National Lakes Assessment: Reporting on the Condition of the Nation's Lakes

A Watershed Academy Webcast

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The Watershed Academy

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Overview of Today's Webcast

Objective: Present key findings of the first National Lakes Assessment (NLA), provide some technical detail, and highlight policy implications.

Presenter: Sarah Lehmann	Presenter: Neil Kamman
▪ National Aquatic Resource Surveys ▪ Design of the NLA ▪ Extent of Lakes and Reservoirs ▪ NLA indicators ▪ Overall results of the NLA	▪ Sampling Approach and Field Work ▪ Reference Condition ▪ Trophic and Recreational Condition ▪ Chemical Stressors ▪ Physical Habitat ▪ Biological Assessment of Taxa Loss ▪ Relative Extent of Stressors and Attributable Risk ▪ Assessment of Change

National Lakes Assessment Overview and Purpose

Sarah Lehmann, U.S. EPA Office of Water

The National Aquatic Resource Surveys (NARS)

- Reasons for the national surveys:
  - CWA Section 305(b) reports do not tell a comprehensive national water quality story
  - States cannot directly compare their conditions to those of adjoining states or in relation to regional conditions
- Benefits of national surveys:
  - EPA: NARS yield complementary assessments of condition in light of broad national initiatives
    - Address key gaps cited by GAO and other independent reviews
  - States: NARS provide regionally explicit statements of condition against which state conditions can be compared

The National Aquatic Resource Surveys (NARS)

- NARS promote State and Tribal capacity for monitoring and assessment
  - Conducted in partnership with states and tribes -- states and tribes, or contractors, carry out the sampling
  - Offer opportunity for state-scale surveys – about 10 states enhanced their NLA assessments with state-scale surveys
  - Establish new monitoring approaches and assessment tools
  - Promote consistency in cross-jurisdictional assessment of water quality

Purpose of National Aquatic Resource Surveys

- Meet Clean Water Act requirement to report on the condition of waters of the U.S.
  - Unbiased estimate of condition based on randomly selected, representative subset of waters
  - Report on core indicators with regional supplements
  - Standardized or comparable methods
- Provide information on key questions:
  - Extent of waters supporting healthy ecosystems, recreation?
  - Extent of resource affected by key water quality problems/stressors?

Basic Components of Surveys

- Randomized design to report on conditions of each resource at national, regional, and state (optional) scale
  - 1,000 sites for national & regional scale in lower 48 states
- Standard field and lab protocols for core indicators
- National QA program and data management
- Nationally consistent and regionally relevant data interpretation and reports

National Aquatic Resource Surveys: A five year recurring cycle

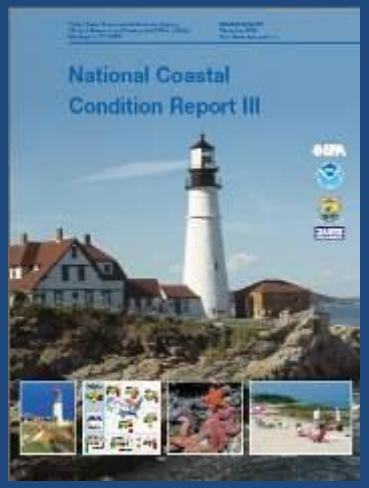
→'07 Lakes

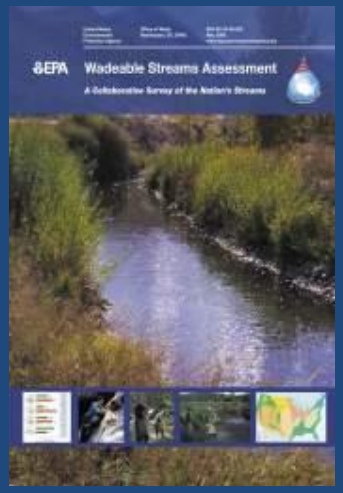
→'08 wadeable streams

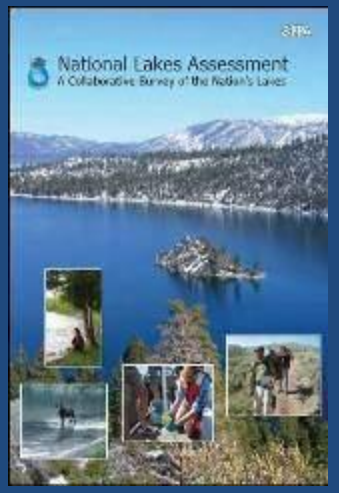
→ '09 large rivers

→'10 coastal estuaries

→'11 wetlands







National Aquatic Resource Surveys: The Survey Team

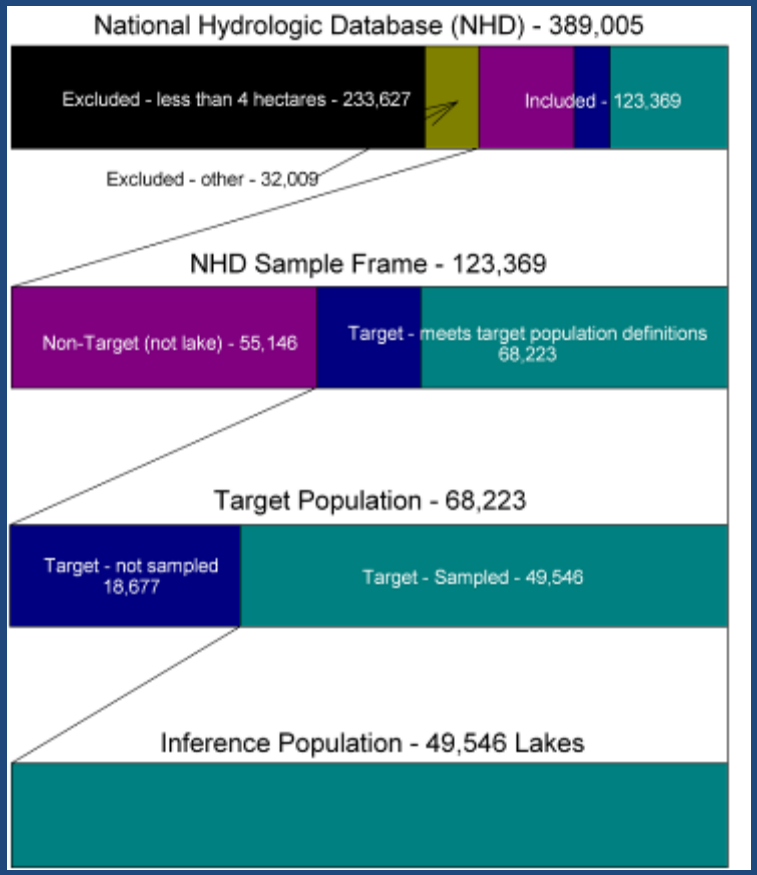
- EPA – Office of Water/Office of Research and Development
  - Administers survey, coordinates pilot surveys and initial design
  - Design survey, manage and analyze data
- State and Tribal Partners
  - Conduct survey, serve on steering committee, state liaison
- Other partners include Federal agencies (USGS, NPS, USFWS), academic partners

National Lakes Assessment is the latest National Aquatic Resource Survey

- First-ever nationally-consistent assessment of the nation's lakes, ponds and reservoirs
  - Biological and habitat condition
  - Recreational condition
  - Trophic state
- The 1,028 unique lakes sampled – plus 124 hand-selected reference lakes, and 100 resample visits – describe the condition of about 50,000 lakes nationwide

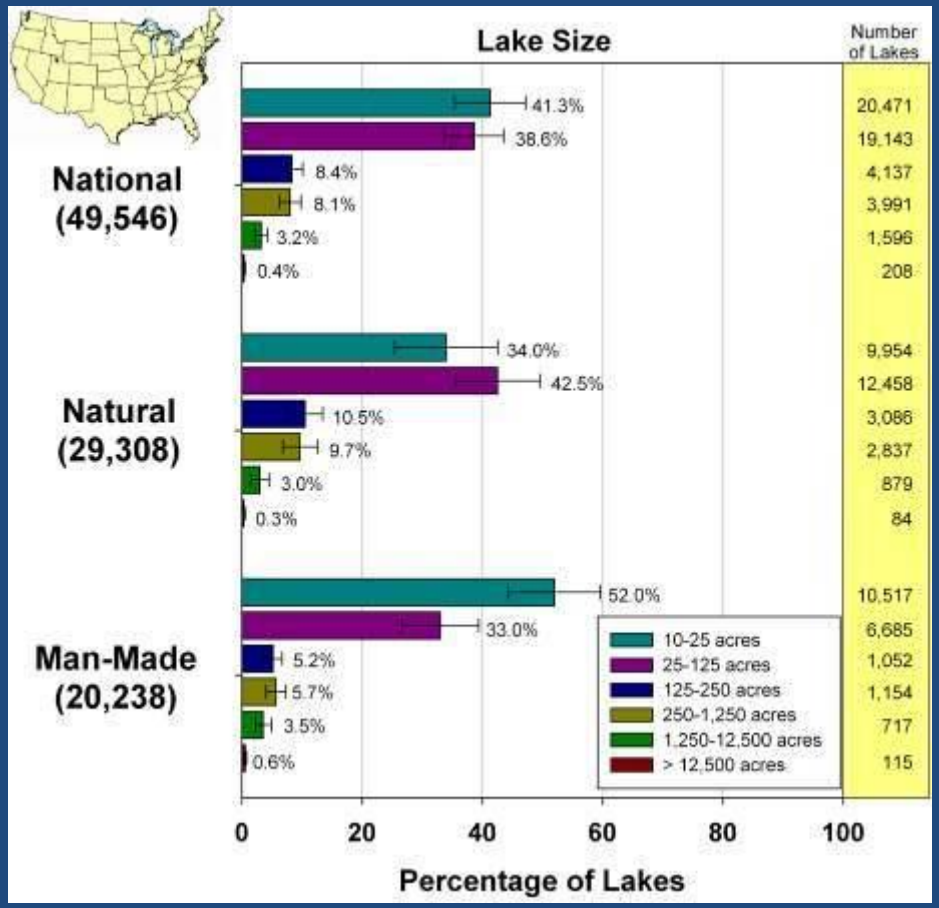
National Lakes Assessment: Design of the Survey

- Lakes selected from National Hydrography Dataset (NHD), leveraging statistical survey methodology
  - Target lakes/reservoirs: >4 ha, >1m deep, non-saline, >0.1 ha open water
  - Stratified by size, state, and level-III ecoregion
  - 200 National Eutrophication Survey lakes revisited during the NLA sampling year to assess changes between 1972 and 2009



The NLA represents:

- 49,560 “lakes”
- 59% natural origin
- 41% constructed



National Lakes Assessment: Selected Indicators

- Biological Integrity
  - Planktonic Index of Taxa Loss
  - Diatom Index of Biotic Integrity
- Trophic State
- Recreational Use
  - Occurrence of microcystin
  - Risk of cyanotoxin exposure
  - Enterococci
- Habitat Quality
  - Lakeshore Vegetation Cover
  - Littoral Quality
  - Human Shoreline Disturbance
- Chemical stressors
  - Nutrients
  - pH
  - DO
  - Salinity
- Change over time
  - Sediment diatom cores

Key NLA Findings

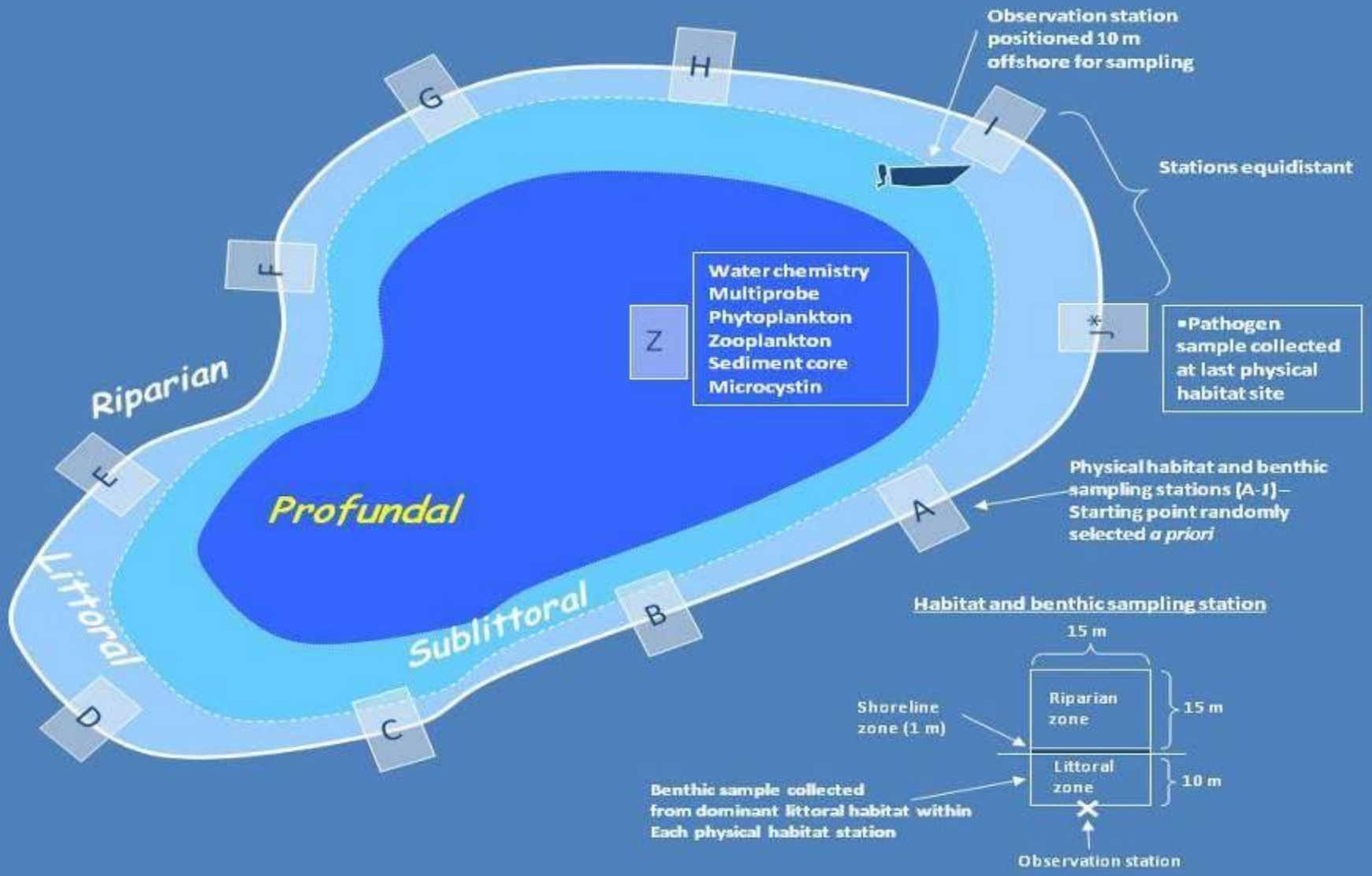
- Condition of the nation's lakes
  - 56% support healthy biological communities
  - Microcystin detected in 30% of lakes and at levels of concern in 1%
  - Parallel study finds that 49% of the nation's lake have fish tissue mercury concentrations that exceed health based limits.
- Key stressors affecting quality
  - 36% of lakes have poor shoreline habitat; poor biological condition is 3 times more common in these lakes
  - 20% percent of lakes have high levels of nitrogen or phosphorus; poor biological condition is 2.5 times more common
- Trends of National Eutrophication Survey (NES) Lakes (1972→2007)
  - 50% of NES lakes showed decreases in phosphorus concentrations

Questions?

National Lakes Assessment Detailed Findings

Neil Kamman, Vermont Department of Environmental Conservation

National Lakes Assessment: Sampling Approach



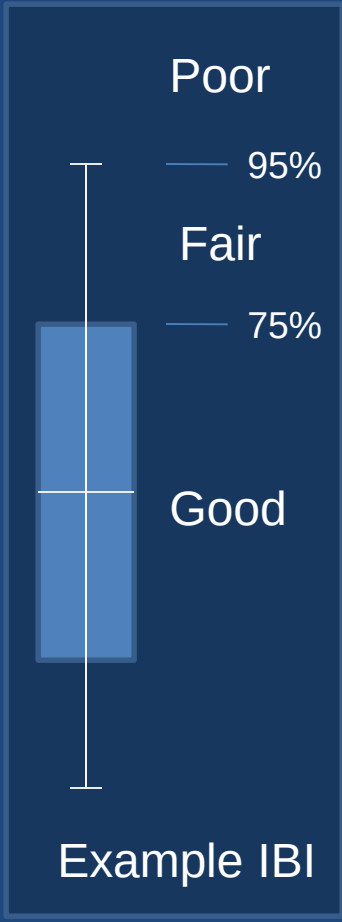
In the Field - Summer 2007…

"At the end of the season, field crews collected 8,536 water and sediment samples; took over 5,800 direct measurements, and recorded in excess of 620,000 observations."

Determining Thresholds: Setting the Bar

For the NLA, two types of thresholds were used to determine condition:

- Nationally-consistent thresholds
  - Fixed values correspond to assessment findings
  - Applied to trophic state and recreational condition
- Regionally reference-based thresholds
  - Fixed percentile defines good/fair and fair/poor
  - Applied to bioindicators, some habitat indicators and some stressors



Determining Thresholds: Setting the Bar

- Two sets of reference lakes:
  - Biological
  - Nutrient

- Reference lakes identified in two steps:
  - Classify into common types
  - Screen using regionally explicit criteria
  - All lakes screened (probability and hand-selected)
  - Lakes that pass criteria comprise the set of reference lakes.

Setting the Bar: Biological Reference Lake Screening Process

Step 1

Cluster analysis:

Elevation
Lat-Long
Precipitation
Mean ann. temp.
Shoreline dev.
Lake size/depth

Step 2

- TP
- TN
- CL
- SO4
- Turb
- ANC (given DOC)
- Euphotic Zone DO
- Shoreline disturbed by Ag
- Shoreline disturbed by non-Ag
- SD – Intensity and extent

	PTL	NTL	CL
A	12	400	200
B	10	300	250
C [1, 2]	15	500	250

Pass all = ref

Setting the Bar: Nutrient Reference Lake Screening Process

Step 1

- Begin with nutrient ecoregions
- Pool certain alike regions to obtain sufficient counts of sampled lakes
- Separate reservoirs from natural lakes in one instance

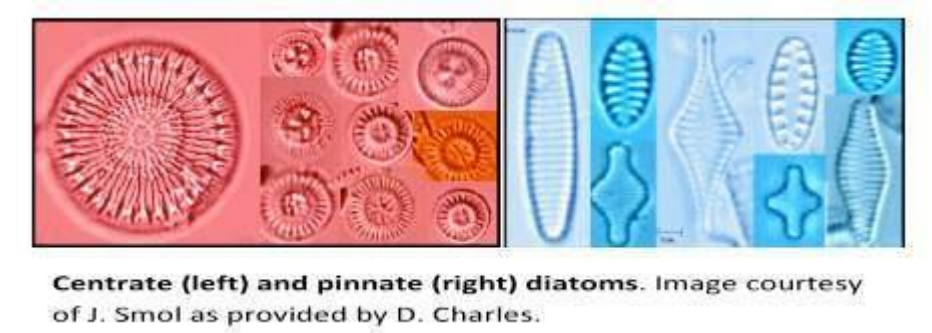
Step 2

- ~~TP~~
- ~~TN~~
- ~~Turb~~
- CL
- SO4
- ANC (given DOC)
- Euphotic Zone DO
- Shoreline disturbed by Ag
- Shoreline disturbed by non-Ag
- SD – Intensity and extent

Nutrient Ecoregion	Chloride (ueq/L)	Sulfate (ueq/L)	Habitat ag disturb	Habitat non-ag disturb	Habitat Ex1a disturb	Assess ag	Assess resid	Assess ind
Coastal Plain	>1000	>400	>0	>0.6	>0.6	>4	>9	>4
II. Western Mts.	>20	>50	>0	>0.2	>0.2	>4	>4	>4
III. Xeric West	>500	>10000	>0.1	>0.6	>0.6	>6	>6	>6
IV. Grass Plains-Man-made	>1000	>10000	>0.2	>0.6	>0.6	>9	>9	>9
IV. Grass Plains-Natural	>400	>400	>0	>0.1	>0.1	>5	>5	>5
IX. SE Plains/Piedmont	>200	>400	>0	>0.4	>0.4	>4	>9	>4
V. Cultivated Great Plains	>1000	>10000	>0.2	>0.6	>0.6	>9	>9	>9
VI. Temperate Plains	>1000	>10000	>0	>0.6	>0.6	>9	>9	>9
VII. Southern Glaciated	>400	>400	>0	>0.6	>0.6	>9	>9	>9
VIII. Northern Glaciated	>20	>200	>0	>0	>0	>4	>9	>4
XI. S. Appalachian Mts.	>500	>500	>0.1	>0.5	>0.5	>9	>9	>9

Biological Condition of the Nation's Lakes

- Index of Biotic Integrity – sediment diatoms
- Model of Taxa Loss – open lake (pelagic) plankton*



Centrate (left) and pinnate (right) diatoms. Image courtesy of J. Smol as provided by D. Charles.

** Primary NLA assessment indicator*

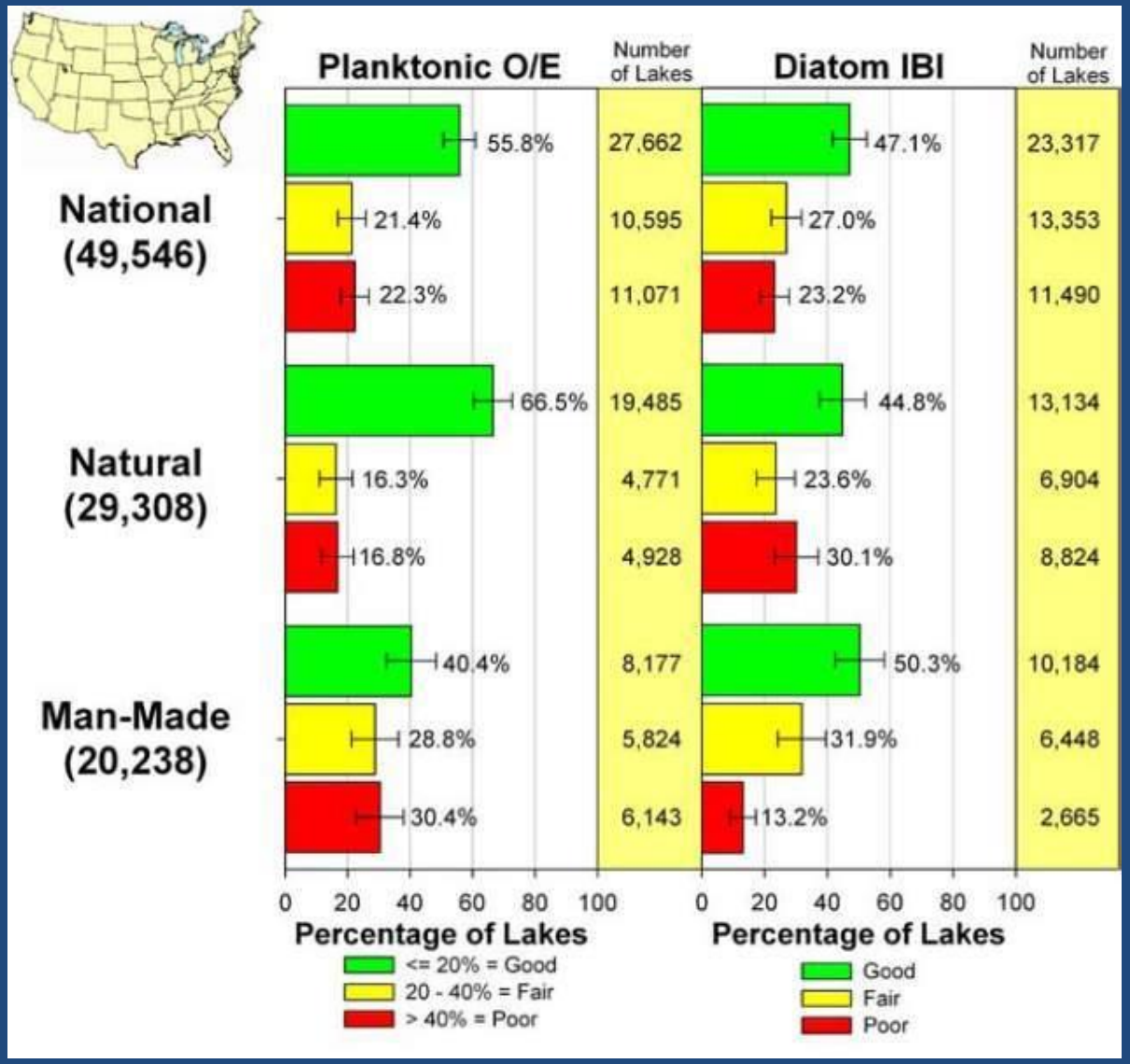
Biological Condition of the Nation's Lakes: Taxa Loss Using an "O/E" Model

- Taxa loss models estimate the taxa Observed at lakes relative to the taxa that are Expected at lakes of a similar type.
  - Process:
    - Reference lakes within regions are classified using physical attributes
    - All lakes are compared to reference classes
    - Expected taxa are determined from the reference lakes, by class
    - Observed taxa are related to expectation
- O/E ranges from near 0 (complete loss) to >1.0 (some benign enrichment evident)

Biological Condition of the Nation's Lakes: Sediment Diatoms

- Index of Biological Integrity (IBI) combines measures of community integrity.
  - Process:
    - Reference lakes are identified within regions
    - A variety of metrics describing the functional and structural attributes of the community are tested
    - Researchers identify those metrics that identify changes from the regional reference lakes that are ecologically relevant
    - IBI is adjusted for natural attributes that affect the community (e.g., depth, lat/long, elevation, pH)
- IBI is scaled to a score of 0-100

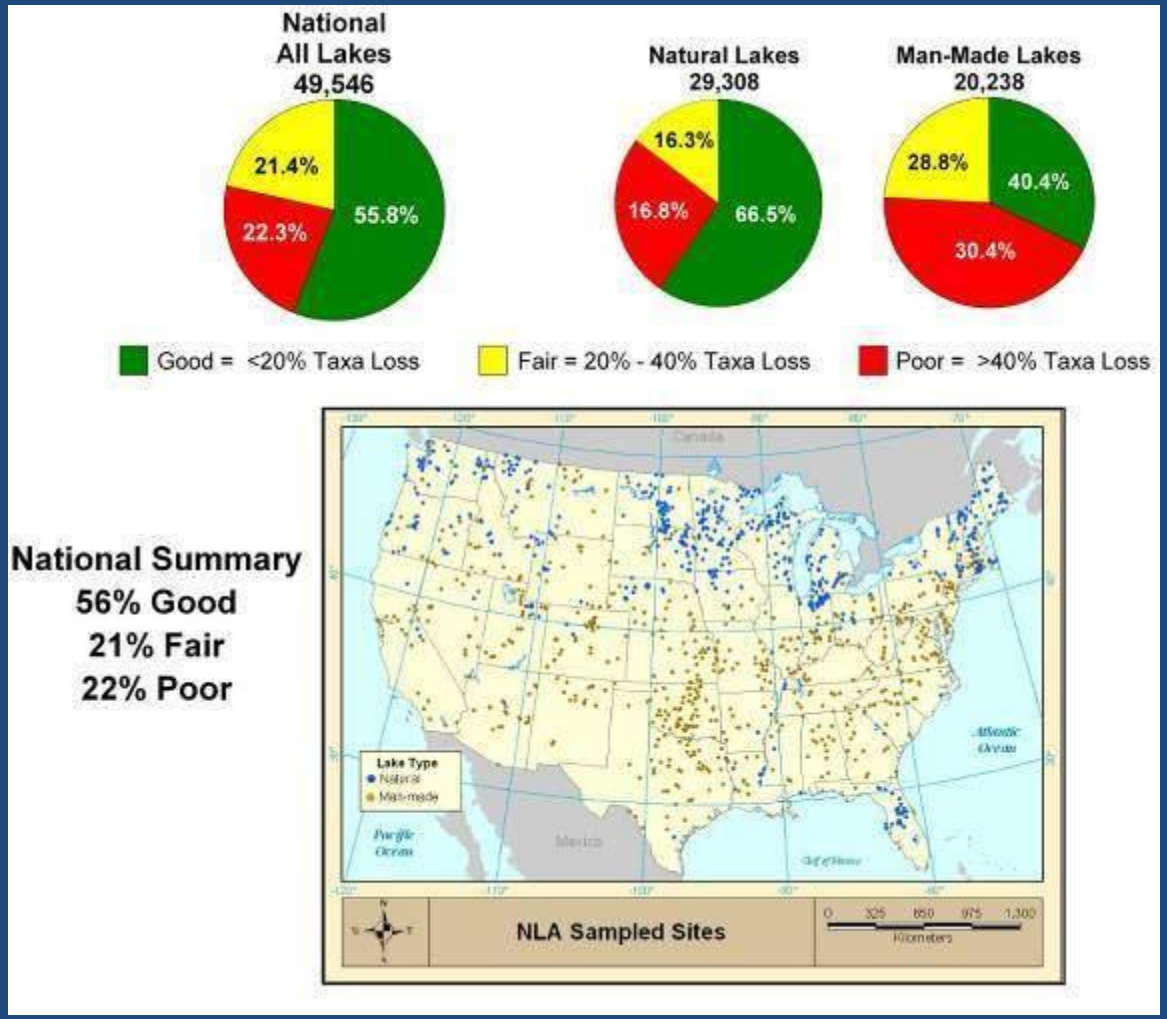
Condition of the Nation's Lakes: Biological Condition



Condition of the Nation's Lakes: Biological Condition Using Taxa Loss Index

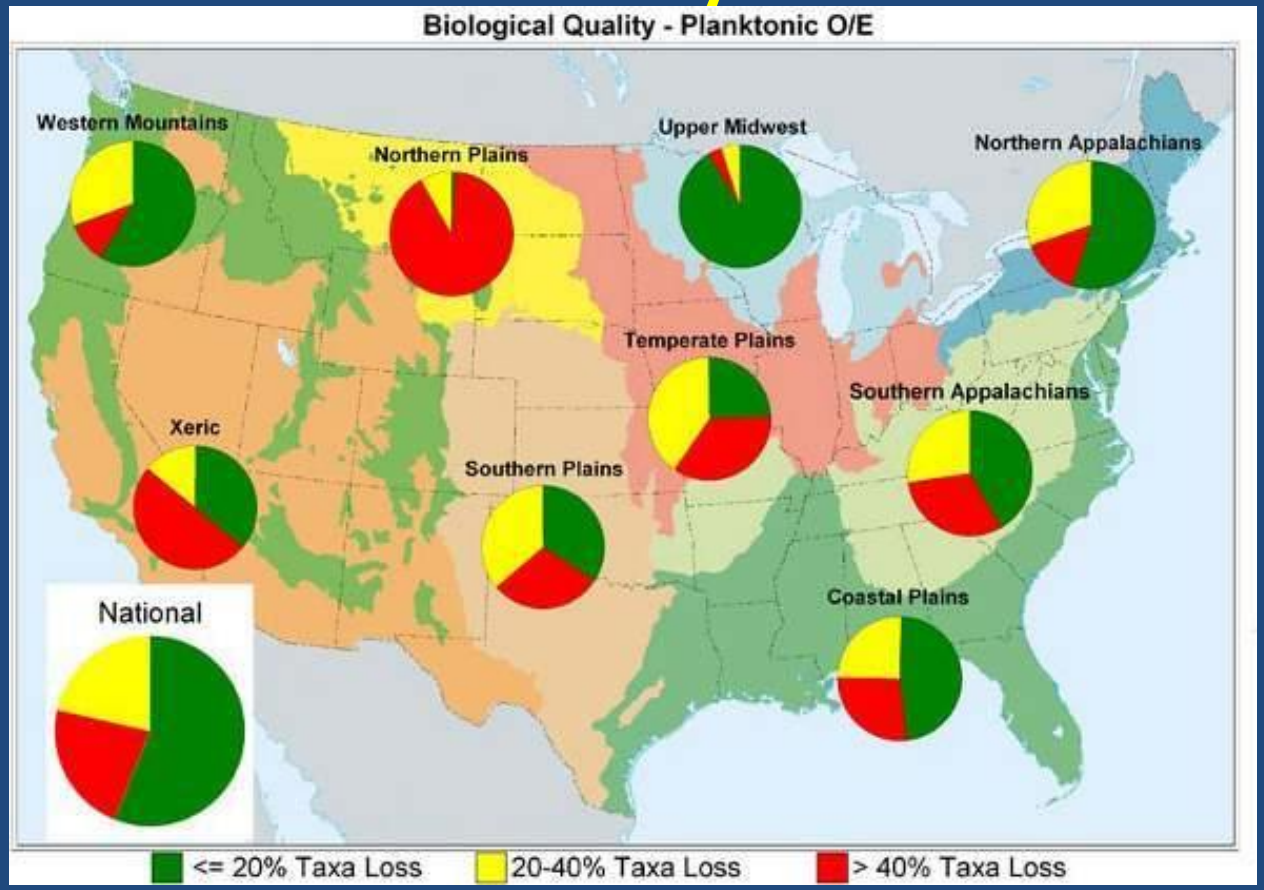
- National Summary:
  - 56% good
  - 21% fair
  - 22% poor

- Consistent national thresholds, but predicated on lake class-specific reference expectations



Biological Condition Varies Across the Country

- Xeric and Northern Plains show the greatest proportion of lakes with excessive taxa loss
- Upper Midwest and Western Mountains have the highest proportion of lakes with low taxa loss.



Questions?

Chemical Stressors in the Nation's Lakes: Nutrients

- Lakes were assessed for their nutrient and turbidity levels using regionally-explicit reference thresholds to determine good, fair, and poor condition

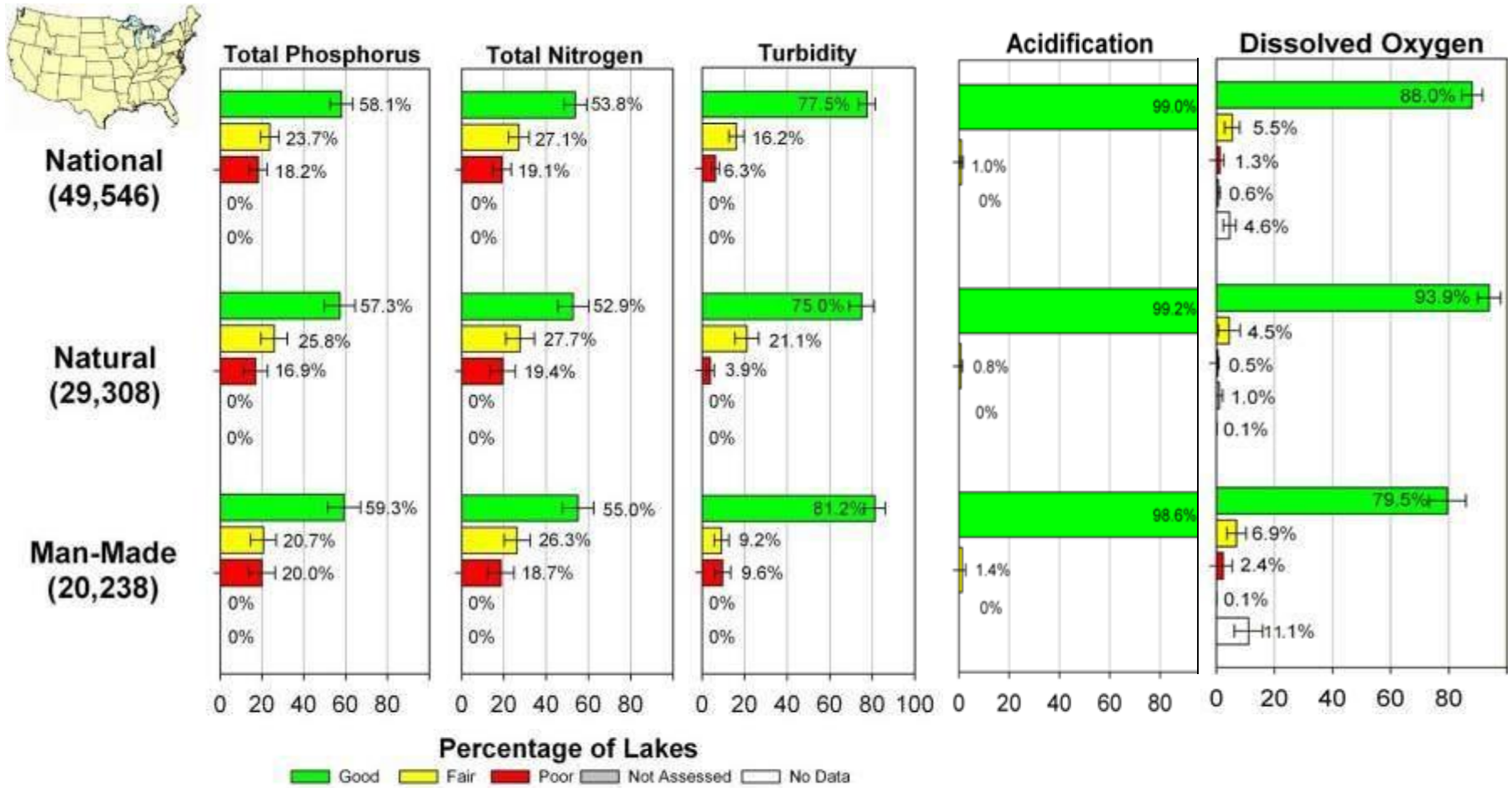
Nutrient Ecoregion	# Ref Lakes	TP (ug/L) Good-Fair	TP (ug/L) Fair-Poor	TN (ug/L) Good-Fair	TN (ug/L) Fair-Poor
Coastal Plain	14	26	75	629	2311
II. Western Mts.	23	15	19	278	380
III. Xeric West	14	48	130	514	2286
IV. Grass Plains-Man-made	9	37	56	513	824
IV. Grass Plains-Natural	6	839	1719	8647	9359

Chemical Stressors in the Nation's Lakes: DO, Acidity

- Lake conditions with respect to dissolved oxygen and acidification were assessed using fixed national thresholds

Oxygen (upper 2 m water column)	**High**	**Moderate**	**Low**
	≥ 5ppm	3-5 ppm	<3 ppm
Acidification	**Non acidic**	**Acidic natural**	**Acidic Anthropogenic**
	>50 ueq. ANC	≤50 ueq ANC (DOC ≤5 ppm)	≤0 ueq. ANC (DOC ≤ 5ppm)

Chemical Stressors in the Nation's Lakes: Nutrients, DO, Acidity

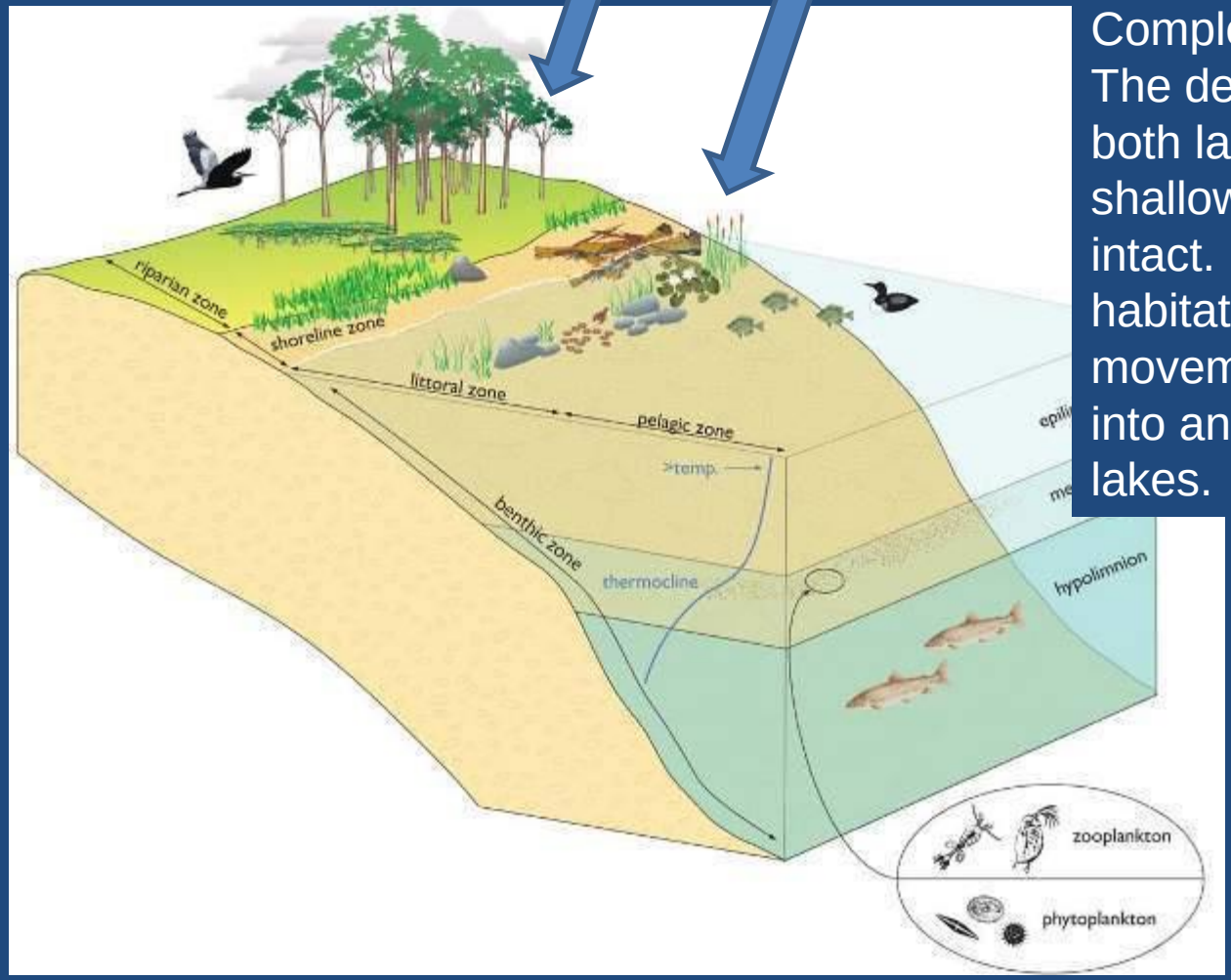


Condition of the Nation's Lakes: Habitat

- 55 individual habitat metrics captured at each site (550/lake).
- Metrics reduced to four indices of habitat quality:
  - Human Disturbance on Lakeshores
  - Riparian Zone Integrity
  - Littoral Zone Integrity
  - Complexity of Riparian/Littoral Interface
- Disturbance index scores assessed against nationally consistent thresholds
- Riparian/littoral indices assessed against regionally-explicit reference conditions (*corrects for expected regional differences*)

Lakeshore zone

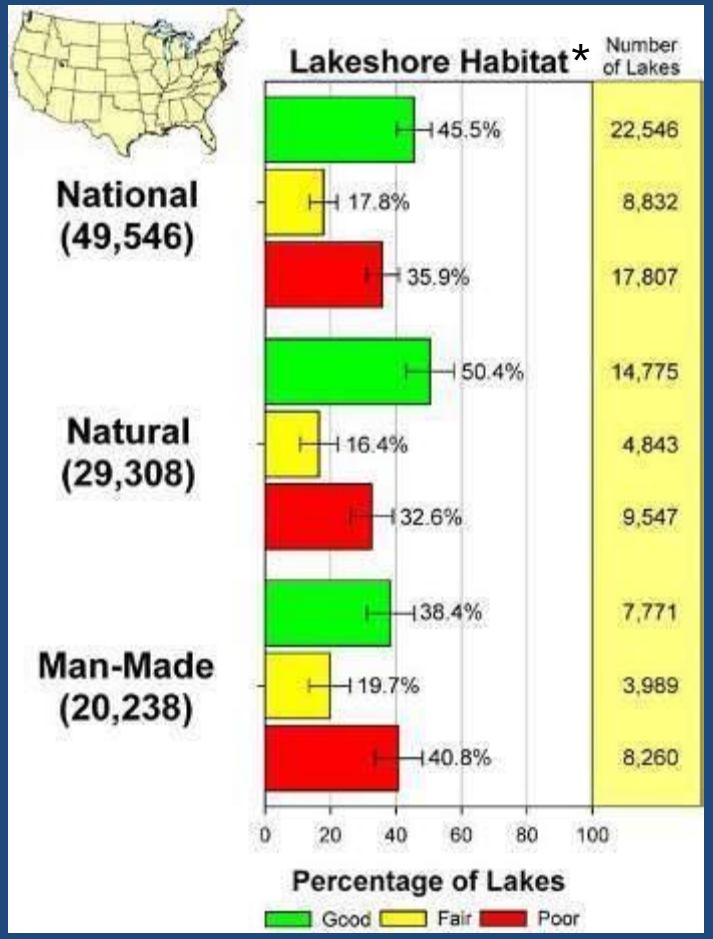
Shallow zone

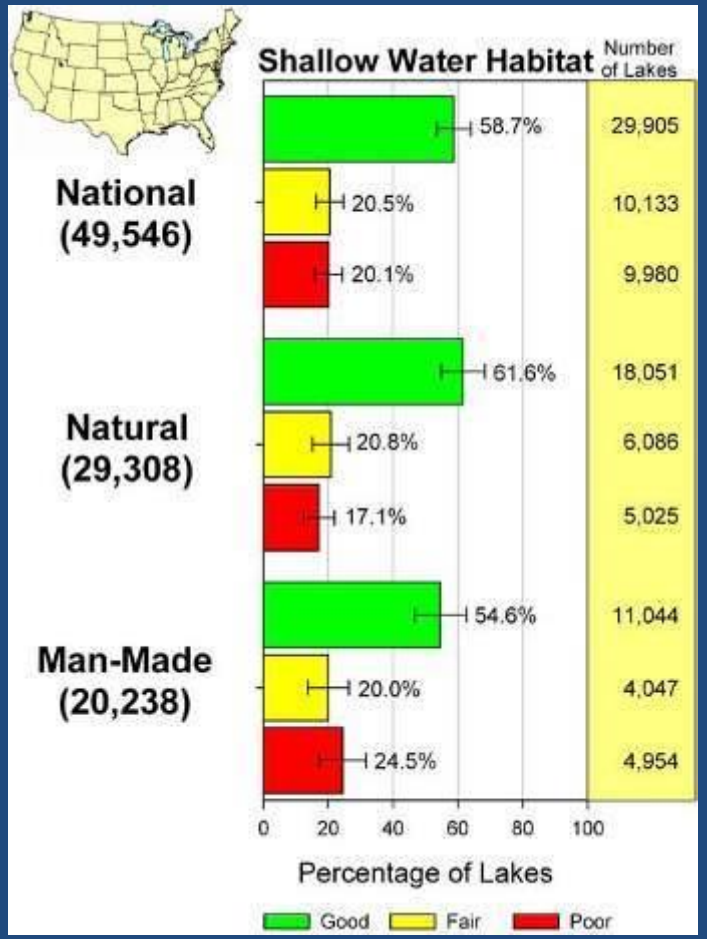


Complexity:
The degree to which both lakeshore and shallow zones are intact. Complex habitats facilitate movement of food into and out of lakes.

Disturbance:

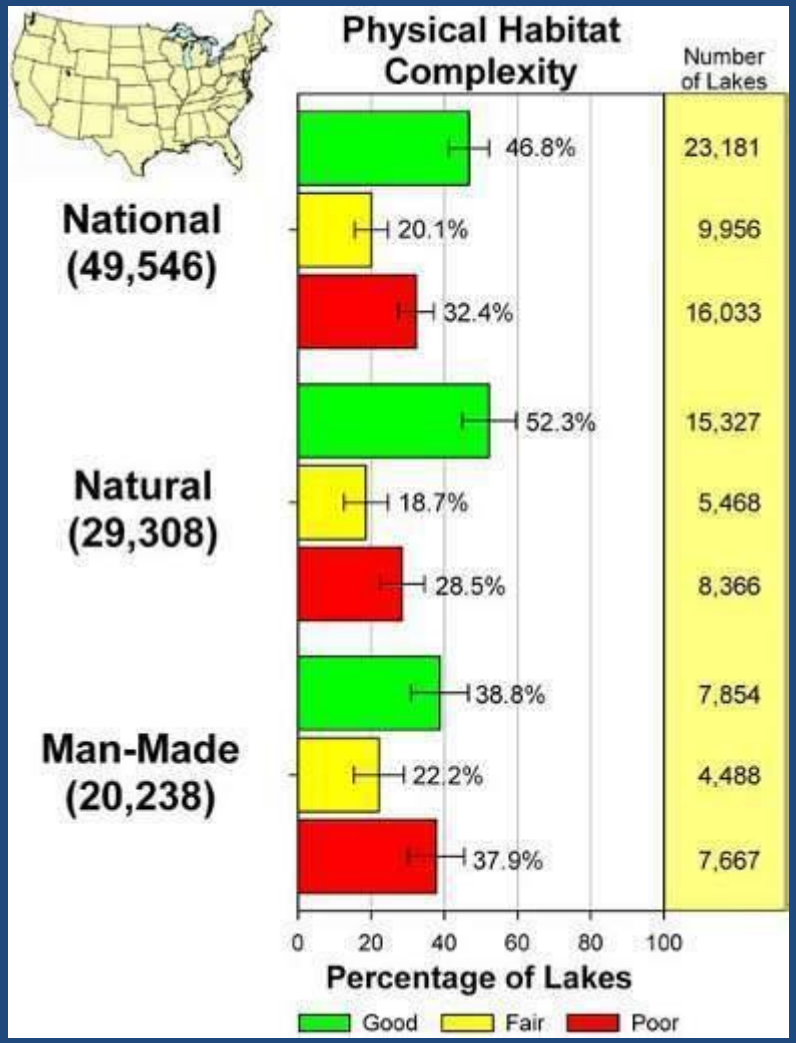
Condition of the Nation's Lakes: Habitat

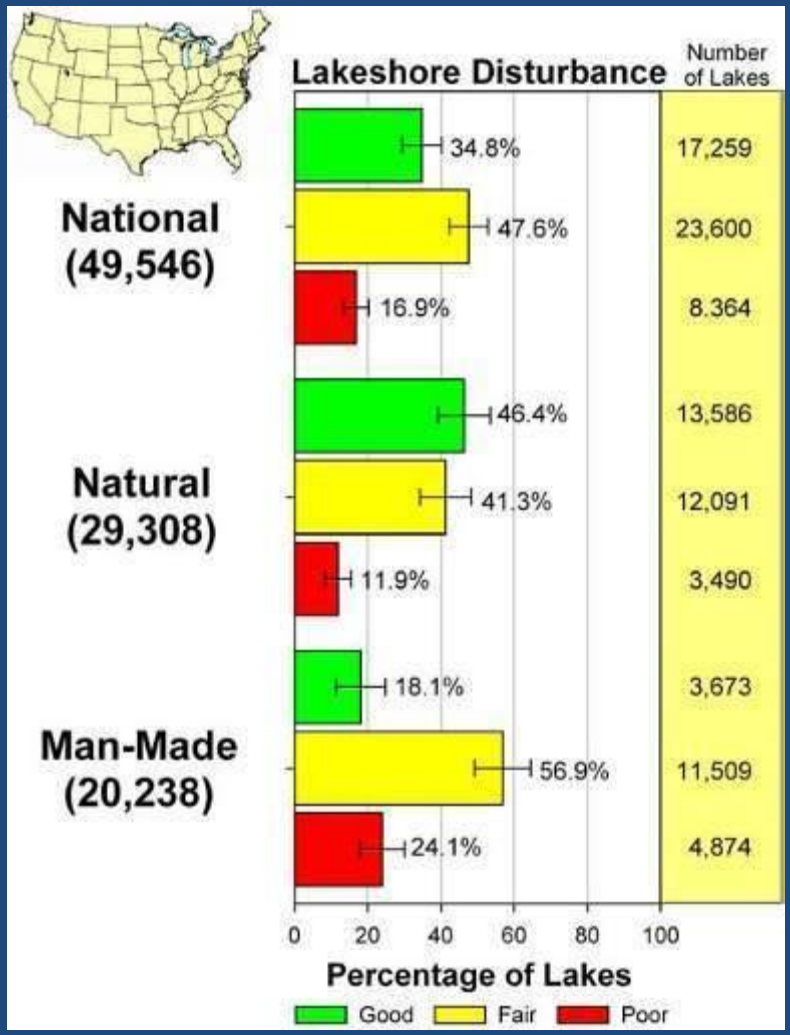




** NLA Primary indicator is Lakeshore Habitat*

Condition of the Nation's Lakes: Habitat

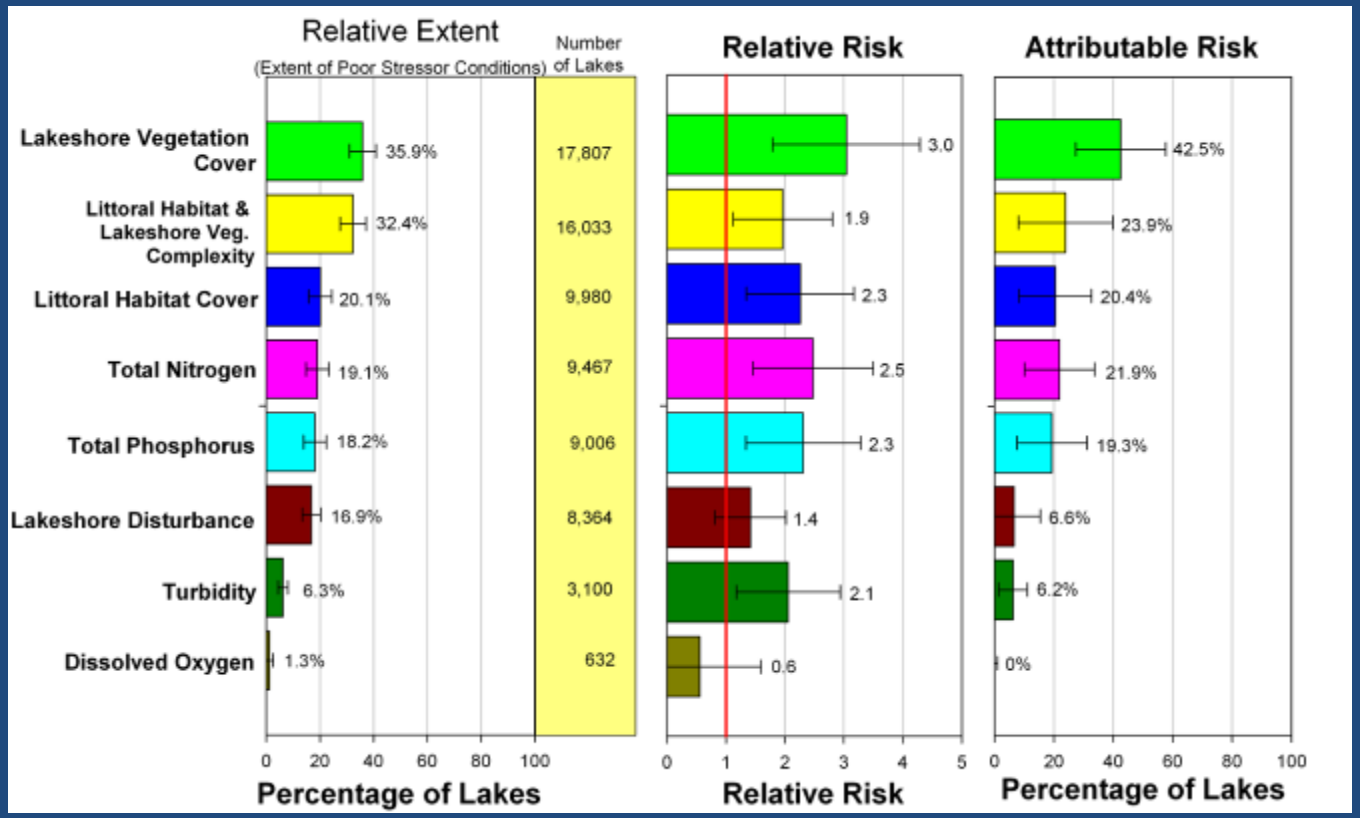




Stressor Extent and Resulting Risk: Relating Stressors to Biological Condition

- NLA evaluated all stressors (chemical and habitat) against biological condition, to assess which are most important.
- Examination of the relationship between three indicators provides:
  - Relative Extent – What is the proportion of stressors in poor condition?
  - Relative Risk – When stressors indicate poor condition, what is the increased proportion of lakes with poor biological condition?
  - Attributable Risk – What percent of lakes that are in poor biological condition should move to good/fair if this stressor is eliminated?

Stressors to the Nation's Lakes: Extent, Relative Risk, and Attributable Risk

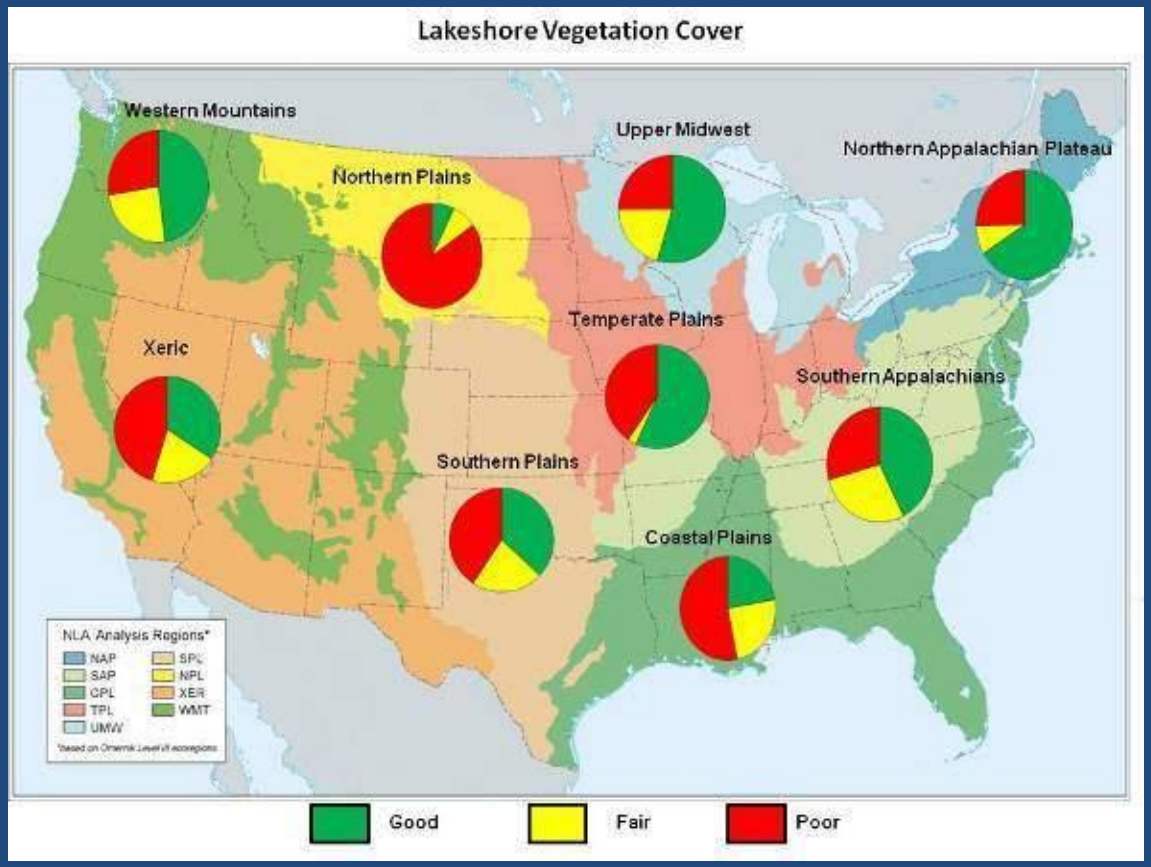


- #1 – Lakeshore vegetation: Poor biology is three times more common when lakeshore vegetation cover is in poor condition. This affects 36% of lakes.
- #2 – Nutrients: Poor biology is 2.5 times more common when nutrients are high. This affects about 20% of lakes.

Poor Biology is Three Times More Common when Lakeshore Habitat is Poor

Regional summary:

- Northern Plains, Coastal Plains and Xeric have highest proportion of lakes with poor habitat conditions
- While Northern Appalachian exhibits the highest proportion of lakes with high-quality habitat, > *25% of lakeshores are in poor condition*



We appear to be loving our lakes too much!

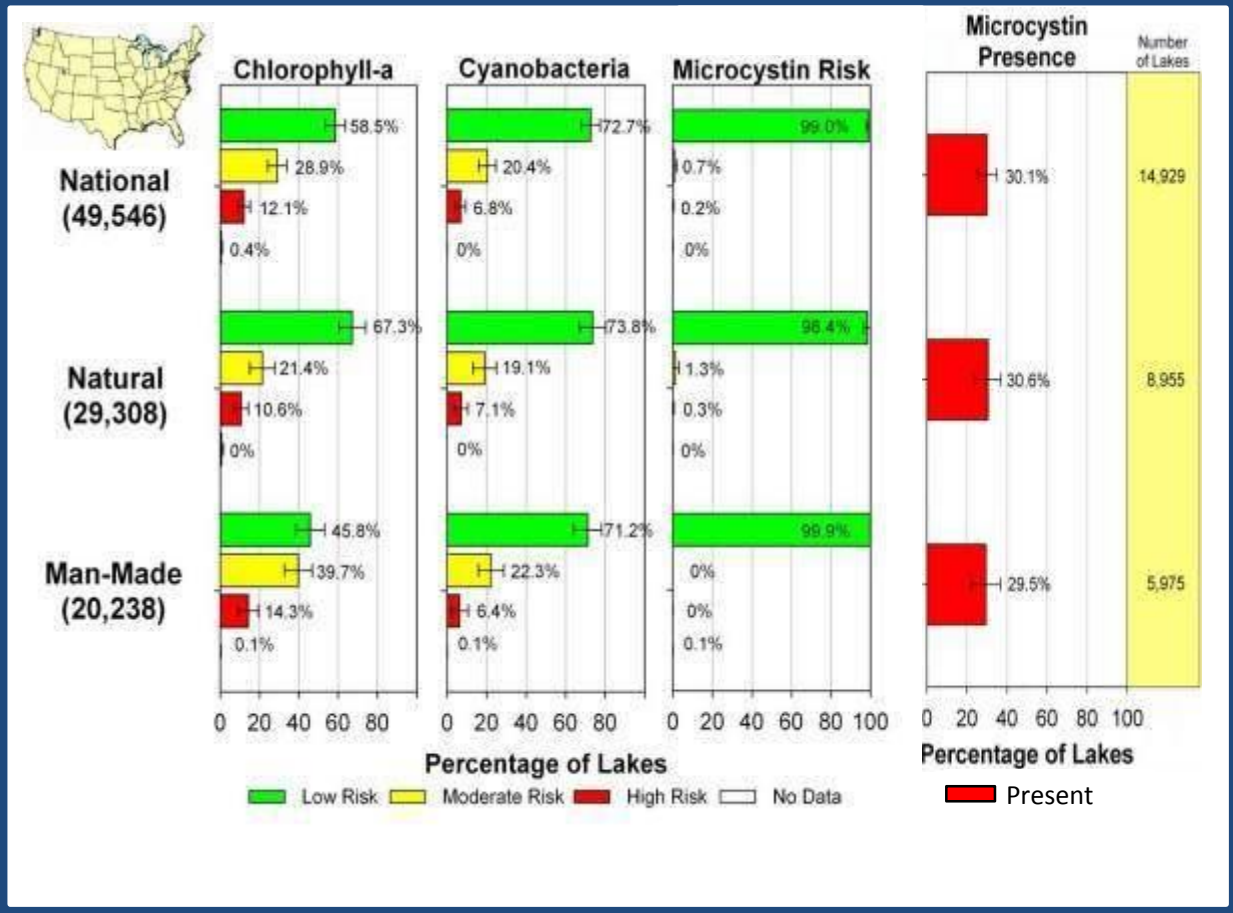
Recreational Condition of the Nation's Lakes: Algal Toxin Exposure Risk

- Sampled 4 indicators suitable for assessment of Harmful Algal Bloom (HAB) toxin risk:
  - Presence of microcystin
  - Chlorophyll-*a*
  - Cyanobacteria cell count
  - Microcystin concentration
- World Health Organization (WHO) thresholds used for assessment
- Identified extent of Microcystin presence; Cyanobacteria cell count used as assessment of potential exposure risk

Recreational Condition of the Nation's Lakes: Algal Toxins

National Summary:

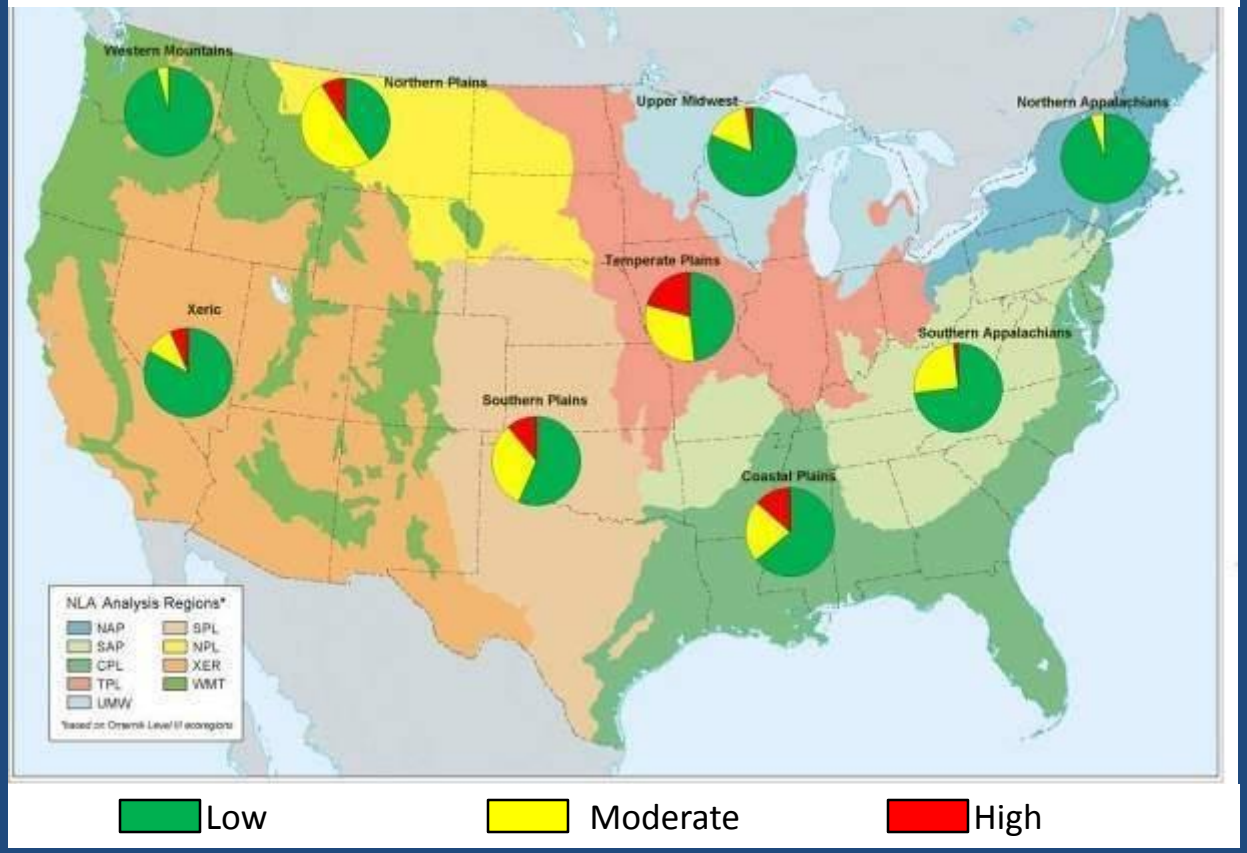
- Microcystin detected in 30% of lakes and at levels of concern in 1%
- Exposure risk based on cyanobacteria:
  - 73% of lakes exhibit low risk
  - 20% moderate risk
  - 7% high risk
- WHO thresholds for cyanobacteria:
  - Low risk (<20K) cells
  - Mod. risk (<100K) cells
  - High risk (>100K cells)



Recreational Condition of the Nation's Lakes: Risk of Cyanotoxin Exposure

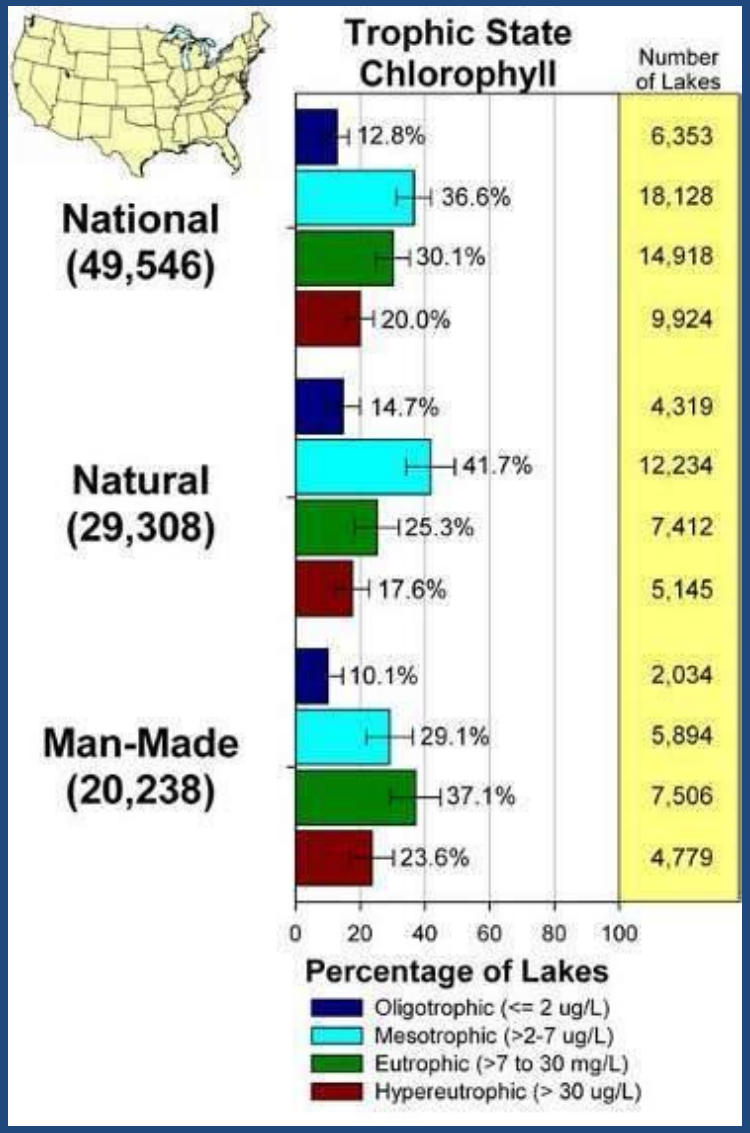
- Plains show greatest proportion of high-risk lakes
- Greatest proportion of lakes exhibiting low risk in Western Mountains and Northern Appalachians

Risk of cyanotoxin exposure based on measured cyanobacteria



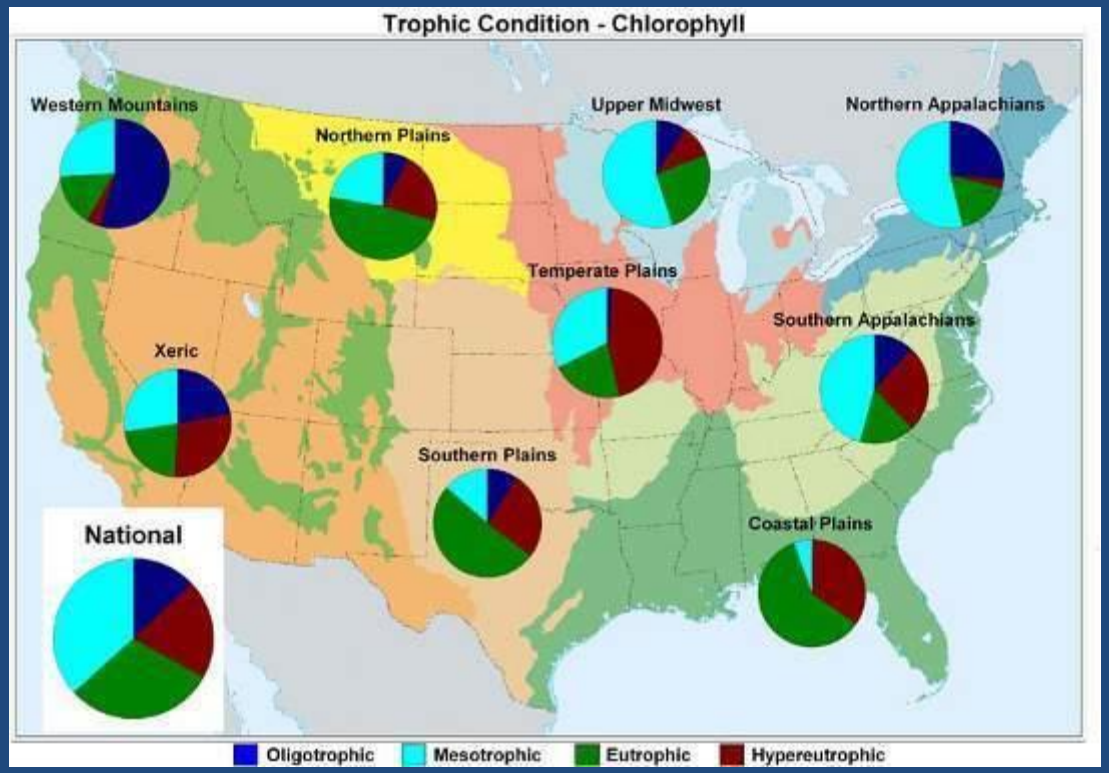
Trophic State of the Nation's Lakes

- National Summary:
  - 13% of lakes are oligotrophic
  - 37% are mesotrophic
  - 30% are eutrophic
  - 20% are hypereutrophic.
- Used chlorophyll-a as primary assessment, with "Carlson" thresholds
- Also assessed trophic state independently using total phosphorus, total nitrogen, Secchi.



Trophic State – Ecoregional Results

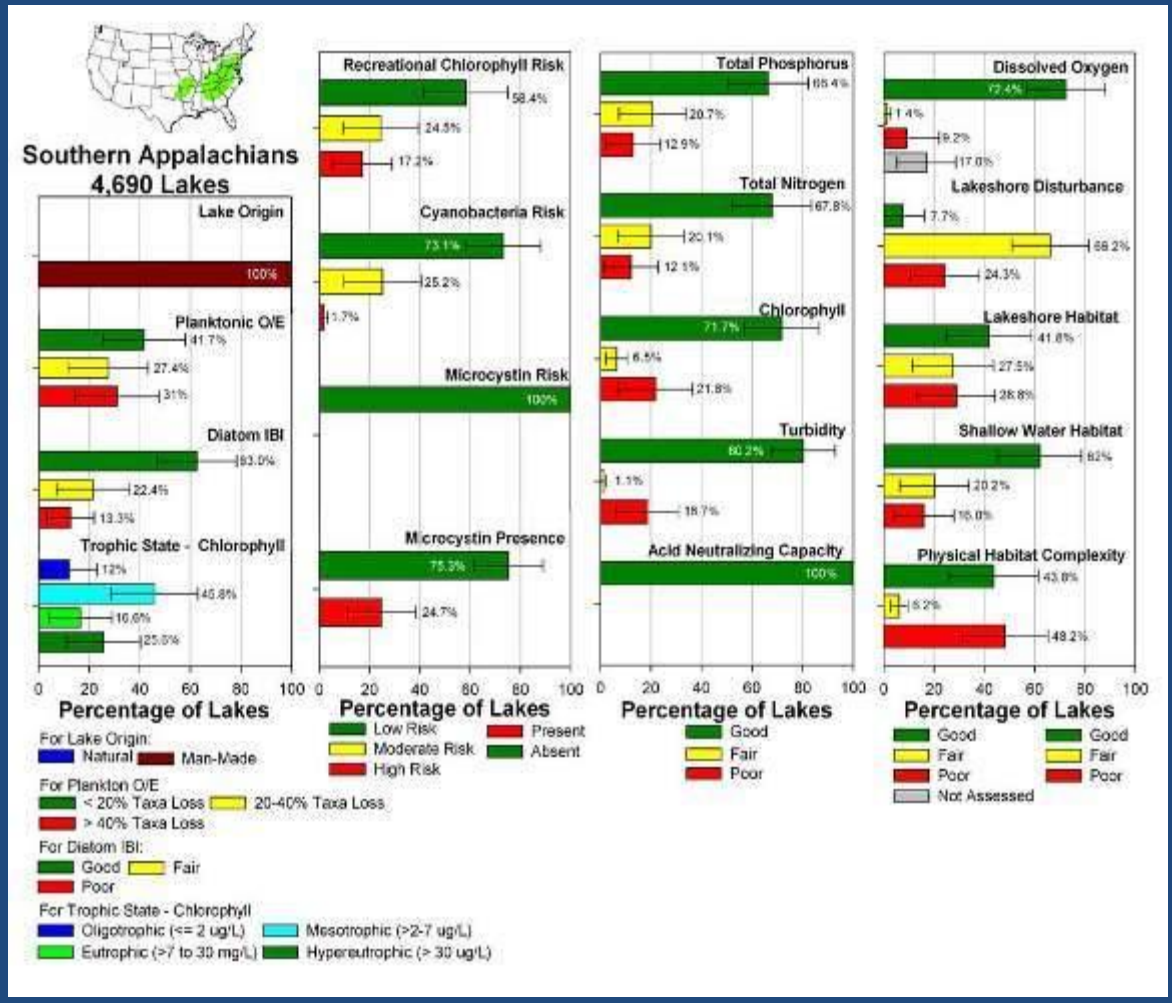
- Western Mountains, Upper Midwest, Northern Appalachians show greatest proportion of oligo/mesotrophic lakes
- Plains show greatest proportion of eutrophic and hypereutrophic lakes
- In some ecoregions (Northern Plains, Xeric) the traditional nutrient : chlorophyll-*a* paradigm does not apply



Questions?

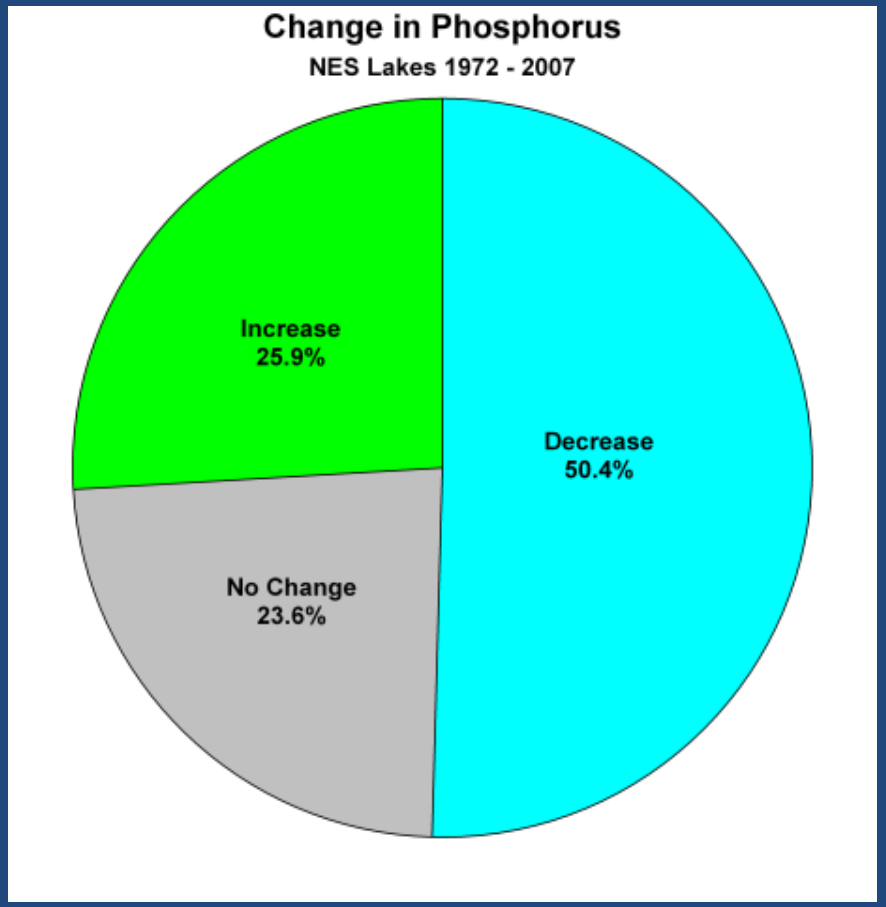
Regional Assessments

- Northern Appalachians
- Southern Appalachians
- Upper Midwest
- Coastal Plains
- Temperate Plains
- Southern Plains
- Northern Plains
- Western Mountains
- Xeric West



Trends: National Eutrophication Survey and NLA Looking at Change Between 1972 and 2007

- Subset of wastewater-impacted National Eutrophication Survey (NES) lakes (200) were revisited for NLA
- Survey methods used to project changes in the 800 lakes originally sampled under NES in 1972
- Phosphorus trend:
  - **24% of lakes showed no change in phosphorus and 50% of lakes showed decreased phosphorus levels**

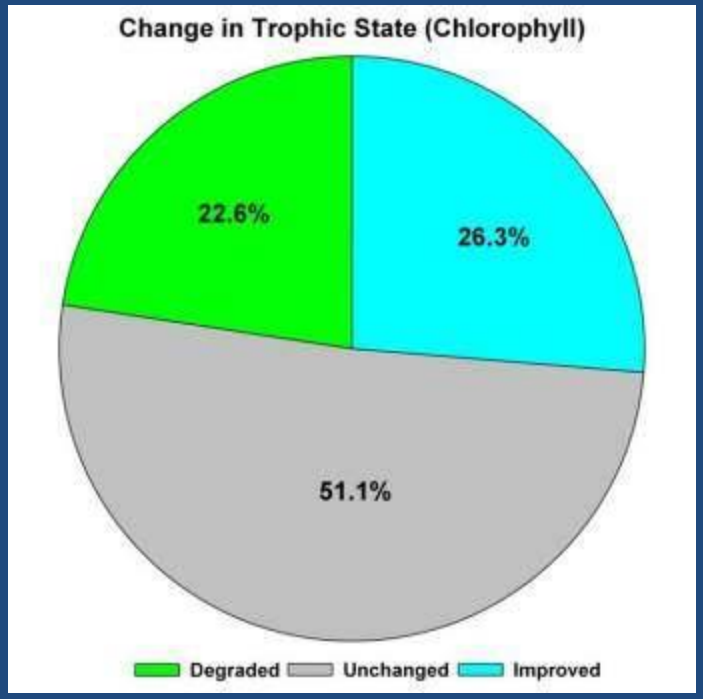


Trends: National Eutrophication Survey and NLA

Trophic state trend:

- 51% of NES lakes showed no change in trophic status
- 26% of NES lakes improved in trophic status

Finding that P improved in 50% of lakes and trophic condition improved in 26% of lakes implies success of wastewater treatment plant improvements and other phosphorus control initiatives.



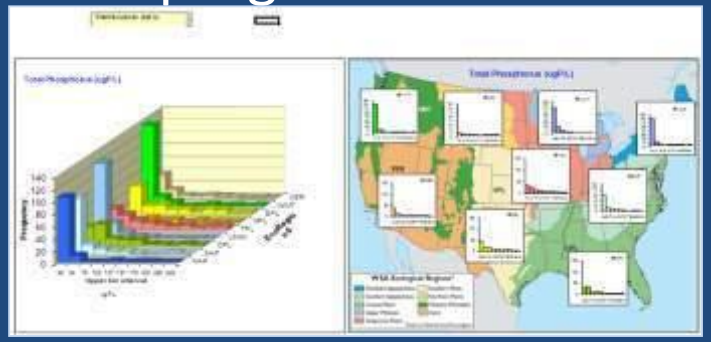
Comparison of change in trophic status of NES lakes

Policy Implications of the NLA Report

- Support for Low Impact Development
  - NLA finding: Habitat alteration is the most important measured stressor in lakes.
  - Supports need to address mitigation of lakeshore habitat impacts.
    - Professional lake community is eager for evidence to support initiatives to protect lakeshores
    - This message should be promoted to the lake community
- Support for nutrient management efforts
  - NLA finding: Nutrients are major stressors in U.S. lakes
- Report trends based on NLA/NES study using statistical surveys
  - Tool to evaluate program effectiveness

Policy Implications of the NLA Report

- Assist with criteria development
  - NLA data may be useful in the development and evaluation of nutrient criteria.
  - Enterococci dataset useful for Critical Path Science Plan
- Enhance state lake monitoring/assessment programs
  - Technical tools for computing indicators and other assessments
  - Materials to assist states in transferring results



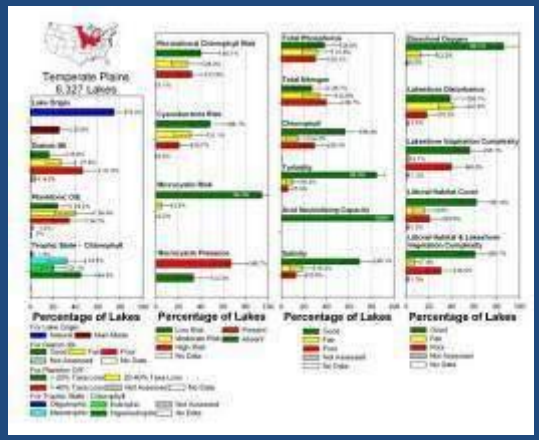
- Further analysis of stressor relationships can identify new directions for lake water quality policy

National Lakes Assessment Report

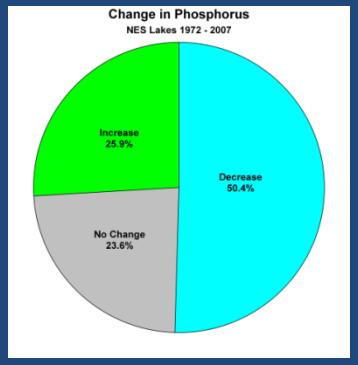
Intro and Design

National Findings

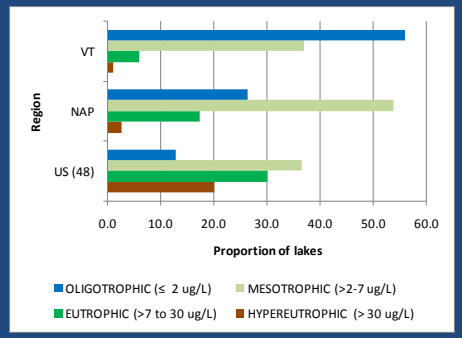
Ecoregional Findings



Change over Time



Uses of the NLA Results



Future Actions – NLA in 2012

National Lakes Assessment Report

- EPA has published a Federal Register notice calling for a 30 day comment period
- NLA Report available for public comment at www.epa.gov/lakessurvey
- National Aquatic Resource Surveys: at www.epa.gov/aquaticsurveys

Questions?

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Next Watershed Academy Webcast

Nutrient Management in the National Estuary Program

Wednesday, February 17, 2010

1:00 – 3:00 PM Eastern

Registration will open approximately three weeks prior to the Webcast at: **www.epa.gov/watershedwebcasts**

Participation Certificate

If you would like to obtain participation certificates for multiple attendees, click the link below:

www.epa.gov/owow/watershed/wacademy/webcasts/pdf/2010_1_05_certificate.pdf

You can type each of the attendees names in and print the certificates