The Influence of Atmospheric Deposition of Nitrogen on a Shallow Seepage Lake in the North Carolina Coastal Plain

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UNDERSTANDING LAKE CHANGES

Data

versus

Assumptions

Water and nutrient budgets--

assess internal + external nutrient sources

Influence of atmospheric deposition--greatest in shallow seepage lakes

Our lake will be clear

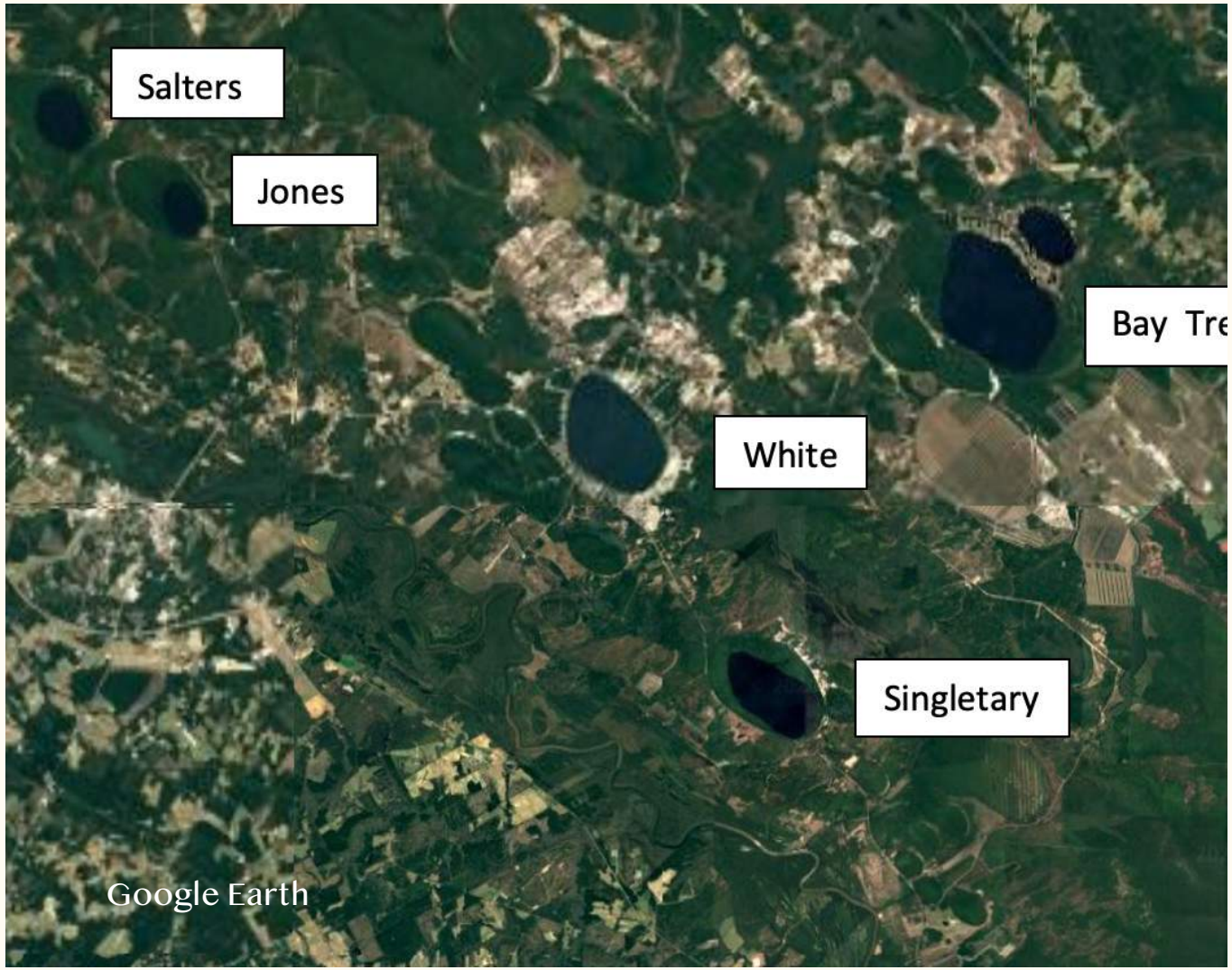
Lake level will be static

NC Bay Lakes

Thousands of Carolina Bays in Atlantic Coastal Plain, with similar morphology--
most are wetlands

Bladen Bay Lakes
are oriented SE-NW

Sand rim at SE shore, situated in wetland basins



WHITE LAKE

Shallow

Mean Depth 1.9 m, Max 2.9 m

Small

1,067 acres

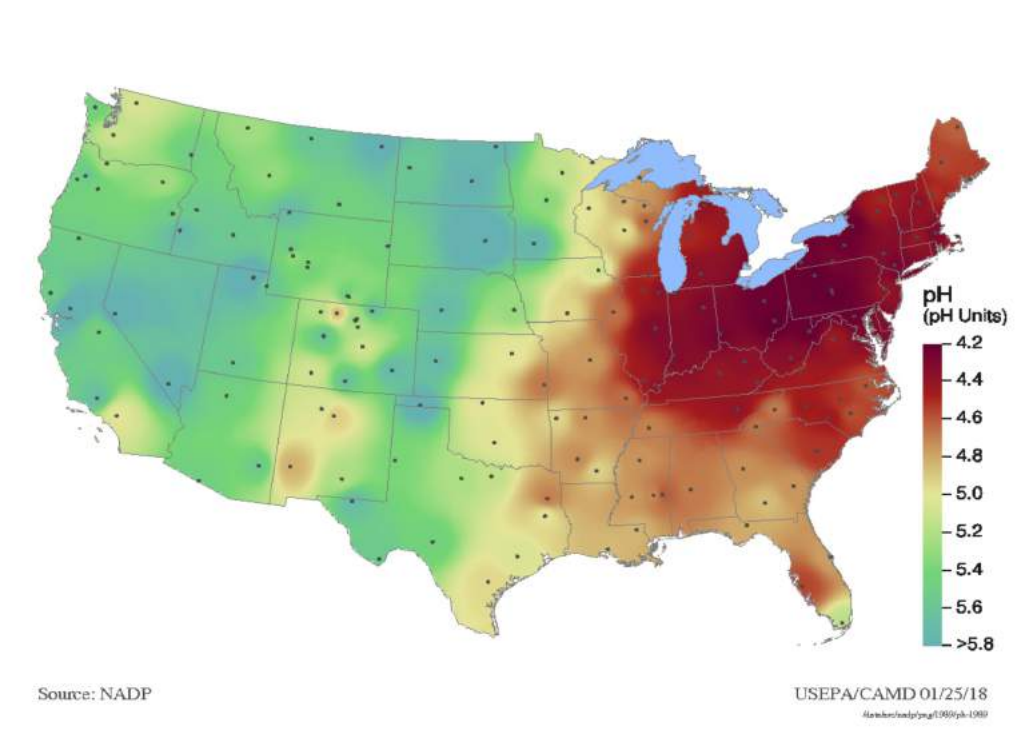
Seepage Lake

No inlet, source water = rainfall + GW

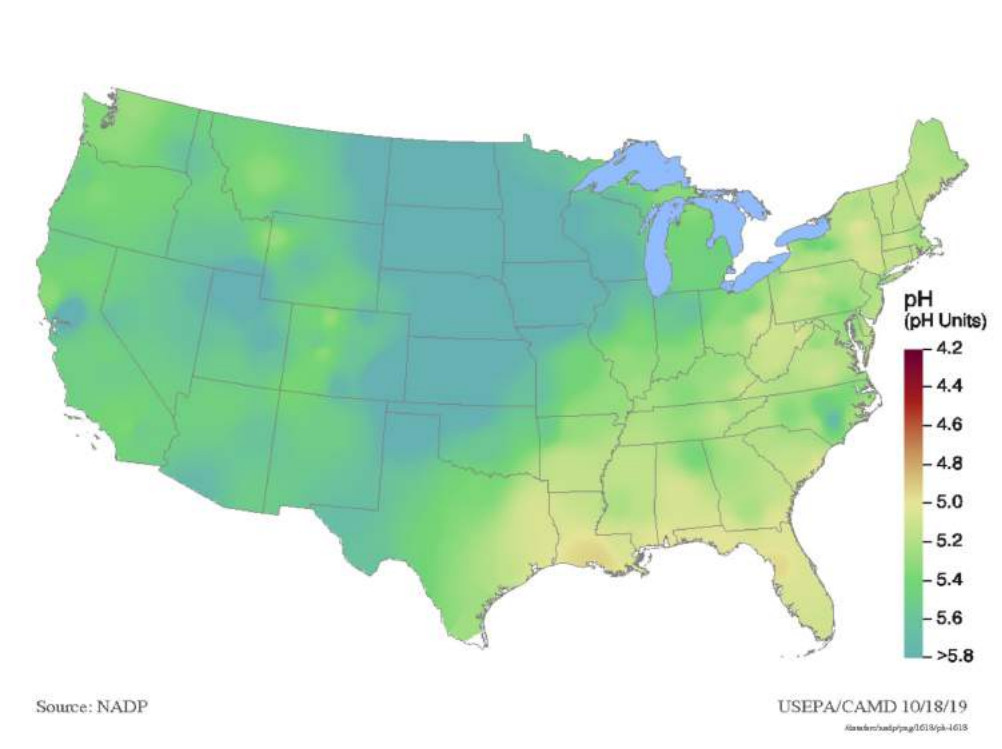
Digital Compilation of 1938 USDA Aerial Photos, Provided by NC Mountains to Sea Trail

Atmospheric Change: Less Acidic Rainfall

pH, 1989

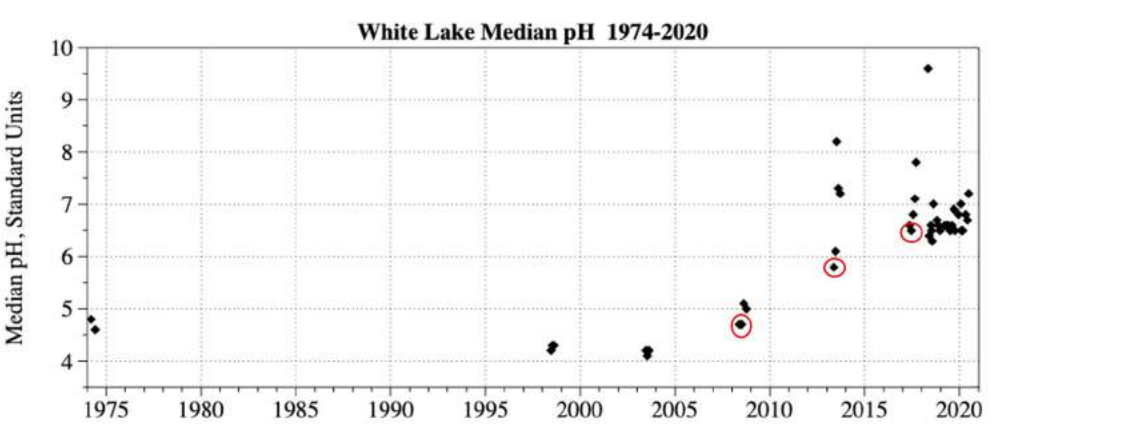


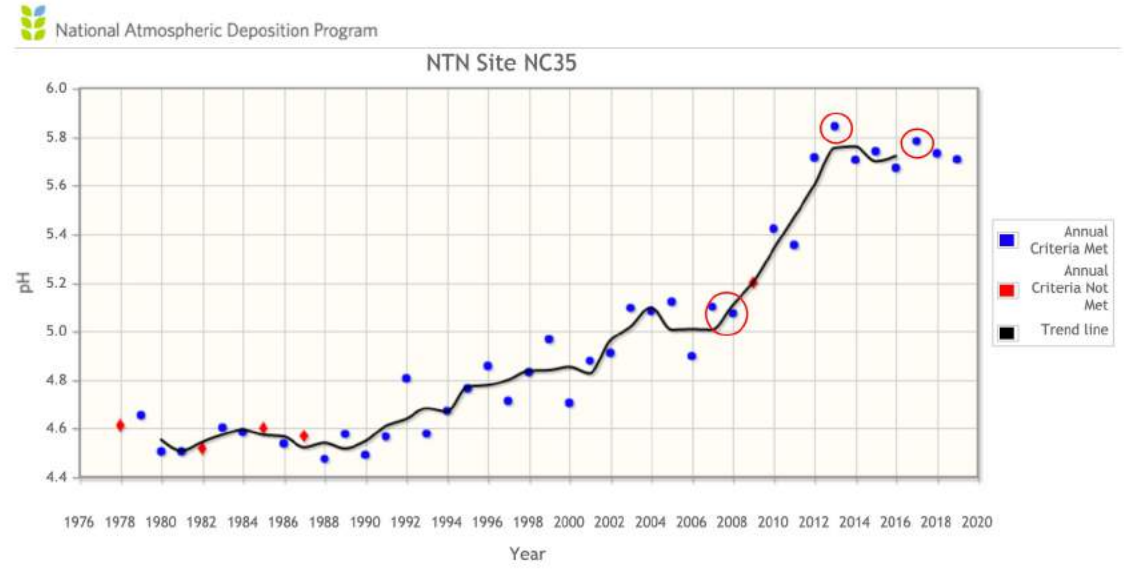
pH, 2016-2018



Data from National Atmospheric Deposition Program, US EPA Clean Air Status and Trends Network (CASTNET)

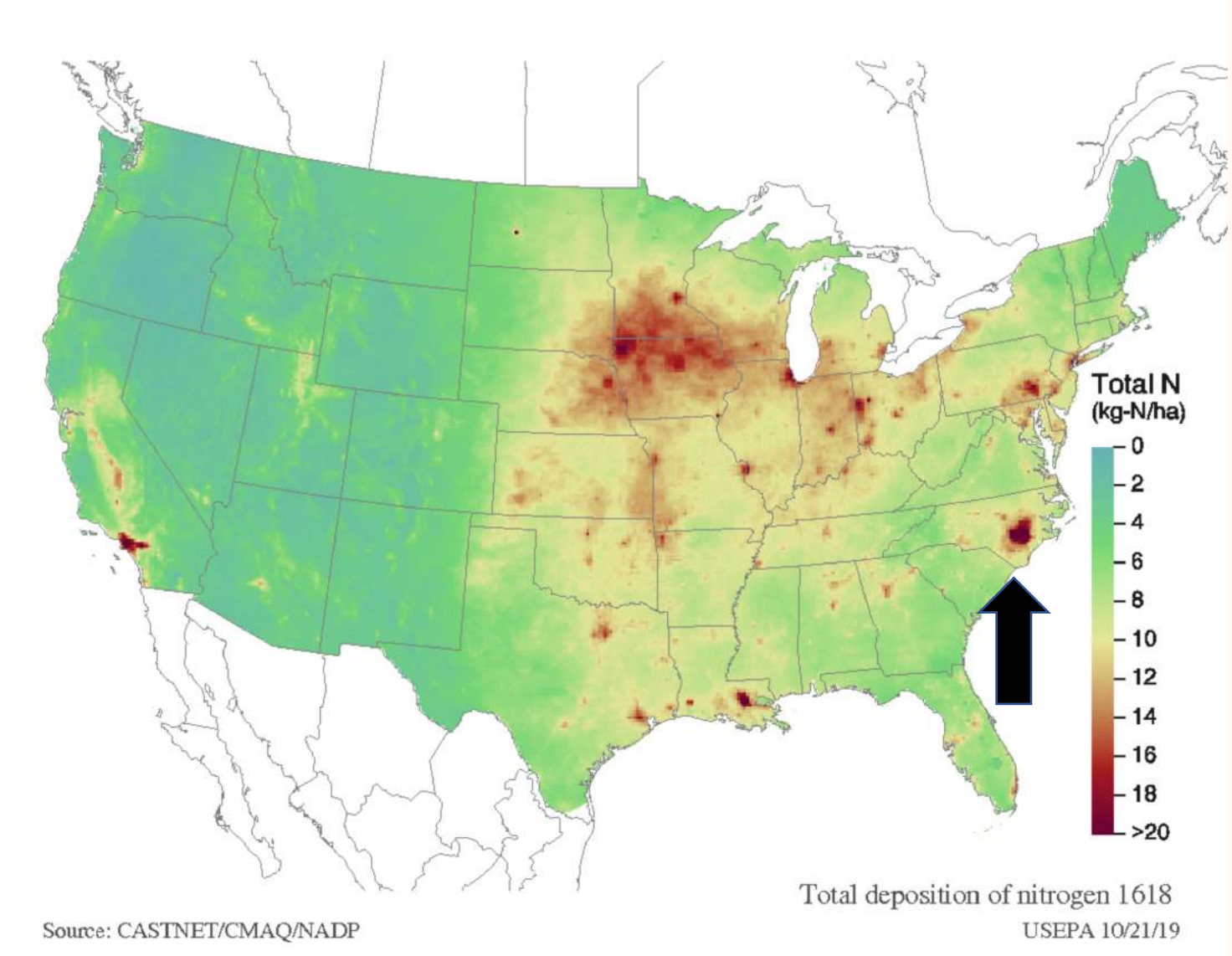
pH Changed in Lake as pH Changed in Rain





Increase in White Lake's pH levels over same period as rainfall pH increased at nearby NADP station (NC 35, at Clinton)

Atmospheric Change: A Nitrogen Hot Spot in NC



Reduction in NO_x (acid)

4x Increase in NH_3 (base)

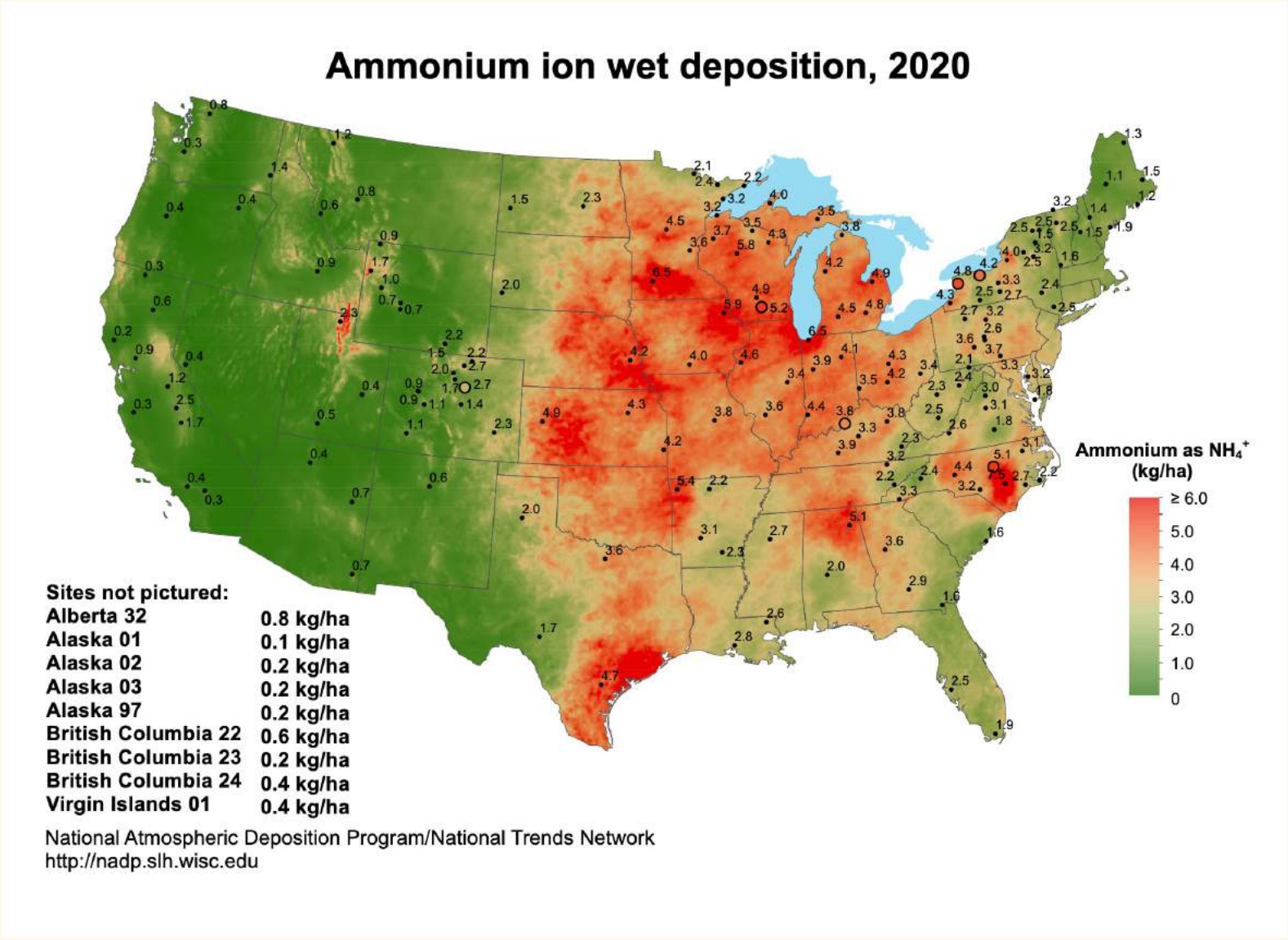
Dry Deposition High

TN Deposition = Wet + Dry
in kg-N/ha/year
(2018 Data)

Data from National Atmospheric Deposition Program, US EPA Clean Air Status and Trends Network (CASTNET)

High Ammonium Deposition

2020 annual deposition level was 7.5 kg/ha at Clinton monitoring station

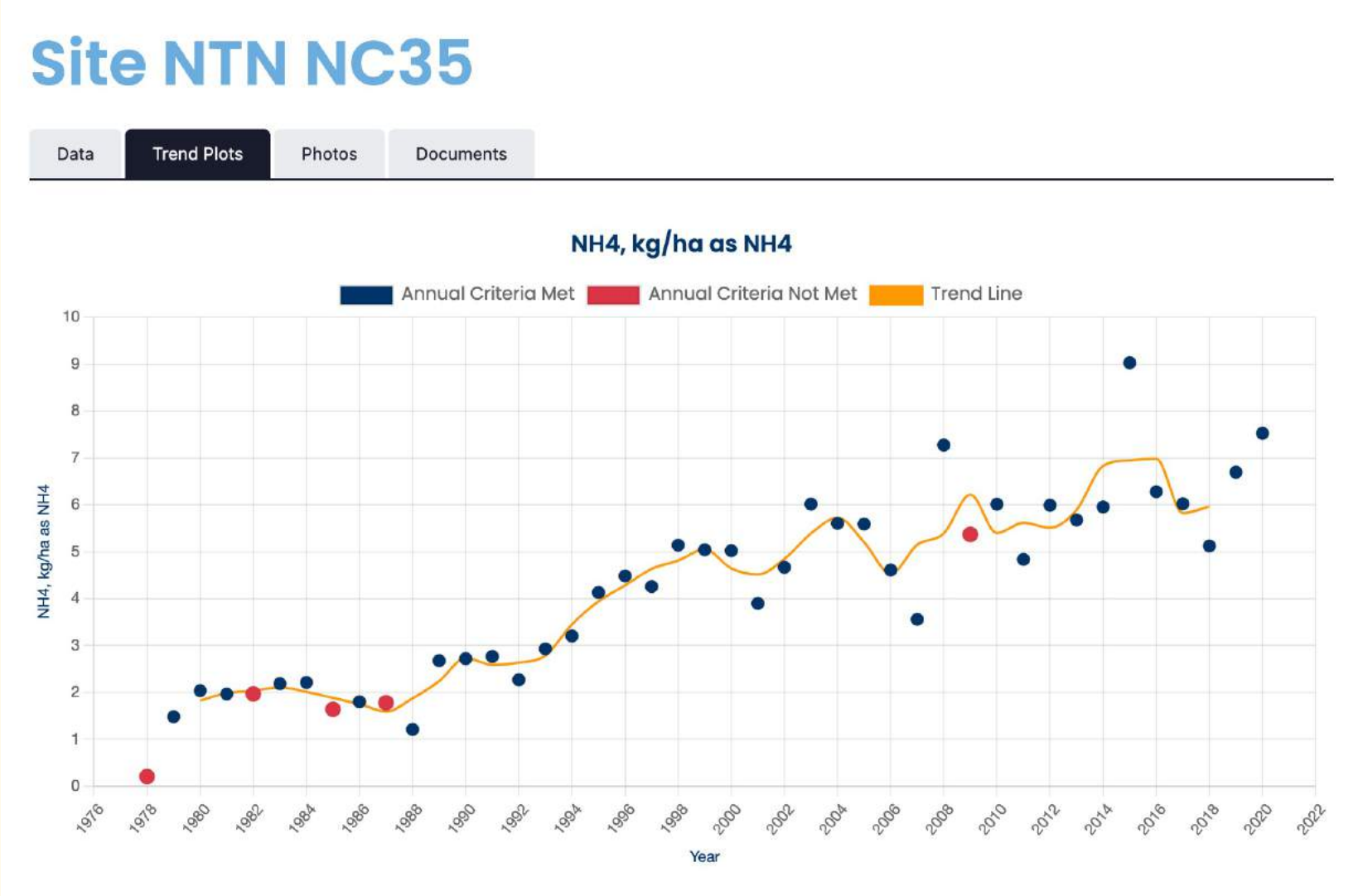


Data from National Atmospheric Deposition Program, US EPA Clean Air Status and Trends Network (CASTNET)

Ammonium Deposition Trend Plot

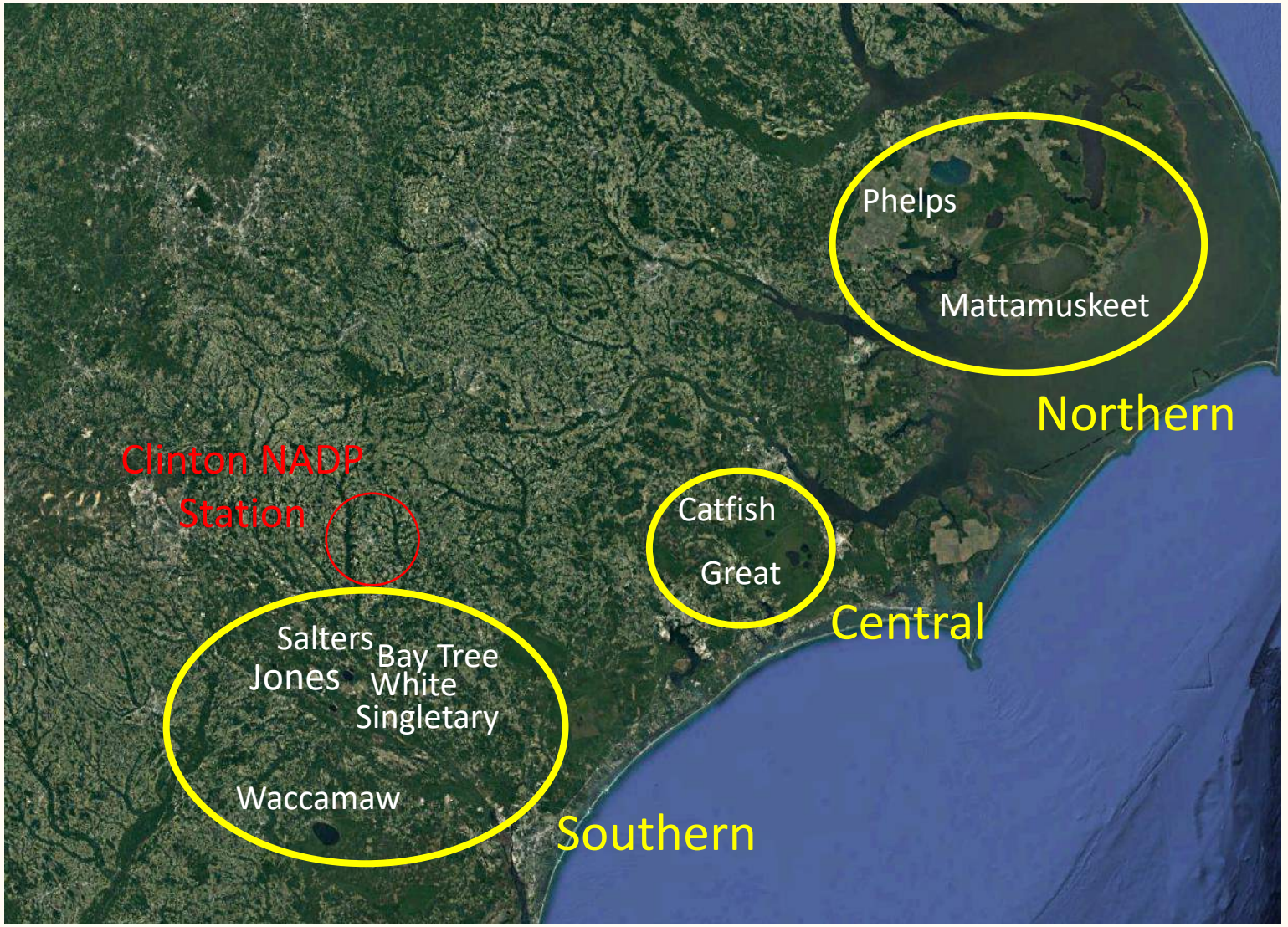
Site NTN NC35 is Clinton NADP monitoring station—close to Bay Lakes

Increase over time, with more annual variability



Data from National Atmospheric Deposition Program, US EPA

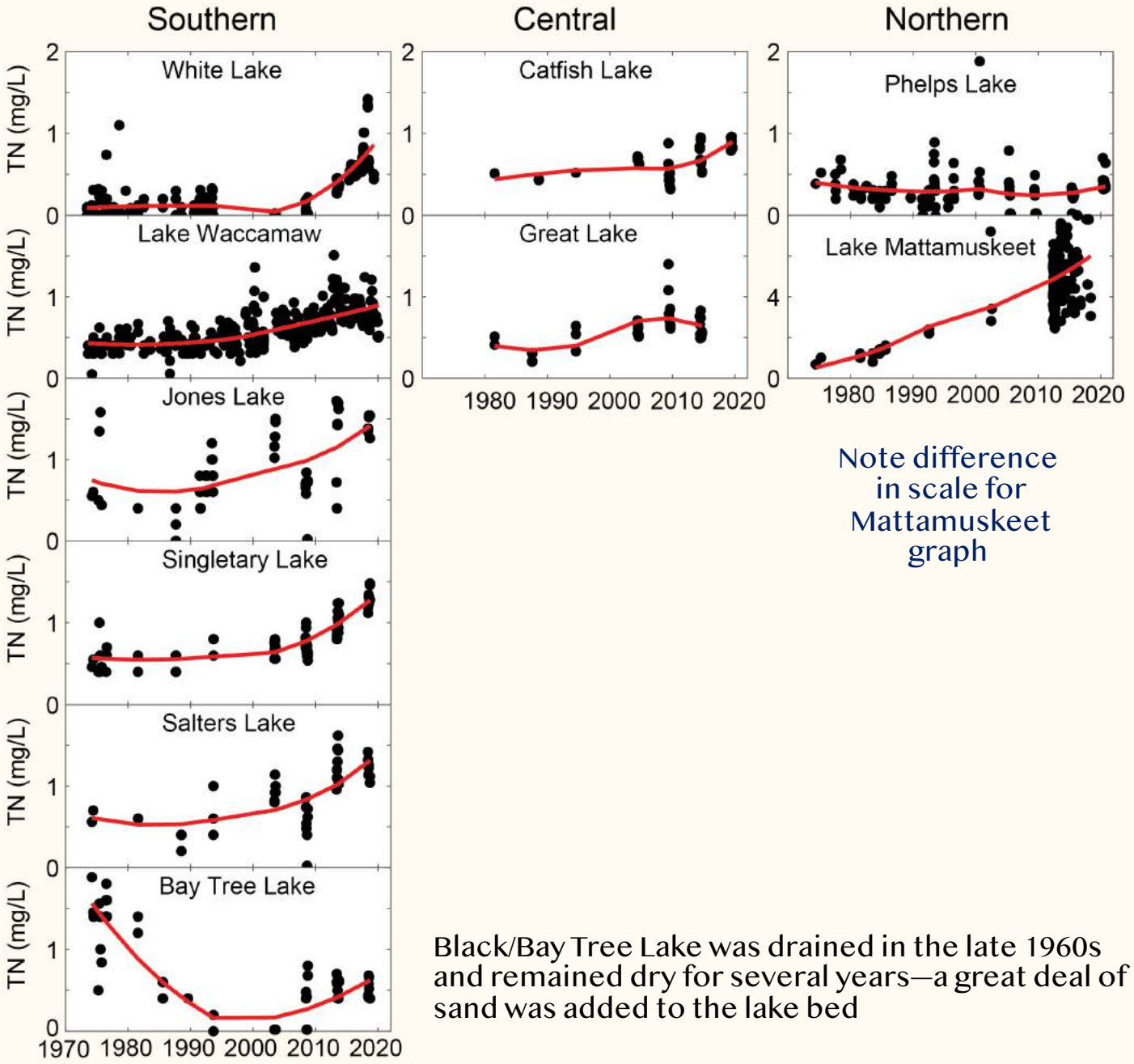
Comparing Bay Lakes Nitrogen Trends Over Time



Bay Lakes Total Nitrogen

Historical Data from: Weiss and Kuenzler (1976), US EPA (1975), NC Division of Water Resources Ambient Monitoring Program (1980-2018)

No similar trend for P



Note difference in scale for Mattamuskeet graph

Black/Bay Tree Lake was drained in the late 1960s and remained dry for several years—a great deal of sand was added to the lake bed

Nutrients in Rainfall and in White Lake

White Lake Rainfall Nutrients 2020-2021

DATE	RAIN (inches)	TP (mg/L)	TN (mg/L)	NH3-NH4 (mg/L)	NO3-NO2 (mg/L)	DIN % TN	RAIN TN/TP (mass)		LAKE NH3-NH4 (mg/L)	LAKE TN/TP (mass)
2/13/20	0.25	0.017	0.586	0.159	0.082	41%	34.5		0.044	27.9
3/5/20	1.25	0.012	0.302	0.123	0.049	57%	25.2		0.050	22.6
4/23/20	0.25	0.008	0.190	0.107	0.068	92%	23.8		0.033	26.3
5/29/20	3.3	0.045	1.35	0.410	0.328	55%	30		0.037	40.3
9/17/20	2.5	0.007	0.385	0.176			55			40.4
11/12/20	2.75	<0.002	0.202	0.018	0.011	14%				
8/18/21	0.75	<0.002	0.190	0.029	0.059	46%			<0.010	30.5

Rain is a Source of Bioavailable P and N

Total Phosphorus Range = <0.002 to 0.045 mg/L

Total Nitrogen Range = 0.19 to 1.35 mg/L
Ammonium Range = 0.018 to 0.410 mg/L
DIN as % of TN = 14 to 92%

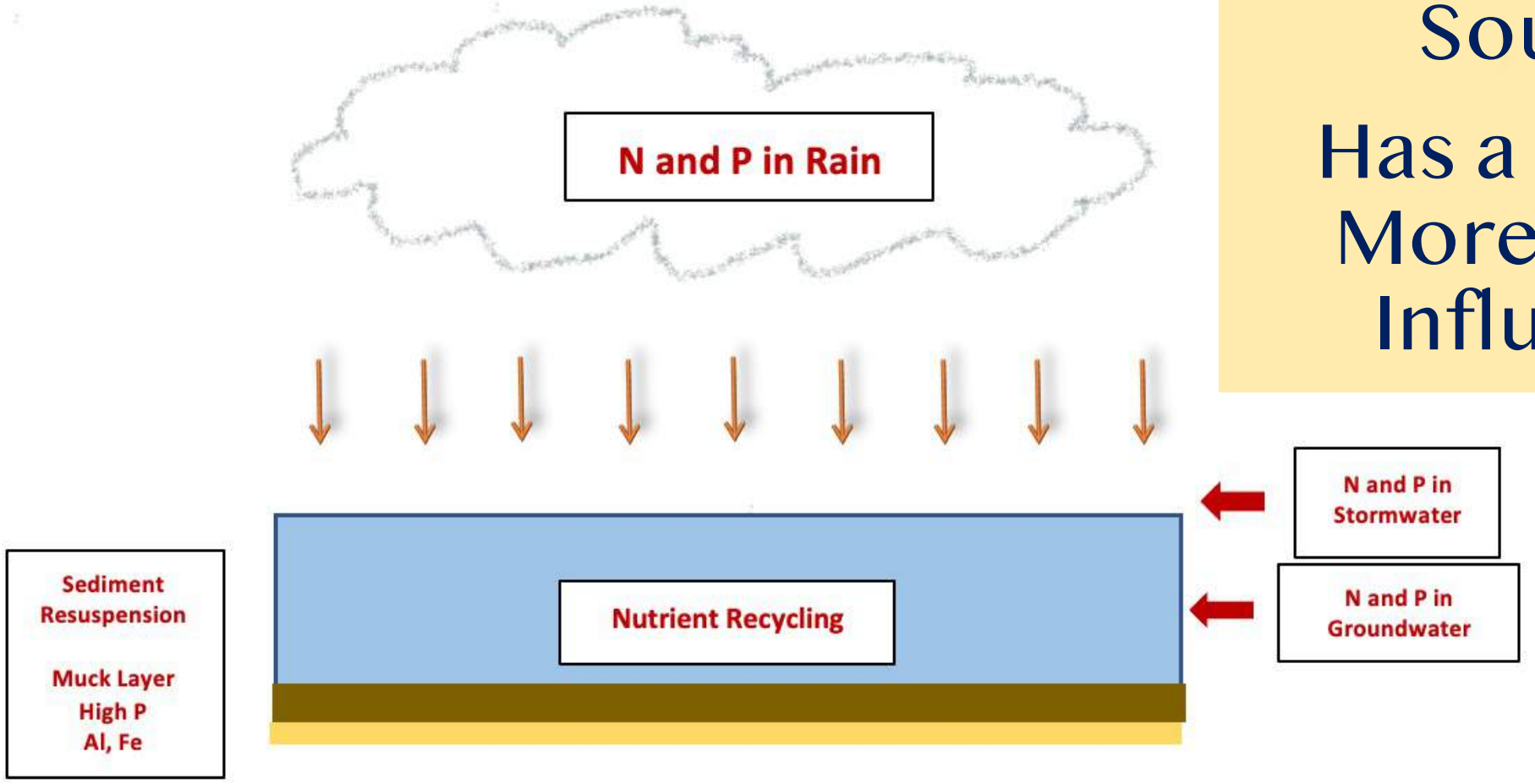
Rain TN/TP (mass) Range = 24 to 55

White Lake TN/TP (mass) Range (Feb-Apr 2020) = 22 to 40
Historical TN/TP (mass) for White Lake = 12

Big Rains (3”+) More Common

Rainfall is a Diffuse Nutrient Source

Has a Larger, More Rapid Influence

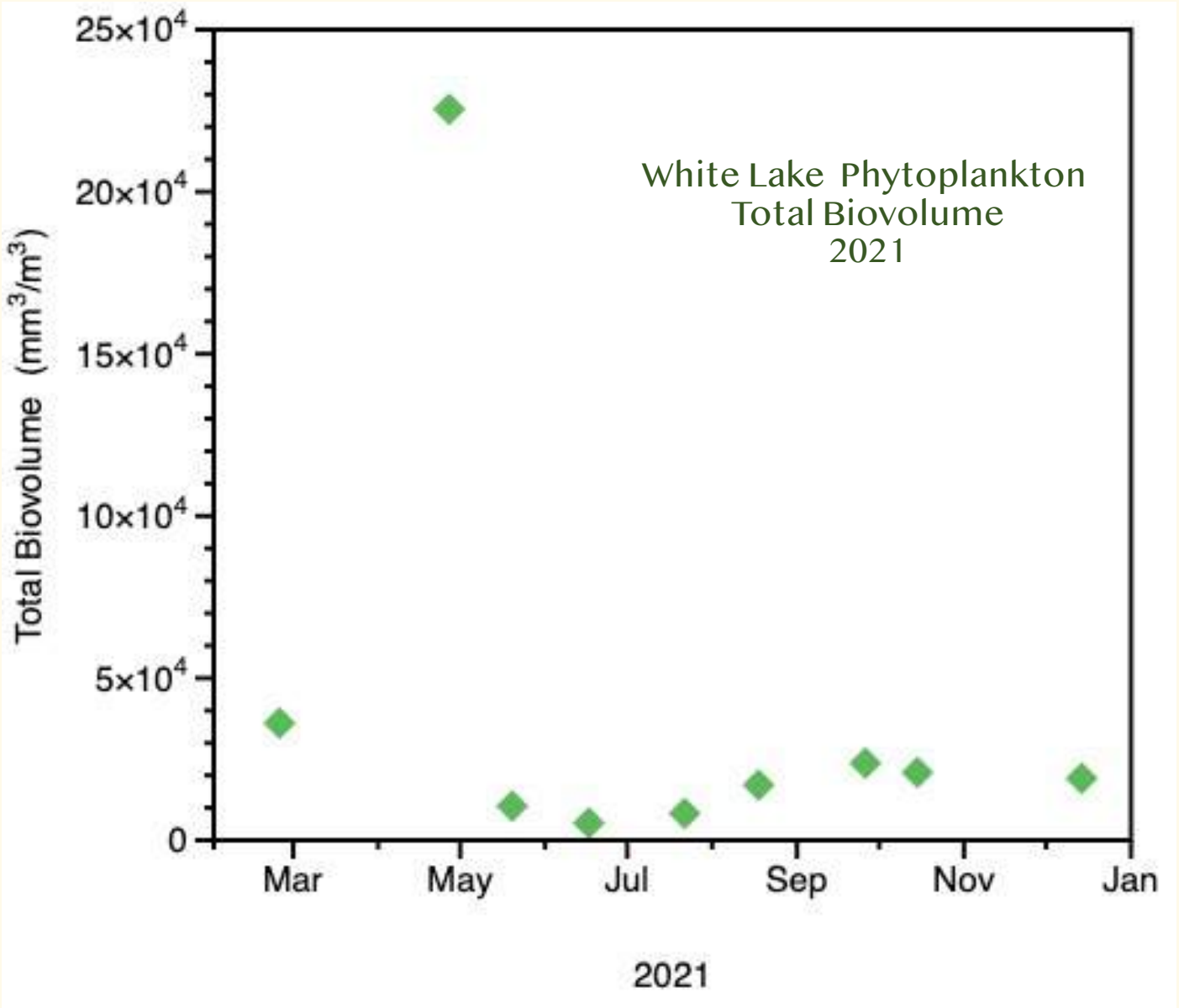


Phytoplankton Response to N in Big Rains

Two >3” rains in February 2021

Bloom of a small desmid, *Cosmarium tinctum*

>90% of Total BV in April



April 2021 Desmid Bloom, and April 2022 Clear Water Conditions (No Big Winter Rains, DIN)

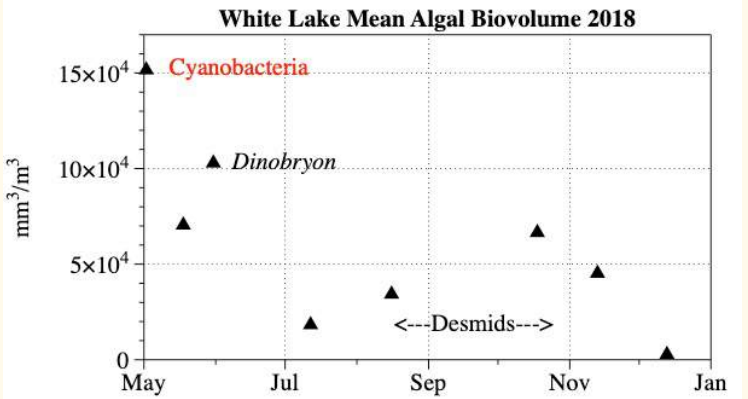
Same Place, March 2018 Filamentous Cyanobacterial Bloom Persisted Through the Winter

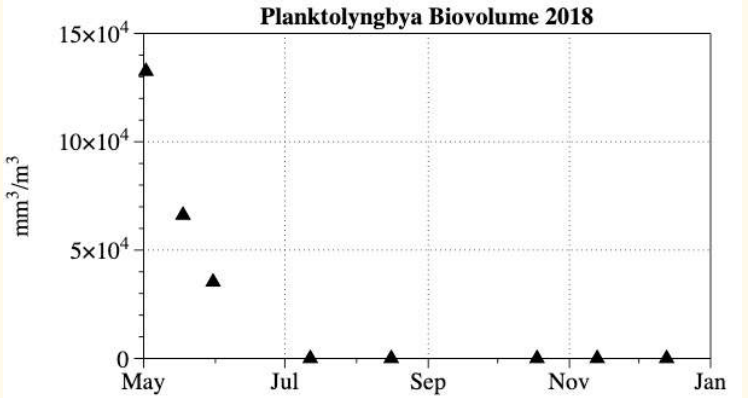
Low-dose Water Column P-stripping Alum Treatment Applied to White Lake May 3-16, 2018

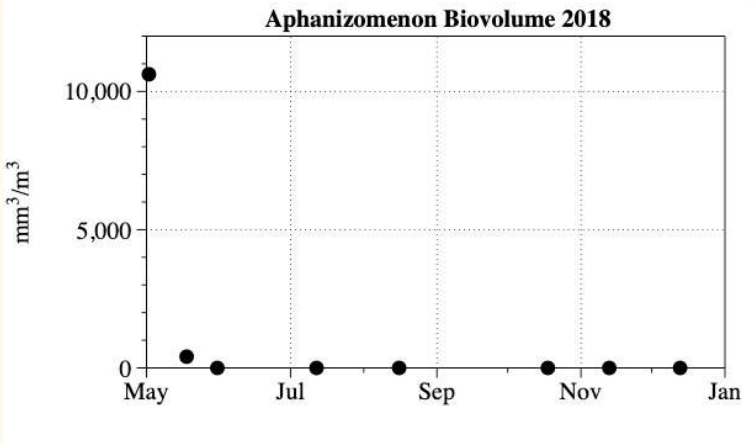
Filamentous Cyanobacteria Eliminated After Treatment

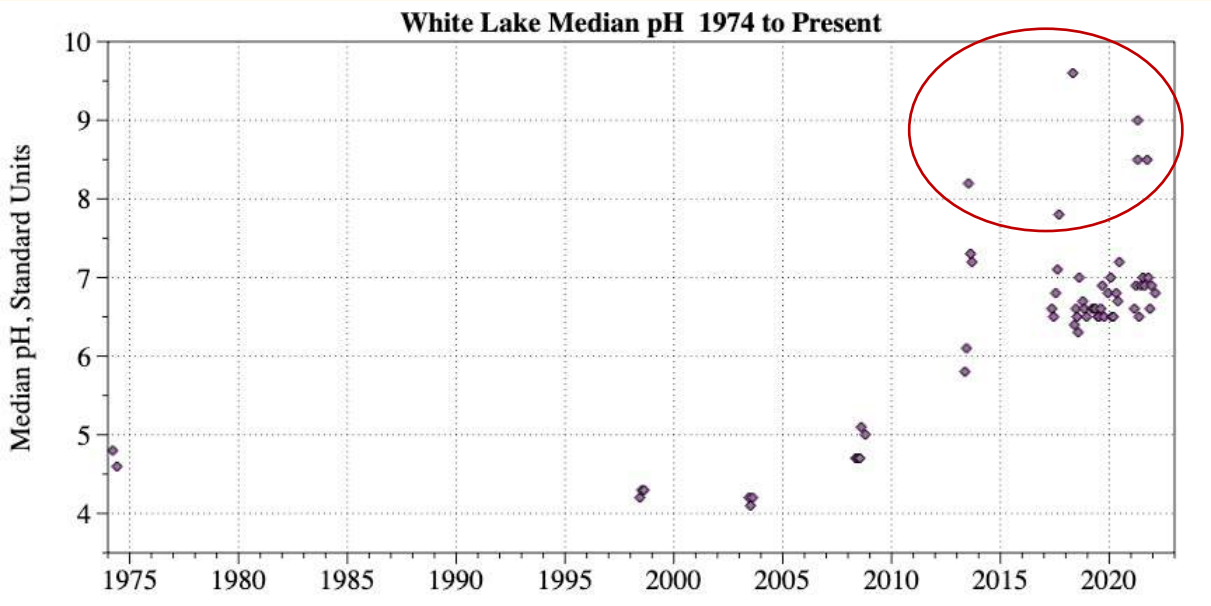
Desmids, Greens, Chrysophytes Generally Dominate Phytoplankton Biovolume

Phytoplankton Diversity Is Increasing









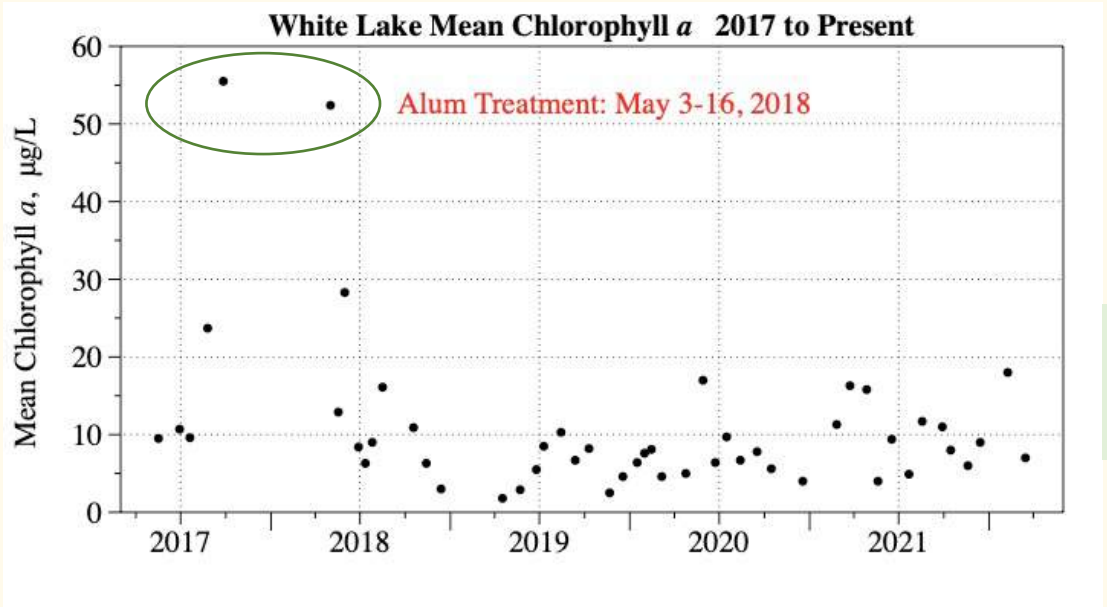
Alkalinity Very Low, pH Can Spike During Blooms

Fish Kill Started as 2018 Alum Treatment Started (pH +2 units in 2 Weeks)

Shallow, Well-Mixed Lake, No pH Refuge

pH Spike in April 2021 (+0.5 in afternoon, to 9)

Highest Chlorophyll a Values Associated with Filamentous Cyanobacterial Bloom— Sept 2017 to May 2018



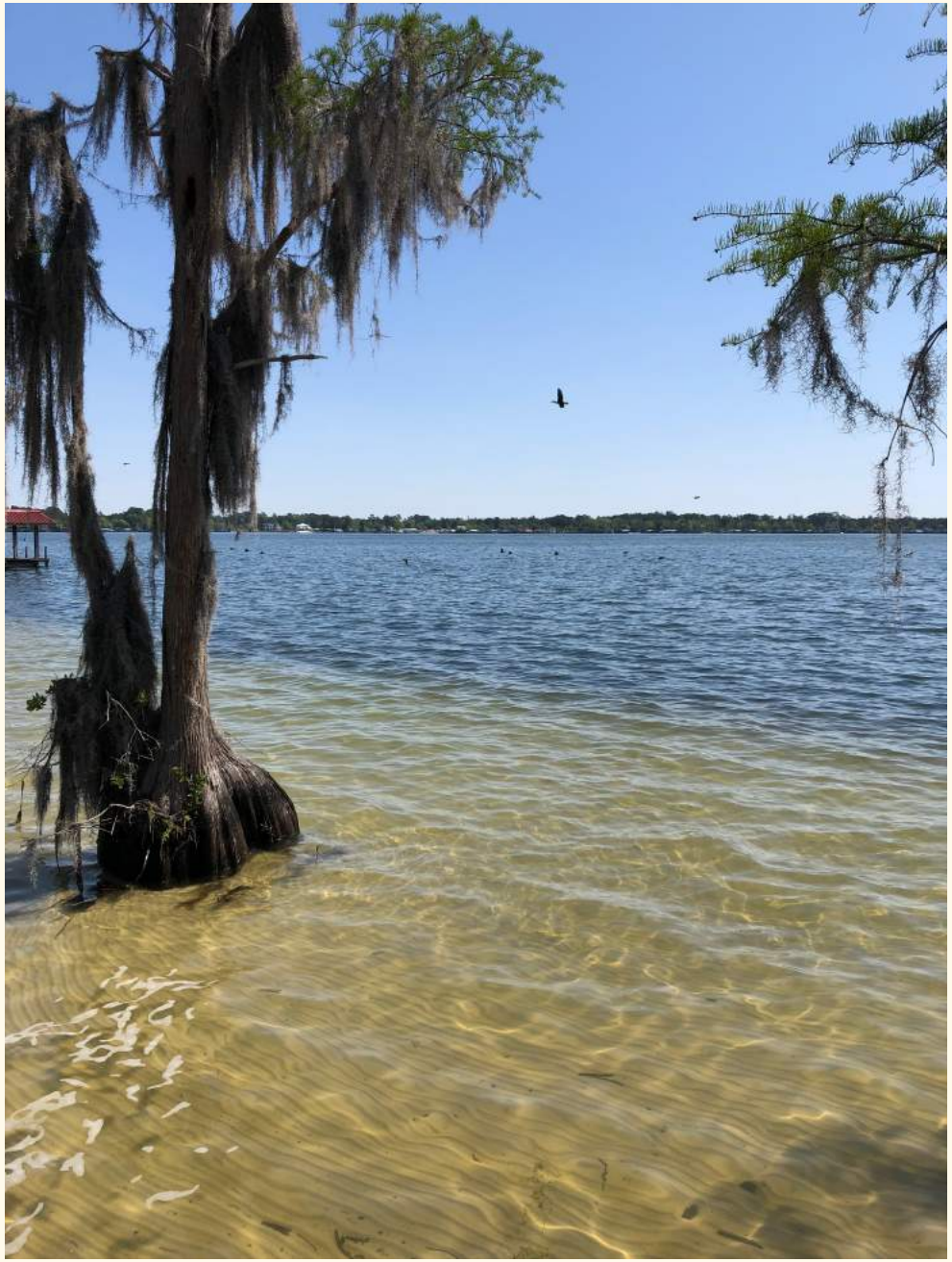
Feb 2022
Gonatozygon
(desmid)

A Healthy, Less Acidic, More Productive White Lake

Unusual aquatic communities:
Desmids,
Aquatic Vegetation

Periods of clarity are a gift, not a given

A challenging message!



Thanks to the Town of White Lake, NC State Parks, and the many scientists who have worked at White Lake

In memory of a grand limnologist, David Frey

White Lake Watch www.whitelakewatch.com