Numeric Nutrient Criteria Development - Update

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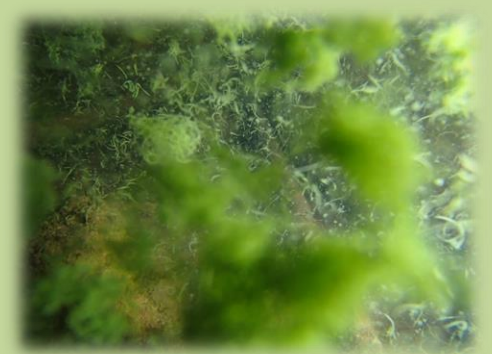
Watershed Protection Program – Monitoring Program
Nutrient Work Group – May 28, 2015

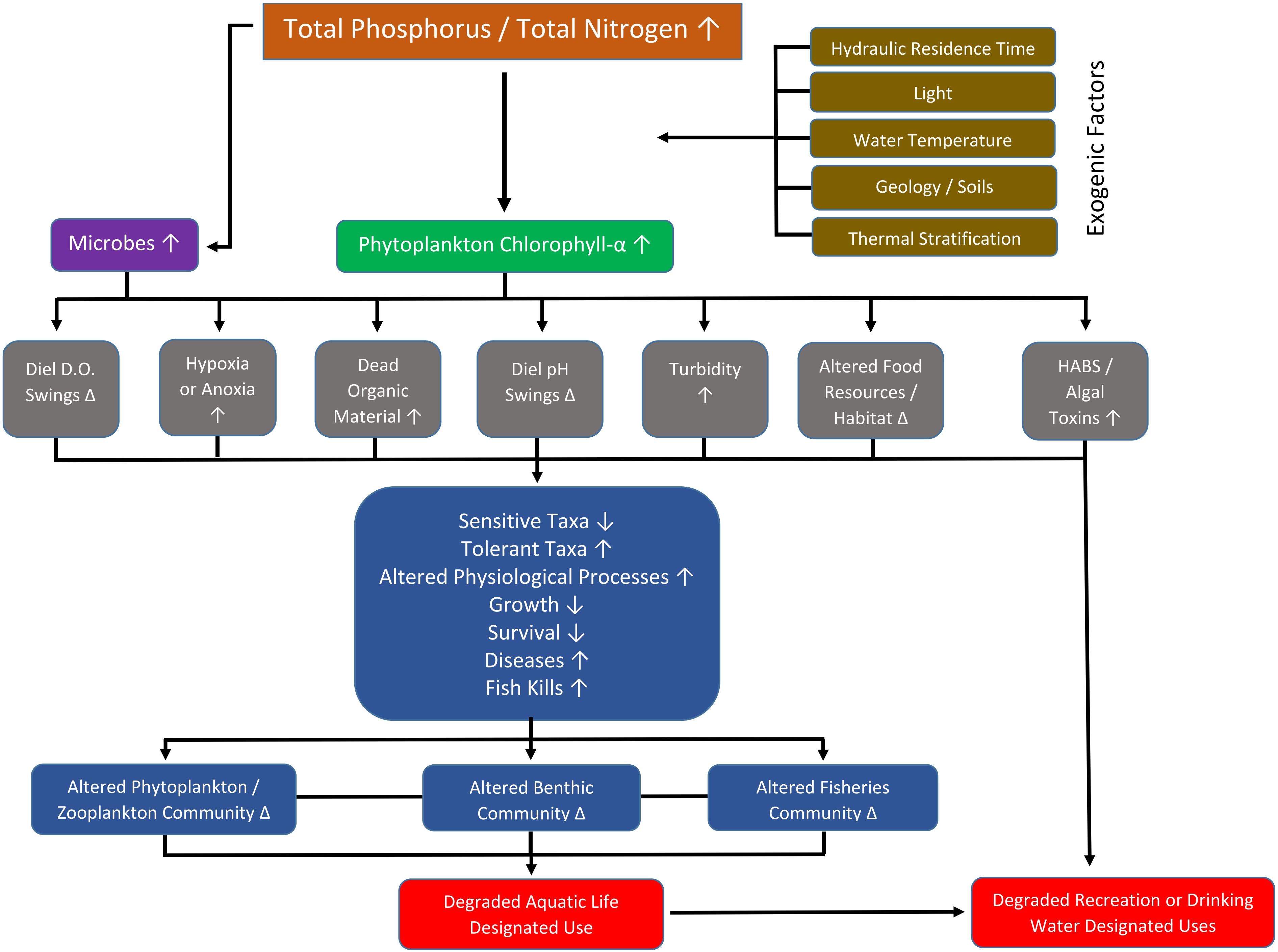
Outline

- Recap from last meeting
  - Impacts from nutrient pollution
  - Scope of Wyoming numeric nutrient criteria
  - Wyoming’s approach to develop nutrient criteria
- Current nutrient criteria development efforts
  - Wyoming Basin lake data
  - Stressor-response approach (5-steps)
  - Lake stratification

Impacts of Nutrient Pollution

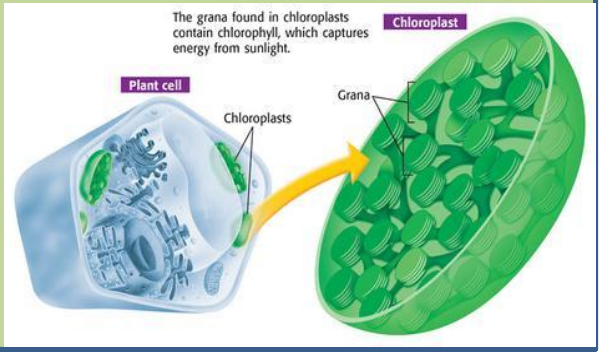
- Excess algal/macrophyte growth caused by elevated loading of phosphorus and nitrogen by human activities
- Loss of water clarity, reduction in recreation and aesthetic quality
- Increased frequency of toxic algal blooms
  - Cyanotoxins – impact rec./drinking water
- Decreased dissolved oxygen, increased pH
- Changes in fisheries and other aquatic life communities, fish kills
- Taste and odor problems (drinking water)
- Interference with industrial, municipal and agricultural uses of water




Total Phosphorus / Total Nitrogen ↑
Hydraulic Residence Time
Light
Water Temperature
Geology / Soils
Thermal Stratification
Exogenic Factors
Microbes ↑
Phytoplankton Chlorophyll-α ↑
Diel D.O. Swings Δ
Hypoxia or Anoxia ↑
Dead Organic Material ↑
Diel pH Swings Δ
Turbidity ↑
Altered Food Resources / Habitat Δ
HABS / Algal Toxins ↑
Sensitive Taxa ↓
Tolerant Taxa ↑
Altered Physiological Processes ↑
Growth ↓
Survival ↓
Diseases ↑
Fish Kills ↑
Altered Phytoplankton / Zooplankton Community Δ
Altered Benthic Community Δ
Altered Fisheries Community Δ
Degraded Aquatic Life Designated Use
Degraded Recreation or Drinking Water Designated Uses

Scope of Wyoming's Numeric Nutrient Criteria

- Establish the amount of nutrients a waterbody can have and still support designated uses
- Scientifically defensible
- Reflect spatial variation (regional, watershed)
- Specific for waterbody types: rivers/streams vs. lakes/reservoirs
- Reflect temporal variability (seasons, flow)
- Nutrient criteria will include
  - Causal Variables: Total Phosphorus (TP) and Total Nitrogen (TN)
  - Response Variables: Chlorophyll-α (primary) and Algal community metrics (secondary), other



Scope of Wyoming's Numeric Nutrient Criteria

Example: Numeric Nutrient Criteria Protective of Aquatic Life Use

(Assessment Endpoints)

Designated Use		Response Variable		Response Variable		Causal Variable
Support aquatic life	⇐	Algal community metrics	⇐	Algal biomass (measured as Chl *a* conc.)	⇐	TN and TP concentration

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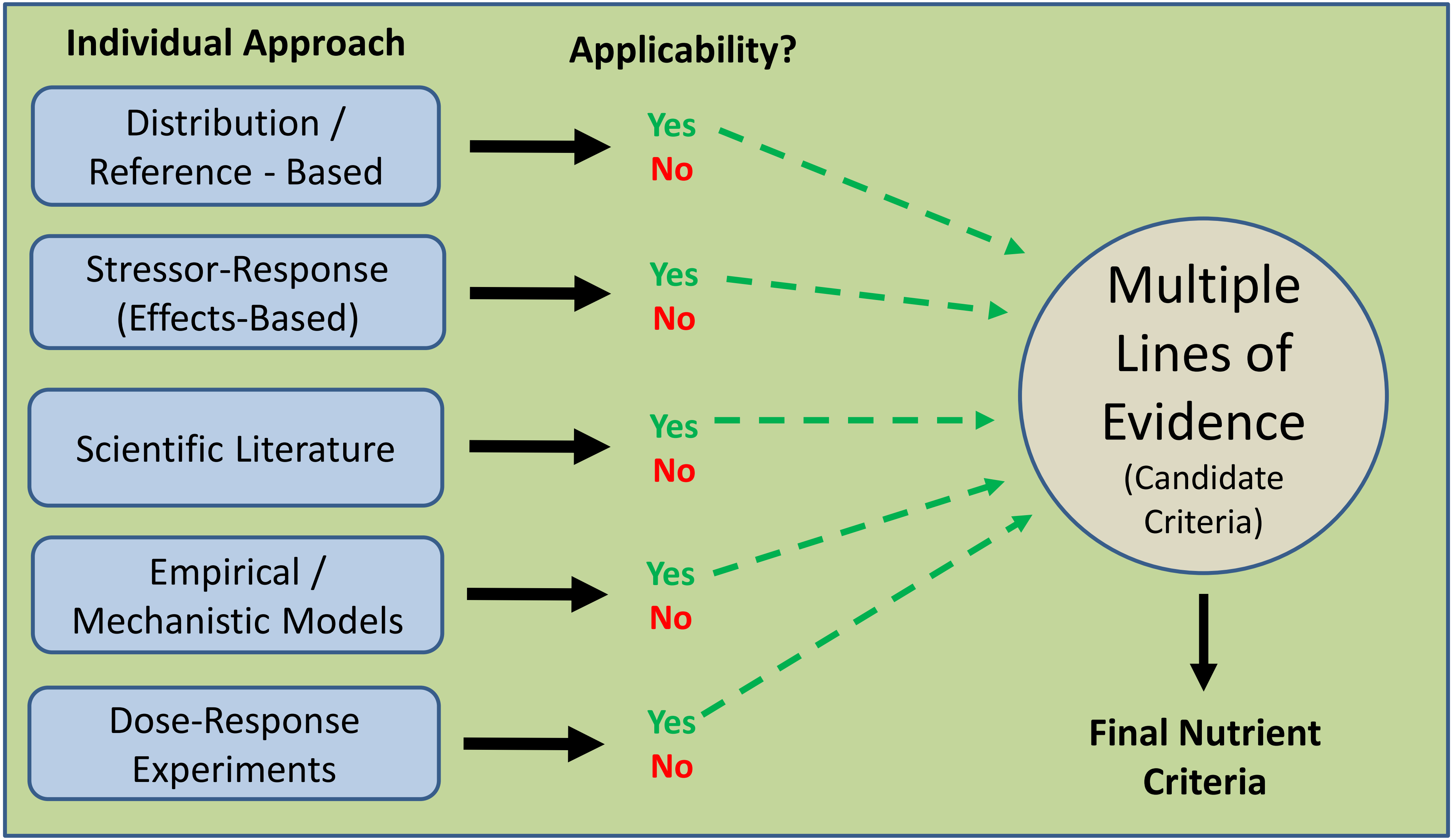
Scope of Wyoming's Numeric Nutrient Criteria

- Why use algae as the aquatic indicator group?
  - Respond rapidly to excess nutrients compared to higher trophic levels

  - Often first signal of nutrient pollution before alterations to benthic or fish communities appear
  - Algal-nutrient responses are well documented in the scientific literature
  - Findings from algal-nutrient responses can be directly translated to chlorophyll-α as the primary indicator

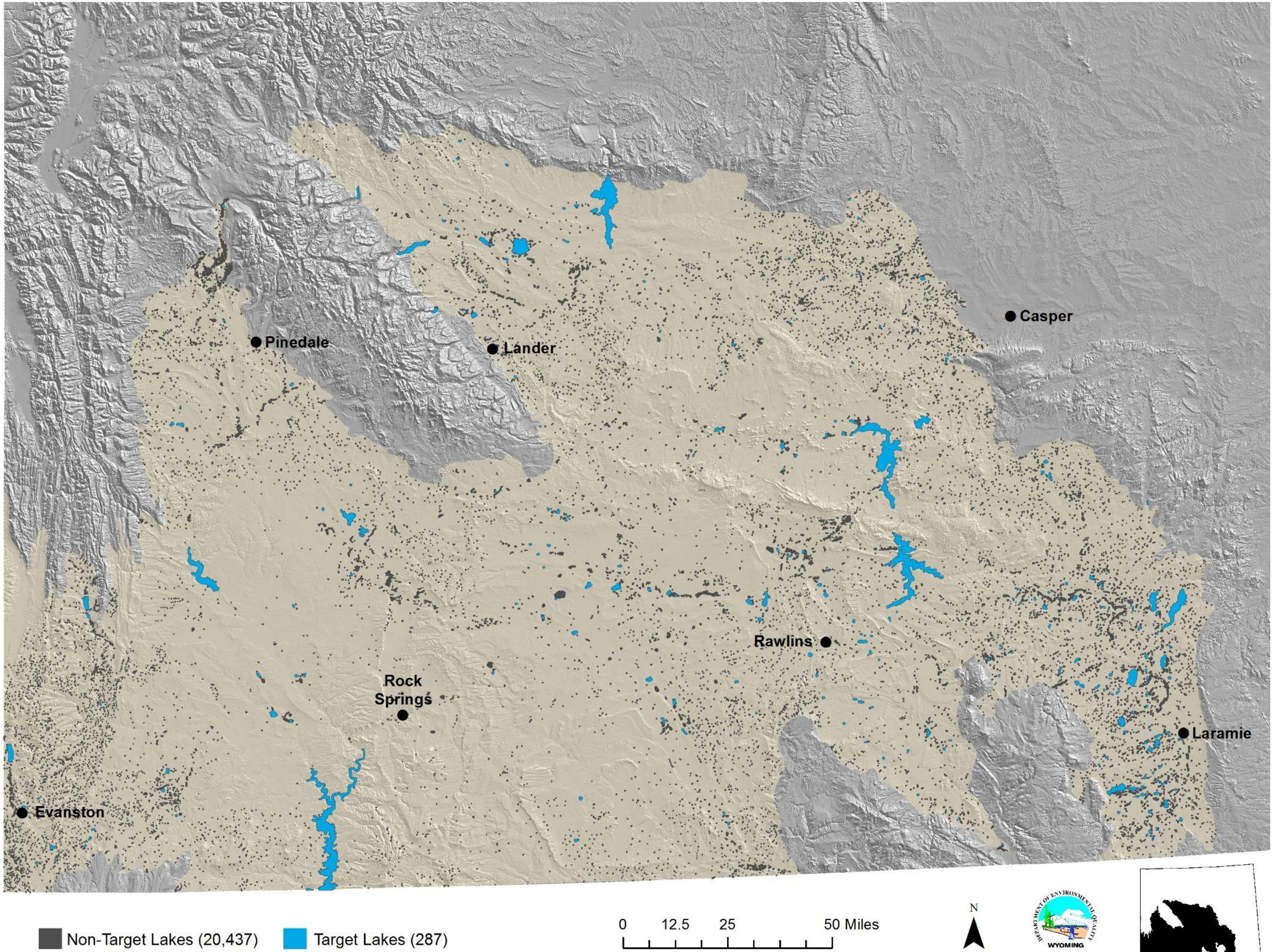
Wyoming's approach for developing nutrient criteria



Current Nutrient Criteria Development Efforts

- Wyoming Basin lakes/reservoirs
  - Consistent with 2008 Nutrient Criteria Development Plan
  - Best existing data quantity/quality and distribution among regions (good starting point)
  - Several publically accessible waterbodies

- Target group
  - Perennial (no treatment or disposal ponds)
  - ≥10 acres and >0.5 m max. depth
  - Target of 287 lakes (20,724 total lakes in Wyoming Basin)
  - All human constructed or enhanced impoundments


Casper
Pinedale
Lander
Rawlins
Rock Springs
Laramie
Evanston
Non-Target Lakes (20,437)
Target Lakes (287)
0
12.5
25
50 Miles
N
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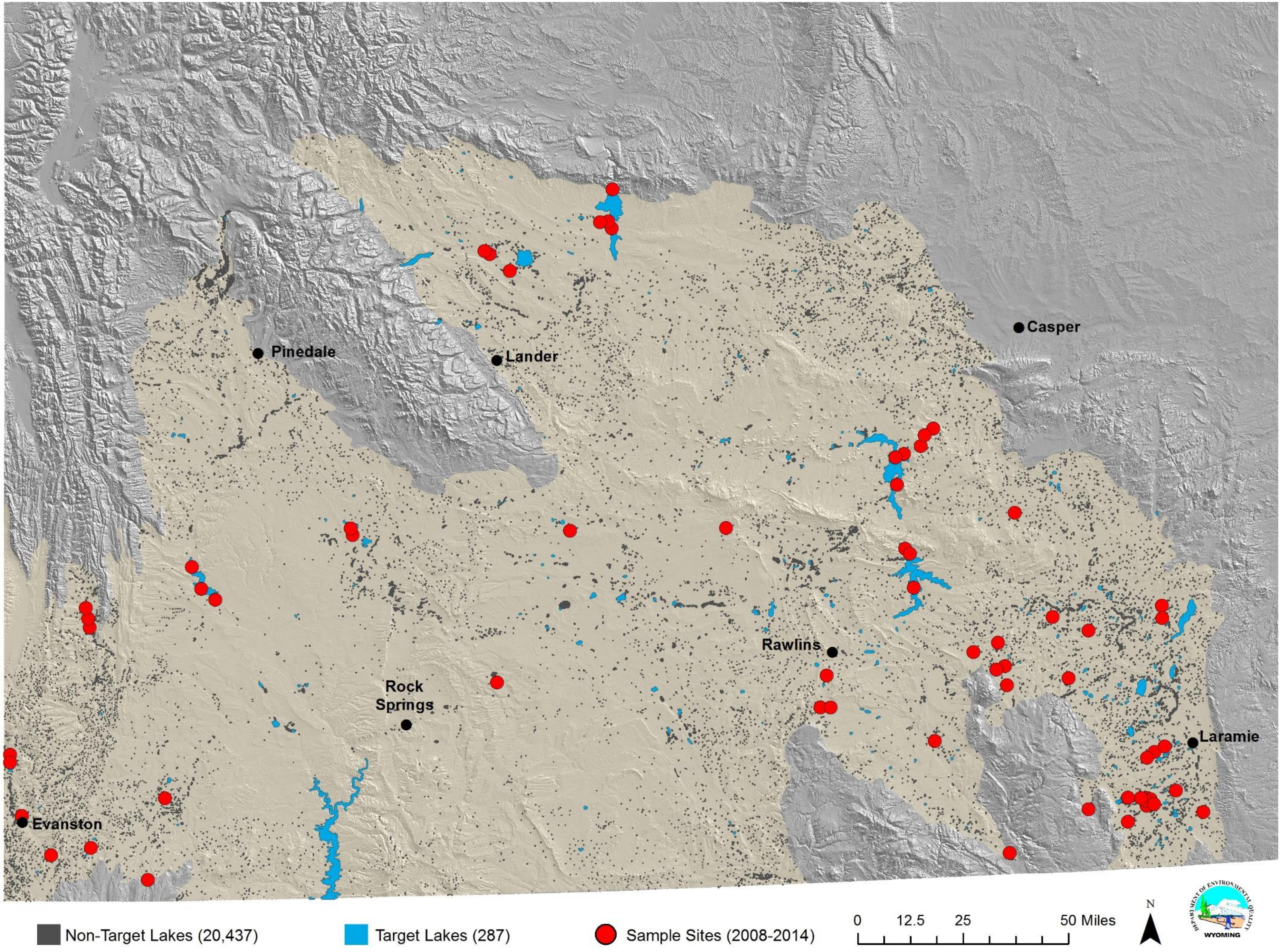
Wyoming Basin lake data

- Pre-2013 data limited to very large reservoirs, limited biological
- 2013-2014 Wyoming Basin lake nutrient monitoring
  - Improve spatial/temporal data resolution/distribution
  - Random study design (lake size and level IV ecoregion)
  - Depth, pH, temp, DO, TP, TN, NO2+NO3, NH3, Conductivity, Alk, SD, Chl-α, depth, vertical profiles and phytoplankton composition/density

- Final dataset
  - 2008-2014
  - Approximately 331 sample sets (1,000's of data points)
  - Data represent June 1 – October 31 period
  - 67 monitoring sites that represent 52 perennial lakes
  - Represents ¼ of the realized target population (197 lakes)



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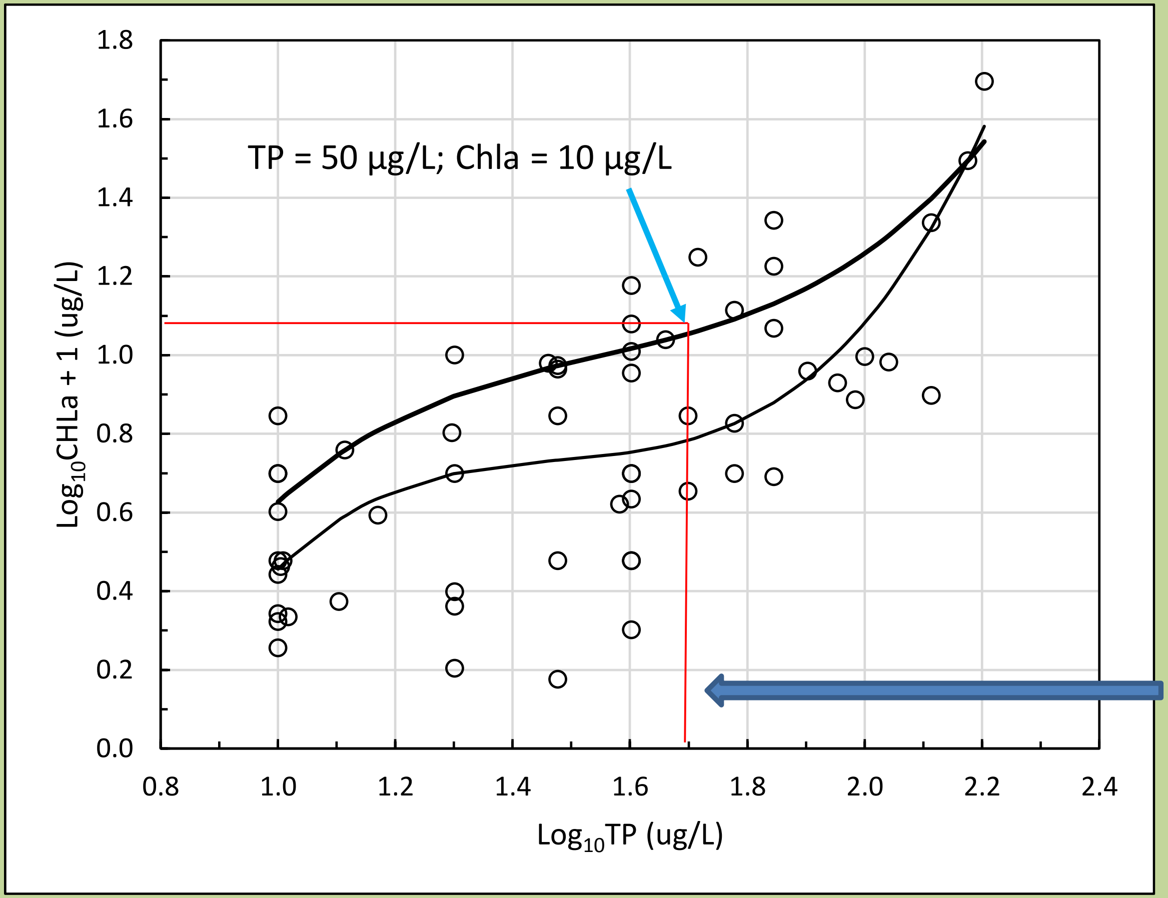
Stressor-Response Approach

- Directly links candidate criteria to protection of the use
- Uses empirical responses of chlorophyll-α/phytoplankton metrics to excess nutrients
- Criteria reflective of actual conditions and nutrient-biological responses for Wyoming Basin lakes



75th Quantile

TP Thresholds derived from TP-Phytoplankton Responses

Stressor-Response Approach
5-step process for deriving criteria

Step 1 – Select & Evaluate Data

Select stressor & response variables
Stressors: total phosphorus, total nitrogen
Responses: Chl-α, phytoplankton metrics (146) and densities
Covariates: Alk, EC, DO, pH, SD, Temp, etc.

Step 2 – Lake Stratification

Stratify lakes into natural sub-units based on exogenic factors
Methods: UPGMA, NMDS
Influences nutrient concentrations necessary to protect uses

Step 3 – Develop Nutrient-Chlorophyll-α Relationships

Establish relationships between Chl-α and TP / TN
Methods: Ordinary least squares regression, step-wise and multiple regression, additive non-parametric quantile regression

Step 4 – Threshold Analyses

Identify TP and TN thresholds that correspond to statistically significant responses in the phytoplankton community
Methods: CART, nCPA, additive non-parametric quantile regression, TITAN

Step 5 – Evaluate Candidate Criteria

Derive candidate criteria
Use nutrient-chlorophyll-α relationships to evaluate and refine candidate criteria. Incorporate into multiple-lines-of-evidence.

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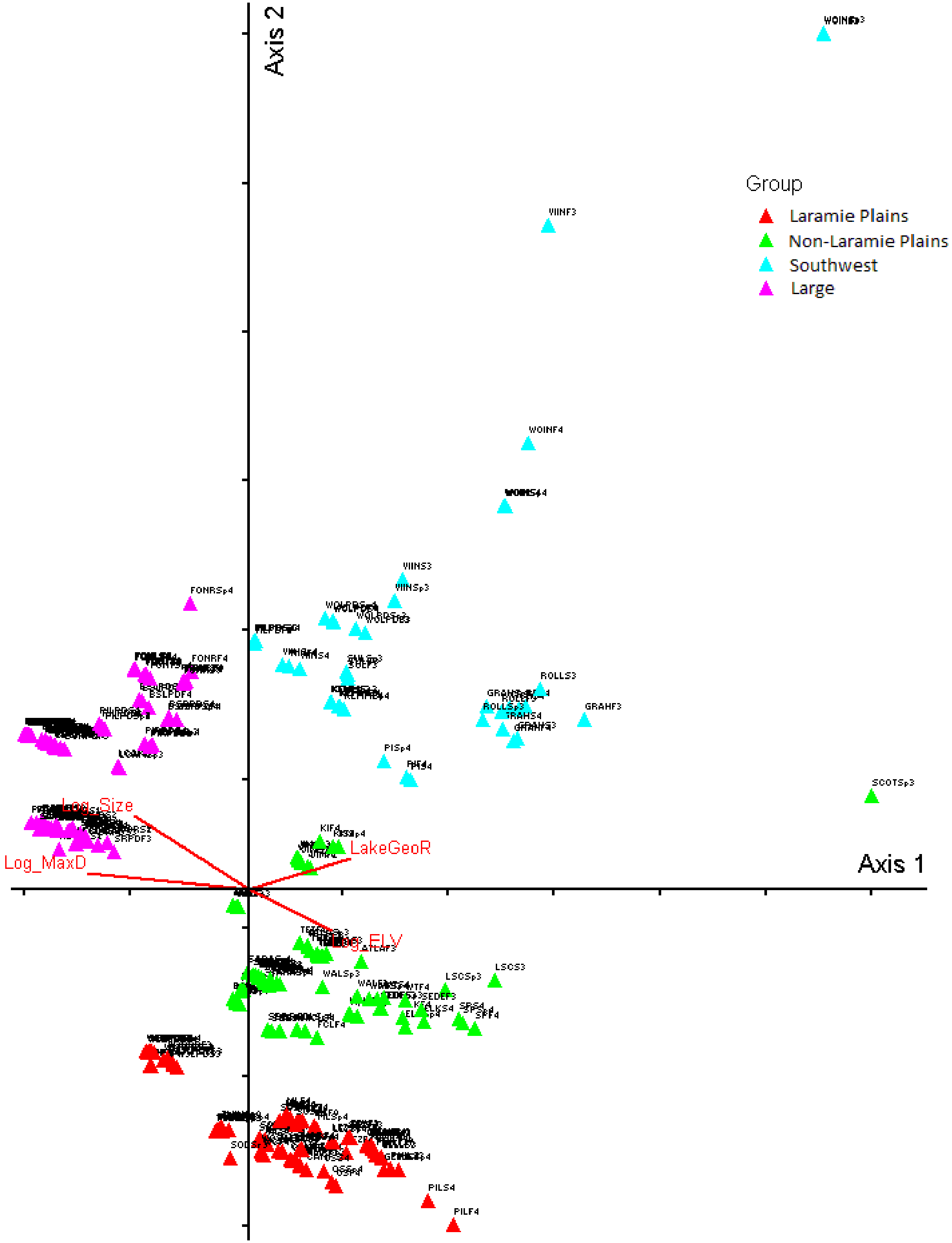
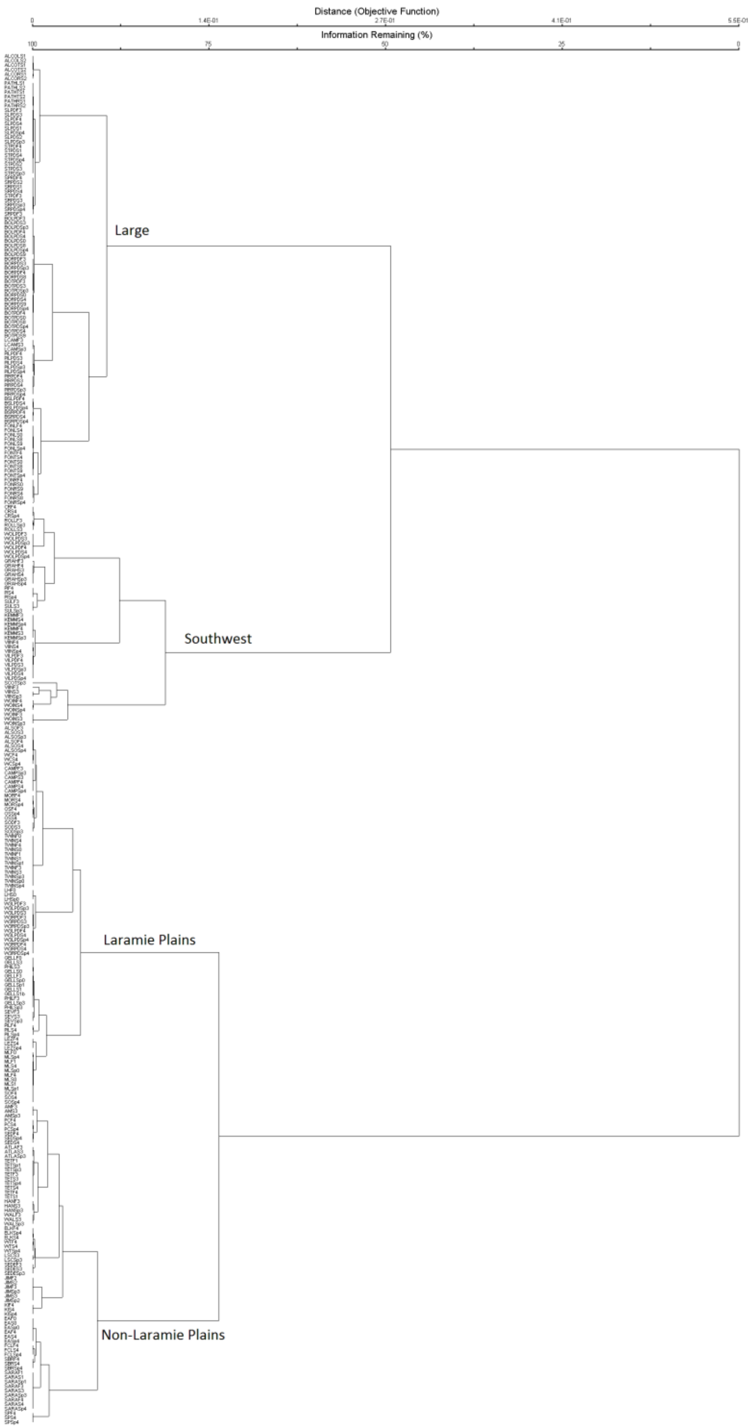


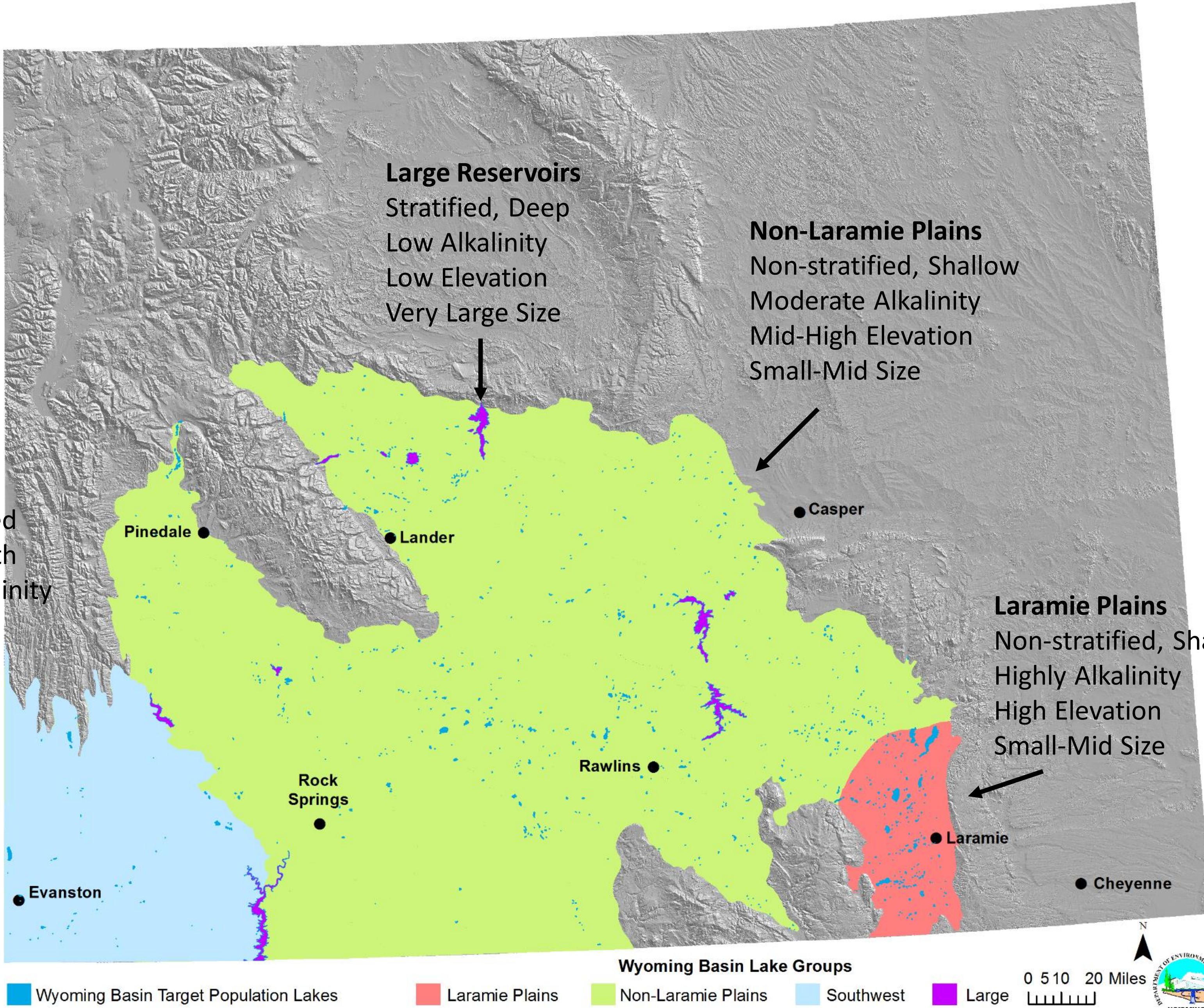
Axis 2
Axis 1
Group
Laramie Plains
Non-Laramie Plains
Southwest
Large
Log_Size
Log_MaxD
LakeGeoR
Log_ELV



Distance (Objective Function)
Information Remaining (%)
Large
Southwest
Laramie Plains
Non-Laramie Plains

Lake Stratification

Southwest
Slightly stratified
Moderate Depth
Moderate Alkalinity
Mid-Elevation
Mid-Large Size



Next Steps…

- Stressor-response approach
  - Develop and refine nutrient-chlorophyll α relationships (~80% complete)
  - Derive TP and TN thresholds from responses of chlorophyll-α/phytoplankton metrics to nutrients (~70% complete)

- Researching scientific literature for TP and TN thresholds protective of aquatic life, recreation and/or drinking water

- Exploring the use of modeling to develop nutrient criteria

Nutrient Criteria Questions

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