 sieve (5 millimeters) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
95	NO4H	USGS STATSGO High value percent by weight of soil material less than 3 inches in size that passes through a No. 4 sieve (5 millimeters) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
96	NO200L	USGS STATSGO Low value percent by weight of soil material lessfs than 3 inches in size that passes through a No. 200 sieve (.074 millimeters) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
97	NO200H	USGS STATSGO High value percent by weight of soil material lessfs than 3 inches in size that passes through a No. 200 sieve (.074 millimeters) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml

98	NO10L	USGS STATSGO Low value percent by weight of soil material less than 3 inches in size that passes through a No. 10 sieve (2 millimeters) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
99	NO10H	USGS STATSGO High value percent by weight of soil material less than 3 inches in size that passes through a No. 10 sieve (2 millimeters) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
100	NO4AVE	USGS STATSGO Average percent by weight of soil material less than 3 inches in size that passes through a No. 4 sieve (5 millimeters) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
101	NO200AVE	USGS STATSGO Average percent by weight of soil material lessfs than 3 inches in size that passes through a No. 200 sieve (.074 millimeters) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
102	NO10AVE	USGS STATSGO Average percent by weight of soil material less than 3 inches in size that passes through a No. 10 sieve (2 millimeters) for map unit lake is within	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
103	CLAY	USGS STATSGO Average value of clay content (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
104	SILT	USGS STATSGO Average value of silt (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
105	SAND	USGS STATSGO Average value of sand (mean percent for map unit lake is within)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
106	GEOV100	TNC Eastern Division geology: acidic sedimentary/metasedimentary (% of 1km buffer)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
107	GEOV200	TNC Eastern Division geology: acidic shale (% of 1km buffer)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
108	GEOV300	TNC Eastern Division geology: calcareous sedimentary/metasedimentary (% of 1km buffer area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
109	GEOV400	TNC Eastern Division geology: moderately calcareous sedimentary/metasedimentary (% of 1km buffer area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
110	GEOV500	TNC Eastern Division geology: acidic granitic (% of 1km buffer area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
111	GEOV600	TNC Eastern Division geology: mafic/intermediate granitic (% of 1km buffer area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
112	GEOV700	TNC Eastern Division geology: ultramafic (% of 1km buffer area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
113	GEOV800	TNC Eastern Division geology: deep coarse unconsolidated surficial sediment (% of 1km buffer area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
114	GEOV888	TNC Eastern Division geology: unconsolidated surficial sediment, unclear if fine or coarse (% of 1km buffer area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
115	GEOV900	TNC Eastern Division geology: deep fine unconsolidated surficial sediment (% of 1km buffer area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
116	BFI_BUFMN	USGS Mean Baseflow index , mean in 1km buffer	http://water.usgs.gov/GIS/metadata/usgswrd/XML/bfi48grd.xml#stdorder
117	IMPPER	Percent Impervious Cover in 1km buffer	http://www.mrlc.gov/nlcd2011.php
118	LC1kV21	NCLD11 Developed, Open Space (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php

119	LC1kV22	NCLD11 Developed, Low Intensity (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
120	LC1kV23	NCLD11 Developed, Medium Intensity (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
121	LC1kV24	NCLD11 Developed, High Intensity (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
122	LC1kV31	NCLD11 Barren Land, Non-natural (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
123	LC1kV32	NCLD11 Barren Land, natural (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
124	LC1kV41	NCLD11 Deciduous Forest (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
125	LC1kV42	NCLD11 Evergreen Forest (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
126	LC1kV43	NCLD11 Mixed Forest (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
127	LC1kV52	NCLD11 Shrub/Scrub (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
128	LC1kV71	NCLD11 Grassland/Herbaceous (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
129	LC1kV81	NCLD11 Pasture/Hay (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
130	LC1kV82	NCLD11 Cultivated Crops (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
131	LC1kV90	NCLD11 Woody Wetlands (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
132	LC1kV95	NCLD11 Emergent Herbaceous Wetlands (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
133	LC1kdevl	NLCD11 Development Low Intensity classes 21-22 (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
134	lc1kdevh	NLCD11 Development Low Intensity classes 23-23(% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
135	LC1kag	NLCD11 Agriculture classes 81 and 82 (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
136	LC1kwet	NLCD11 Wetland classes 90 and 95 (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
137	LC1kfor	NLCD11 Forest classes 41-43 (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
138	LC1kNAt	NLCD11 Natural cover classes 41-43, 52, 71, 90, and 95 (% of 1km buffer)	http://www.mrlc.gov/nlcd2011.php
139	LC1kind	Landscape index for the 1km buffer; Impact = 0.5 * % agriculture + 0.75* % low intensity development+ 1.0* % high intensity development (NLCD cover classes 81/82, 21/22, 23/24).	http://www.mrlc.gov/nlcd2011.php
140	GAPV0	Percent of the 100m buffer that is not in conservation land; unsecured	TNC Eastern Conservation Science Secured Lands Database 2013
141	GAPV1	Percent of the 100m buffer that is in GAP status 1, secured in natural state without interference	TNC Eastern Conservation Science Secured Lands Database 2013
142	GAPV2	Percent of the 100m buffer that is in GAP status 2, secured in primarily natural state, but may include some managements such as supression of natural disturbance	TNC Eastern Conservation Science Secured Lands Database 2013
143	GAPV3	Percent of the 100m buffer that is in GAP status 3, secured for multiple uses such as forest management and recreation	TNC Eastern Conservation Science Secured Lands Database 2013
144	LC100MV21	NCLD11 Developed, Open Space (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
145	LC100MV22	NCLD11 Developed, Low Intensity (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
146	LC100MV23	NCLD11 Developed, Medium Intensity (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php

147	LC100MV24	NCLD11 Developed, High Intensity (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
148	LC100MV31	NCLD11 Barren Land, Non-natural (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
149	LC100MV32	NCLD11 Barren Land, natural (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
150	LC100MV41	NCLD11 Deciduous Forest (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
151	LC100MV42	NCLD11 Evergreen Forest (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
152	LC100MV43	NCLD11 Mixed Forest (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
153	LC100MV52	NCLD11 Shrub/Scrub (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
154	LC100MV71	NCLD11 Grassland/Herbaceous (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
155	LC100MV81	NCLD11 Pasture/Hay (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
156	LC100MV82	NCLD11 Cultivated Crops (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
157	LC100MV90	NCLD11 Woody Wetlands (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
158	LC100MV95	NCLD11 Emergent Herbaceous Wetlands (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
159	LC100devl	NLCD11 Development Low Intensity classes 21-22 (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
160	lc100devh	NLCD11 Development Low Intensity classes 23-23(% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
161	LC100kag	NLCD11 Agriculture classes 81 and 82 (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
162	LC100wet	NLCD11 Wetland classes 90 and 95 (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
163	LC100kfor	NLCD11 Forest classes 41-43 (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
164	LC100NAt	NLCD11 Natural cover classes 41-43, 52, 71, 90, and 95 (% of 100m buffer)	http://www.mrlc.gov/nlcd2011.php
165	LC100ind	Landscape index for the 100m buffer; Impact = 0.5 * % agriculture + 0.75* % low intensity development+ 1.0* % high intensity development (NLCD cover classes 81/82, 21/22, 23/24).	http://www.mrlc.gov/nlcd2011.php
166	SOILV1	SSURGO Soil Texture Group: Loamy Sand, Sand % of 1km buffer	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053627
167	SOILV2	SSURGO Soil Texture Group: Loam, Sandy Loam, Sandy Clay Loam % of 1km buffer	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053627
168	SOILV3	SSURGO Soil Texture Group: Silty Loam, Silty Clay Loam, Clay Loam, Silt % of 1km buffer	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053627
169	SOILV4	SSURGO Soil Texture Group: Clay, Silty Clay, Sandy Clay % of 1km buffer	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053627
170	soilcmMN	SSURGO Soil mean root zone depth of 1km buffer	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053627
171	slp1kMN	Mean slope in 1km buffer	USGS NED 30m
172	LF1kV3	TNC Eastern Division Landforms: Steep slope cool aspect % of 1km buffer	TNC Eastern Conservation Science 2015
173	LF1kV4	TNC Eastern Division Landforms: Steep slope warm aspect % of 1km buffer	TNC Eastern Conservation Science 2015
174	LF1kV5	TNC Eastern Division Landforms: Cliff % of 1km buffer	TNC Eastern Conservation Science 2015

175	LF1kV11	TNC Eastern Division Landforms: Summit/ridgetop % of 1km buffer	TNC Eastern Conservation Science 2015
176	LF1kV13	TNC Eastern Division Landforms: Slope crest % of 1km buffer	TNC Eastern Conservation Science 2015
177	LF1kV21	TNC Eastern Division Landforms: Hilltop (flat) % of 1km buffer	TNC Eastern Conservation Science 2015
178	LF1kV22	TNC Eastern Division Landforms: Hill (gentle slope) % of 1km buffer	TNC Eastern Conservation Science 2015
179	LF1kV23	TNC Eastern Division Landforms: Sideslope cool aspect % of 1km buffer	TNC Eastern Conservation Science 2015
180	LF1kV24	TNC Eastern Division Landforms: Sideslope warm aspect % of 1km buffer	TNC Eastern Conservation Science 2015
181	LF1kV30	TNC Eastern Division Landforms: Dry flats % of 1km buffer	TNC Eastern Conservation Science 2015
182	LF1kV31	TNC Eastern Division Landforms: Wet flats % of 1km buffer	TNC Eastern Conservation Science 2015
183	LF1kV32	TNC Eastern Division Landforms: Valley/toeslope % of 1km buffer	TNC Eastern Conservation Science 2015
184	LF1kV39	TNC Eastern Division Landforms: Moist flats in upland landcover % of 1km buffer	TNC Eastern Conservation Science 2015
185	LF1kV41	TNC Eastern Division Landforms: Flat at bottom of steep slope % of 1km buffer	TNC Eastern Conservation Science 2015
186	LF1kV43	TNC Eastern Division Landforms: Cove/footslope cool aspect % of 1km buffer	TNC Eastern Conservation Science 2015
187	LF1kV44	TNC Eastern Division Landforms: Cove/footslope warm aspect % of 1km buffer	TNC Eastern Conservation Science 2015
188	DivDASqKM	divergence-routed cumulative drainage area in sq.km; a measure of full upstream watershed size for lakes with a NHD 1:100,000 flowline through the waterbody (value of 0 for other headwater and isolated lakes where watershed or upstream network area is not available)	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
	Please note that the attributes below ending in "N" are the accumulation of upstream network (watershed) characteristics for lakes that had an NHD centerline within them. These network (N) summaries for the entire upstream watershed were only available for non-headwater and non-isolated waterbodies which had a NHDV2 centerline through the lake (20,952 waterbodies; 57% of all) because total upstream accumulations of variables had been done using the NHD V2 stream and centerline network as summarized for the Appalachian LCC (Olivero-Sheldon and Anderson, 2014). When entire upstream watershed attributes were not available for given waterbodies, we filled the blanks with the 1km buffer attributes as we felt this area adequately represented the smaller local scale or direct watershed of these smaller headwater and isolated waterbodies. When the 1km buffer data was not available, the blanks are filled in with -999		
189	CumPrecip	Mean annual precipitation accumulated down the NHD flowline network. Mean annual precipitation in area upstream of the bottom of flowline in millimeters * 100	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
190	CumTemp	Mean annual temperature in area upstream of the bottom of flowline in degrees centigrade * 100 of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
191	incEROM_010001	Incremental flow from gage adjustment (cfs) for January of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
192	incEROM_020001	Incremental flow from gage adjustment (cfs) for February of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
193	incEROM_030001	Incremental flow from gage adjustment (cfs) for March of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php

194	incEROM_040001	Incremental flow from gage adjustment (cfs) for April of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
195	incEROM_050001	Incremental flow from gage adjustment (cfs) for May of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
196	incEROM_060001	Incremental flow from gage adjustment (cfs) for June of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
197	incEROM_070001	Incremental flow from gage adjustment (cfs) for July of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
198	incEROM_080001	Incremental flow from gage adjustment (cfs) for August of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
199	incEROM_090001	Incremental flow from gage adjustment (cfs) for September of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
200	incEROM_100001	Incremental flow from gage adjustment (cfs) for October of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
201	incEROM_110001	Incremental flow from gage adjustment (cfs) for November of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
202	incEROM_120001	Incremental flow from gage adjustment (cfs) for December of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
203	incEROM_MA0001	Incremental mean annual flow from gage adjustment (cfs) of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
204	IncrPrecipMA	Incremental mean annual precipitation in millimeters * 100 of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
205	IncrPrecipMM01	Mean precipitation in millimeters * 100 for January of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
206	IncrPrecipMM02	Mean precipitation in millimeters * 100 for February of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
207	IncrPrecipMM03	Mean precipitation in millimeters * 100 for March of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
208	IncrPrecipMM04	Mean precipitation in millimeters * 100 for April of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
209	IncrPrecipMM05	Mean precipitation in millimeters * 100 for May of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
210	IncrPrecipMM06	Mean precipitation in millimeters * 100 for June of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
211	IncrPrecipMM07	Mean precipitation in millimeters * 100 for July of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
212	IncrPrecipMM08	Mean precipitation in millimeters * 100 for August of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php

213	IncrPrecipMM09	Mean precipitation in millimeters * 100 for September of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
214	IncrPrecipMM10	Mean precipitation in millimeters * 100 for October of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
215	IncrPrecipMM11	Mean precipitation in millimeters * 100 for November of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
216	IncrPrecipMM12	Mean precipitation in millimeters * 100 for December of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
217	IncrTempMA	Incremental mean annual temperature in degrees centigrade * 100 of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
218	IncrTempMM01	Mean annual temperature in degrees centigrade * 100 for January of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
219	IncrTempMM02	Mean annual temperature in degrees centigrade * 100 for February of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
220	IncrTempMM03	Mean annual temperature in degrees centigrade * 100 for March of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
221	IncrTempMM04	Mean annual temperature in degrees centigrade * 100 for April of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
222	IncrTempMM05	Mean annual temperature in degrees centigrade * 100 for May of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
223	IncrTempMM06	Mean annual temperature in degrees centigrade * 100 for June of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
224	IncrTempMM07	Mean annual temperature in degrees centigrade * 100 for July of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
225	IncrTempMM08	Mean annual temperature in degrees centigrade * 100 for August of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
226	IncrTempMM09	Mean annual temperature in degrees centigrade * 100 for September of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
227	IncrTempMM10	Mean annual temperature in degrees centigrade * 100 for October of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
228	IncrTempMM11	Mean annual temperature in degrees centigrade * 100 for November of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
229	IncrTempMM12	Mean annual temperature in degrees centigrade * 100 for December of flowline exiting the waterbody	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
230	awc_avgN	USGS STATSGO Average value for the range in available water capacity (fraction), network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
231	bd_avgN	USGS STATSGO Average value for the range in bulk density (grams per cubic centimeter), network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml

232	bfi_avgN	USGS Mean Baseflow index, network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/bfi48grd.xml#stdorder
233	caco3h_avgN	USGS STATSGO % calcium carbonate high value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
234	caco3l_avgN	USGS STATSGO % calcium carbonate low value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
235	cech_avgN	USGS STATSGO cation exchange capacity high value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
236	cecl_avgN	USGS STATSGO cation exchange capacity low value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
237	clay_avgN	USGS STATSGO Average value of clay content (mean percent of catchment)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
238	ct_avgN	USGS Mean contact time	http://water.usgs.gov/GIS/metadata/usgswrd/XML/nhd_contact.xml
239	elevcm_avgN	Average elevation (cm) of the network area calculated using the NHDPlus v2 NED Digital Elevation Model	http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php
240	geol_100N	TNC Eastern Division geology: acidic sedimentary/metasedimentary (% of local)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
241	geol_200N	TNC Eastern Division geology: acidic shale (% of local)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
242	geol_300N	TNC Eastern Division geology: calcareous sedimentary/metasedimentary (% of network area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
243	geol_400N	TNC Eastern Division geology: moderately calcareous sedimentary/metasedimentary (% of network area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
244	geol_500N	TNC Eastern Division geology: acidic granitic (% of network area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
245	geol_600N	TNC Eastern Division geology: mafic/intermediate granitic (% of network area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
246	geol_700N	TNC Eastern Division geology: ultramafic (% of network area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
247	geol_800N	TNC Eastern Division geology: deep coarse unconsolidated surficial sediment (% of network area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
248	geol_900N	TNC Eastern Division geology: deep fine unconsolidated surficial sediment (% of network area)	TNC Eastern Conservation Science 2015, from multiple state and federal sources
249	hga_avgN	USGS STATSGO Hydrologic soil group A (mean percent of network area)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
250	hgac_avgN	USGS STATSGO Hydrologic soil group AC (mean percent of network area)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
251	hgad_avgN	USGS STATSGO Hydrologic soil group AD (mean percent of network area)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
252	hgb_avgN	USGS STATSGO Hydrologic soil group B (mean percent of network area)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
253	hgbc_avgN	USGS STATSGO Hydrologic soil group BC (mean percent of network area)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
254	hgbd_avgN	USGS STATSGO Hydrologic soil group BD (mean percent of network area)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
255	hgc_avgN	USGS STATSGO Hydrologic soil group C (mean percent of network area)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
256	hgcd_avgN	USGS STATSGO Hydrologic soil group CD (mean percent of network area)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
257	hgd_avgN	USGS STATSGO Hydrologic soil group D (mean percent of network area)	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml

258	imp11_perN	Percent of the network catchment in NLCD 2011 imperviousness cover, network value	http://www.mrlc.gov/nlcd11_data.php
259	kfact_avgN	USGS STATSGO soil erodibility (k-factor; dimensionless), network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
260	kfactup_avgN	USGS STATSGO soil erodibility factor of uppermost soil horizon (includes rock fragments, dimensionless), network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
261	lf_03N	TNC Eastern Division Landforms: Steep slope cool aspect % of network area	TNC Eastern Conservation Science 2015
262	lf_04N	TNC Eastern Division Landforms: Steep slope warm aspect % of network area	TNC Eastern Conservation Science 2015
263	lf_05N	TNC Eastern Division Landforms: Cliff % of network area	TNC Eastern Conservation Science 2015
264	lf_11N	TNC Eastern Division Landforms: Summit/ridgetop % of network area	TNC Eastern Conservation Science 2015
265	lf_13N	TNC Eastern Division Landforms: Slope crest % of network area	TNC Eastern Conservation Science 2015
266	lf_21N	TNC Eastern Division Landforms: Hilltop (flat) % of network area	TNC Eastern Conservation Science 2015
267	lf_22N	TNC Eastern Division Landforms: Hill (gentle slope) % of network area	TNC Eastern Conservation Science 2015
268	lf_23N	TNC Eastern Division Landforms: Sideslope cool aspect % of network area	TNC Eastern Conservation Science 2015
269	lf_24N	TNC Eastern Division Landforms: Sideslope warm aspect % of network area	TNC Eastern Conservation Science 2015
270	lf_30N	TNC Eastern Division Landforms: Dry flats % of network area	TNC Eastern Conservation Science 2015
271	lf_31N	TNC Eastern Division Landforms: Wet flats % of network area	TNC Eastern Conservation Science 2015
272	lf_32N	TNC Eastern Division Landforms: Valley/toeslope % of network area	TNC Eastern Conservation Science 2015
273	lf_39N	TNC Eastern Division Landforms: Moist flats in upland landcover % of network area	TNC Eastern Conservation Science 2015
274	lf_41N	TNC Eastern Division Landforms: Flat at bottom of steep slope % of network area	TNC Eastern Conservation Science 2015
275	lf_43N	TNC Eastern Division Landforms: Cove/footslope cool aspect % of network area	TNC Eastern Conservation Science 2015
276	lf_44N	TNC Eastern Division Landforms: Cove/footslope warm aspect % of network area	TNC Eastern Conservation Science 2015
277	nid_storN	% mean annual flow (gage-adjusted) stored behind dams, network value	https://nccwsc.usgs.gov/display-project/51014e04e4b033b1feeb2c26/512cf142e4b0855fde669828
278	nlcd11_11N	NCLD11 Open Water (% of network area)	http://www.mrlc.gov/nlcd2011.php
279	nlcd11_21N	NCLD11 Developed, Open Space (% of network area)	http://www.mrlc.gov/nlcd2011.php
280	nlcd11_22N	NCLD11 Developed, Low Intensity (% of network area)	http://www.mrlc.gov/nlcd2011.php
281	nlcd11_23N	NCLD11 Developed, Medium Intensity (% of network area)	http://www.mrlc.gov/nlcd2011.php
282	nlcd11_24N	NCLD11 Developed, High Intensity (% of network area)	http://www.mrlc.gov/nlcd2011.php
283	nlcd11_31N	NCLD11 Barren Land (% of network area)	http://www.mrlc.gov/nlcd2011.php
284	nlcd11_41N	NCLD11 Deciduous Forest (% of network area)	http://www.mrlc.gov/nlcd2011.php
285	nlcd11_42N	NCLD11 Evergreen Forest (% of network area)	http://www.mrlc.gov/nlcd2011.php

286	nlcd11_43N	NCLD11 Mixed Forest (% of network area)	http://www.mrlc.gov/nlcd2011.php
287	nlcd11_52N	NCLD11 Shrub/Scrub (% of network area)	http://www.mrlc.gov/nlcd2011.php
288	nlcd11_71N	NCLD11 Grassland/Herbaceous (% of network area)	http://www.mrlc.gov/nlcd2011.php
289	nlcd11_81N	NCLD11 Pasture/Hay (% of network area)	http://www.mrlc.gov/nlcd2011.php
290	nlcd11_82N	NCLD11 Cultivated Crops (% of network area)	http://www.mrlc.gov/nlcd2011.php
291	nlcd11_90N	NCLD11 Woody Wetlands (% of network area)	http://www.mrlc.gov/nlcd2011.php
292	nlcd11_95N	NCLD11 Emergent Herbaceous Wetlands (% of network area)	http://www.mrlc.gov/nlcd2011.php
293	nlcd11_agN	NLCD11 Agriculture classes 81 and 82 (% of network area)	http://www.mrlc.gov/nlcd2011.php
294	nlcd11_devN	NLCD11 Development classes 21-24 (% of network area)	http://www.mrlc.gov/nlcd2011.php
295	nlcd11_forN	NLCD11 Forest classes 41-43 (% of network area)	http://www.mrlc.gov/nlcd2011.php
296	nlcd11_NAtN	NLCD11 Natural cover classes 41-43, 52, 71, 90, and 95 (% of network area)	http://www.mrlc.gov/nlcd2011.php
297	nlcd11_wetlN	NLCD11 Wetland classes 90 and 95 (% of network area)	http://www.mrlc.gov/nlcd2011.php
298	no10_avgN	USGS STATSGO Average percent by weight of soil material less than 3 inches in size that passes through a No. 10 sieve (2 millimeters), network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
299	no200_avgN	USGS STATSGO Average percent by weight of soil material lessfs than 3 inches in size that passes through a No. 200 sieve (.074 millimeters), network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
300	no4_avgN	USGS STATSGO Average percent by weight of soil material less than 3 inches in size that passes through a No. 4 sieve (5 millimeters), network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
301	om_avgN	USGS STATSGO Average value for the range in organic matter content (percent by weight), network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
302	perm_avgN	USGS STATSGO Average value for the range in permeability (inches per hour), network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
303	rckdeph_avgN	USGS STATSGO soil thickness (inches) high value, network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
304	rckdepl_avgN	USGS STATSGO soil thickness (inches) low value, network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
305	sand_avgN	USGS STATSGO Average value of sand (mean percent of catchment), network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
306	silt_avgN	USGS STATSGO Average value of silt (mean percent of network catchment), network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
307	slope_avgN	USGS STATSGO Average Slope (%), network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
308	ss_1N	SSURGO Soil Texture Group: Loamy Sand, Sand % of network area	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627
309	ss_2N	SSURGO Soil Texture Group: Loam, Sandy Loam, Sandy Clay Loam % of network area	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627
310	ss_3N	SSURGO Soil Texture Group: Silty Loam, Silty Clay Loam, Clay Loam, Silt % of network area	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627

311	ss_4N	SSURGO Soil Texture Group: Clay, Silty Clay, Sandy Clay % of network area	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627
312	wtdep_avgN	USGS STATSGO Average value for the range in depth to the seasonally high water table (feet), network value	http://water.usgs.gov/GIS/metadata/usgswrd/XML/muid.xml
313	PRIMPUR	General primary purpose of the largest dam on that lake	Northeast Aquatic Connectivity Project: http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/freshwater/stream/Pages/default.aspx
314	ECOREG	Terrestrial Ecoregion	TNC Eastern Conservation Science 2015
315	CPLAIN	Coastal Plain Ecoregions lumped together vs. Non-Coastal Plain Ecoregions	TNC Eastern Conservation Science 2015

Appendix IV: Lake and pond habitat guide pages

This appendix includes the 18 lake and pond habitat guide pages along with a description of the elements on each page.

Description of elements on the lake and pond habitat guide pages

Each of the informational element on the habitat guide pages is described below. A labeled example of each element can be found in Figures 1 and 2 for "Cold, oligo-mesotrophic, acidic lakes and ponds".

1.) **Habitat Name**: Lake and pond habitat types are based on a combination of temperature, trophic class, and alkalinity

2.) **Habitat Macrogroup**: Major grouping of lake and pond habitats based on maximum depth

3.) **Distribution Map**: Regional map displaying distribution of the specified aquatic habitat.

4.) **State Distribution and Securement information**: State distribution of lakes and ponds based on the surface area of waterbodies as mapped for the Northeast Lake and Pond Classification Systems using National Hydrography Dataset Plus 1:100,000 Version 2 polygons and an additional 4, 023 polygons from the high resolution National Hydrography Dataset. The securement information for this section was derived using the 2013 TNC Secured Lands dataset for the Northeast and Mid-Atlantic. The total acreage of a 100m buffer riparian area around the lake or pond was sampled to calculate the total percent of this 100m buffer riparian habitat that was secured. The table is sorted by the percent of the overall habitat measured as surface waterbody area found in each state to show regional distribution.

5.) **Photo of Representative Habitat:** This photo shows a lake or pond of the habitat type. These photos are intended to convey the look and structure of the habitat; not all lakes and ponds in the same habitat type will look identical. These photos were primarily obtained through Creative Commons and are publically distributable with attribution and license. Photos of lakes and ponds are primarily from states with many occurrences of this habitat type.

6.) **Photo Credit:** Name of lake or pond, photographer, and license type for each photo pictured.

7.) **Description**: A capsule description of the habitat, describing its temperature, trophic class, and alkalinity. Descriptions were compiled from various existing field guides, lake classifications, and Natural Heritage Program documents.

8.) **Number of waterbodies**: Number of lakes and/or ponds of each habitat type.

9.) **Habitat Type Criteria**: This section lists the criteria and bounds that were used to place waterbodies into discrete habitat types.

10.) **Places to Visit this Habitat**: We selected five places to see the habitat based on the total acres of secured riparian buffer that are open to the public. These places are a mix of U.S. Fish and Wildlife, The Nature Conservancy, and other public parks. They do not always cover every state in which this habitat type is present.

11.) **Associated Species:** This section provides a list of fish species commonly found within this habitat. We used common names for the guide, and a glossary of common names and their equivalent scientific names are available in Appendix I and Appendix II of the Northeast Habitat Guide (Anderson et al. 2013). Descriptions were compiled from various existing field guides, lake classifications, and Natural Heritage Program documents. The geographic coverage of our data was uneven, but we hope these lists reflect a plausible first attempt at describing common fish species that that could be found in each habitat.

12.) **Species of Concern (G1-G4):** This information was compiled from species locations obtained from the Natural Heritage programs and NatureServe. We used common names for the guide, and a glossary of common names and their equivalent standard names are available in Appendix I and Appendix II of the Northeast Habitat Guide. We considered a Species of Concern to be any species with a global rank of G1-G4. Only G1-G4 fish, mussels, crayfish, amphibians, freshwater turtles, and freshwater snail species with $\geq$ 3 occurrences in our dataset were reported in the guide. For each of these species, the # of occurrences falling on a given lake type was compared to the number expected by chance given the distribution of acres of the lake type and total number of occurrences of this species in the dataset. When the number of species occurrences observed was greater than the number expected by chance, the species was listed as associated with the habitat. Please note that because rare species often have very specific habitat requirements they may be responding to habitat factors at a finer scale than the major habitat types mapped in this guide.

13.) **Depth and Temperature Profile:** A figure indicating the average depth and temperature profile for lakes and ponds in each temperature and trophic class.

14.) **Habitat Securement Chart**: A chart summarizing the total percent of the 100m riparian buffer area around each waterbody of this habitat found in GAP 1-2 (land secured for biodiversity and natural processes), Gap 3 (land secured for multiple uses), and Unsecured.

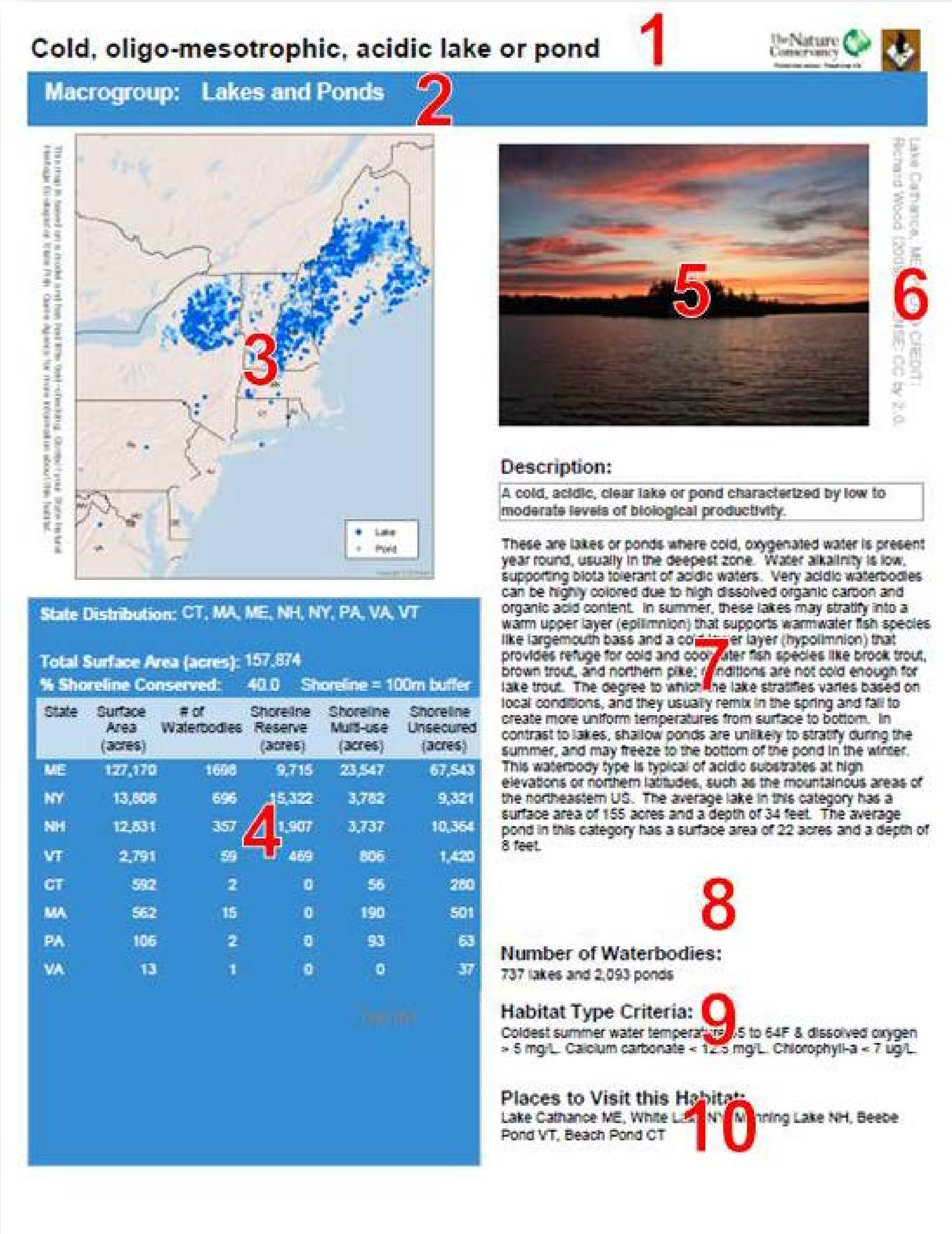
15.) **Land Cover Class Chart**: The percent of land cover in the 100m riparian buffer area (NLCD 2011).

16.) **Dams by Primary Purpose Chart**: Percent of waterbodies dammed by dams of a given primary purpose. Dams were compiled from state dam datasets and all dams in the National Inventory of Dams as of 2011 (Martin 2011).

17.) **Watershed Cumulative Impervious Characteristics Chart:** Impervious surface data were obtained from the NLCD 201. The summaries for the entire upstream watershed were only available for non-headwater and non-isolated waterbodies which had a NHDV2 centerline through the lake (20,952 waterbodies) because total upstream accumulations had been done using the NHD V2 stream and centerline network. When entire upstream watershed attributes were not available for given waterbodies, we filled the blanks with the 1000m buffer attributes as we felt this area adequately represented the smaller local scale or direct watershed of these smaller headwater and isolated waterbodies. Water quality, and consequently the biotic condition in the lake or pond, declines with increasing watershed imperviousness. Each waterbody was assigned to one of four impact classes: class 1 = 0-0.5%, class 2 = 0.5% - 2%, class 3 = 2%-10%, class 4 >10% (classes derived from Baker and King 2010).

18.) **Website for Habitat Guide**: The Nature Conservancy's online gateway for information and data relating to the Northeast Lake and Pond Classification system.

Figure 1. Example page 1 of habitat guide: cold, oligo-mesotrophic, acidic lake or pond



Cold, oligo-mesotrophic, acidic lake or pond

1

Macrogroup: Lakes and Ponds

2

3

5

6

Lake Cathance, ME [illegible] CREDIT: Richard Wood (2005) [illegible] CC by 2.0

State Distribution: CT, MA, ME, NH, NY, PA, VA, VT

Total Surface Area (acres): 157,874

% Shoreline Conserved: 40.0 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
ME	127,170	1698	9,715	23,547	67,543
NY	13,808	696	15,322	3,782	9,321
NH	12,831	357	1,907	3,737	10,364
VT	2,791	59	469	806	1,420
CT	592	2	0	56	280
MA	562	15	0	190	501
PA	106	2	0	93	63
VA	13	1	0	0	37

4

Description:

A cold, acidic, clear lake or pond characterized by low to moderate levels of biological productivity.

These are lakes or ponds where cold, oxygenated water is present year round, usually in the deepest zone. Water alkalinity is low, supporting biota tolerant of acidic waters. Very acidic waterbodies can be highly colored due to high dissolved organic carbon and organic acid content. In summer, these lakes may stratify into a warm upper layer (epilimnion) that supports warmwater fish species like largemouth bass and a co[illegible]er layer (hypolimnion) that provides refuge for cold and coo[illegible]ter fish species like brook trout, brown trout, and northern pike; [illegible]nditions are not cold enough for lake trout. The degree to which [illegible]he lake stratifies varies based on local conditions, and they usually remix in the spring and fall to create more uniform temperatures from surface to bottom. In contrast to lakes, shallow ponds are unlikely to stratify during the summer, and may freeze to the bottom of the pond in the winter. This waterbody type is typical of acidic substrates at high elevations or northern latitudes, such as the mountainous areas of the northeastern US. The average lake in this category has a surface area of 155 acres and a depth of 34 feet. The average pond in this category has a surface area of 22 acres and a depth of 8 feet.

7

8

Number of Waterbodies:

737 lakes and 2,093 ponds

Habitat Type Criteria:

9

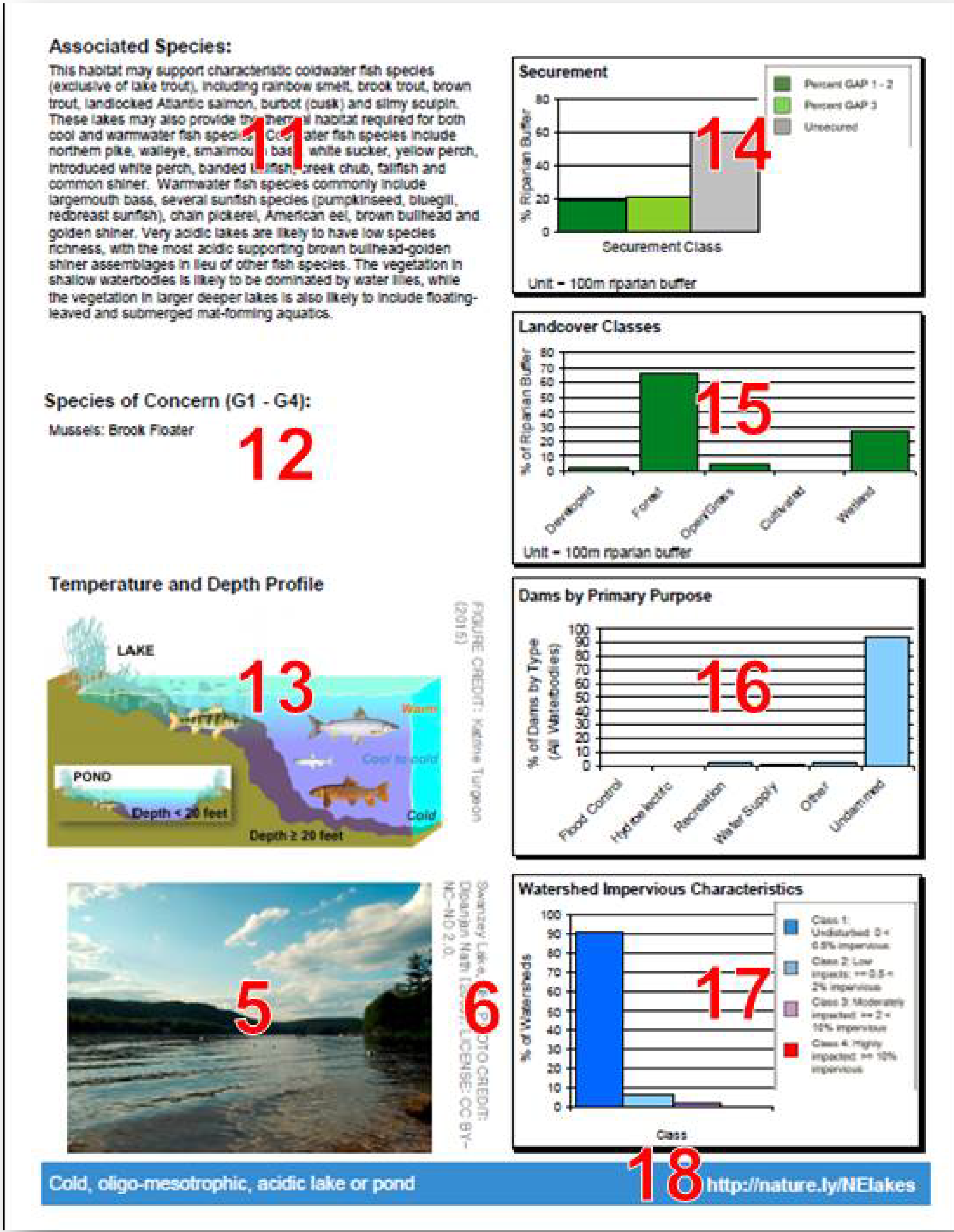
Coldest summer water temperat[illegible].5 to 64F & dissolved oxygen > 5 mg/L. Calcium carbonate < 12.5 mg/L. Chlorophyll-a < 7 ug/L.

Places to Visit this Habitat:

10

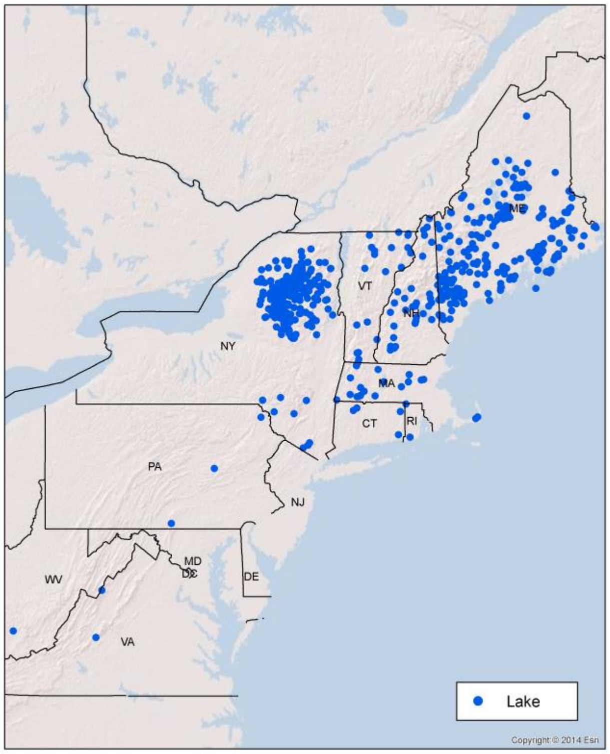
Lake Cathance ME, White L[illegible] NY, M[illegible]nning Lake NH, Beebe Pond VT, Beach Pond CT

Figure 2. Example page 2 of habitat guide: cold, oligo-mesotrophic, acidic lake or pond



Very cold, oligo-mesotrophic, acidic lake

Macrogroup: Lakes



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

Lake Sunapee, NH. PHOTO CREDIT: Rick Kloeppel (2006). LICENSE: CC BY-SA 2.0.

State Distribution: CT, MA, ME, NH, NY, PA, RI, VA, VT, WV

Total Surface Area (acres): 561,016

% Shoreline Conserved: 32.6 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
ME	369,728	228	7,668	15,874	70,133
NH	82,970	33	937	1,443	17,954
NY	66,118	270	17,869	3,942	19,790
MA	31,572	20	148	5,837	2,585
VT	6,751	20	108	1,328	2,442
CT	2,719	4	0	10	1,312
RI	405	2	50	77	182
PA	279	3	0	204	53
WV	260	1	0	0	451
VA	213	2	78	51	120

Description:

A very cold, deep, acidic, clear lake characterized by high dissolved oxygen content and low to moderate levels of biological productivity.

These are deep lakes where very cold, highly oxygenated water is present year round, usually in the deepest zone. Water alkalinity is low, supporting biota tolerant of acidic waters. In summer, these lakes may stratify into a warm upper layer (epilimnion) that supports warmwater fish species like largemouth bass and a cold lower layer (hypolimnion) that provides refuge for coldwater fish species like lake trout and brook trout. Thermal habitat for coolwater fish species like northern pike is present throughout. The degree to which the lake stratifies varies based on local conditions, and they usually remix in the spring and fall to create more uniform temperatures from surface to bottom. This lake type is typical of acidic substrates, northern latitudes, or deep kettle holes on the coastal plain. A few very deep reservoirs in the mid-Atlantic also support this habitat. The average lake in this category has a surface area of 962 acres and a depth of 68 feet.

Number of Waterbodies:

583 lakes

Habitat Type Criteria:

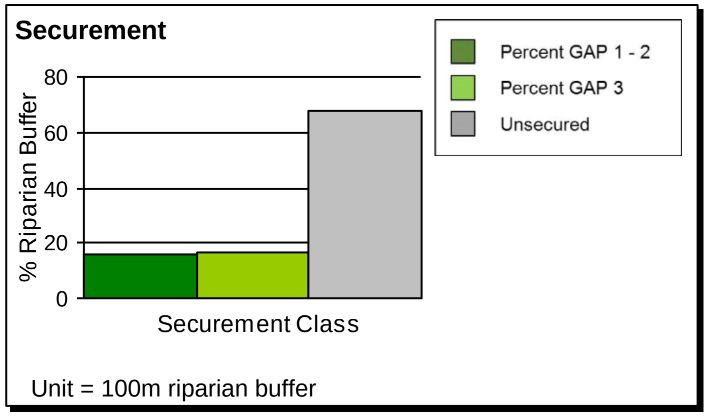
Coldest summer water temperature < 55F & dissolved oxygen > 5 mg/L. Calcium carbonate < 12.5 mg/L. Chlorophyll-a < 7 ug/L.

Places to Visit this Habitat:

Lake Winnipesaukee NH, Schoodic Lake ME, Lewey Lake NY, Sheep Pond MA, West Hill Pond CT

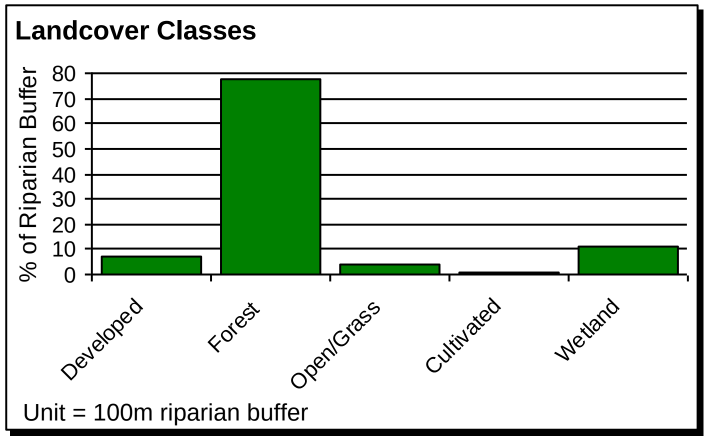
Associated Species:

This habitat may support very coldwater species such as lake trout (togue), in addition to other characteristic coldwater fish species such as rainbow smelt, brook trout, brown trout, landlocked Atlantic salmon, whitefish, burbot (cusk) and slimy sculpin. These lakes may also provide the thermal habitat required for both cool and warmwater fish species. Coolwater fish species include northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Warmwater fish species commonly include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. Very acidic lakes are likely to have low species richness, with the most acidic supporting brown bullhead-golden shiner assemblages in lieu of other fish species.



Species of Concern (G1 - G4):

Fish: Landlocked Arctic Char   Mussels: Yellow Lampmussel, Tidewater Mucket



Temperature and Depth Profile

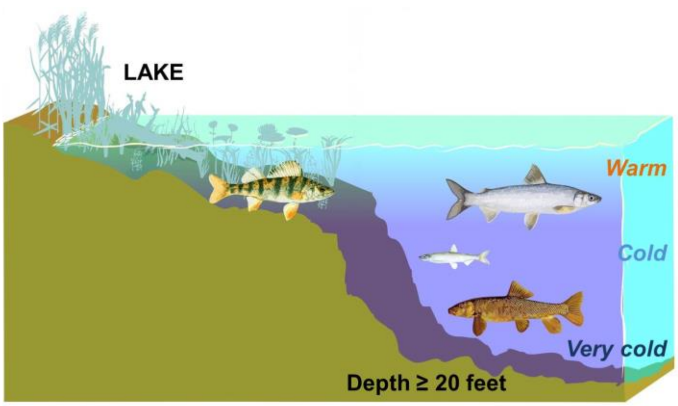
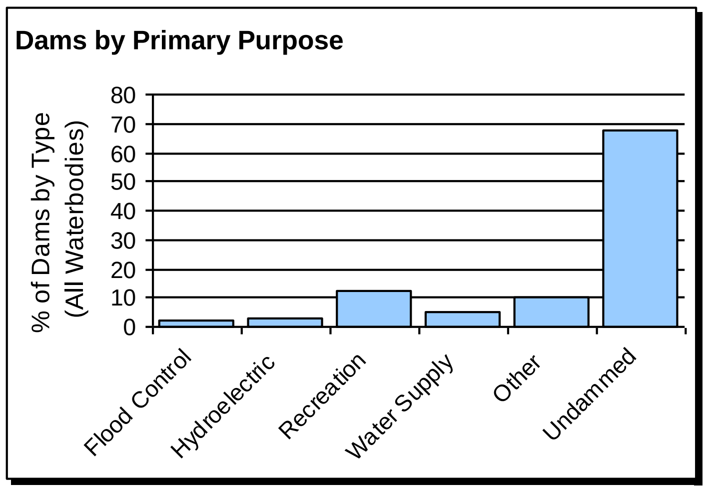
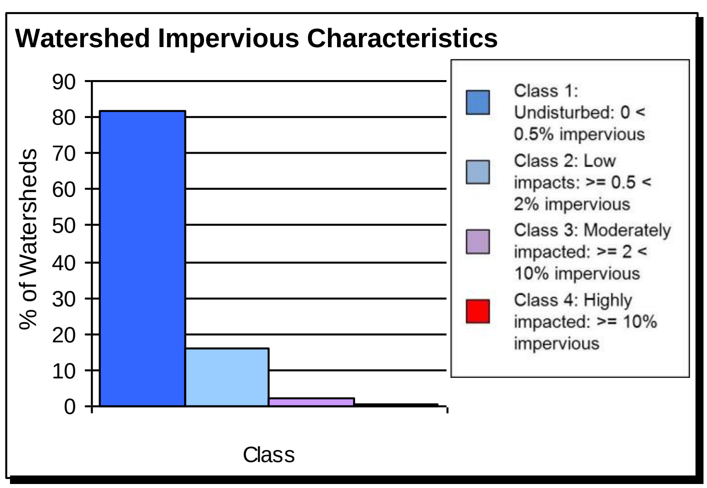


FIGURE CREDIT: Katrine Turgeon (2015)

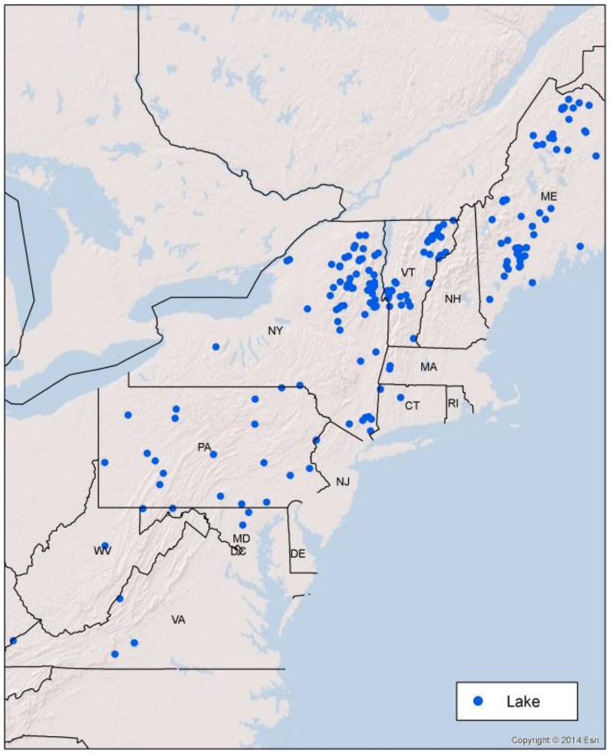


Damariscotta Lake, ME. PHOTO CREDIT: Keith Carver (2007). LICENSE: CC BY-NC-ND 2.0.

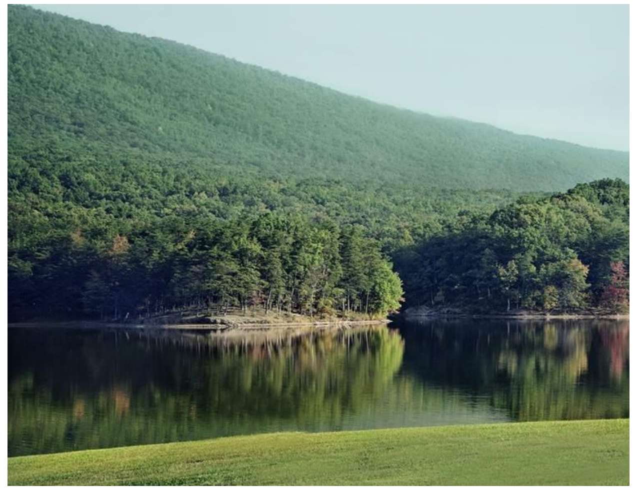


Very cold, oligo-mesotrophic, neutral lake

Macrogroup: Lakes



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.



Lake Habeeb, MD. PHOTO CREDIT: javcon177 (2012). LICENSE: CC BY-SA 2.0, cropped.

State Distribution: CT, MA, MD, ME, NH, NJ, NY, PA, VA, VT, WV

Total Surface Area (acres): 189,559

% Shoreline Conserved: 25.1 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
NY	67,657	66	5,243	1,301	14,008
ME	66,194	55	2,073	2,417	16,269
VA	28,112	4	55	1,813	20,052
PA	10,548	19	2,245	1,098	3,884
VT	9,781	34	92	779	3,886
MD	4,693	3	2,846	163	1,420
CT	1,176	2	0	19	496
WV	610	1	0	0	625
NH	538	1	0	138	95
NJ	169	1	0	5	93
MA	81	2	0	100	2

Description:

A very cold, deep, circumneutral, clear lake characterized by high dissolved oxygen content and low to moderate levels of biological productivity.

These are deep lakes where very cold, highly oxygenated water is present year round, usually in the deepest zone. Water alkalinity is medium, supporting biota tolerant of circumneutral waters. In summer, these lakes may stratify into a warm upper layer (epilimnion) that supports warmwater fish species like largemouth bass and a cold lower layer (hypolimnion) that provides refuge for coldwater fish species like lake trout and brook trout. Thermal habitat for coolwater fish species like northern pike is present throughout. The degree to which the lake stratifies varies based on local conditions, and they usually remix in the spring and fall to create more uniform temperatures from surface to bottom. This lake type is typical of neutral substrates, northern latitudes, or deep kettle holes on the coastal plain. A few very deep reservoirs in the mid-Atlantic also support this habitat. The average lake in this category has a surface area of 1008 acres and a depth of 77 feet.

Number of Waterbodies:

188 lakes

Habitat Type Criteria:

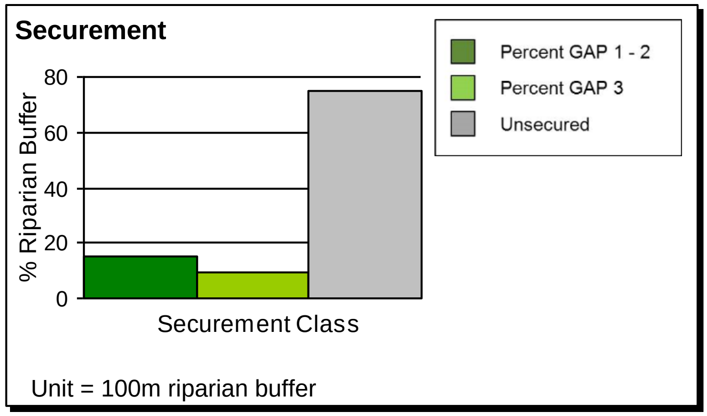
Coldest summer water temperature < 55F & dissolved oxygen > 5 mg/L. Calcium carbonate 12.5 to 50 mg/L. Chlorophyll-a < 7 ug/L.

Places to Visit this Habitat:

Square Lake ME, Joe's Pond VT, Cork Center Reservoir NY, Lake Habeeb MD, Quaker Lake PA

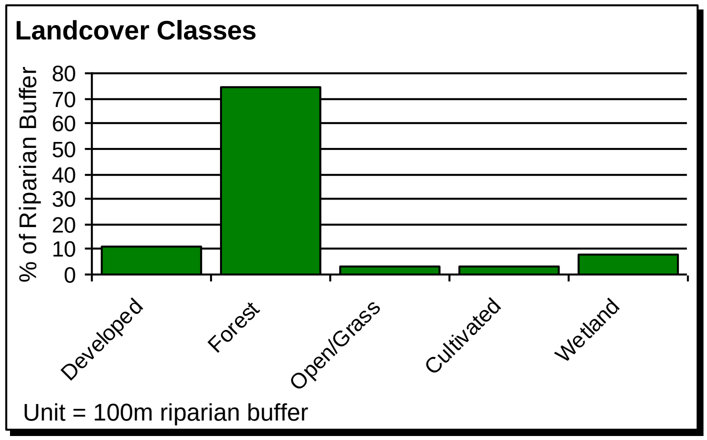
Associated Species:

This habitat may support very cold water species such as lake trout (togue), in addition to other characteristic coldwater fish species such as rainbow smelt, brook trout, brown trout, landlocked Atlantic salmon, whitefish, burbot (cusk) and slimy sculpin. These lakes may also provide the thermal habitat required for both cool and warmwater fish species. Coolwater fish species include northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Warmwater fish species commonly include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner.



Species of Concern (G1 - G4):

Fish: Landlocked Arctic Char   Mussels: James Spinymussel



Temperature and Depth Profile

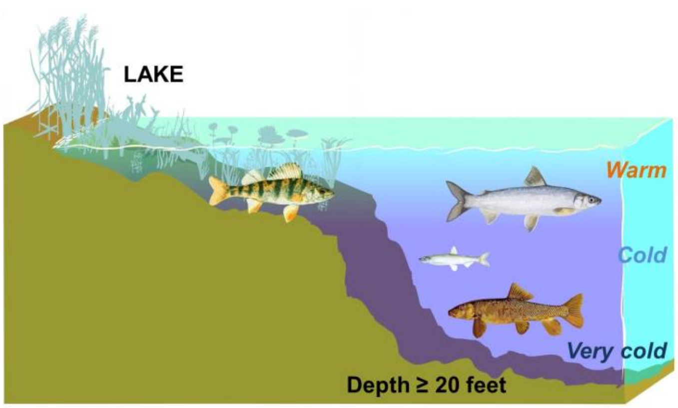
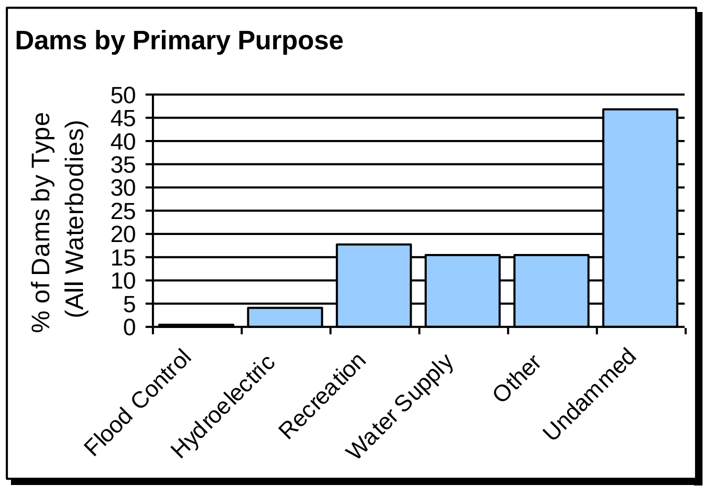
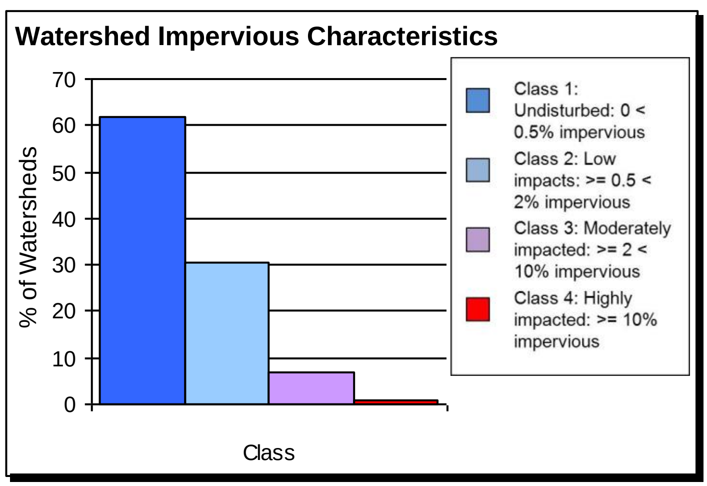


FIGURE CREDIT: Katrine Turgeon (2015)

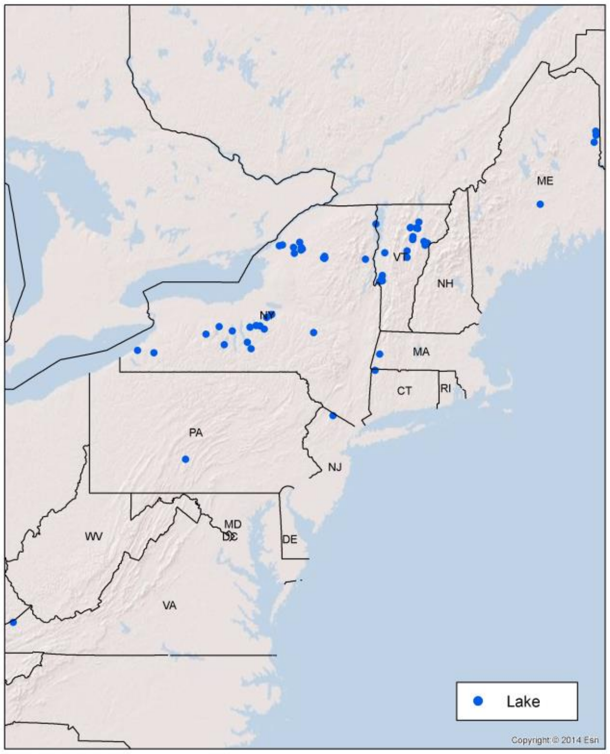


Chazy Lake, NY. PHOTO CREDIT: yuan2003 (2008). LICENSE: CC BY-NC 2.0.



Very cold, oligo-mesotrophic, alkaline lake

Macrogroup: Lakes



This map is based on a model and has had little field–checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

Wawayanda Lake, NJ. PHOTO CREDIT: Daniel X. Wang (2013).

State Distribution: CT, MA, ME, NJ, NY, PA, VA, VT

Total Surface Area (acres): 414,295

% Shoreline Conserved: 11.9 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
VT	271,612	19	1,300	2,308	21,818
NY	131,921	32	254	1,547	14,502
PA	8,272	1	198	0	4,346
VA	1,177	1	0	0	1,621
CT	541	1	0	0	194
ME	377	4	12	0	404
NJ	234	1	188	0	0
MA	161	1	0	3	115

Description:

A very cold, deep, alkaline, clear lake characterized by high dissolved oxygen content and low to moderate levels of biological productivity.

These are deep lakes where very cold, highly oxygenated water is present year round, usually in the deepest zone. Water alkalinity is high, supporting biota tolerant of alkaline waters. In summer, these lakes may stratify into a warm upper layer (epilimnion) that supports warmwater fish species like largemouth bass and a cold lower layer (hypolimnion) that provides refuge for coldwater fish species like lake trout and brook trout. Thermal habitat for coolwater fish species like northern pike is present throughout. The degree to which the lake stratifies varies based on local conditions, and they usually remix in the spring and fall to create more uniform temperatures from surface to bottom. This lake type is typical of calcareous substrates at high elevations or northern latitudes. A few very deep reservoirs in the mid-Atlantic also support this habitat. The average lake in this category has a surface area of 6,905 acres and a depth of 104 feet.

Number of Waterbodies:

60 lakes

Habitat Type Criteria:

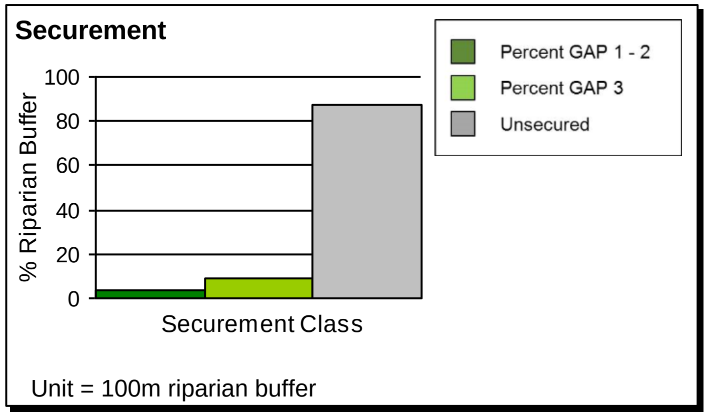
Coldest summer water temperature < 55F & dissolved oxygen > 5 mg/L. Calcium carbonate > 50 mg/L. Chlorophyll-a < 7 ug/L.

Places to Visit this Habitat:

Seneca Lake NY, Raystown Lake PA, Lake Bomoseen VT, Nickerson Lake ME, John W Flannagan Reservoir VA

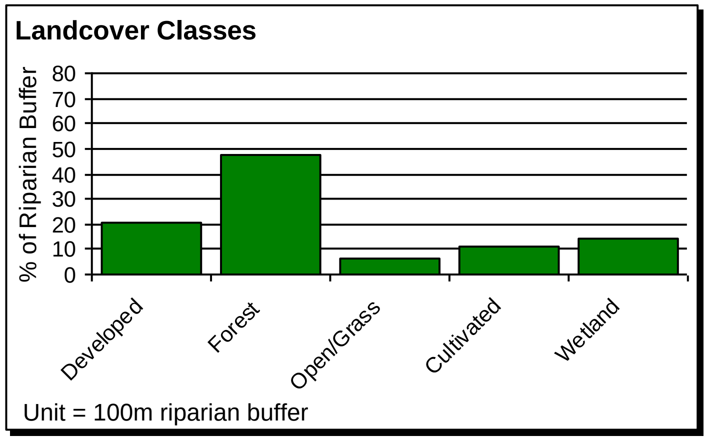
Associated Species:

This habitat may support very cold water species such as lake trout (togue), in addition to other characteristic coldwater fish species such as rainbow smelt, brook trout, brown trout, landlocked Atlantic salmon, whitefish, burbot (cusk) and slimy sculpin. These lakes may also provide the thermal habitat required for both cool and warmwater fish species. Coolwater fish species include northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Warmwater fish species commonly include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner.



Species of Concern (G1 - G4):

Fish: Blacknose Shiner, Bridle Shiner



Temperature and Depth Profile

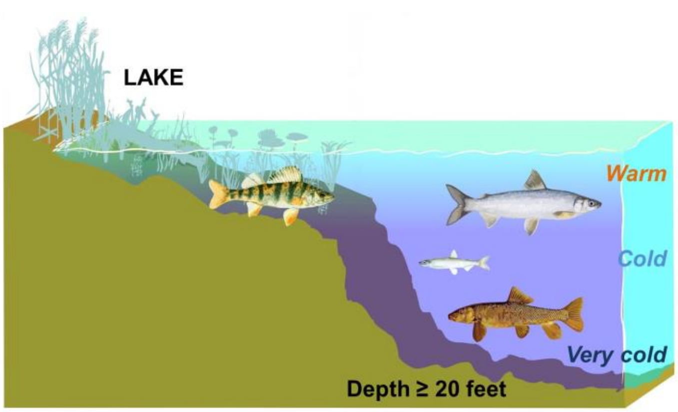
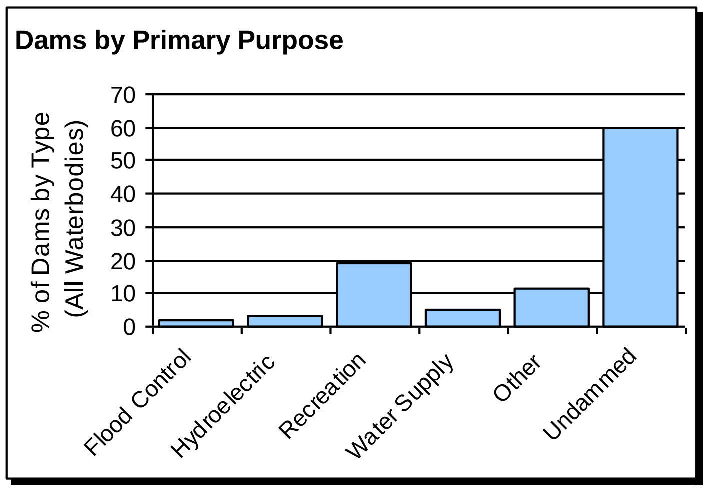
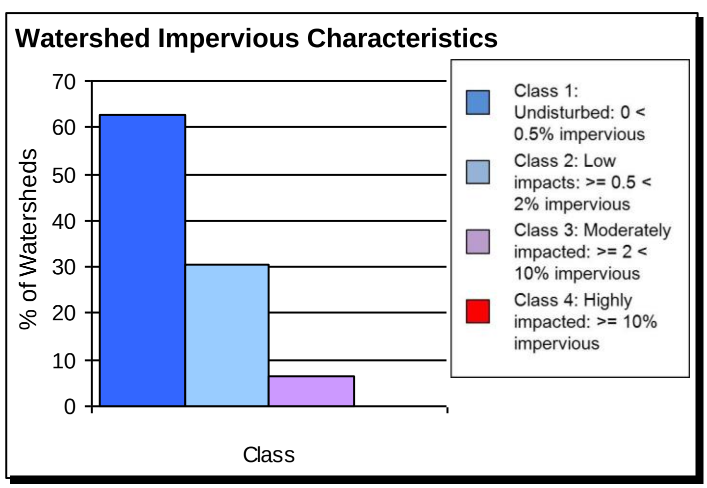


FIGURE CREDIT: Katrine Turgeon (2015)

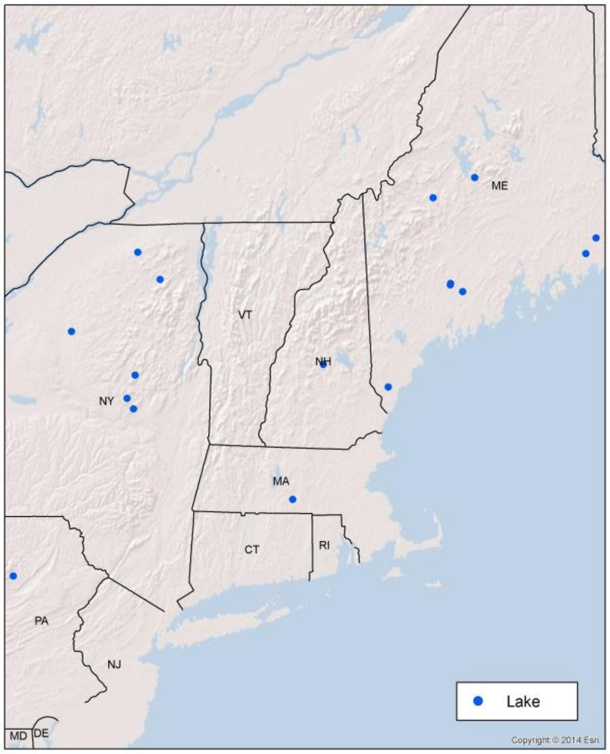


Canandaigua Lake, NY. PHOTO CREDIT: Lida (Barb; 2006). LICENSE: CC BY-ND 2.0.



Very cold, eutrophic, acidic lake

Macrogroup: Lakes



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

State Distribution: MA, ME, NH, NY, PA

Total Surface Area (acres): 5,359

% Shoreline Conserved: 32.6 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
NY	2,444	6	278	252	848
ME	2,091	8	54	373	741
PA	586	1	0	2	313
MA	215	1	0	10	126
NH	24	1	19	0	19

Description:

A very cold, deep, acidic lake characterized by high biological productivity and high concentrations of nitrogen and phosphorus.

These are murky deep lakes where very cold oxygenated water is present year round, but these nutrient rich lakes have less dissolved oxygen than oligo-mesotrophic lakes because they support an abundance of plant and algae growth. Excess nutrients may be due to agricultural run-off or other human alterations. The water can be clear if aquatic plants predominate, but is often cloudy due to high algae content. Water alkalinity is low, supporting biota tolerant of acidic waters. In summer, these lakes may stratify into a warm upper layer (epilimnion) that supports warmwater fish species like largemouth bass and a cold lower layer (hypolimnion) that provides refuge for coldwater fish species like brook trout and possibly lake trout. Thermal habitat for coolwater fish species like northern pike is present throughout. The degree to which the lake stratifies varies based on local conditions, and they usually remix in the spring and fall to create more uniform temperatures from surface to bottom. This is an unusual lake type that may indicate highly altered conditions. The average lake in this category has a surface area of 315 acres and depth of 61 feet.

Number of Waterbodies:

17 lakes

Habitat Type Criteria:

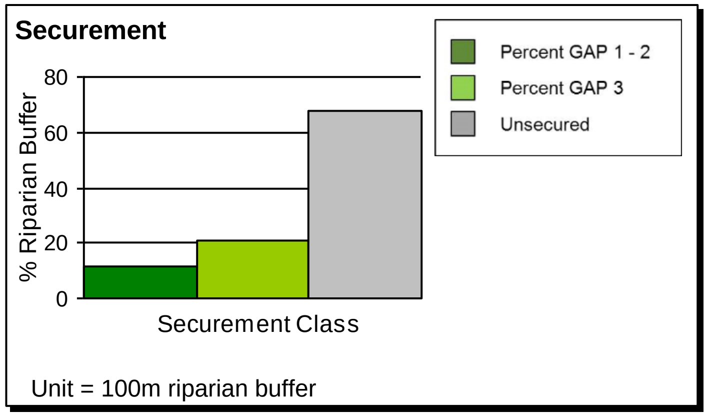
Coldest summer water temperature < 55F & dissolved oxygen > 5 mg/L. Calcium carbonate < 12.5 mg/L. Chlorophyll-a >7 ug/L.

Places to Visit this Habitat:

Harveys Lake PA, Quacumquasit Pond MA, Gilman Lake NY, Rum Pond ME

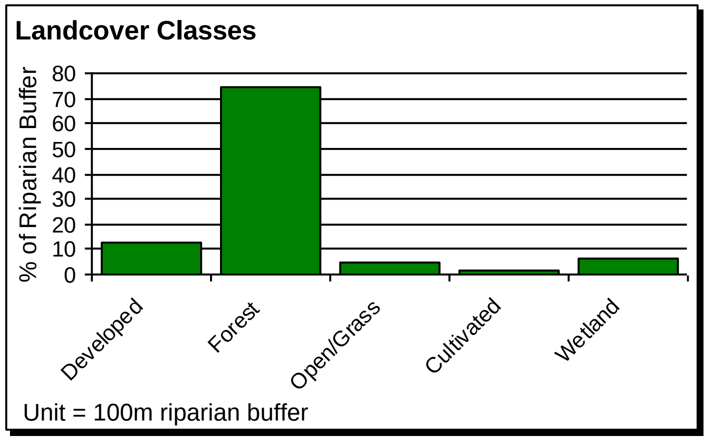
Associated Species:

This habitat may support very cold water species such as lake trout (togue), in addition to other characteristic coldwater fish species such as rainbow smelt, brook trout, brown trout, landlocked Atlantic salmon, whitefish, burbot (cusk) and slimy sculpin. These lakes may also provide the thermal habitat required for both cool and warmwater fish species. Coolwater fish species include northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Warmwater fish species commonly include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. Very acidic lakes are likely to have low species richness, with the most acidic supporting brown bullhead-golden shiner assemblages in lieu of other fish species.



Species of Concern (G1 - G4):

None



Temperature and Depth Profile

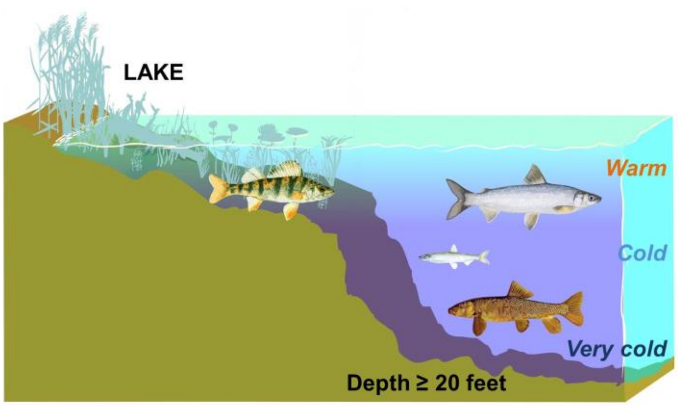
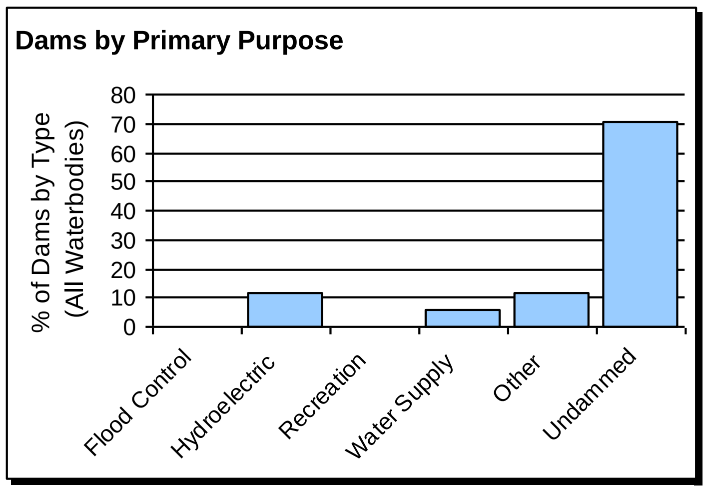
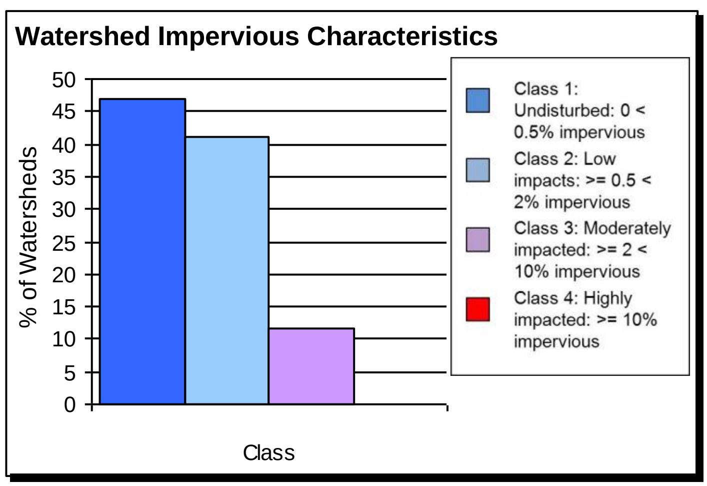


FIGURE CREDIT: Katrine Turgeon (2015)

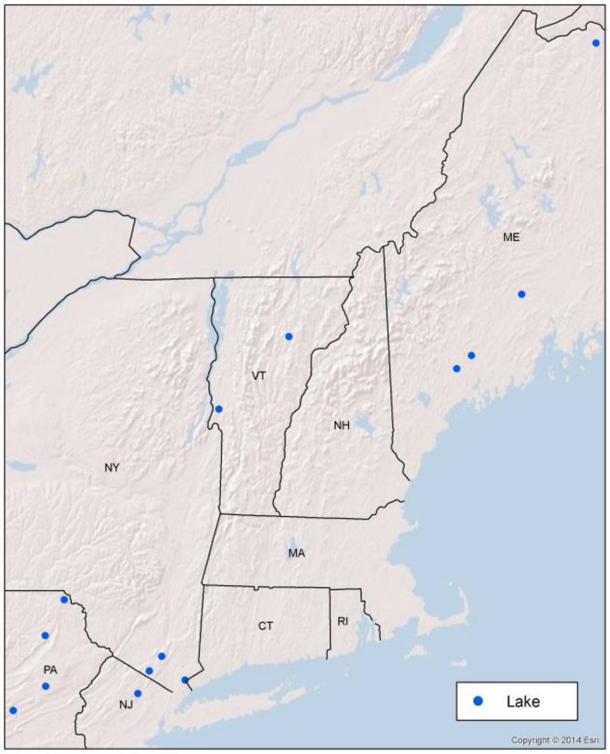


Togus Pond, ME. PHOTO CREDIT: Doug Kerr (2012). LICENSE: CC BY-SA 2.0.

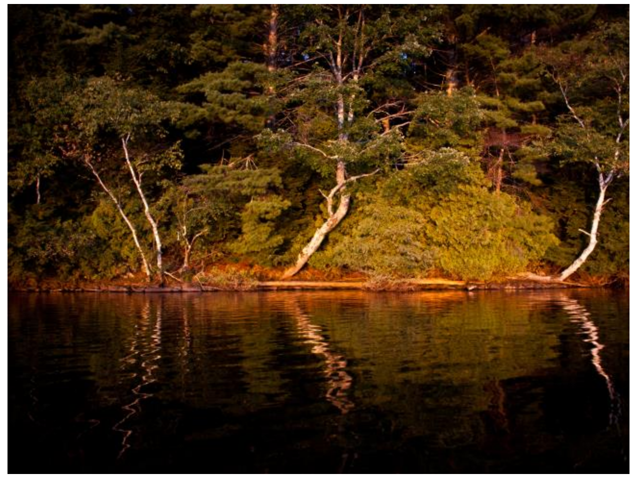


Very cold, eutrophic, neutral lake

Macrogroup: Lakes



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.



Cobbosseecontee Lake, ME. PHOTO CREDIT: Chris Goldberg (2012). LICENSE: CC BY-NC 2.0.

State Distribution: ME, NJ, NY, PA, VT

Total Surface Area (acres): 19,405

% Shoreline Conserved: 4.7 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
ME	18,422	4	40	5	4,478
NY	406	3	0	9	328
PA	380	4	130	20	213
VT	187	2	0	49	102
NJ	10	1	0	0	32

Description:

A very cold, deep, circumneutral lake characterized by high biological productivity and high concentrations of nitrogen and phosphorus.

These are murky deep lakes where very cold oxygenated water is present year round, but these nutrient rich lakes have less dissolved oxygen than oligo-mesotrophic lakes because they support an abundance of plant growth. Excess nutrients may be due to agricultural run-off or other human alterations. The water can be clear if aquatic plants predominate, but is often cloudy due to high algae content. Water alkalinity is medium, supporting biota tolerant of neutral conditions. In summer, these lakes may stratify into a warm upper layer (epilimnion) that supports warmwater fish species like largemouth bass and a cold lower layer (hypolimnion) that provides refuge for coldwater fish species like brook trout and possibly lake trout. Thermal habitat for coolwater fish species like northern pike is present throughout. The degree to which the lake stratifies varies based on local conditions, and they usually remix in the spring and fall to create more uniform temperatures from surface to bottom. This is an unusual lake type that may indicate highly altered conditions. The average lake in this category has a surface area of 1,386 acres and a depth of 68 feet.

Number of Waterbodies:

14 lakes

Habitat Type Criteria:

Coldest summer water temperature < 55F & dissolved oxygen > 5 mg/L. Calcium carbonate 12.5 to 50 mg/L. Chlorophyll-a >7 ug/L.

Places to Visit this Habitat:

Cobbosseecontee Lake ME, Tuxedo Lake NY, Starlight Lake PA, Spruce Pond VT, East Lake NJ

Associated Species:

This habitat may support very cold water species such as lake trout (togue), in addition to other characteristic coldwater fish species such as rainbow smelt, brook trout, brown trout, landlocked Atlantic salmon, whitefish, burbot (cusk) and slimy sculpin. These lakes may also provide the thermal habitat required for both cool and warmwater fish species. Coolwater fish species include northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Warmwater fish species commonly include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner.

Species of Concern (G1 - G4):

None

Temperature and Depth Profile

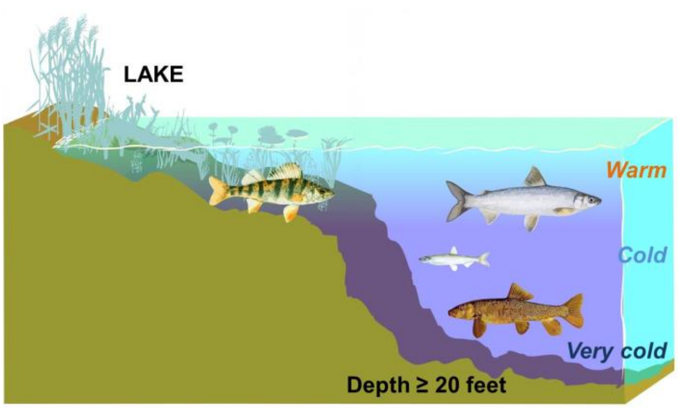
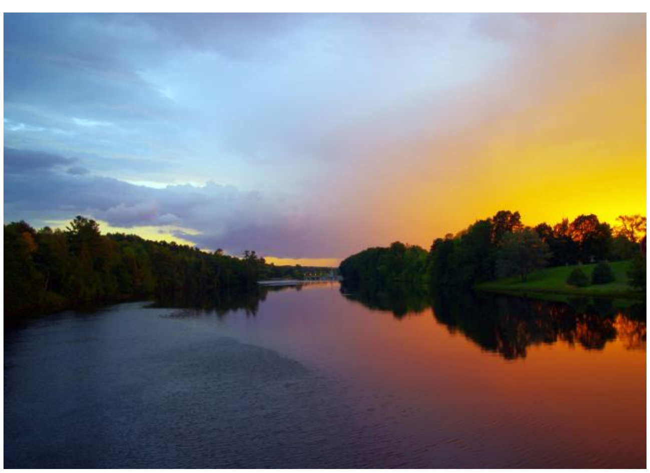
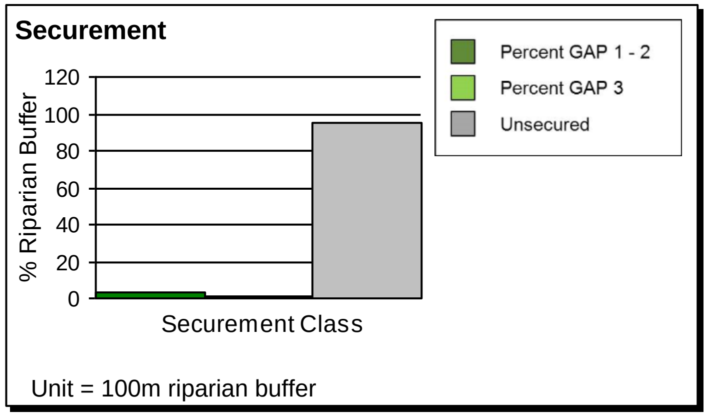
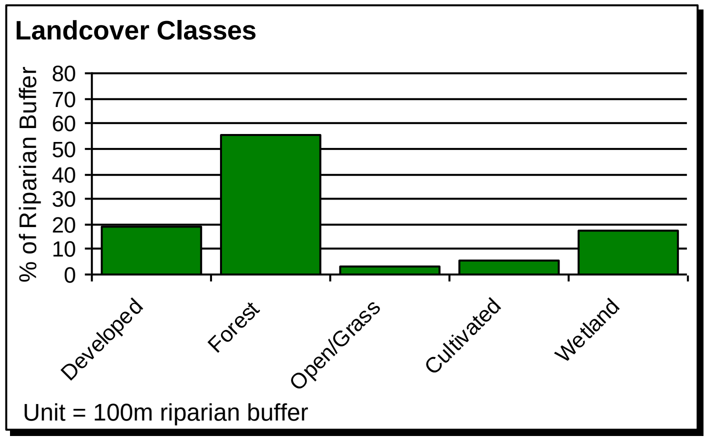


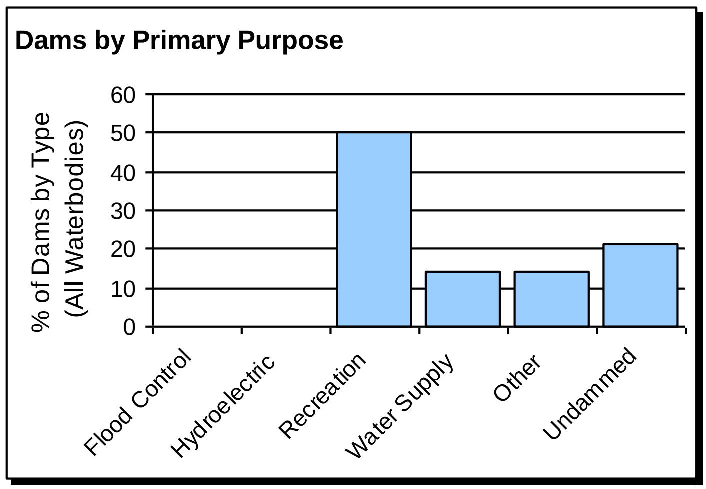
FIGURE CREDIT: Katrine Turgeon (2015)

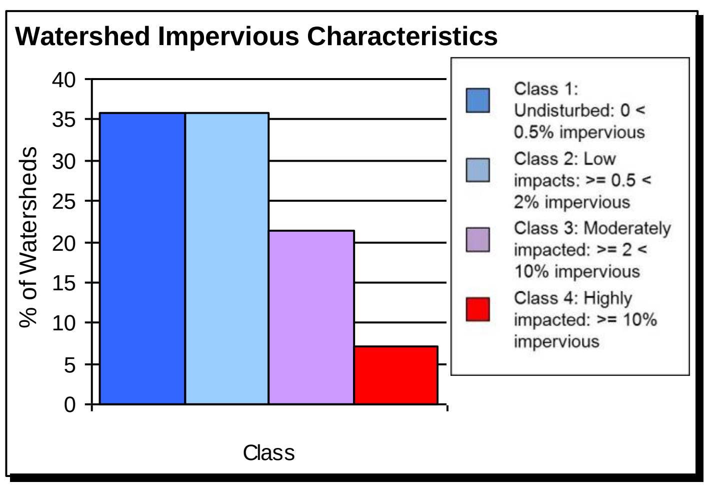


Sebasticook Lake, ME. PHOTO CREDIT: Jody Roberts (2011). LICENSE: CC BY–NC–SA 2.0..









Very cold, eutrophic, alkaline lake

Macrogroup: Lakes

This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

Sylvan Lake, NY. PHOTO CREDIT: Brandi (2008). LICENSE: CC BY 2.0, cropped and color-corrected.

State Distribution: NY, PA, VA

Total Surface Area (acres): 8,017

% Shoreline Conserved: 49.6 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
VA	7,714	1	0	2,752	2,669
NY	266	2	0	53	117
PA	38	1	0	0	61

Description:

A very cold, deep, alkaline lake characterized by high biological productivity and high concentrations of nitrogen and phosphorus.

These are murky deep lakes where very cold oxygenated water is present year round, but these nutrient rich lakes have less dissolved oxygen than oligo-mesotrophic lakes because they support an abundance of plant and algae growth. Excess nutrients may be due to agricultural run-off or other human alterations. The water can be clear if aquatic plants predominate, but is often cloudy due to high algae content. Water alkalinity is high, supporting biota tolerant of more alkaline conditions. In summer, these lakes may stratify into a warm upper layer (epilimnion) that supports warmwater fish species like largemouth bass and a cold lower layer (hypolimnion) that provides refuge for coldwater fish species like brook trout and possibly lake trout. Thermal habitat for coolwater fish species like northern pike is present throughout. The degree to which the lake stratifies varies based on local conditions, and they usually remix in the spring and fall to create more uniform temperatures from surface to bottom. This is an unusual lake type that may indicate highly altered conditions. The average lake in this category has a surface area of 2,004 acres and a depth of 118 feet.

Number of Waterbodies:

4 lakes

Habitat Type Criteria:

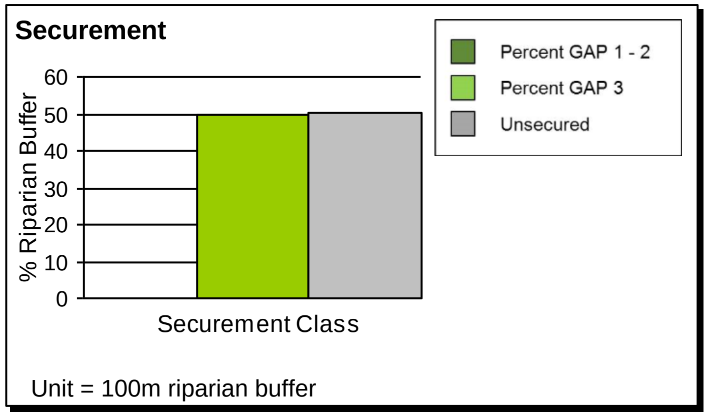
Coldest summer water temperature < 55F & dissolved oxygen > 5 mg/L. Calcium carbonate > 50 mg/L. Chlorophyll-a >7 ug/L.

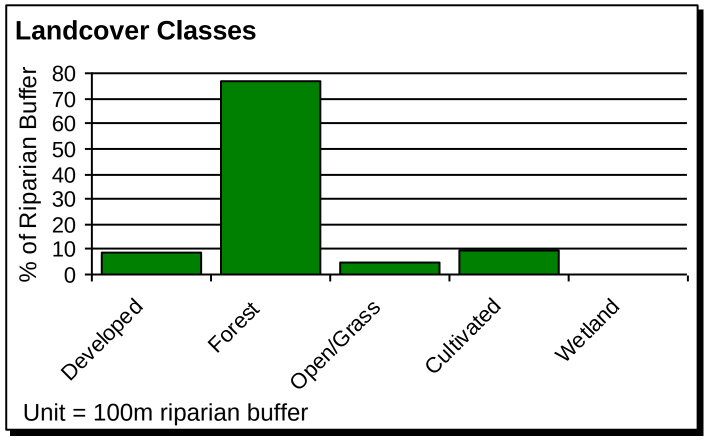
Places to Visit this Habitat:

Sylvan Lake NY, South Holston Lake VA, Lake Gleneida NY

Associated Species:

This habitat may support very cold water species such as lake trout (togue), in addition to other characteristic coldwater fish species such as rainbow smelt, brook trout, brown trout, landlocked Atlantic salmon, whitefish, burbot (cusk) and slimy sculpin. These lakes may also provide the thermal habitat required for both cool and warmwater fish species. Coolwater fish species include northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Warmwater fish species commonly include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner.





Species of Concern (G1 - G4):

None

Temperature and Depth Profile

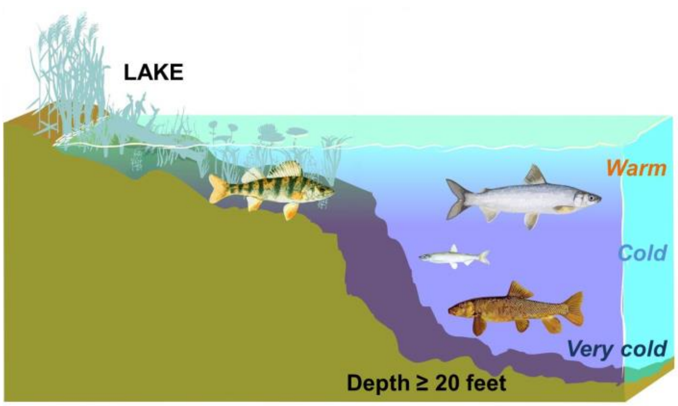
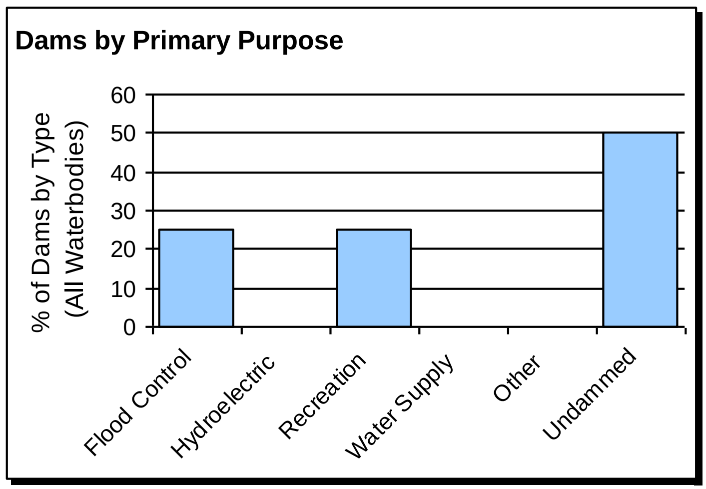
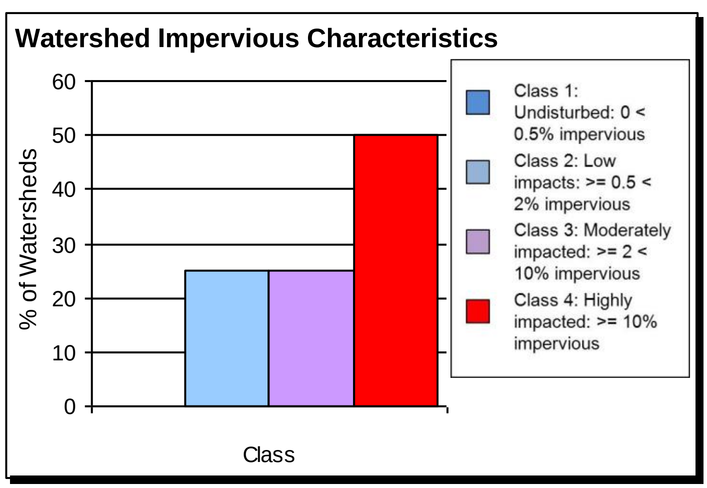


FIGURE CREDIT: Katrine Turgeon (2015)

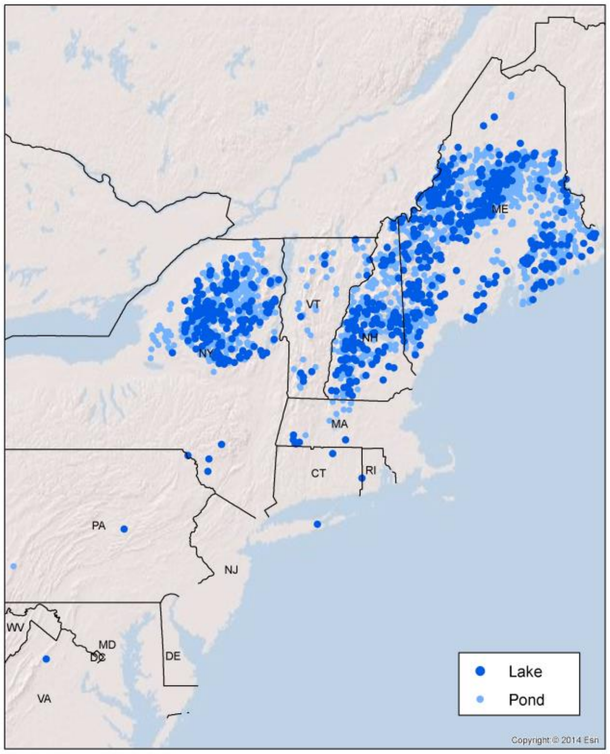


South Holston Lake, VA. PHOTO CREDIT: Ben Collins. LICENSE: CC BY-NC 2.0.



Cold, oligo-mesotrophic, acidic lake or pond

Macrogroup: Lakes and Ponds



This map is based on a model and has had little field–checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

State Distribution: CT, MA, ME, NH, NY, PA, VA, VT

Total Surface Area (acres): 157,874

% Shoreline Conserved: 40.0 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
ME	127,170	1698	9,715	23,547	67,543
NY	13,808	696	15,322	3,782	9,321
NH	12,831	357	1,907	3,737	10,364
VT	2,791	59	469	806	1,420
CT	592	2	0	56	280
MA	562	15	0	190	501
PA	106	2	0	93	63
VA	13	1	0	0	37

Description:

A cold, acidic, clear lake or pond characterized by low to moderate levels of biological productivity.

These are lakes or ponds where cold, oxygenated water is present year round, usually in the deepest zone. Water alkalinity is low, supporting biota tolerant of acidic waters. Very acidic waterbodies can be highly colored due to high dissolved organic carbon and organic acid content. In summer, these lakes may stratify into a warm upper layer (epilimnion) that supports warmwater fish species like largemouth bass and a cold lower layer (hypolimnion) that provides refuge for cold and coolwater fish species like brook trout, brown trout, and northern pike; conditions are not cold enough for lake trout. The degree to which the lake stratifies varies based on local conditions, and they usually remix in the spring and fall to create more uniform temperatures from surface to bottom. In contrast to lakes, shallow ponds are unlikely to stratify during the summer, and may freeze to the bottom of the pond in the winter. This waterbody type is typical of acidic substrates at high elevations or northern latitudes, such as the mountainous areas of the northeastern US. The average lake in this category has a surface area of 155 acres and a depth of 34 feet. The average pond in this category has a surface area of 22 acres and a depth of 8 feet.

Number of Waterbodies:

737 lakes and 2,093 ponds

Habitat Type Criteria:

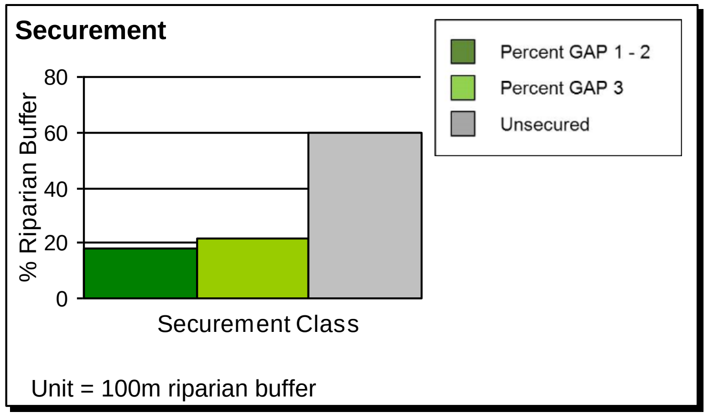
Coldest summer water temperature 55 to 64F & dissolved oxygen > 5 mg/L. Calcium carbonate < 12.5 mg/L. Chlorophyll-a < 7 ug/L.

Places to Visit this Habitat:

Lake Cathance ME, White Lake NY, Manning Lake NH, Beebe Pond VT, Beach Pond CT

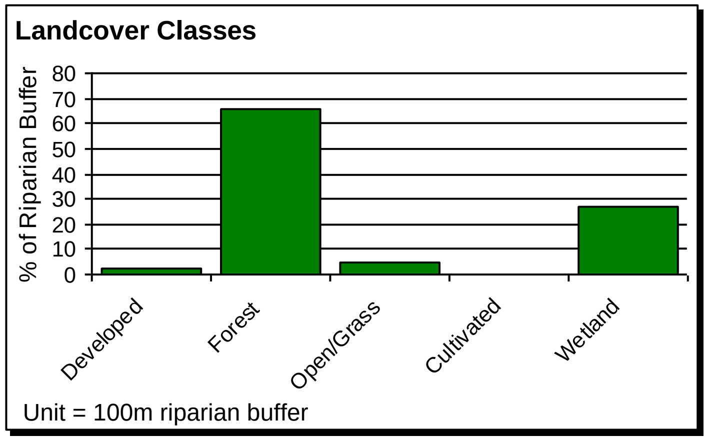
Associated Species:

This habitat may support characteristic coldwater fish species (exclusive of lake trout), including rainbow smelt, brook trout, brown trout, landlocked Atlantic salmon, burbot (cusk) and slimy sculpin. These lakes may also provide the thermal habitat required for both cool and warmwater fish species. Coolwater fish species include northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Warmwater fish species commonly include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. Very acidic lakes are likely to have low species richness, with the most acidic supporting brown bullhead-golden shiner assemblages in lieu of other fish species. The vegetation in shallow waterbodies is likely to be dominated by water lilies, while the vegetation in larger deeper lakes is also likely to include floating-leaved and submerged mat-forming aquatics.



Species of Concern (G1 - G4):

Mussels: Brook Floater



Temperature and Depth Profile

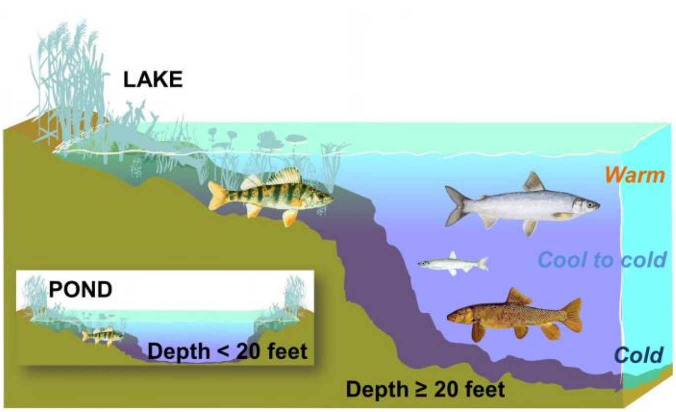
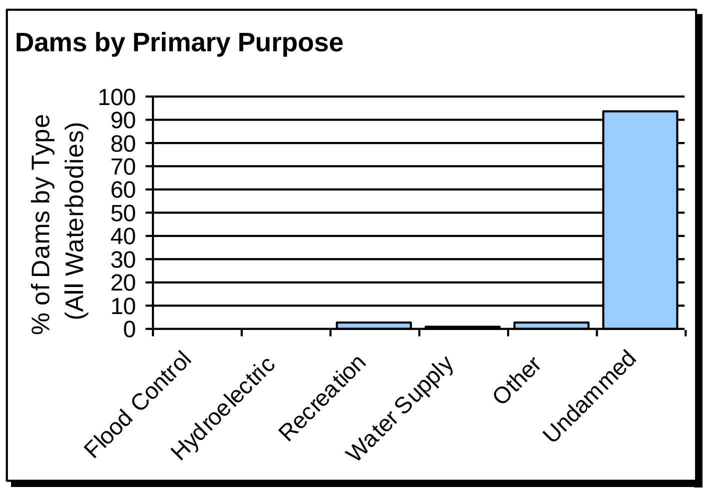
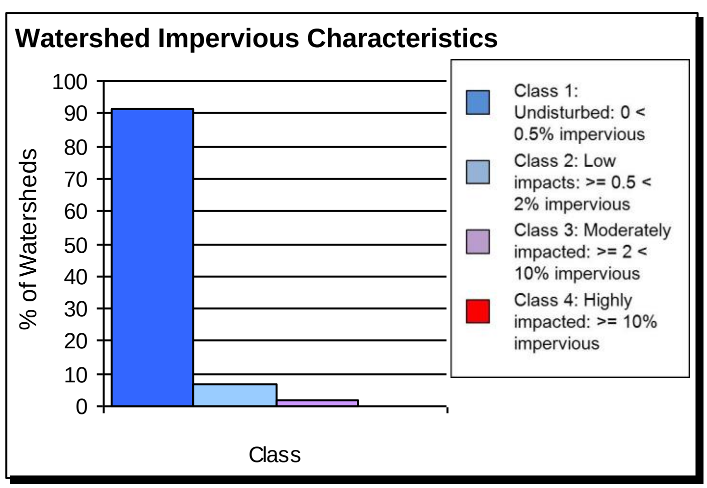


FIGURE CREDIT: Katrine Turgeon (2015)

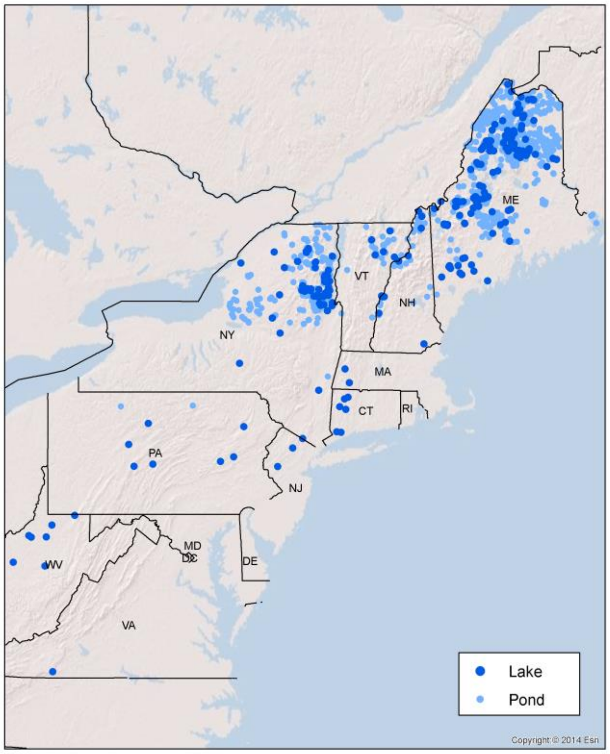


Swanzey Lake, NH. PHOTO CREDIT: Dipanjan Nath (2009). LICENSE: CC BY–NC–ND 2.0.



Cold, oligo-mesotrophic, neutral lake or pond

Macrogroup: Lakes and Ponds



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

Brant Lake, NY. PHOTO CREDIT: Diane Cordell (2010). LICENSE: CC BY-NC-ND 2.0.

State Distribution: CT, MA, ME, NH, NJ, NY, PA, VA, VT, WV

Total Surface Area (acres): 81,260

% Shoreline Conserved: 27.0 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
ME	64,050	799	1,595	10,976	39,713
NY	5,970	282	2,327	1,028	7,422
NH	4,680	41	70	1,569	1,494
NJ	2,780	2	696	2	27
CT	2,077	6	10	402	998
VT	1,038	28	0	224	1,173
PA	409	9	131	43	386
VA	125	1	0	0	204
WV	95	7	0	0	295
MA	36	2	0	35	38

Description:

A cold, circumneutral, clear lake or pond characterized by low to moderate levels of biological productivity.

These are lakes or ponds where cold, oxygenated water is present year round, usually in the deepest zone. Water alkalinity is medium, supporting biota tolerant of circumneutral waters. In summer, these lakes may stratify into a warm upper layer (epilimnion) that supports warmwater fish species like largemouth bass and a cold lower layer (hypolimnion) that provides refuge for cold and coolwater fish species like brook trout, brown trout, and northern pike; conditions are not cold enough for lake trout. The degree to which the lake stratifies varies based on local conditions, and they usually remix in the spring and fall to create more uniform temperatures from surface to bottom. In contrast to lakes, shallow ponds are unlikely to stratify during the summer, and may freeze to the bottom of the pond in the winter. This waterbody type is typical of neutral substrates at high elevations or northern latitudes, such as the mountainous areas of the northeastern US. The average lake in this category has a surface area of 248 acres and a depth of 38 feet. The average pond in this category has a surface area of 26 acres and reaches a maximum depth of 6 feet.

Number of Waterbodies:

232 lakes and 945 ponds

Habitat Type Criteria:

Coldest summer water temperature 55 to 64F & dissolved oxygen > 5 mg/L. Calcium carbonate 12.5 to 50 mg/L. Chlorophyll-a < 7 ug/L.

Places to Visit this Habitat:

Upper Mattawamkeag Lake ME, Greenwood Lake VT, Brant Lake NY, Big Island Pond NH, Highland Lake CT

Associated Species:

This habitat may support characteristic coldwater fish species (exclusive of lake trout), including rainbow smelt, brook trout, brown trout, landlocked Atlantic salmon, burbot (cusk) and slimy sculpin. These lakes may also provide the thermal habitat required for both cool and warmwater fish species. Coolwater fish species include northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Warmwater fish species commonly include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. The vegetation in shallow waterbodies is likely to be dominated by water lilies, while the vegetation in larger deeper lakes is also likely to include floating-leaved and submerged mat-forming aquatics.

Species of Concern (G1 - G4):

Fish: Landlocked Arctic Char Mussels: Brook Floater, Yellow Lampmussel

Temperature and Depth Profile

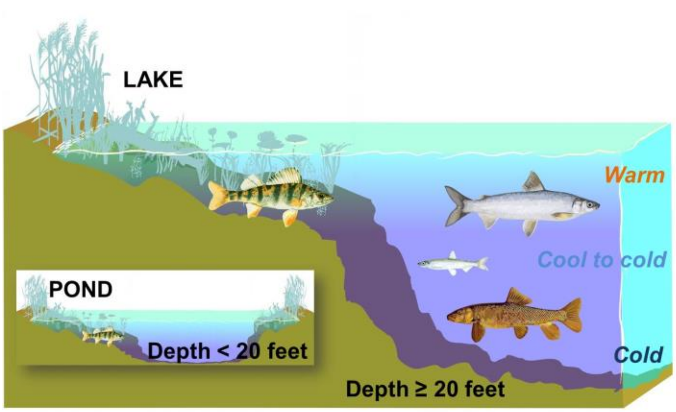
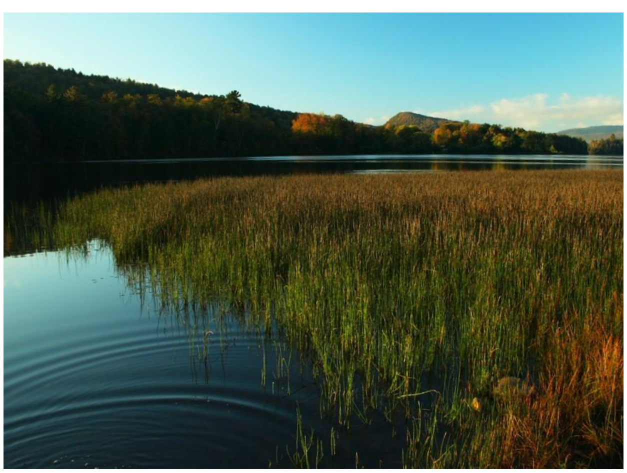
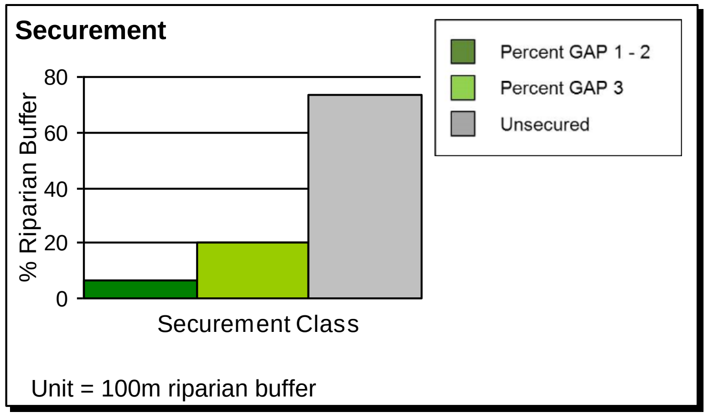
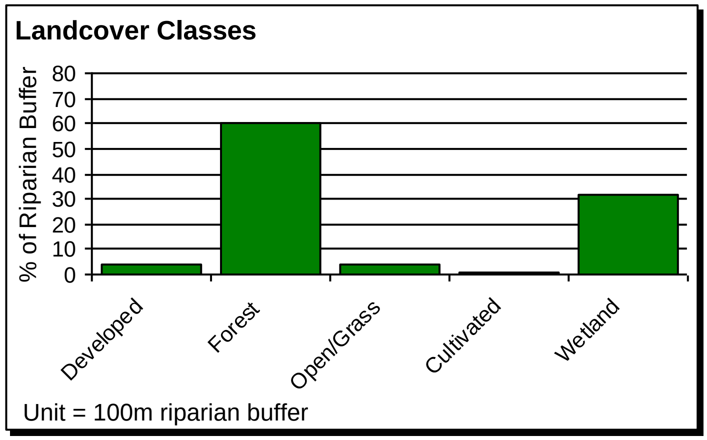


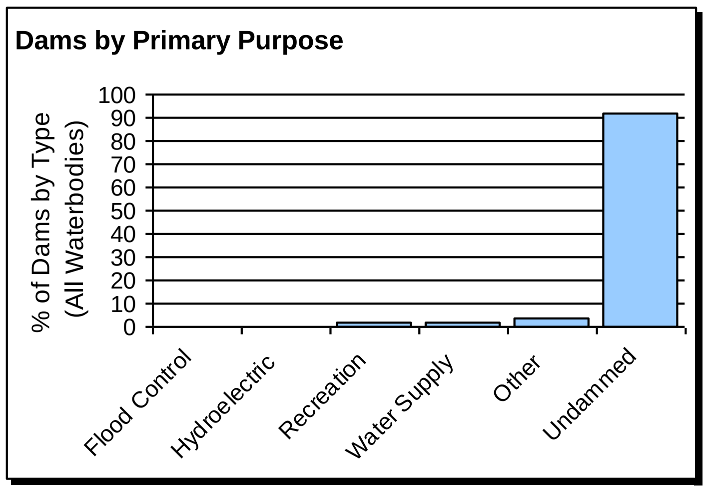
FIGURE CREDIT: Katrine Turgeon (2015)

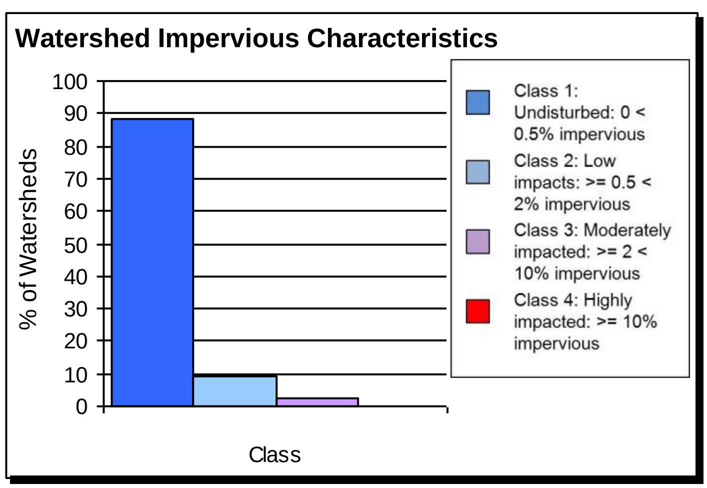


Eden Lake, VT. PHOTO CREDIT: Maurice Huang (2007). LICENSE: CC BY-NC-ND 2.0, straightened.



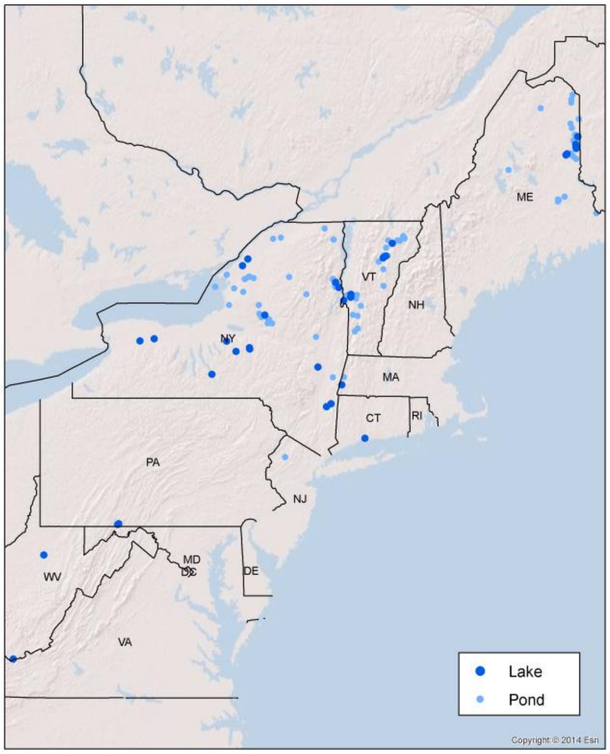






Cold, oligo-mesotrophic, alkaline lake or pond

Macrogroup: Lakes and Ponds



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

State Distribution: CT, MA, ME, NJ, NY, PA, VT, WV

Total Surface Area (acres): 4,391

% Shoreline Conserved: 11.2 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
NY	1,951	55	107	442	1,993
ME	946	29	51	38	1,852
VT	516	30	0	101	924
CT	385	1	0	0	233
PA	366	2	0	0	508
MA	115	2	0	0	117
WV	69	2	0	0	152
NJ	42	1	0	0	70

Echo Lake, VT. PHOTO CREDIT: Willie Miller (2011).

Description:

A cold, alkaline, clear lake or pond characterized by low to moderate levels of biological productivity.

These are lakes or ponds where cold, oxygenated water is present year round, usually in the deepest zone. Water alkalinity is high, supporting biota tolerant of alkaline waters. In summer, these lakes may stratify into a warm upper layer (epilimnion) that supports warmwater fish species like largemouth bass and a cold lower layer (hypolimnion) that provides refuge for cold and coolwater fish species like brook trout, brown trout, and northern pike; conditions are not cold enough for lake trout. The degree to which the lake stratifies varies based on local conditions, and they usually remix in the spring and fall to create more uniform temperatures from surface to bottom. In contrast to lakes, shallow ponds are unlikely to stratify during the summer, and may freeze to the bottom of the pond in the winter. This waterbody type is found on alkaline substrates. The average lake in this category has a surface area of 91 acres and a depth of 45 feet. The average pond in this category has a surface area of 14 acres and a depth of 6 feet.

Number of Waterbodies:

34 lakes and 88 ponds

Habitat Type Criteria:

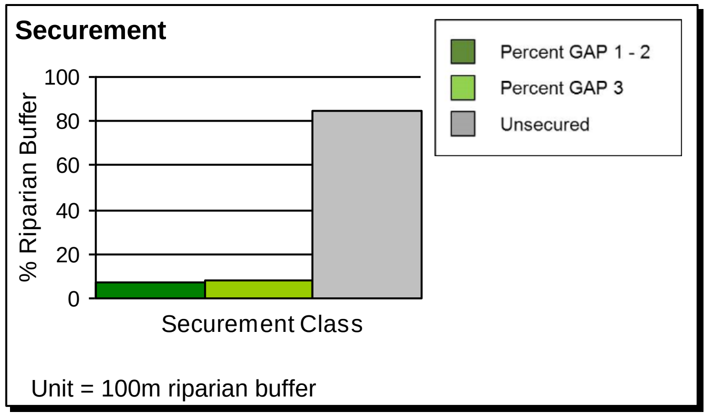
Coldest summer water temperature 55 to 64F & dissolved oxygen > 5 mg/L. Calcium carbonate > 50 mg/L. Chlorophyll-a < 7 ug/L.

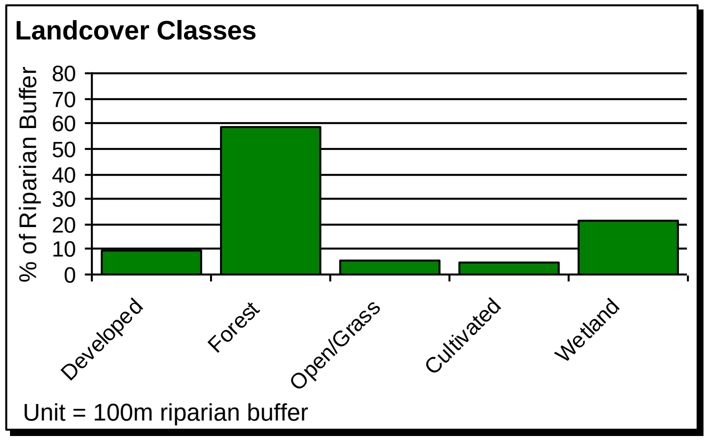
Places to Visit this Habitat:

Lake Koon PA, Spaulding Lake ME, Sabin Pond VT, Woodman Pond NY, Cub Lake NJ

Associated Species:

This habitat may support characteristic coldwater fish species (exclusive of lake trout), including rainbow smelt, brook trout, brown trout, landlocked Atlantic salmon, burbot (cusk) and slimy sculpin. These lakes may also provide the thermal habitat required for both cool and warmwater fish species. Coolwater fish species include northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Warmwater fish species commonly include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. The vegetation in shallow waterbodies is likely to be dominated by water lilies, while the vegetation in larger deeper lakes is also likely to include floating-leaved and submerged mat-forming aquatics.





Species of Concern (G1 - G4):

None

Temperature and Depth Profile

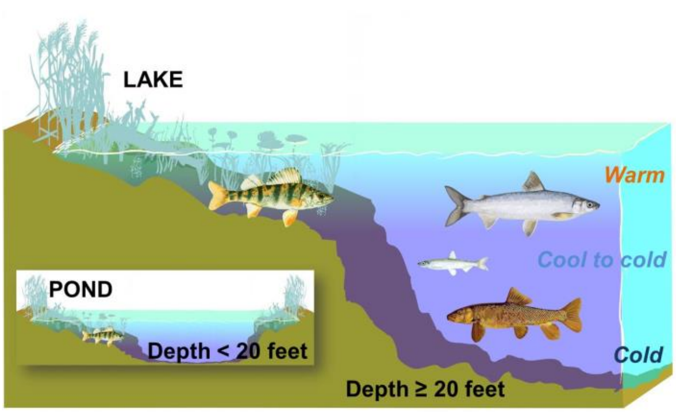
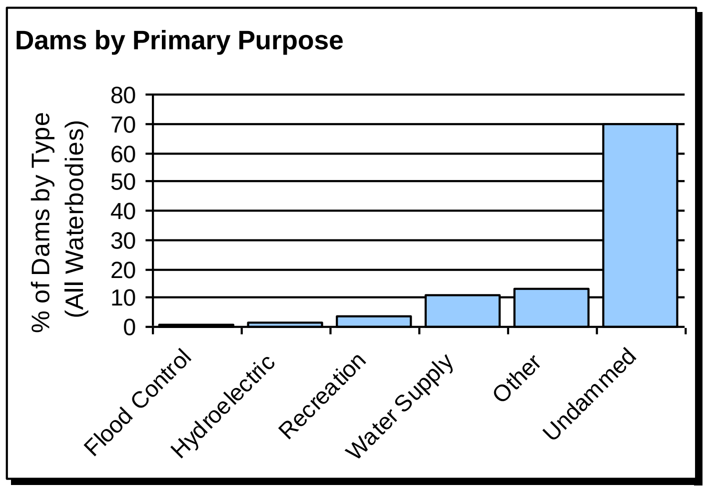
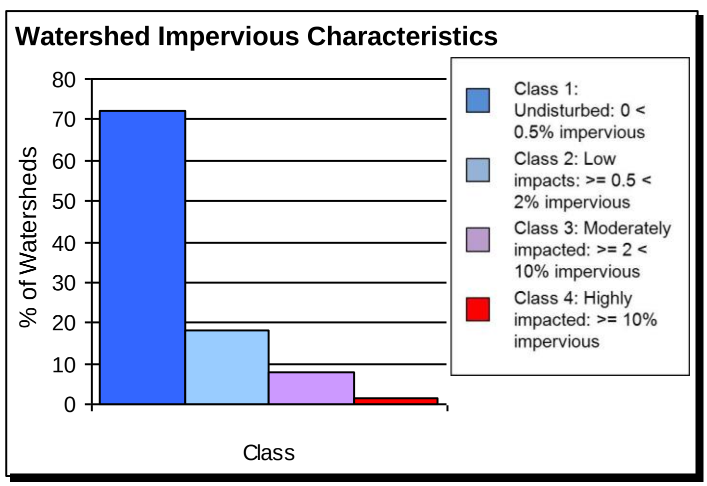


FIGURE CREDIT: Katrine Turgeon (2015)

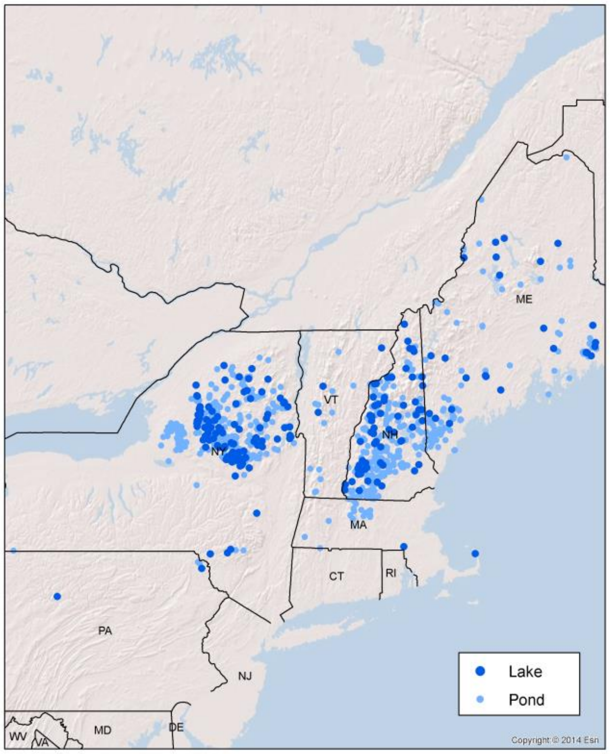


Leland Pond, NY. PHOTO CREDIT: Carrie Nelson (2011). LICENSE: CC BY-NC-ND 2.0.



Cold, eutrophic, acidic lake or pond

Macrogroup: Lakes and Ponds



This map is based on a model and has had little field–checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

Pleasant Lake, ME. PHOTO CREDIT: Bob Travis (2011). LICENSE: CC BY–NC 2.0.

State Distribution: MA, ME, NH, NY, PA, VT

Total Surface Area (acres): 14,356

% Shoreline Conserved: 44.7 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
ME	7,057	136	205	1,171	5,116
NY	3,576	401	6,596	1,905	3,841
NH	3,134	293	432	2,081	6,476
PA	321	4	157	2	188
MA	164	23	65	206	348
VT	103	15	46	161	168

Description:

A cold, acidic lake or pond characterized by high biological productivity and high concentrations of nitrogen and phosphorus.

These are murky lakes and ponds where cold water is present year round, but these nutrient rich lakes have less dissolved oxygen than oligo-mesotrophic lakes because they support an abundance of plant and algae growth. Excess nutrients may be due to agricultural run-off or other human alterations. The water can be clear if aquatic plants predominate, but is often cloudy due to high algae content. Water alkalinity is low, supporting biota tolerant of acidic waters. Very acidic waterbodies can be highly colored due to high dissolved organic carbon and organic acid content. In summer, these lakes may stratify into a warm upper layer (epilimnion) that supports warmwater fish species like largemouth bass and a cold lower layer (hypolimnion) that provides refuge for cold and coolwater fish species like brook trout, brown trout, and northern pike; conditions are not cold enough for lake trout. The degree to which the lake stratifies varies based on local conditions, and they usually remix in the spring and fall to create more uniform temperatures from surface to bottom. In contrast to lakes, shallow ponds are unlikely to stratify during the summer, and may freeze to the bottom of the pond in the winter. This waterbody type isfound on acidic substrates at high elevations or northern latitudes. The average lake in this category has a surface area of 34 acres and a depth of 17 feet. The average pond in this category has a surface area of 10 acres and a depth of 5 feet.

Number of Waterbodies:

208 lakes and 664 ponds

Habitat Type Criteria:

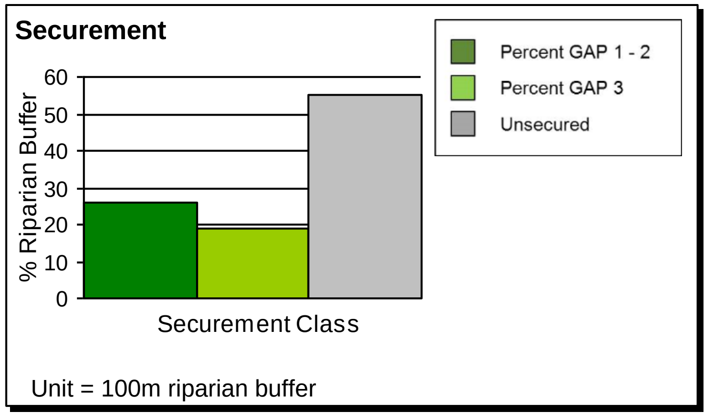
Coldest summer water temperature 55 to 64F & dissolved oxygen > 5 mg/L. Calcium carbonate < 12.5 mg/L. Chlorophyll-a >7 ug/L.

Places to Visit this Habitat:

Half Moon Pond ME, Neal Pond VT, Millsfield Pond NH, Uncas Pond MA, Duck Harbor Pond PA

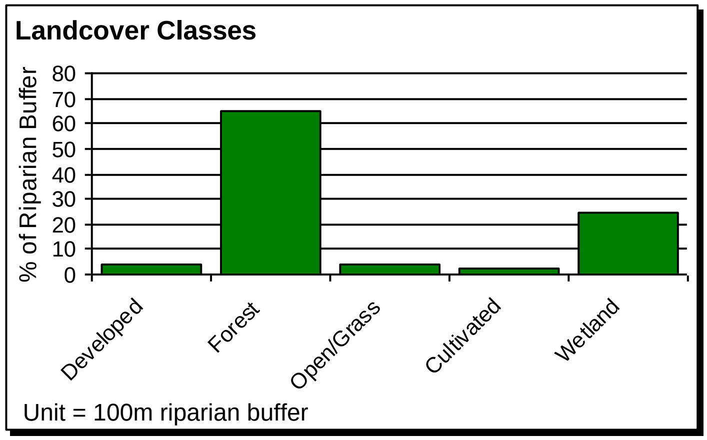
Associated Species:

This habitat may support characteristic coldwater fish species (exclusive of lake trout), including rainbow smelt, brook trout, brown trout, landlocked Atlantic salmon, burbot (cusk) and slimy sculpin. These lakes may also provide the thermal habitat required for both cool and warmwater fish species. Coolwater fish species include northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Warmwater fish species commonly include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. Very acidic lakes are likely to have low species richness, with the most acidic supporting brown bullhead-golden shiner assemblages in lieu of other fish species. The vegetation in shallow waterbodies is likely to be dominated by water lilies, while the vegetation in larger deeper lakes is also likely to include floating-leaved and submerged mat-forming aquatics.



Species of Concern (G1 - G4):

Mussel: Triangle Floater



Temperature and Depth Profile

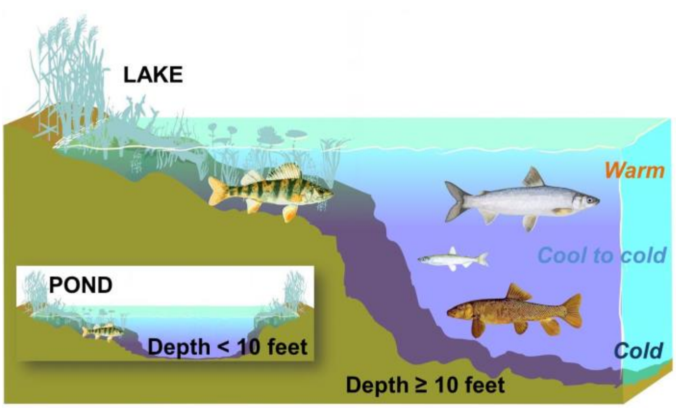
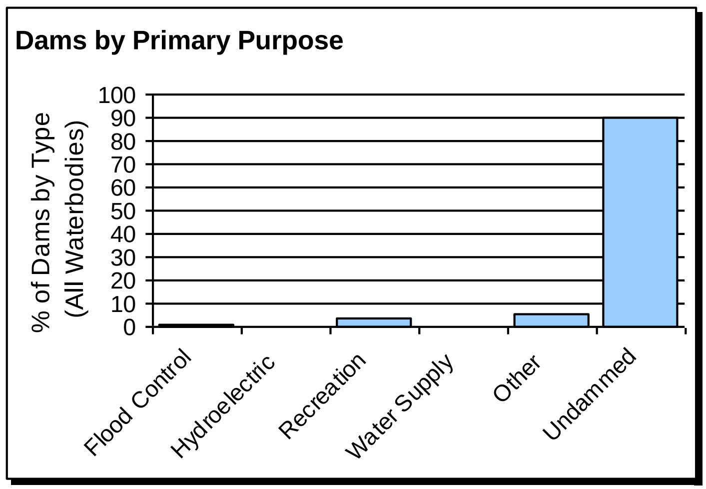
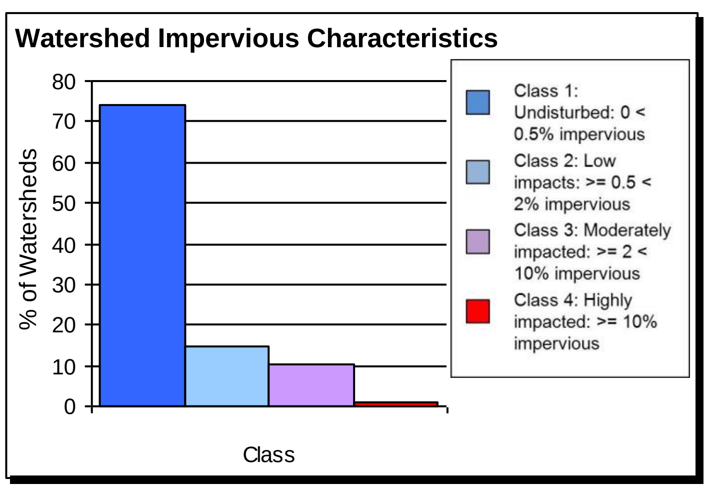


FIGURE CREDIT: Katrine Turgeon (2015)

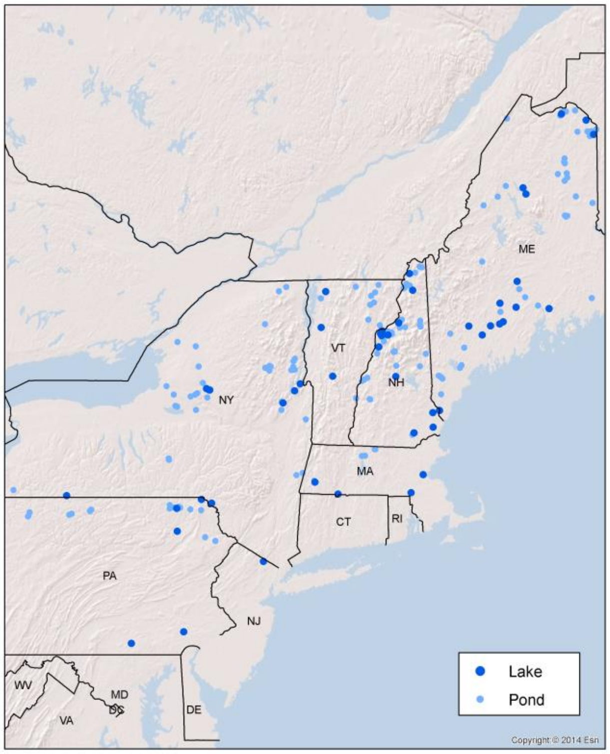


Kettle Creek Lake, PA. PHOTO CREDIT: Nicholas A. Tonelli (2008). LICENSE: CC BY 2.0.



Cold, eutrophic, neutral lake or pond

Macrogroup: Lakes and Ponds



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

Webber Pond, ME. PHOTO CREDIT: Movement Six (2015). LICENSE: CC BY-NC 2.0.

State Distribution: \MA, ME, NH, NJ, NY, PA, VT

Total Surface Area (acres): 13,506

% Shoreline Conserved: 19.6 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
ME	10,856	62	215	421	4,381
VT	752	13	21	114	512
NH	636	54	107	180	1,391
PA	534	24	65	263	557
MA	376	9	26	88	331
NY	339	42	276	141	814
NJ	13	1	0	31	0

Description:

A cold, circumneutral lake or pond characterized by high biological productivity and high concentrations of nitrogen and phosphorus.

These are murky lakes and ponds where cold water is present year round, but these nutrient rich lakes have less dissolved oxygen than oligo-mesotrophic lakes because they support an abundance of plant and algae growth. Excess nutrients may be due to agricultural run-off or other human alterations. The water can be clear if aquatic plants predominate, but is often cloudy due to high algae content. Water alkalinity is medium, supporting biota tolerant of circumneutral waters. In summer, these lakes may stratify into a warm upper layer (epilimnion) that supports warmwater fish species like largemouth bass and a cold lower layer (hypolimnion) that provides refuge for cold and coolwater fish species like brook trout, brown trout, and northern pike; conditions are not cold enough for lake trout. The degree to which the lake stratifies varies based on local conditions, and they usually remix in the spring and fall to create more uniform temperatures from surface to bottom. In contrast to lakes, shallow ponds are unlikely to stratify during the summer, and may freeze to the bottom of the pond in the winter. This waterbody type is found on circumneutral substrates in northern latitudes. The average lake in this category has a surface area of 229 acres and a depth of 29 feet. The average pond in this category has a surface area of 13 acres and a depth of 5 feet.

Number of Waterbodies:

50 lakes and 155 ponds

Habitat Type Criteria:

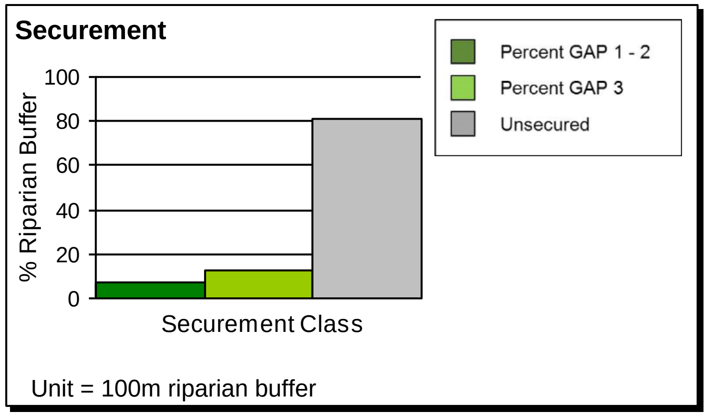
Coldest summer water temperature 55 to 64F & dissolved oxygen > 5 mg/L. Calcium carbonate 12.5 to 50 mg/L. Chlorophyll-a >7 ug/L.

Places to Visit this Habitat:

Middle Pond MA, Beaver Lake NH, Sand Pond NY, Webber Pond ME, Fairfield Pond VT

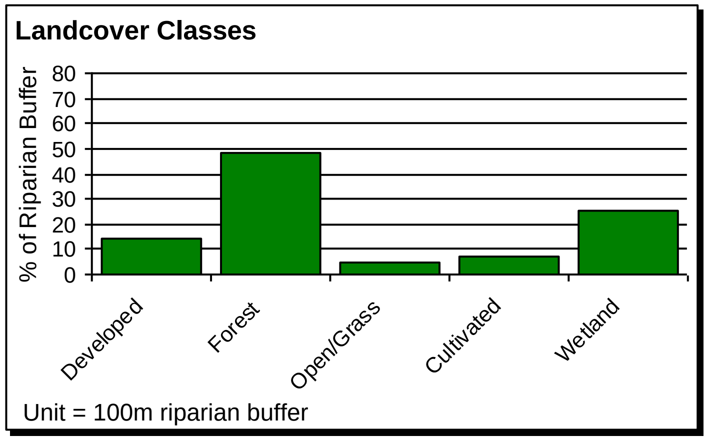
Associated Species:

This habitat may support characteristic coldwater fish species (exclusive of lake trout), including rainbow smelt, brook trout, brown trout, landlocked Atlantic salmon, burbot (cusk) and slimy sculpin. These lakes may also provide the thermal habitat required for both cool and warmwater fish species. Coolwater fish species include northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Warmwater fish species commonly include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. The vegetation in shallow waterbodies is likely to be dominated by water lilies, while the vegetation in larger deeper lakes is also likely to include floating-leaved and submerged mat-forming aquatics.



Species of Concern (G1 - G4):

Fish: Bridle Shiner Mussels: Tidewater Mucket, Yellow Lampmussel



Temperature and Depth Profile

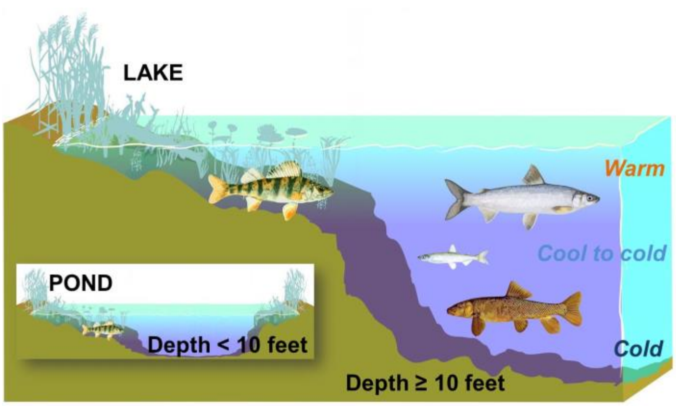
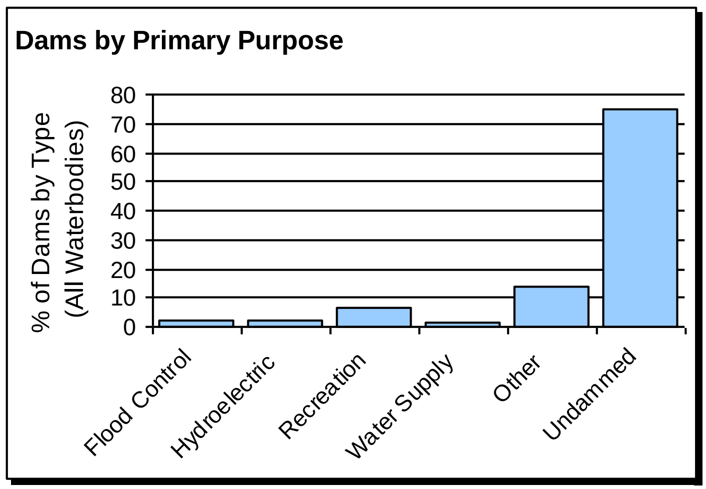
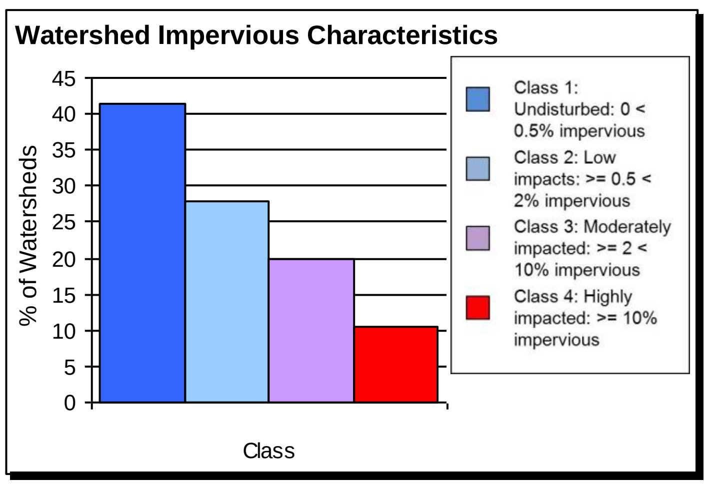


FIGURE CREDIT: Katrine Turgeon (2015)

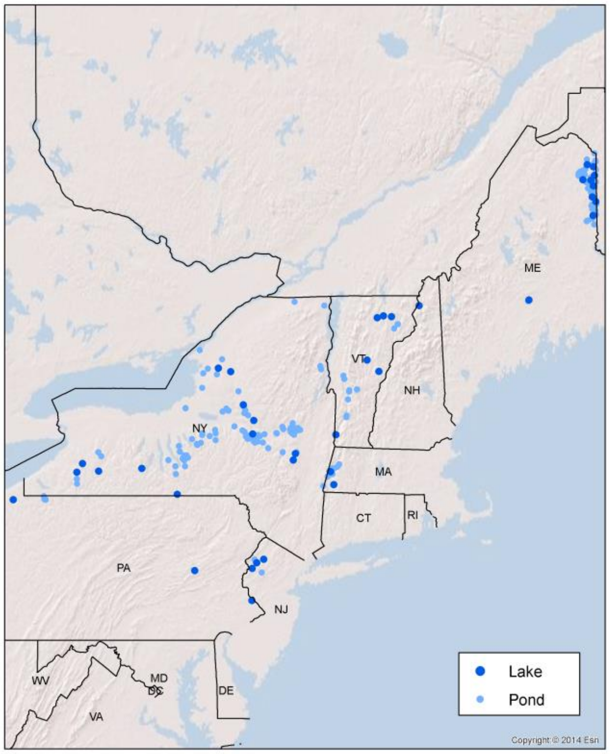


Streeter Pond, NH. PHOTO CREDIT: Carleton Atwater (2012). LICENSE: CC BY-NC-SA 2.0, color-corrected.



Cold, eutrophic, alkaline lake or pond

Macrogroup: Lakes and Ponds



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

Lake Buel, MA. PHOTO CREDIT: Kingturtle. LICENSE: Public domain.

State Distribution: MA, ME, NH, NJ, NY, PA, VT

Total Surface Area (acres): 3,918

% Shoreline Conserved: 4.2 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
NY	1,494	112	0	128	3,412
ME	1,457	73	0	13	2,654
VT	438	18	0	43	642
MA	216	9	0	7	294
NJ	148	5	37	51	111
PA	148	7	0	19	228
NH	16	1	0	27	10

Description:

A cold, alkaline lake or pond characterized by high biological productivity and high concentrations of nitrogen and phosphorus.

These are murky lakes and ponds where cold water is present year round, but these nutrient rich lakes have less dissolved oxygen than oligo-mesotrophic lakes because they support an abundance of plant and algae growth. Excess nutrients may be due to agricultural run-off or other human alterations. The water can be clear if aquatic plants predominate, but is often cloudy due to high algae content. Water alkalinity is high, supporting biota tolerant of circumneutral waters. In summer, these lakes may stratify into a warm upper layer (epilimnion) that supports warmwater fish species like largemouth bass and a cold lower layer (hypolimnion) that provides refuge for refuge for cold and coolwater fish species like brook trout, brown trout, and northern pike; conditions are not cold enough for lake trout. The degree to which the lake stratifies varies based on local conditions, and they usually remix in the spring and fall to create more uniform temperatures from surface to bottom. In contrast to lakes, shallow ponds are unlikely to stratify during the summer, and may freeze to the bottom of the pond in the winter. This waterbody type is found on alkaline substrates in northern latitudes. The average lake in this category has a surface area of 65 acres and a depth of 26 feet. The average pond in this category has a surface area of 7 acres and a depth of 4 feet.

Number of Waterbodies:

37 lakes and 188 ponds

Habitat Type Criteria:

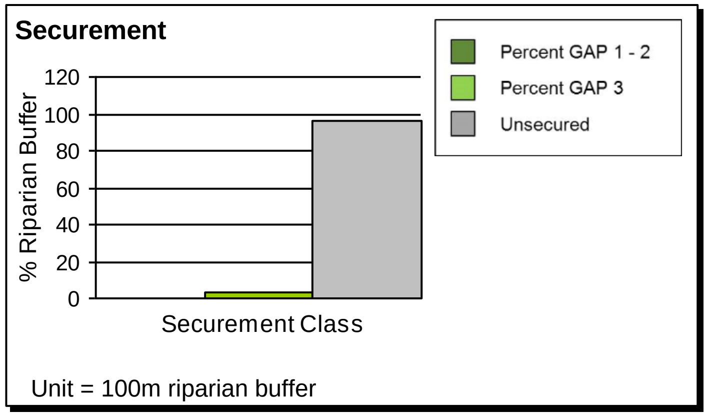
Coldest summer water temperature 55 to 64F & dissolved oxygen > 5 mg/L. Calcium carbonate > 50 mg/L. Chlorophyll-a >7 ug/L.

Places to Visit this Habitat:

Lake Parker VT, Monson Pond ME, Rushford Lake NY, Mountain Lake NJ, Lime Pond NH

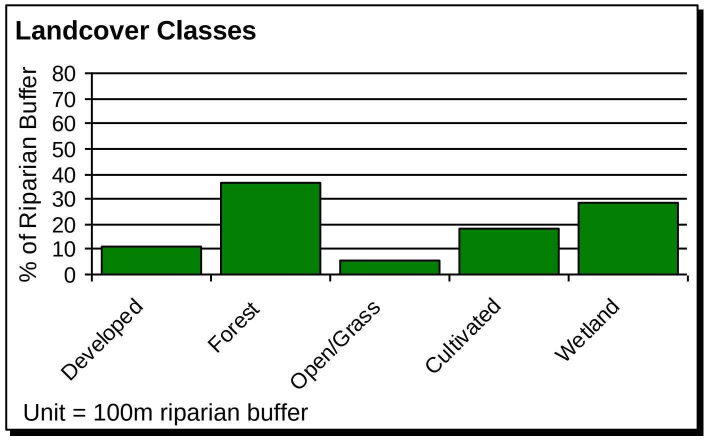
Associated Species:

This habitat may support characteristic coldwater fish species (exclusive of lake trout), including rainbow smelt, brook trout, brown trout, landlocked Atlantic salmon, burbot (cusk) and slimy sculpin. These lakes may also provide the thermal habitat required for both cool and warmwater fish species. Coolwater fish species include northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Warmwater fish species commonly include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. The vegetation in shallow waterbodies is likely to be dominated by water lilies, while the vegetation in larger deeper lakes is also likely to include floating-leaved and submerged mat-forming aquatics.



Species of Concern (G1 - G4):

Fish: Bridle Shiner



Temperature and Depth Profile

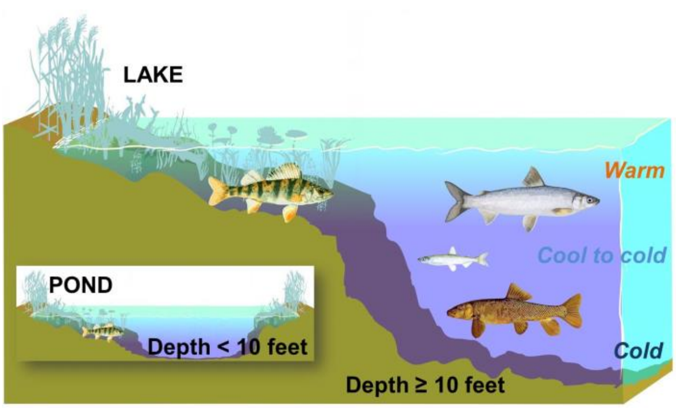
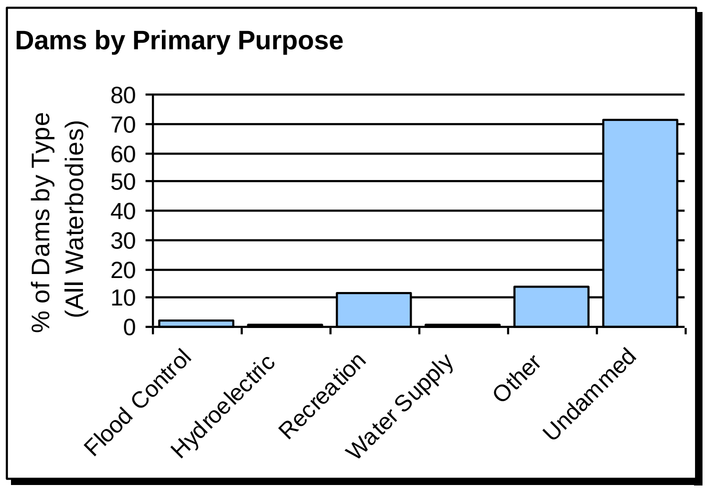
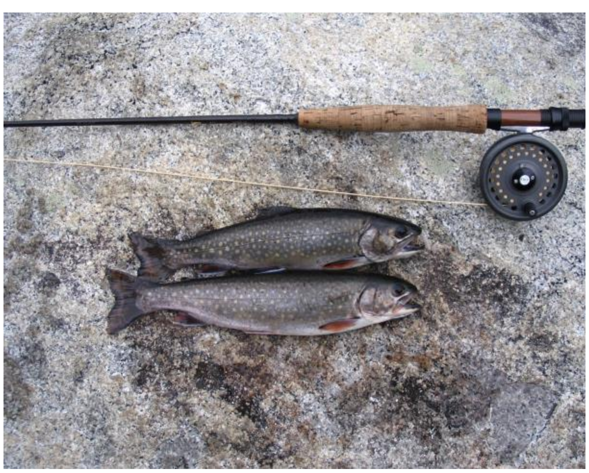
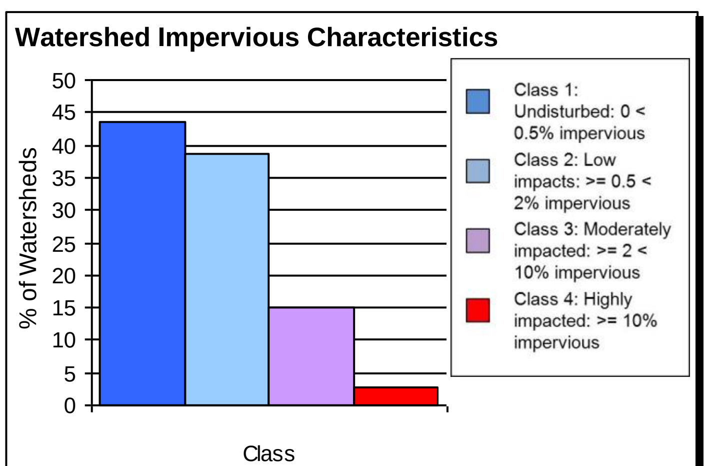


FIGURE CREDIT: Katrine Turgeon (2015)



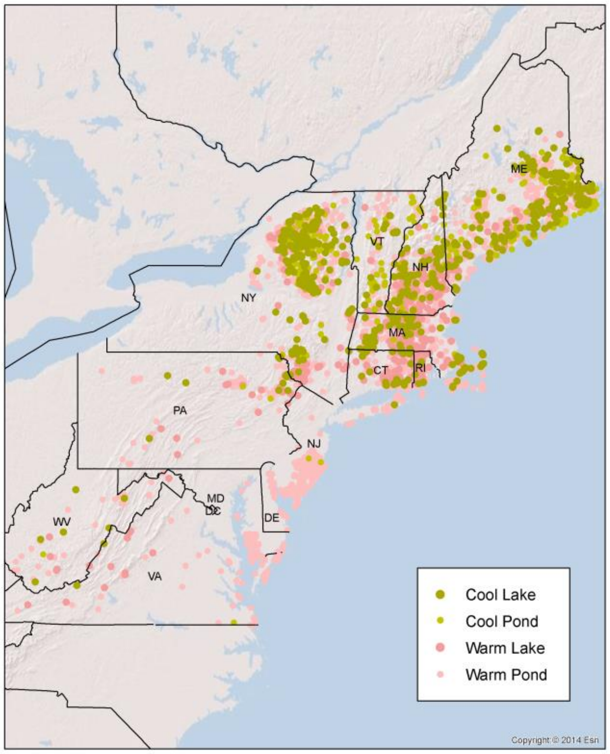


Trout, Debsconeag Lakes Wilderness Area, ME. PHOTO CREDIT: Rob Vogel. LICENSE: The Nature Conservancy.



Warm to cool, oligo-mesotrophic, acidic lake or pond

Macrogroup: Lakes and Ponds



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

State Distribution: CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VA, VT, WV

Total Surface Area (acres): 466,842

% Shoreline Conserved: 33.4 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
ME	240,495	946	3,833	16,362	96,286
NY	78,118	797	20,038	12,919	35,331
NH	53,650	429	2,420	7,897	30,697
MA	40,103	527	2,271	11,604	23,345
RI	12,365	126	506	2,962	6,526
CT	10,804	218	931	3,993	8,760
NJ	8,529	365	7,546	2,269	5,886
VA	5,689	91	2,246	742	1,511
PA	5,646	102	1,053	1,596	3,599
MD	4,937	167	2,445	2,157	2,729
VT	4,308	116	536	1,867	3,365
WV	1,625	47	166	828	1,549
DE	571	41	1,031	126	365

Plum Orchard Lake, WV. PHOTO CREDIT: Gene (2014). LICENSE: CC BY-NC-ND 2.0.

Description:

A warm to cool, acidic lake or pond characterized by low to moderate levels of biological productivity.

These are lakes and ponds where warm to cool, somewhat oxygenated water is present year round. Water alkalinity is low, supporting biota tolerant of acidic waters and these waterbodies may support beds of submerged aquatic vegetation. Very acidic waterbodies can be highly colored due to high dissolved organic carbon and organic acid content. Lakes of this type are relatively shallow compared to colder lakes in the region, and generally support warmwater fish like largemouth bass and sunfish. Cooler examples may support coolwater fish species like northern pike, but these lakes and ponds are unlikely to contain the dissolved oxygen and thermal habitat requirements suitable for coldwater fish. These lakes are located on acidic substrates in temperate regions. The average lake in this category has a surface area of 357 acres and a depth of 32 feet. The average pond in this category has a surface area of 43 acres and a depth of 8 feet.

Number of Waterbodies:

Cool: 541 lakes & 320 ponds; Warm: 398 lakes & 2,713 ponds

Habitat Type Criteria:

Cool: Coldest summer water temperature 64-70F & dissolved oxygen > 4 mg/L. Warm: Coldest summer water temperature >70F. Calcium carbonate < 12.5 mg/L. Chlorophyll-a < 7 ug/L.

Places to Visit this Habitat:

Carr Pond RI, Lake Sabbatia MA, Alligator Lake ME, Bashan Lake CT, Lake Raponda VT

Associated Species:

Warmwater fish species commonly found in this habitat include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. Cooler examples of this habitat may support characteristic coolwater fish species including northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Very acidic lakes are likely to have low species richness, with the most acidic supporting brown bullhead-golden shiner assemblages in lieu of other fish species. The shallower waterbodies are often dominated by submersed macrophytes such as pondweeds, bladderwort, watermilfoil, naiad, and Elodea in the phototrophic zone.

Species of Concern (G1 - G4):

Fish: Bridle Shiner Mussels: Tidewater Mucket, Yellow Lampmussel, Eastern Pondmussel, Triangle Floater Reptiles: Northern Red-bellied Cooter

Temperature and Depth Profile

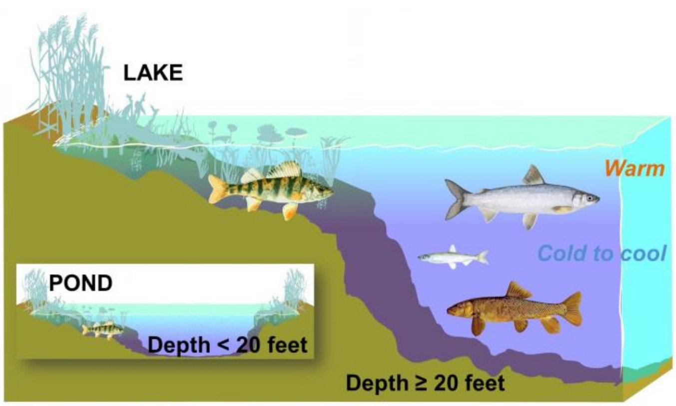
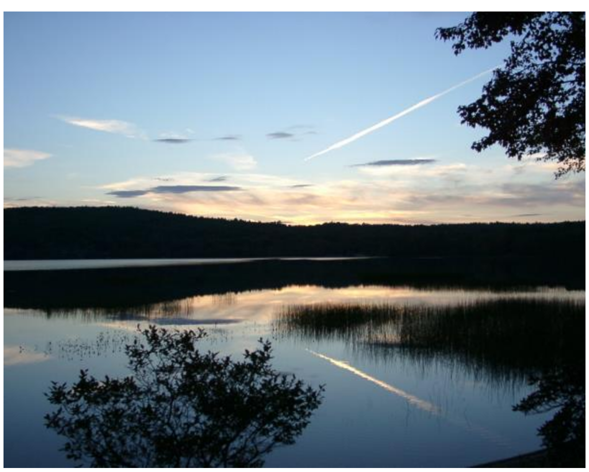
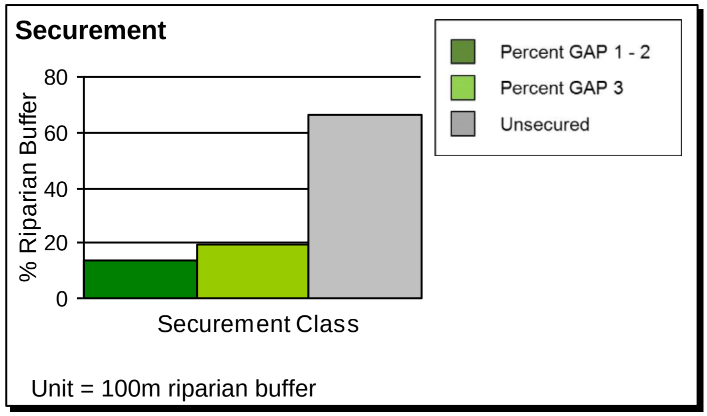
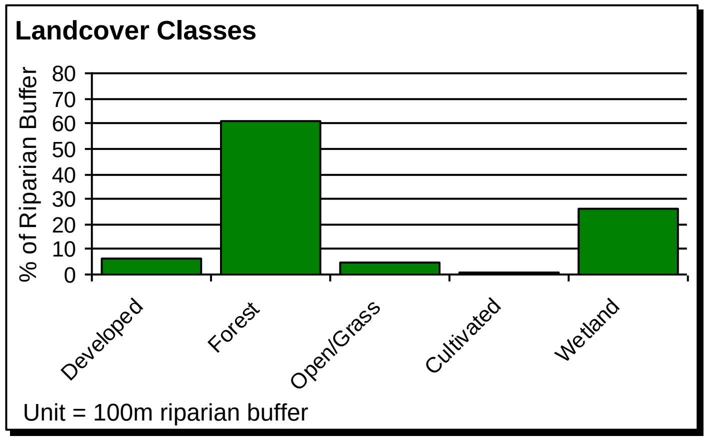


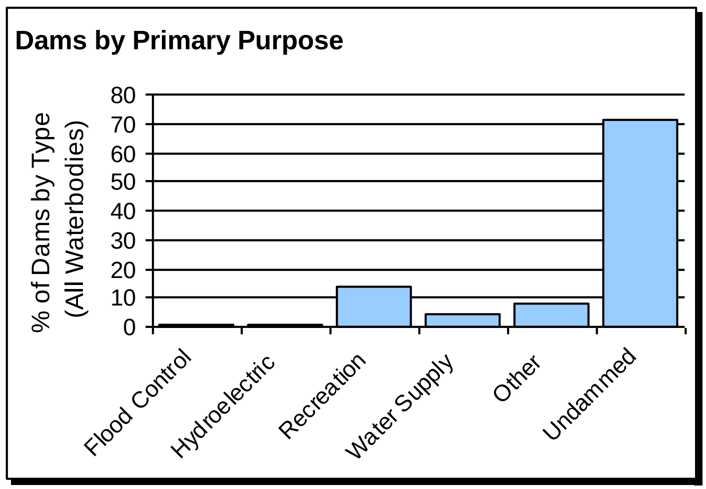
FIGURE CREDIT: Katrine Turgeon (2015)

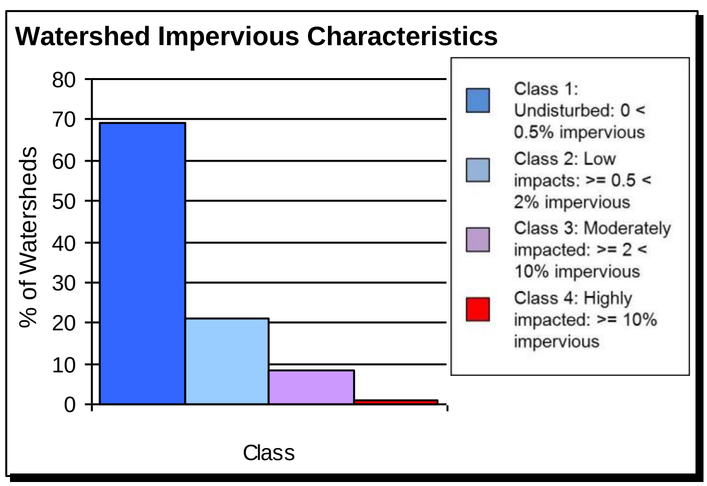


Jenness Pond, NH. PHOTO CREDIT: Rose Vines (2001). LICENSE: CC BY-NC 2.0.



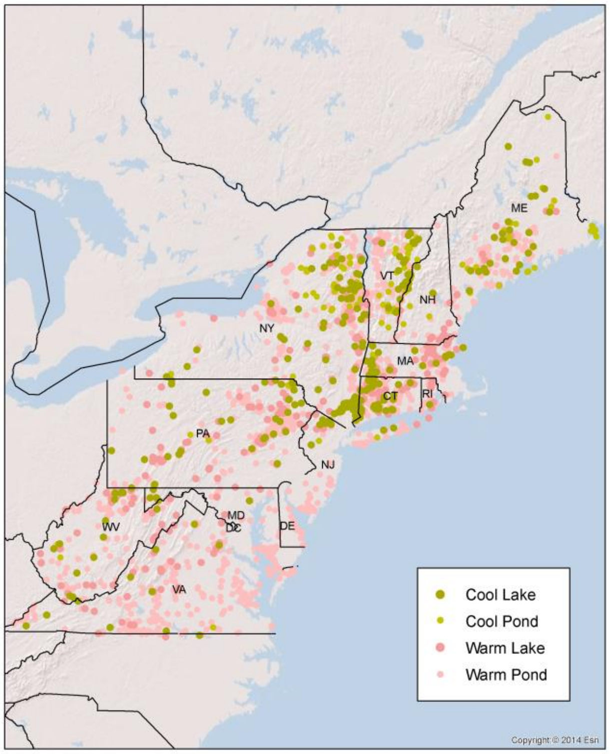






Warm to cool, oligo-mesotrophic, neutral lake or pond

Macrogroup: Lakes and Ponds



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

Great Sacandaga Lake, NY. PHOTO CREDIT: Scott Saghirian (2008). LICENSE: CC BY 2.0.

Description:

A warm to cool, circumneutral, clear lake or pond characterized by low to moderate levels of biological productivity.

These are lakes and ponds where warm to cool, somewhat oxygenated water is present year round. Water alkalinity is medium, supporting biota tolerant of circumneutral waters and these waterbodies may support beds of submerged aquatic vegetation. Lakes of this type are relatively shallow compared to colder lakes in the region, and generally support warmwater fish like largemouth bass and sunfish. Cooler examples may support coolwater fish species like northern pike, but are unlikely to contain the dissolved oxygen and thermal habitat requirements suitable for coldwater fish. These lakes are located on circumneutral substrates in temperate regions. The average lake in this category has a surface area of 363 acres and a depth of 36 feet. The average pond in this category has a surface area of 30 acres and a depth of 8 feet.

State Distribution: CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VA, VT, WV

Total Surface Area (acres): 248,730

% Shoreline Conserved: 27.3 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
NY	81,385	547	5,138	7,445	32,642
VA	47,797	272	1,078	2,583	30,794
ME	38,812	175	1,200	1,063	21,100
WV	16,288	161	802	9,273	8,577
PA	13,108	270	1,937	2,458	11,060
MA	12,465	134	689	3,710	6,774
MD	10,190	134	4,144	2,353	4,078
CT	8,705	181	529	1,472	8,145
VT	6,007	173	70	1,011	6,856
NJ	4,723	53	1,996	226	2,114
RI	4,702	37	265	332	3,306
NH	3,870	41	31	388	3,099
DE	679	56	988	684	113

Number of Waterbodies:

Cool: 267 lakes & 111 ponds; Warm: 275 lakes & 1,581 ponds

Habitat Type Criteria:

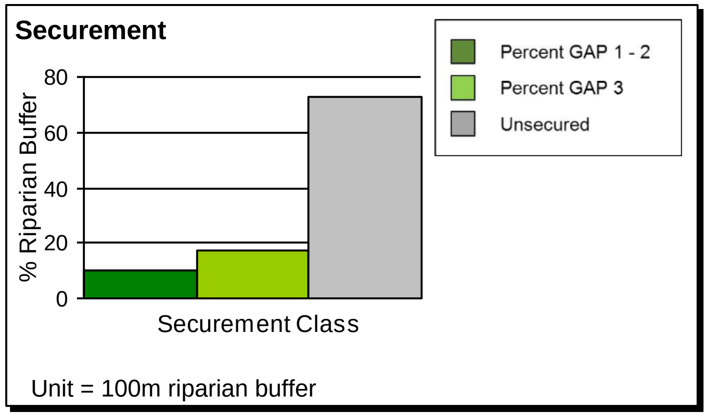
Cool: Coldest summer water temperature 64-70F & dissolved oxygen > 4 mg/L. Warm: Coldest summer water temperature >70F. Calcium carbonate < 12.5 to 50 mg/L. Chlorophyll-a < 7

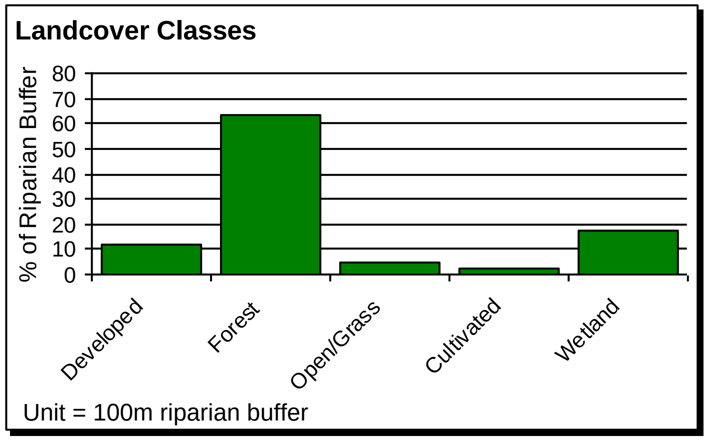
Places to Visit this Habitat:

Tygart Lake WV, Lovell Lake NH, Twin Island Lake NY, Lake Mishnock RI, Pleasant Lake Stetson ME

Associated Species:

Warmwater fish species commonly found in this habitat include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. This habitat may support characteristic coolwater fish species including northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. The shallower waterbodies are often dominated by submersed macrophytes such as pondweeds, bladderword, watermilfoil, naiad, and Elodea in the phototrophic





Species of Concern (G1 - G4):

Fish: Bridle Shiner, Ohio Lamprey, Ironcolor Shiner Mussels: Brook Floater, Tidewater Mucket, Yellow Lampmussel, Eastern Pondmussel

Temperature and Depth Profile

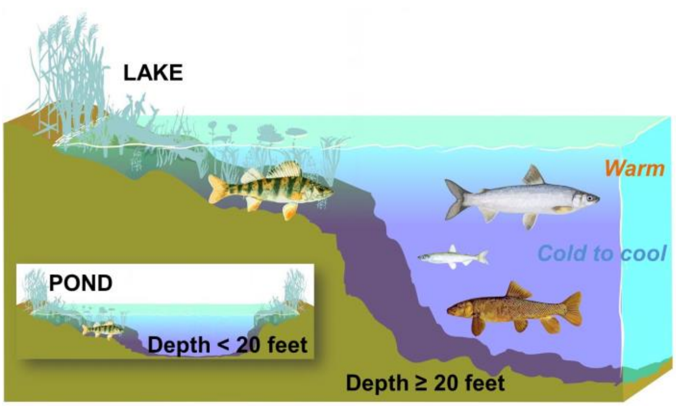
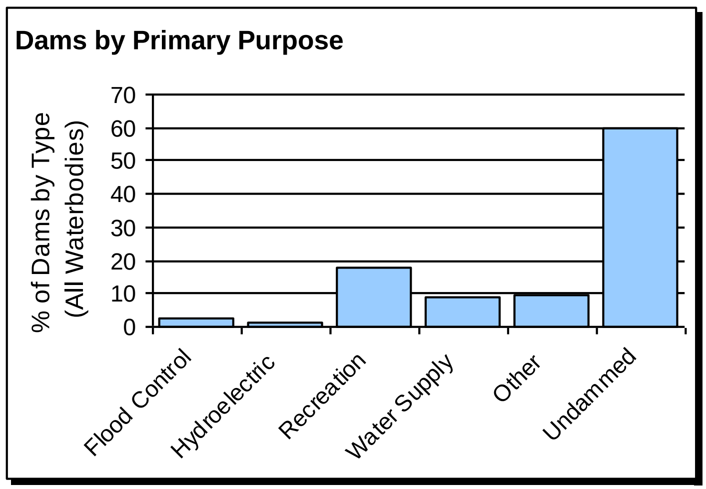
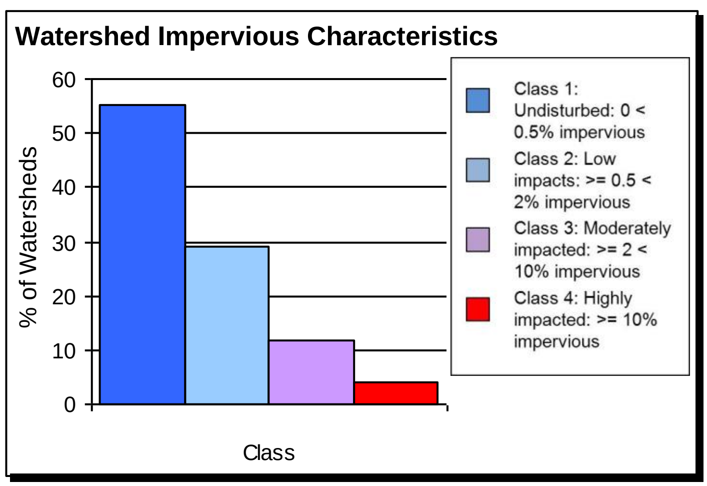


FIGURE CREDIT: Katrine Turgeon (2015)

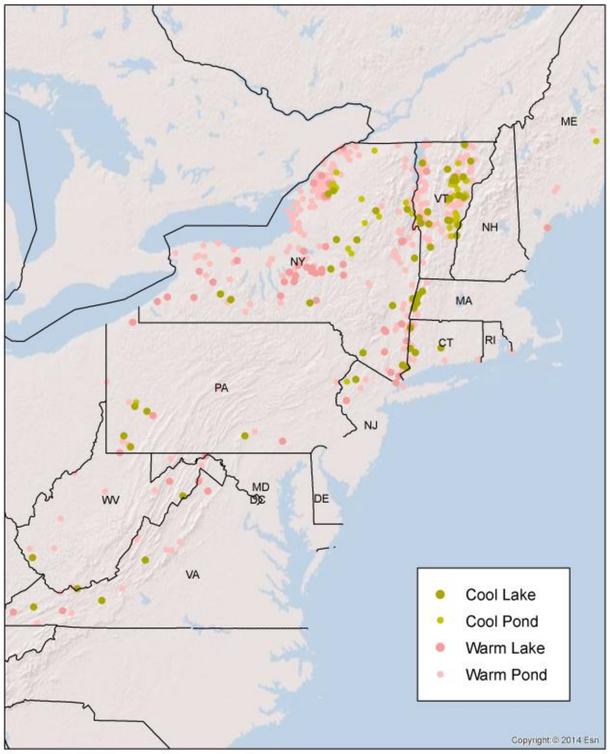


Lake Kanasatka, NH. PHOTO CREDIT: foreverseptember (2009). LICENSE: CC BY–ND 2.0.



Warm to cool, oligo-mesotrophic, alkaline lake or pond

Macrogroup: Lakes and Ponds



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

State Distribution: CT, MA, MD, ME, NH, NJ, NY, PA, RI, VA, VT, WV

Total Surface Area (acres): 114,469

% Shoreline Conserved: 20.8 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
NY	76,070	284	749	4,922	18,248
PA	11,552	17	84	60	4,584
VT	10,823	183	1,119	1,275	7,479
CT	8,120	14	233	412	4,510
VA	3,768	22	97	370	2,704
MA	1,617	11	0	138	955
NJ	1,409	5	750	0	127
RI	418	1	59	7	125
WV	337	14	55	44	672
ME	335	5	90	0	382
MD	20	1	0	0	40

Description:

A warm to cool, alkaline, clear lake or pond characterized by low to moderate levels of biological productivity.

These are lakes and ponds where warm to cool, somewhat oxygenated water is present year round. Water alkalinity is high, supporting biota tolerant of alkaline waters, and these waterbodies may support beds of submerged aquatic vegetation. Lakes of this type are relatively shallow compared to colder lakes in the region, and generally support warmwater fish like largemouth bass and sunfish. Cooler examples may support coolwater fish species like northern pike, but these lakes and ponds are unlikely to contain the dissolved oxygen and thermal habitat requirements suitable for coldwater fish. These lakes are located on calcareous substrates in temperate regions. The average lake in this category has a surface area of 838 acres and reaches a maximum depth of 42 feet. The average pond in this category has a surface area of 30 acres and a depth of 9 feet.

Number of Waterbodies:

Cool: 60 lakes & 36 ponds; Warm: 61 lakes & 400 ponds

Habitat Type Criteria:

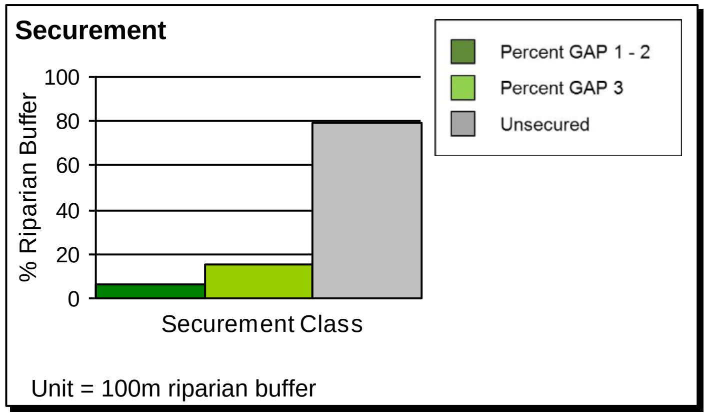
Cool: Coldest summer water temperature 64-70F & dissolved oxygen > 4 mg/L. Warm: Coldest summer water temperature >70F. Calcium carbonate > 50 mg/L. Chlorophyll-a < 7 ug/L.

Places to Visit this Habitat:

Canadarago Lake NY, Hardwick Lake VT, Wononpakook Lake CT, Spruce Run Reservoir NJ, Lake Bonaventure VA

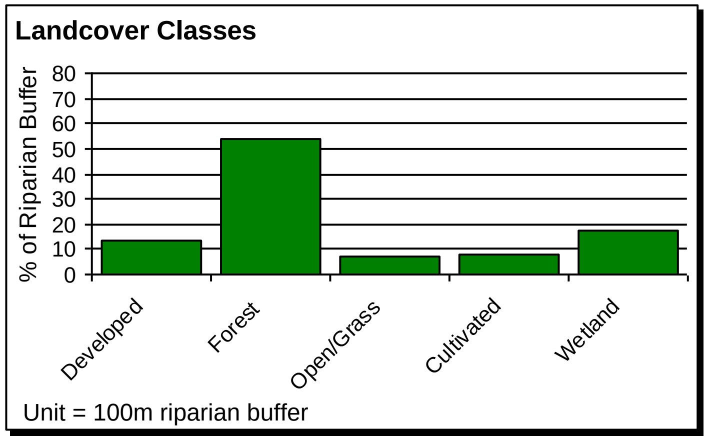
Associated Species:

Warmwater fish species commonly found in this habitat include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. Cooler examples of this habitat may support characteristic coolwater fish species including northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. The shallower waterbodies are often dominated by submersed macrophytes such as pondweeds, bladderword, watermilfoil, naiad, Elodea and algae such as Chara in the phototrophic zone.



Species of Concern (G1 - G4):

Fish: Bridle Shiner, Lake Sturgeon Mussels: James Spinymussel



Temperature and Depth Profile

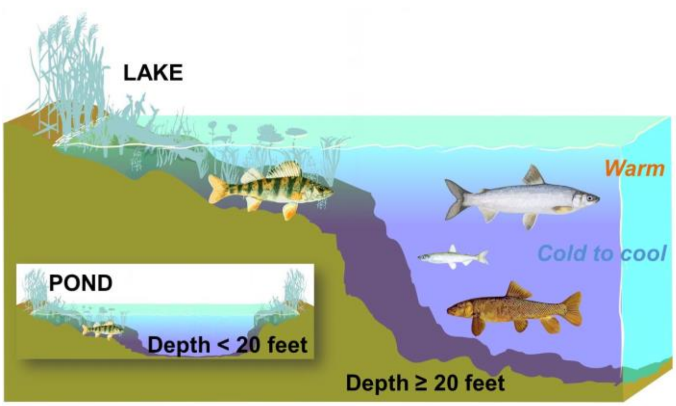
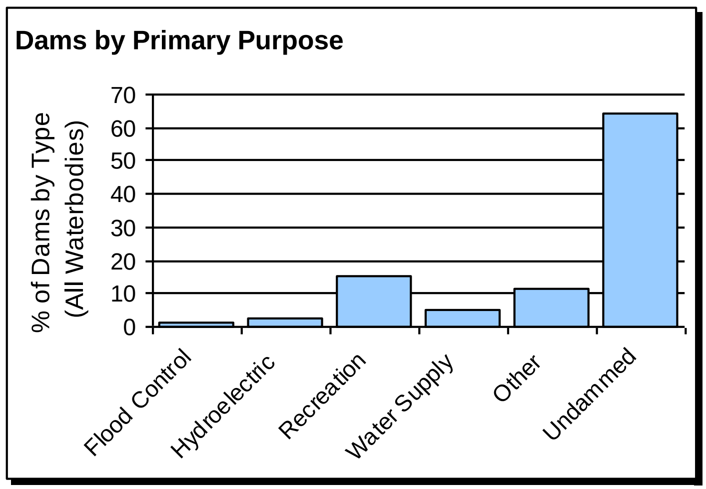
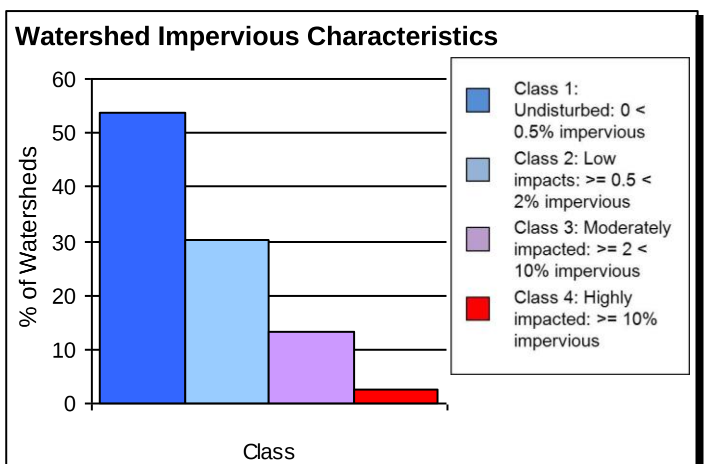


FIGURE CREDIT: Katrine Turgeon (2015)

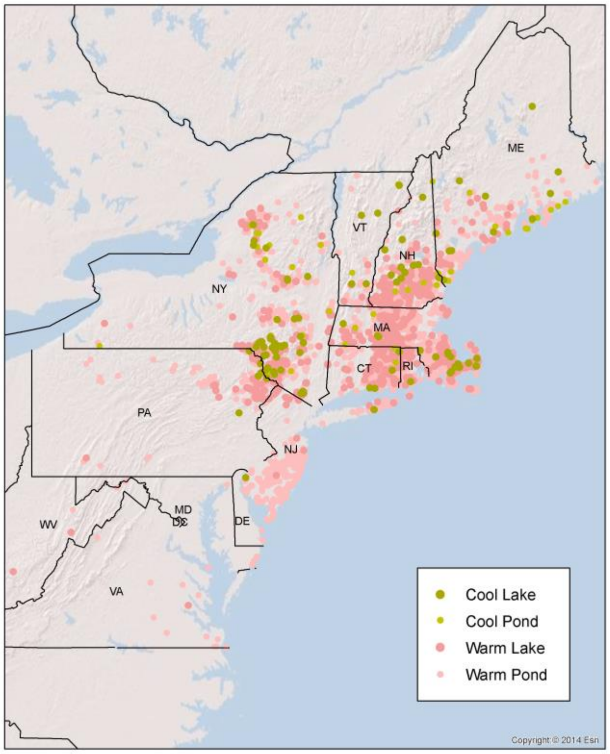


Lake Champlain, VT. PHOTO CREDIT: Jay Parker (2010). LICENSE: CC BY-NC 2.0.



Warm to cool, eutrophic, acidic lake or pond

Macrogroup: Lakes and Ponds



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

Green Pond, NJ. PHOTO CREDIT: Kd5463 (2006). LICENSE: CC BY-SA 3.0.

State Distribution: CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VA, VT, WV

Total Surface Area (acres): 90,369

% Shoreline Conserved: 25.4 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
MA	32,787	1329	2,904	9,902	42,708
NY	12,873	644	3,165	5,022	17,335
NH	11,177	468	638	5,029	15,364
NJ	8,180	394	2,450	1,590	13,083
CT	6,949	368	664	2,431	10,727
ME	6,525	192	451	468	7,781
PA	6,386	190	1,352	1,904	5,382
RI	3,799	108	228	805	3,735
VT	791	37	126	340	1,051
MD	300	9	26	284	257
VA	285	12	69	29	561
DE	259	3	0	268	19
WV	59	4	35	39	116

Description:

A warm to cool, acidic lake or pond characterized by high biological productivity and high concentrations of nitrogen and phosphorus.

These are murky lakes and ponds where warm to cool, somewhat oxygenated water is present year round. Water alkalinity is low, supporting biota tolerant of acidic waters. Very acidic waterbodies can be highly colored due to high dossolved organic carbon and organic acid content. These high nutrient lakes are likely to support a diverse array of organisms and an abundance of plant and algae growth. Excess nutrients may be due to agricultural run-off or other human alterations. Hypereutrophic lakes can also be dominated by vegetative overgrowth and algal blooms, resulting in low biodiversity, dark water with poor visibility, and anoxic conditions ("dead zones"). Lakes of this type are relatively shallow compared to colder lakes in the region, and generally support warmwater fish like largemouth bass and sunfish. Cooler examples may support coolwater fish species like northern pike, but these lakes and ponds are unlikely to contain the dissolved oxygen and thermal habitat requirements suitable for coldwater fish. These lakes are located on acidic substrates in temperate regions. The average lake in this category has a surface area of 52 acres and a depth of 17 feet. The average pond in this category has a surface area of 16 acres and a depth of 5 feet.

Number of Waterbodies:

Cool: 99 lakes & 47 ponds; Warm: 707 lakes and 2,905 ponds

Habitat Type Criteria:

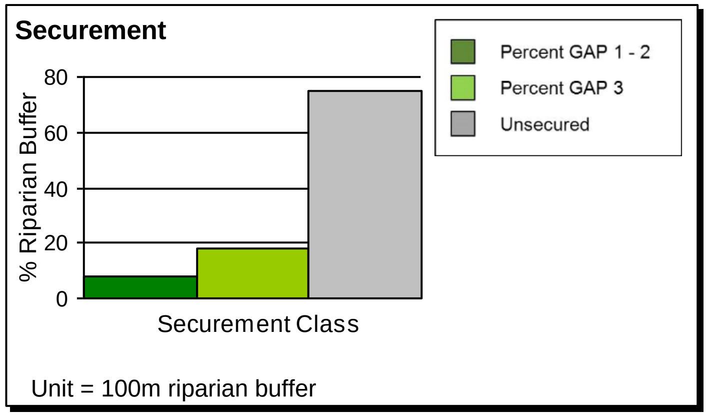
Cool: Coldest summer water temperature 64-70F & dissolved oxygen > 4 mg/L. Warm: Coldest summer water temperature >70F. Calcium carbonate < 12.5 mg/L. Chlorophyll-a >7 ug/L.

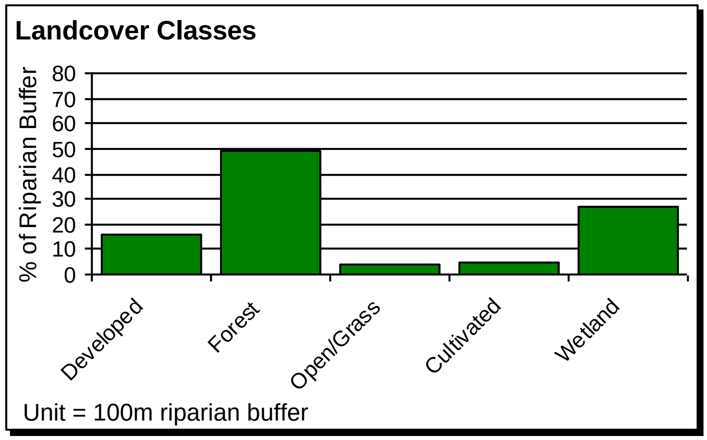
Places to Visit this Habitat:

Halfway Pond MA, Sewell Pond ME, Perkins Pond NH, Artist Lake NY, Pocotopaug Lake CT

Associated Species:

Warmwater fish species commonly found in this habitat include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. Cooler examples of this habitat may support characteristic coolwater fish species including northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. Very acidic lakes are likely to have low species richness, with the most acidic supporting brown bullhead-golden shiner assemblages in lieu of other fish species. The shallower waterbodies are often dominated by submersed macrophytes such as pondweeds, bladderwort, watermilfoil, naiad, and Elodea in the phototrophic zone.





Species of Concern (G1 - G4):

Fish: Bridle Shiner   Mussels: Tidewater Mucket, Eastern Pondmussel, Triangle Floater   Reptile: Northern Red-bellied Cooter

Temperature and Depth Profile

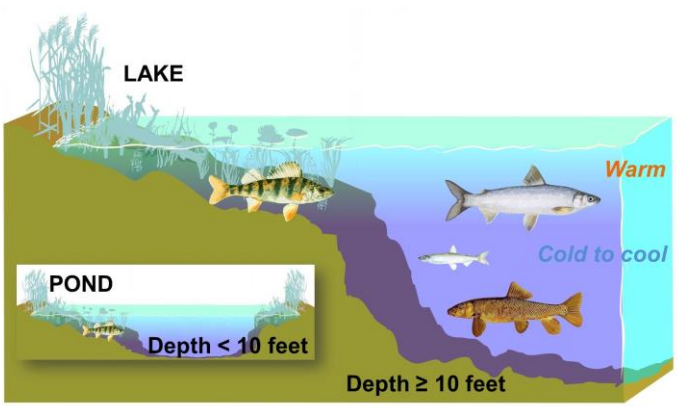
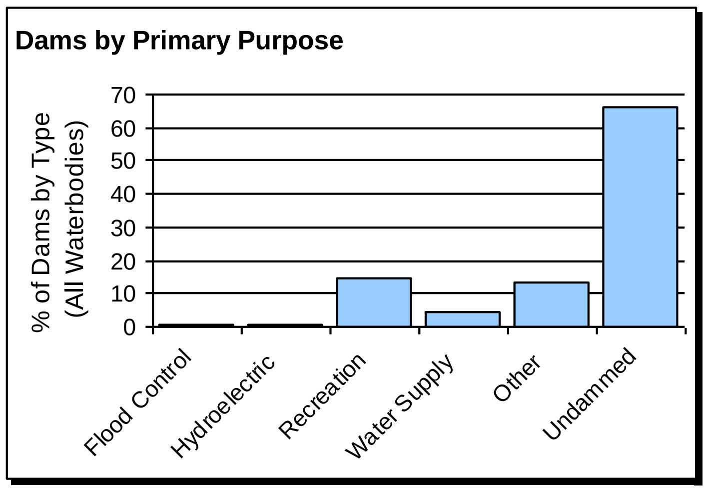
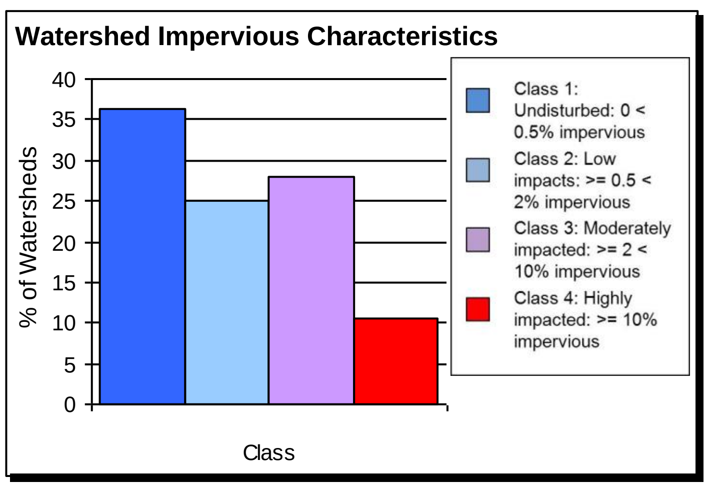


FIGURE CREDIT: Katrine Turgeon (2015)

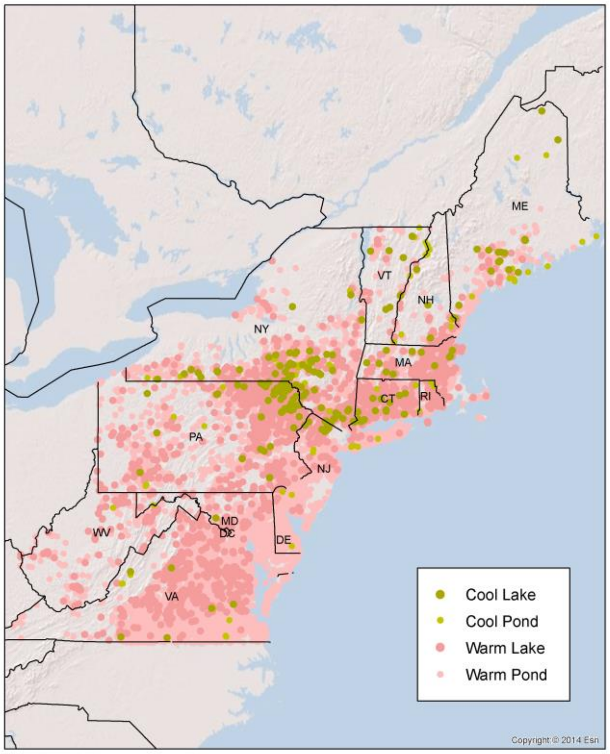


Shohola Marsh Reservoir, PA. PHOTO CREDIT: Jason (2009). LICENSE: CC BY–NC–ND 2.0.



Warm to cool, eutrophic, neutral lake or pond

Macrogroup: Lakes and Ponds



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

Lake Quannapowitt, MA. PHOTO CREDIT: Alex1961 (2013). LICENSE: CC BY-SA 2.0, straightened and color-corrected.

State Distribution: CT, DC, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VA, VT, WV

Total Surface Area (acres): 376,054

% Shoreline Conserved: 15.5 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
VA	119,163	4596	922	17,768	186,493
PA	84,720	2468	7,417	9,626	87,968
NY	37,947	1609	1,087	8,721	51,525
MA	31,076	1181	901	8,748	43,263
NJ	27,318	1074	7,823	2,788	37,229
MD	18,373	773	3,026	6,015	24,843
CT	18,313	1065	2,098	3,931	32,001
DE	10,431	366	2,212	3,928	12,686
ME	8,883	202	136	305	10,149
WV	7,536	235	330	2,867	7,732
RI	5,792	243	616	1,108	8,463
NH	3,942	188	329	1,084	7,450
VT	2,321	78	133	145	2,528
DC	238	7	0	0	448

Description:

A warm to cool, circumneutral lake or pond characterized by high biological productivity and high concentrations of nitrogen and phosphorus.

These are murky lakes and ponds where warm to cool, somewhat oxygenated water is present year round. Water alkalinity is medium, supporting biota tolerant of circumneutral waters. These high nutrient lakes are likely to support a diverse array of organisms and an abundance of plant and algae growth. Excess nutrients may be due to agricultural run-off or other human alterations. Hypereutrophic lakes can also be dominated by vegetative overgrowth and algal blooms, resulting in low biodiversity, dark water with poor visibility, and anoxic conditions (“dead zones”). Lakes of this type are relatively shallow compared to colder lakes in the region, and generally support warmwater fish like largemouth bass and sunfish. Cooler examples may support coolwater fish species like northern pike, but these lakes and ponds are unlikely to contain the dissolved oxygen and thermal habitat requirements suitable for coldwater fish. These lakes are located on circumneutral substrates in temperate regions. The average lake in this category has a surface area of 92 acres and a depth of 18 feet. The average pond in this category has a surface area of 12 acres and a depth of 4 feet.

Number of Waterbodies:

Cool: 200 lakes & 86 ponds; Warm: 2,111 lakes & 11,688 ponds

Habitat Type Criteria:

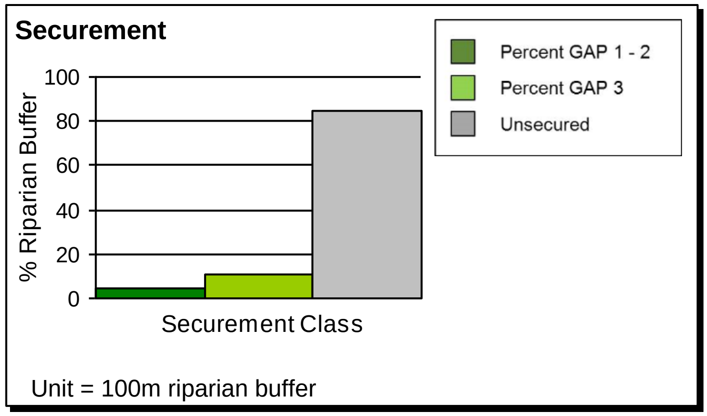
Cool: Coldest summer water temperature 64-70F & dissolved oxygen > 4 mg/L. Warm: Coldest summer water temperature >70F. Calcium carbonate < 12.5 to 50 mg/L. Chlorophyll-a >7

Places to Visit this Habitat:

Bantam Lake CT, Lake Carmi VT, Pinchot Lake PA, Johnsons Pond MD, Belleville Pond RI

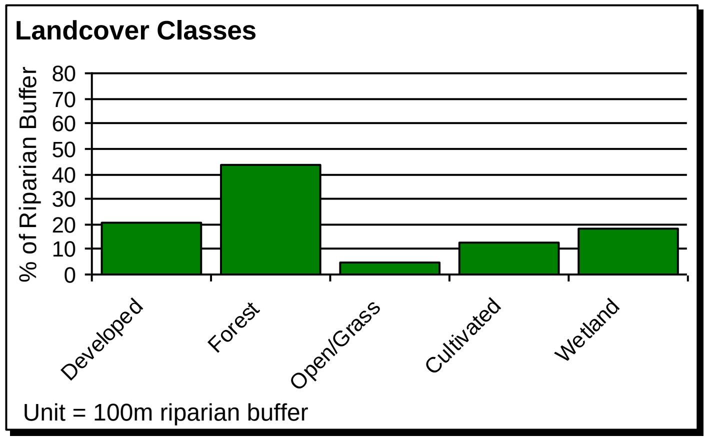
Associated Species:

Warmwater fish species commonly found in this habitat include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. Cooler examples of this habitat may support characteristic coolwater fish species including northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. The shallower waterbodies are often dominated by submersed macrophytes such as pondweeds, bladderword, watermilfoil, naiad, and Elodea in the phototrophic zone.



Species of Concern (G1 - G4):

Fish: Ohio Lamprey, Blackbanded Sunfish, Ironcolor Shiner
Mussels: Green Floater, Eastern Pondmussel



Temperature and Depth Profile

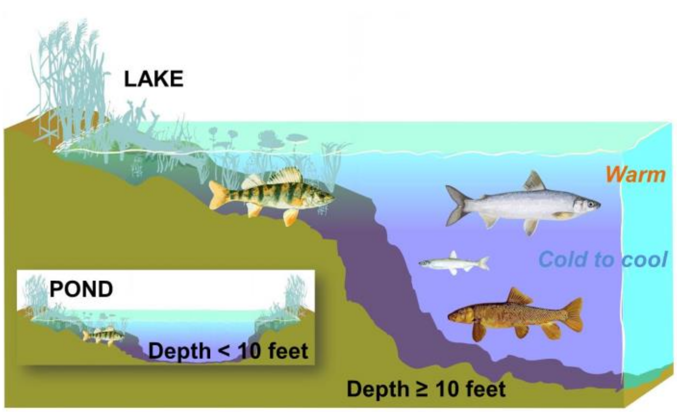
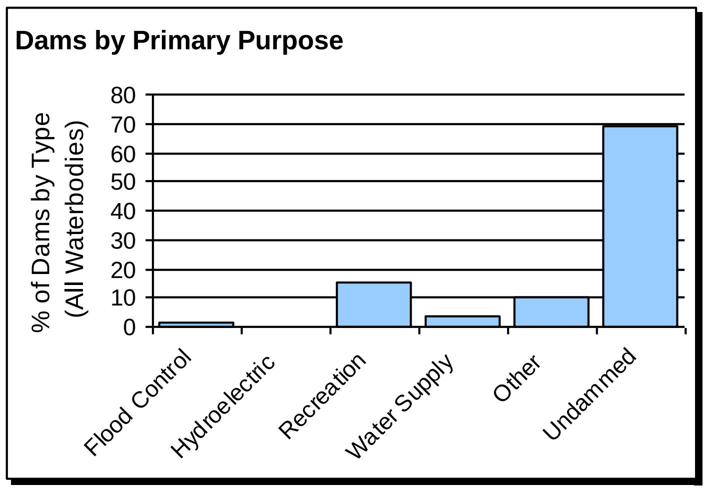
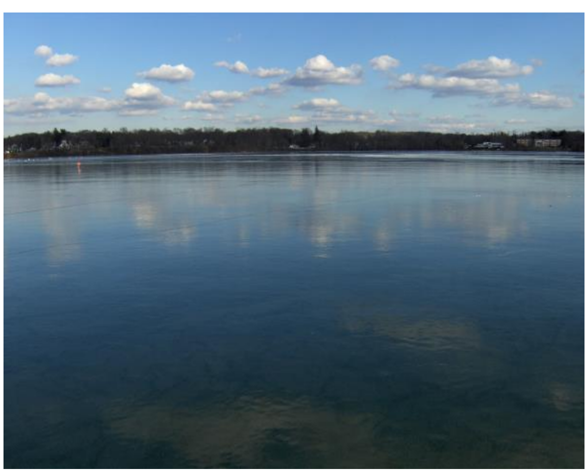
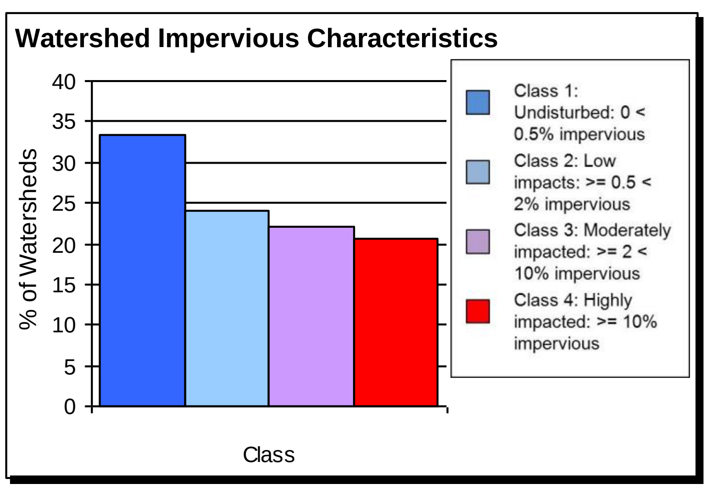


FIGURE CREDIT: Katrine Turgeon (2015)



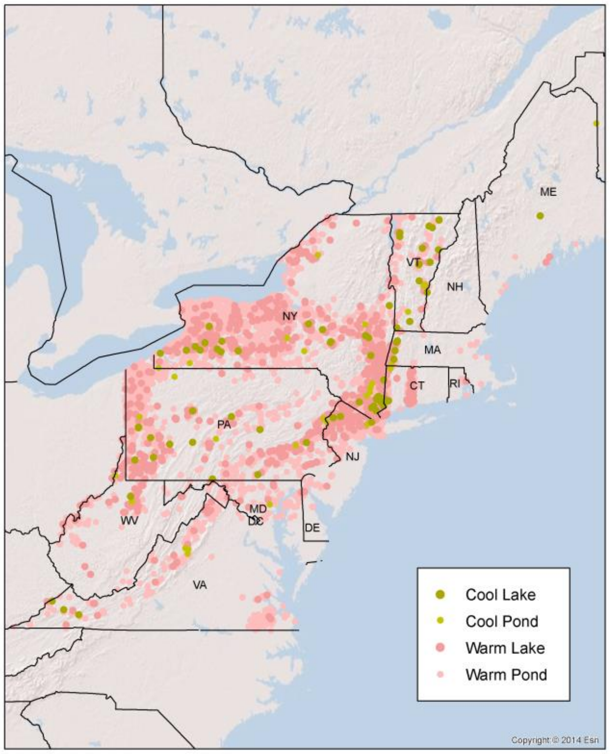


Lake Ronkonkoma, NY. PHOTO CREDIT: Joe Shlabotnik (2007). LICENSE: CC BY 2.0.



Warm to cool, eutrophic, alkaline lake or pond

Macrogroup: Lakes and Ponds



This map is based on a model and has had little field-checking. Contact your State Natural Heritage Ecologist or State Fish Game Agency for more information about this habitat.

Pymatuning Swamp, PA. PHOTO CREDIT: Shannon (2012). LICENSE: CC BY-NC-ND 2.0.

State Distribution: CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VA, VT, WV

Total Surface Area (acres): 194,785

% Shoreline Conserved: 13.5 Shoreline = 100m buffer

State	Surface Area (acres)	# of Waterbodies	Shoreline Reserve (acres)	Shoreline Multi-use (acres)	Shoreline Unsecured (acres)
NY	106,560	2824	3,560	11,504	106,401
PA	50,923	1239	6,221	4,459	43,620
NJ	16,804	552	2,634	985	20,322
VA	5,982	313	114	173	13,265
CT	4,274	245	304	1,005	7,630
VT	3,078	118	279	325	4,145
WV	2,444	216	193	296	6,761
MA	2,094	80	45	412	3,052
MD	1,524	122	198	118	3,715
DE	606	26	22	158	1,224
ME	248	22	26	0	641
RI	178	9	10	15	357
NH	69	6	25	5	164

Description:

A warm to cool, alkaline lake or pond characterized by high biological productivity and high concentrations of nitrogen and phosphorus.

These are murky lakes and ponds where warm to cool, somewhat oxygenated water is present year round. Water alkalinity is high, supporting biota tolerant of alkaline waters. These high nutrient lakes are likely to support a diverse array of organisms and an abundance of plant and algae growth. Excess nutrients may be due to agricultural run-off or other human alterations. Hypereutrophic lakes can also be dominated by vegetative overgrowth and algal blooms, resulting in low biodiversity, dark water with poor visibility, and anoxic conditions ("dead zones"). Lakes of this type are relatively shallow compared to colder lakes in the region, and generally support warmwater fish like largemouth bass and sunfish. Cooler examples may support coolwater fish species like northern pike, but these lakes and ponds are unlikely to contain the dissolved oxygen and thermal habitat requirements suitable for coldwater fish. These lakes are located on calcareous substrates in temperate regions. The average lake in this category has a surface area of 126 acres and a depth of 19 feet. The average pond in this category has a surface area of 12 acres and reaches a maximum depth of 4 feet.

Number of Waterbodies:

Cool: 72 lakes & 36 ponds; Warm: 888 lakes & 4,776 ponds

Habitat Type Criteria:

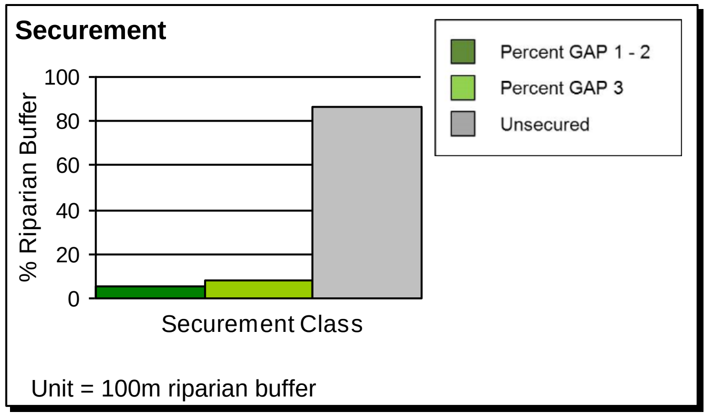
Cool: Coldest summer water temperature 64-70F & dissolved oxygen > 4 mg/L. Warm: Coldest summer water temperature >70F. Calcium carbonate > 50 mg/L. Chlorophyll-a >7 ug/L.

Places to Visit this Habitat:

Cross Lake NY, Shelburne Pond VT, Colonial Lake NJ, Pymatuning Swamp PA, Lake Kittamaqundi MD

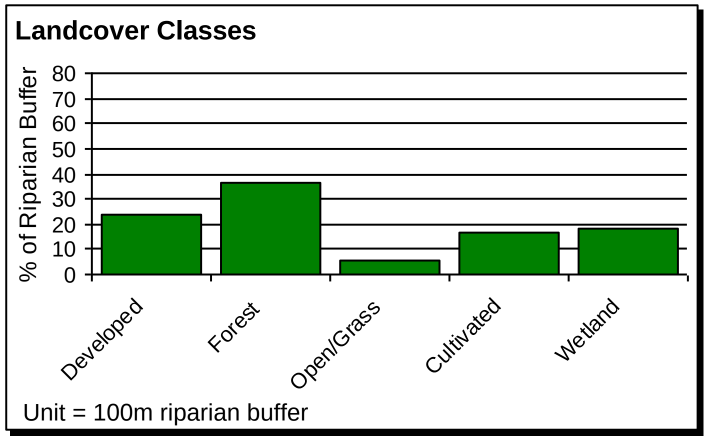
Associated Species:

Warmwater fish species commonly found in this habitat include largemouth bass, several sunfish species (pumpkinseed, bluegill, redbreast sunfish), chain pickerel, American eel, brown bullhead and golden shiner. Cooler examples of this habitat may support characteristic coolwater fish species including northern pike, walleye, smallmouth bass, white sucker, yellow perch, introduced white perch, banded killifish, creek chub, fallfish and common shiner. The vegetation in shallow waterbodies is likely to be dominated by water lilies, while the vegetation in larger deeper lakes is also likely to include floating-leaved and submerged mat-forming aquatics.



Species of Concern (G1 - G4):

Fish: Lake Sturgeon, Pugnose Shiner, Blacknose Shiner, Ironcolor Shiner Mussels: Clubshell



Temperature and Depth Profile

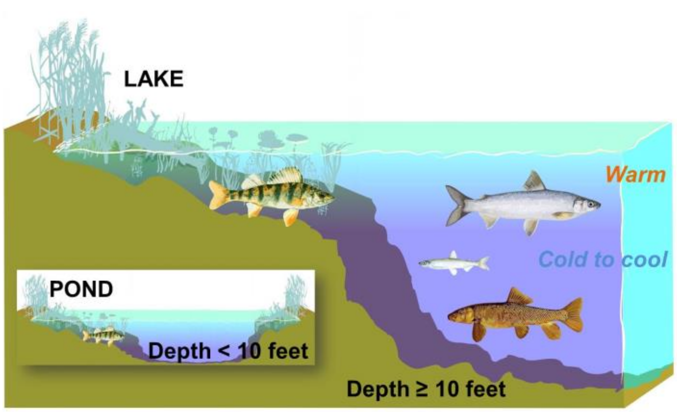
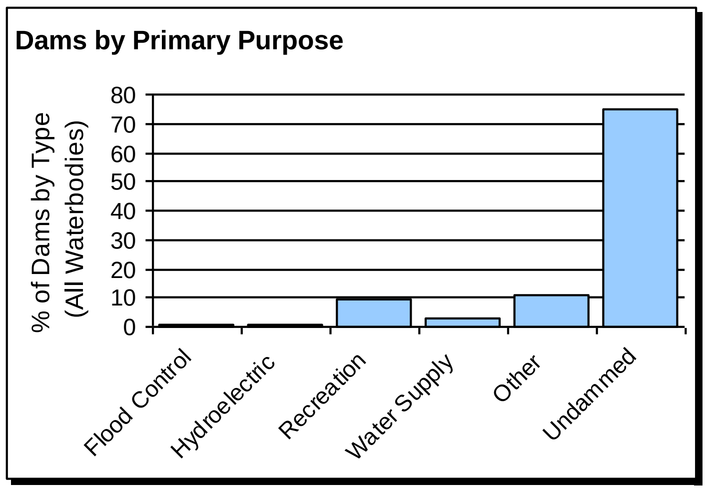


FIGURE CREDIT: Katrine Turgeon (2015)



Shelburne Pond, VT. PHOTO CREDIT: Dean J. Williams (2011). LICENSE: CC BY–NC–ND 2.0.