



**REGFORM**  
**2017 MISSOURI WATER SEMINAR**

**Sept. 7, 2017**

**Numeric Nutrient Criteria  
for Lakes**

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## **Numeric Nutrient Criteria Timeline**

**1998 - EPA sets goal for states to have criteria by 2003**

**2005 - First MO stakeholders meeting**

**2008 - Proposed criteria submitted to MO & EPA**

**2011 - EPA rejects majority of proposed criteria**

**2016 - EPA sued for not implementing a replacement standard**

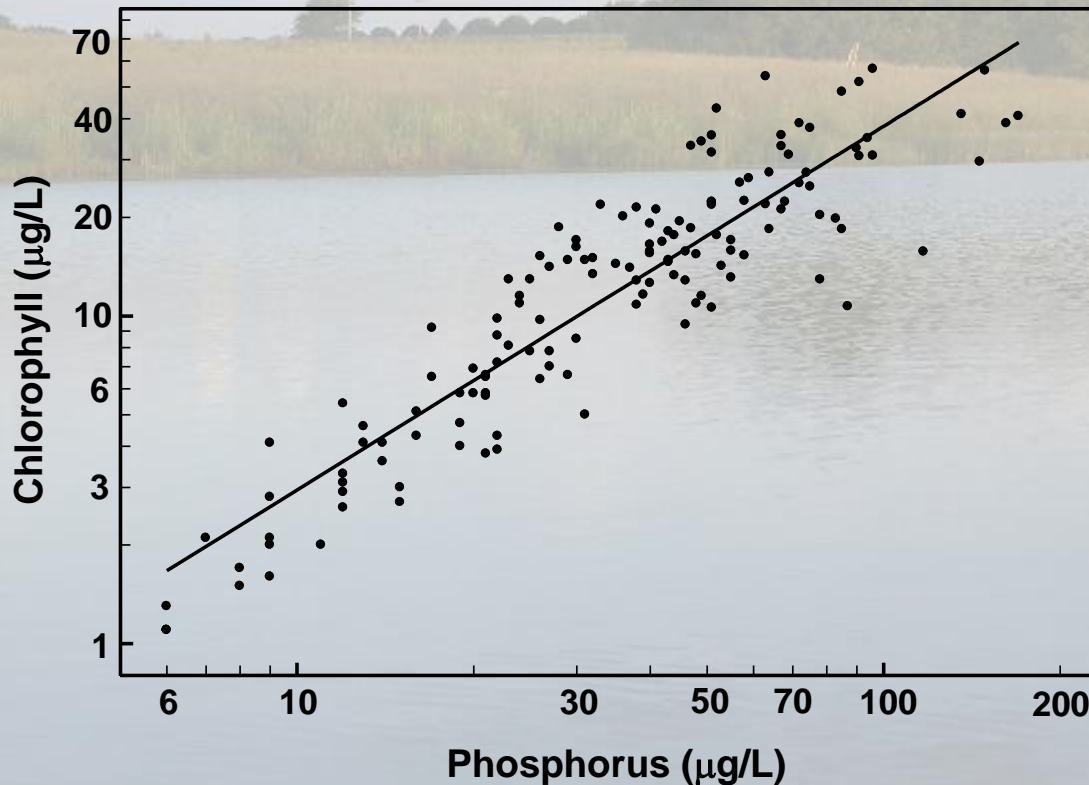
# Nutrients

## Phosphorus and Nitrogen

Naturally occurring

Human activities = increased inputs

Promotion of algal growth



# Algae

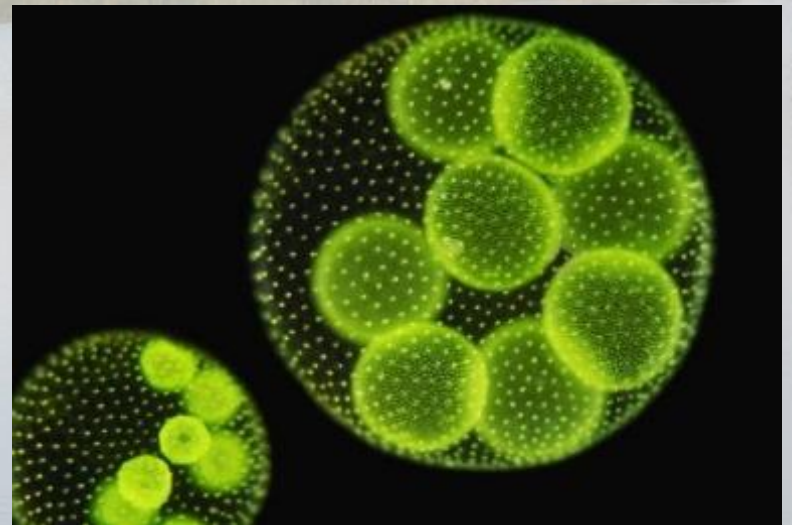
Plant-like organisms

Estimate by measuring chlorophyll pigment

Positives

Source of dissolved oxygen

Base of food web





# Algae

## Negatives

Turbid water

Loss of recreation

Large DO and pH fluctuations

Can produce toxins

Can cause taste and odors problems, as well as disinfection by-products in drinking water



**Unit of measure for nutrients and algal chlorophyll is micrograms per liter ( $\mu\text{g/L}$ ).**

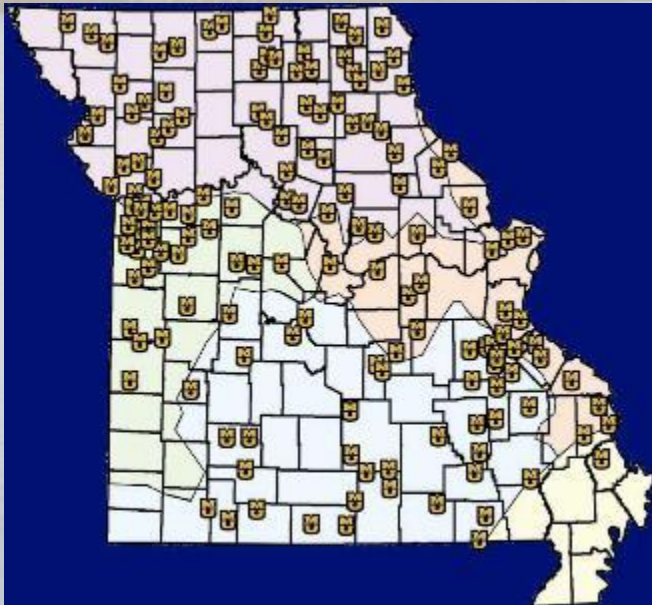
**Can be thought of as parts per billion (ppb).**

<b>Region</b>	<b>Phosphorus</b>	<b>Nitrogen</b>	<b>Chlorophyll</b>
<b>Plains</b> (n=99)	14 - 189	385 - 2195	2 - 114
<b>Border</b> (n=22)	7 - 90	275 - 1060	1 - 36
<b>Ozarks</b> (n=34)	6 - 59	195 - 950	1 - 25

**Range of nutrient and chlorophyll values for lakes in three regions of MO (Jones et al. 2008).**

**Missouri's reservoirs are diverse and there is no single value that represents a point when water quality goes from good to bad.**

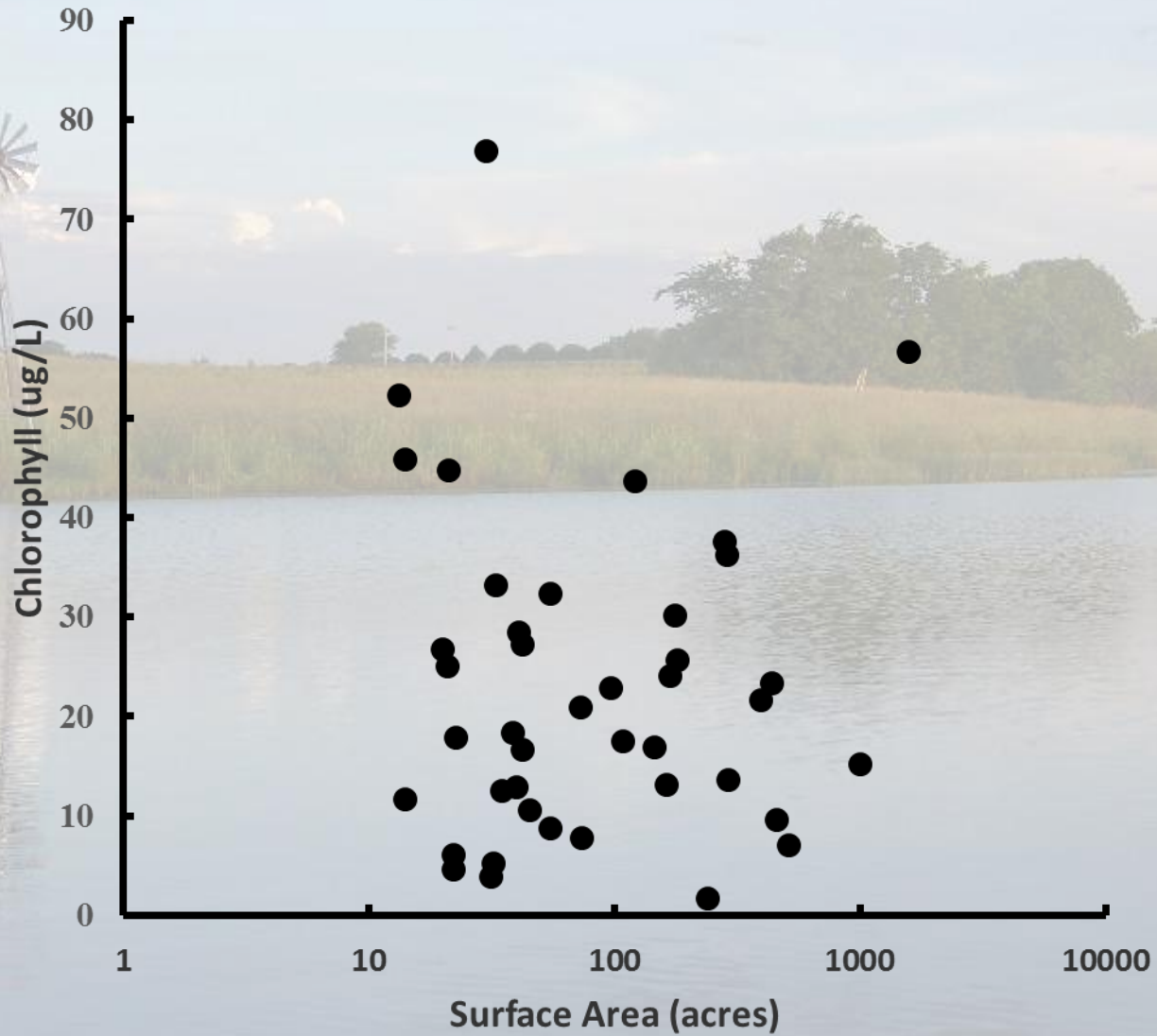
**A goal for this effort was to avoid a one-size fits all approach.**



**214 reservoirs monitored  
by University of MO**

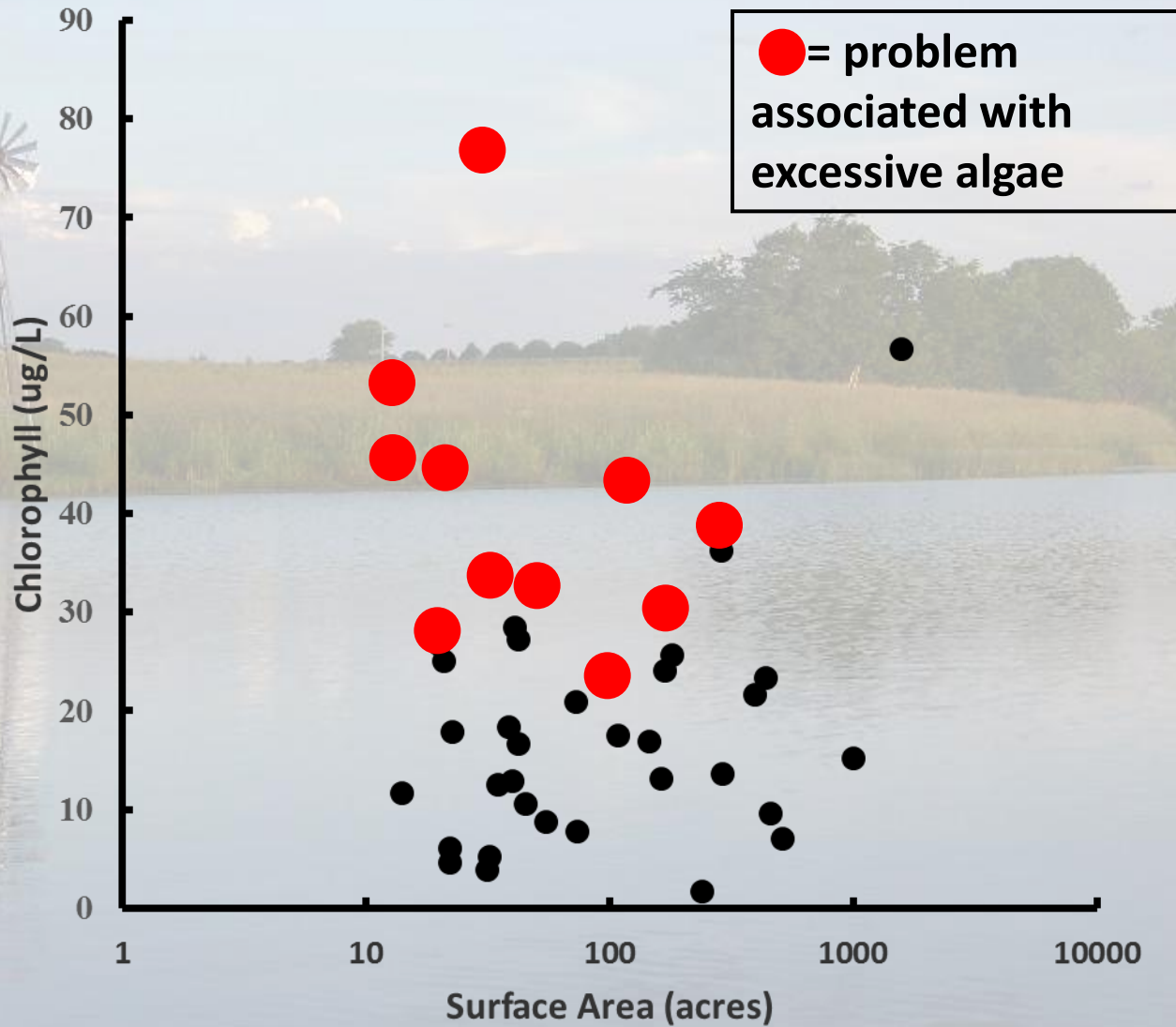


# Plains Reservoirs

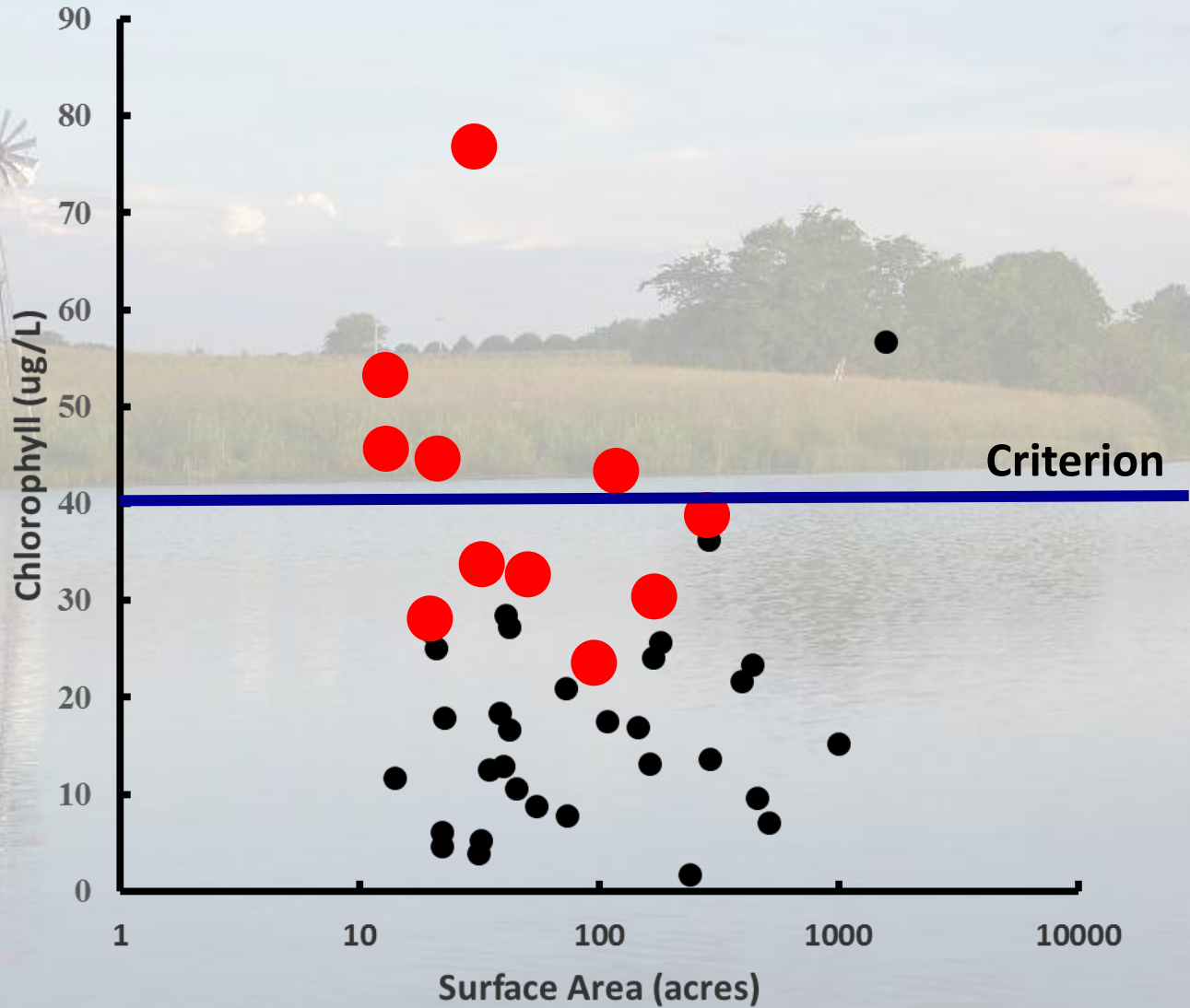




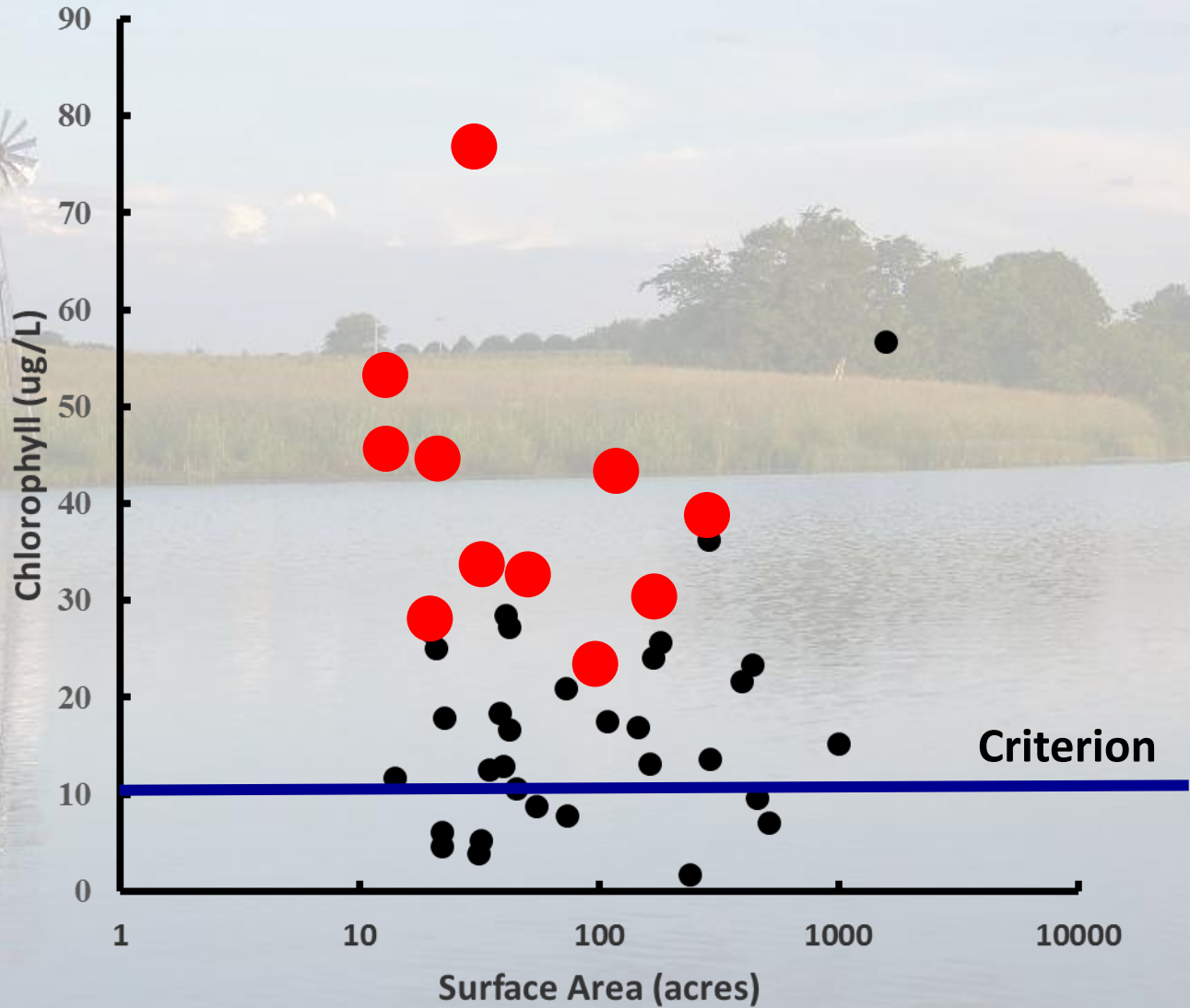
# Plains Reservoirs



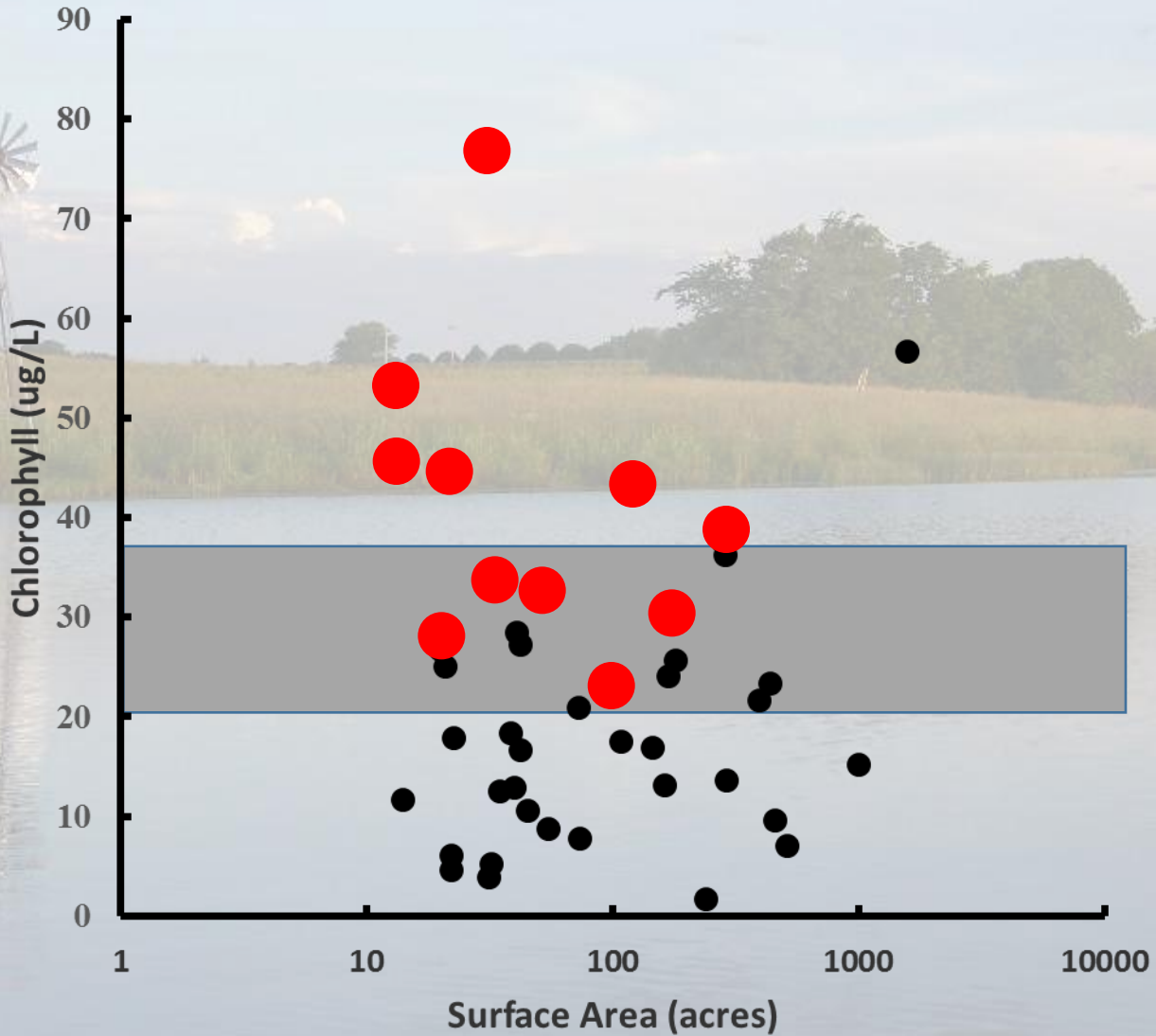
# Plains Reservoirs



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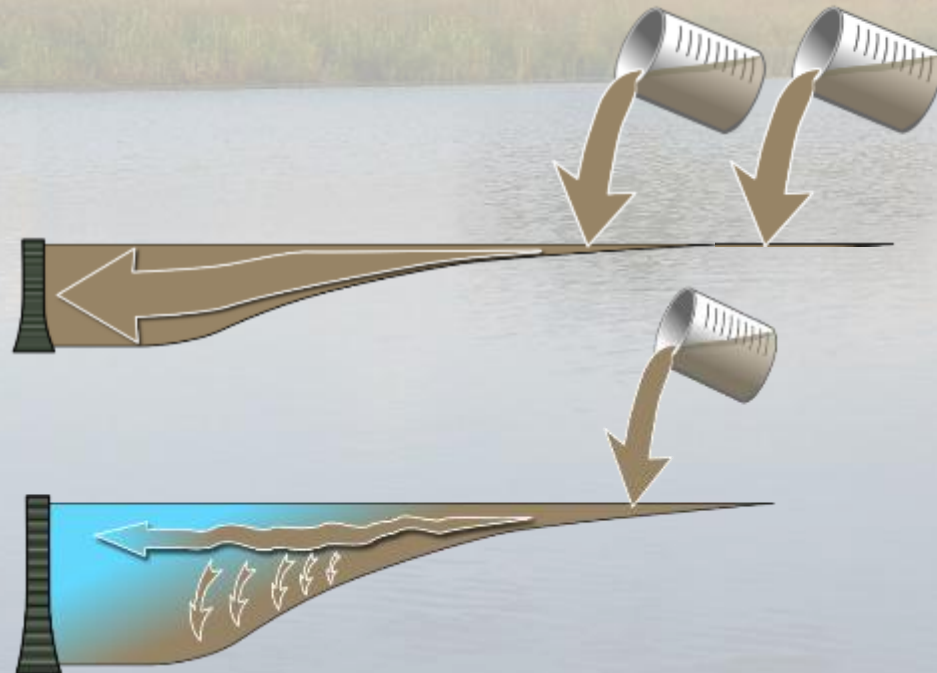
# Plains Reservoirs



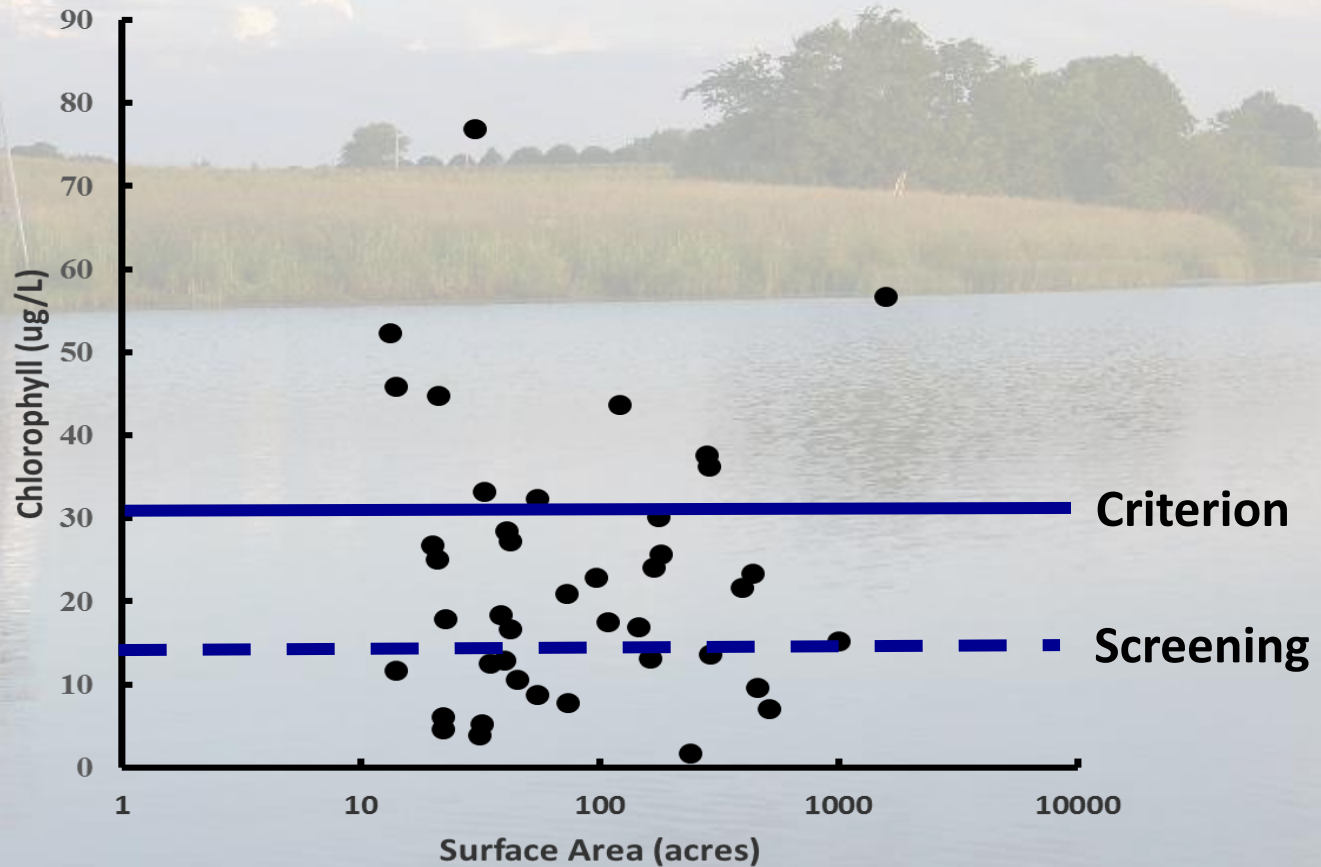


**The 2008 approach used factors that determine nutrient concentrations (maximum depth & hydrology) to predict phosphorus levels.**

**Criteria were then set accordingly.**



**Current approach uses higher  
criterion value and a lower screening  
value to work around one size fits all**



# CURRENT PROPOSED APPROACH AQUATIC LIFE CRITERIA

Regional criterion values reflect regional differences in water quality and potential differences in aquatic life.



# Lines of Evidence

**Study A**

**Analysis B**

**Study C**



**GRADIENT OF ALGAL CHLOROPHYLL**



# Line of Evidence #1

## **2012 publication *Influence of Environmental Variables and Species Interactions on Sport Fish Communities in Small Missouri Impoundments***

**Investigating influence of nutrients/chlorophyll on five game fish species using four measures of fishery health.**

**Largemouth Bass  
Bluegill  
Redear Sunfish  
Black Crappie  
White Crappie**

**Catch per effort  
Proportional size distribution  
Preferred-size distribution  
Mean length at age 3**

## **Line of Evidence #1**

**Phosphorus/chlorophyll were generally positive, but often secondary in importance (only most important factor in 2 of 20 analyses)**

**Phosphorus was not important for either crappie species**

**A few of the analyses suggested positive chlorophyll influence up to ~60 $\mu$ g/L**

**Harmful effects of nutrients limited to hypereutrophic conditions (TP = 100 $\mu$ g/L / CHL = 40 $\mu$ g/L)**

**Target chlorophyll level of 30 $\mu$ g/L in Plains to protect aquatic life while maintaining fisheries. Lower values in Border and Ozark regions to reflect regional differences.**

## Line of Evidence #2

**Evaluate relation between species diversity and productivity in scientific literature**

**Relationships between species diversity and primary productivity is mixed, often showing no pattern. When a pattern is observed it is often described as a “hump-shaped” with maximum diversity occurring at moderate levels of primary productivity.**

## Line of Evidence #2

**Table 6-1. Relationship between Diversity and Productivity for Three Different Aquatic Groups. Data represent information shown in Figure 4 of Mittleback et al. (2001).**

<b>Aquatic Group (# of studies)</b>	<b>Shape of Diversity-Productivity Relationship</b>				
	<b>Hump-shaped</b>	<b>Positive</b>	<b>Negative</b>	<b>U-Shaped</b>	<b>No Pattern</b>
<b>Fish (7)</b>	3	2	0	0	2
<b>Invertebrates (28)</b>	11	2	3	2	10
<b>Plants (20)</b>	9	1	1	2	7
<b># of Studies (%)</b>	23 (42%)	5 (9%)	4 (7%)	4 (7%)	19 (35%)



## Line of Evidence #2

Another study that looked at diversity among different aquatic groups across multiple regions concluded the best way to truly maintain aquatic diversity would be to “maintain a variety of lake types on a regional scale.” (Declerck et al. 2005)

Ozark Highlands the 75<sup>th</sup>% of chlorophyll range is ~11µg/L

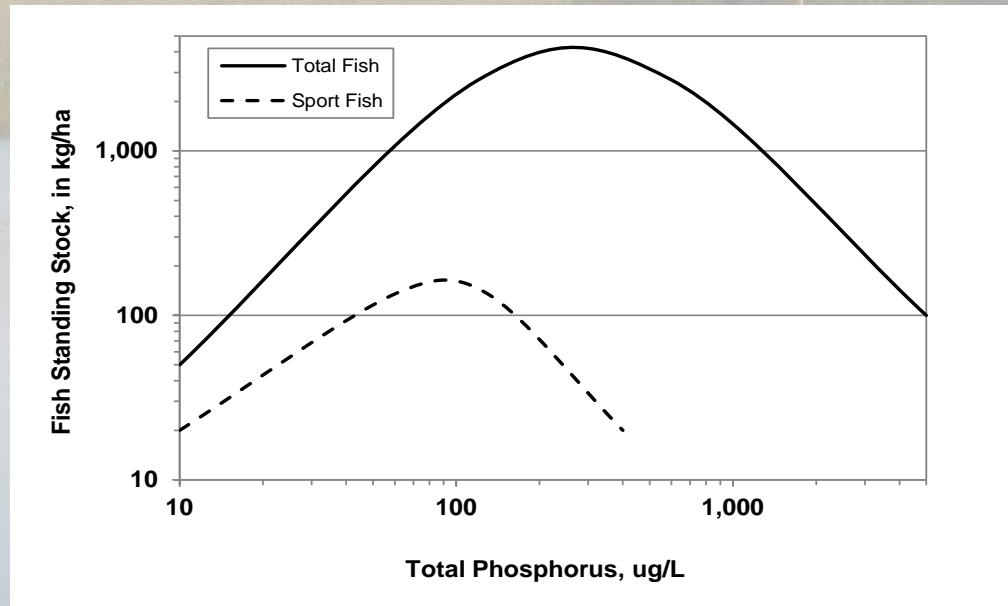
Ozark Border the 75<sup>th</sup>% of chlorophyll range is ~16µg/L

Plains the 75<sup>th</sup>% of chlorophyll range is ~28µg/L

## Line of Evidence #3

Ney (1996) reports that sport fish biomass peaks around  $100\mu\text{g/L}$  total phosphorus, which would result in a chlorophyll concentration of  $36\mu\text{g/L}$  in the Plains Region.

Figure 6-1. Generalized Relationship of Total and Sport Fish Standing Stock to Total Phosphorus Concentrations in Reservoirs Adapted from Ney 1996.



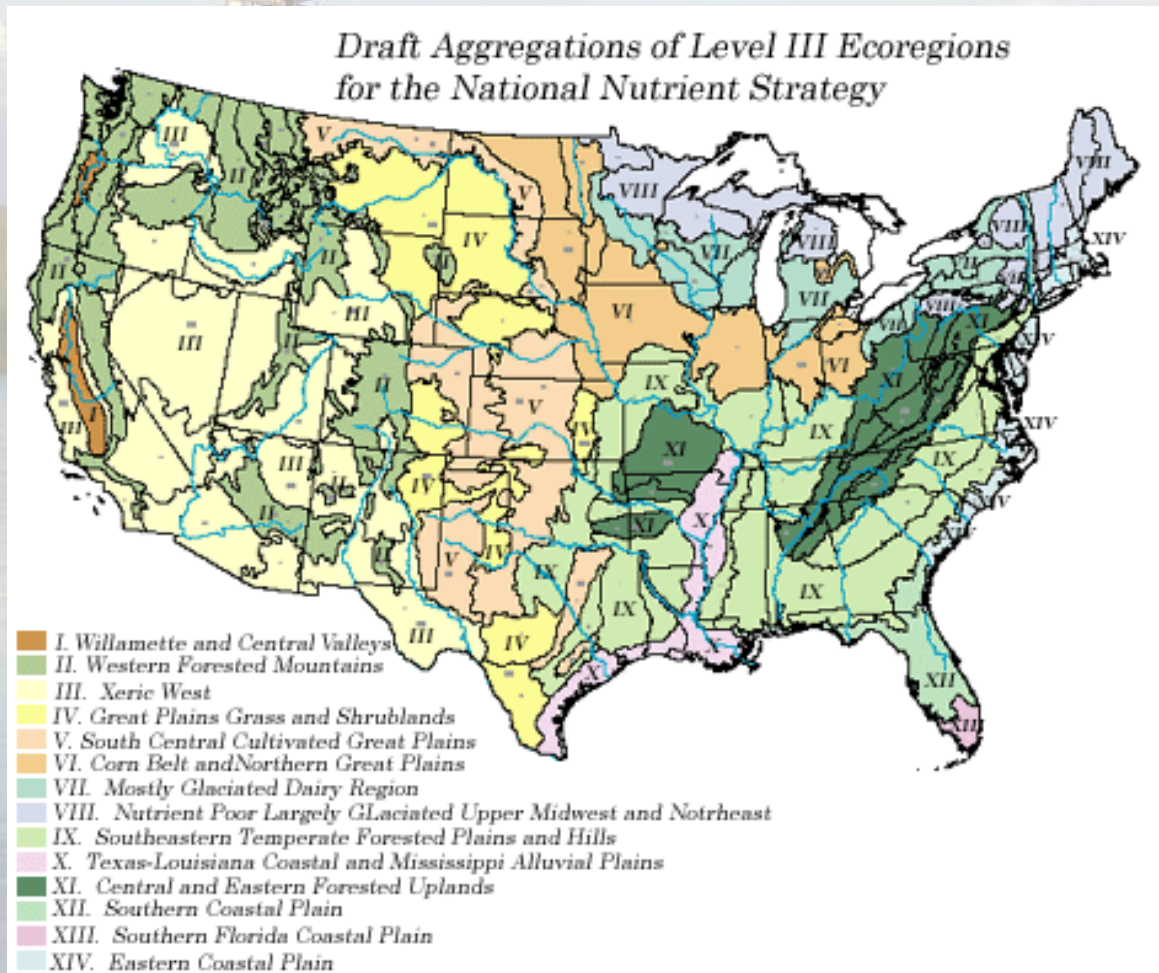
## Line of Evidence #4

**What numeric nutrient criteria have been accepted in other states?**

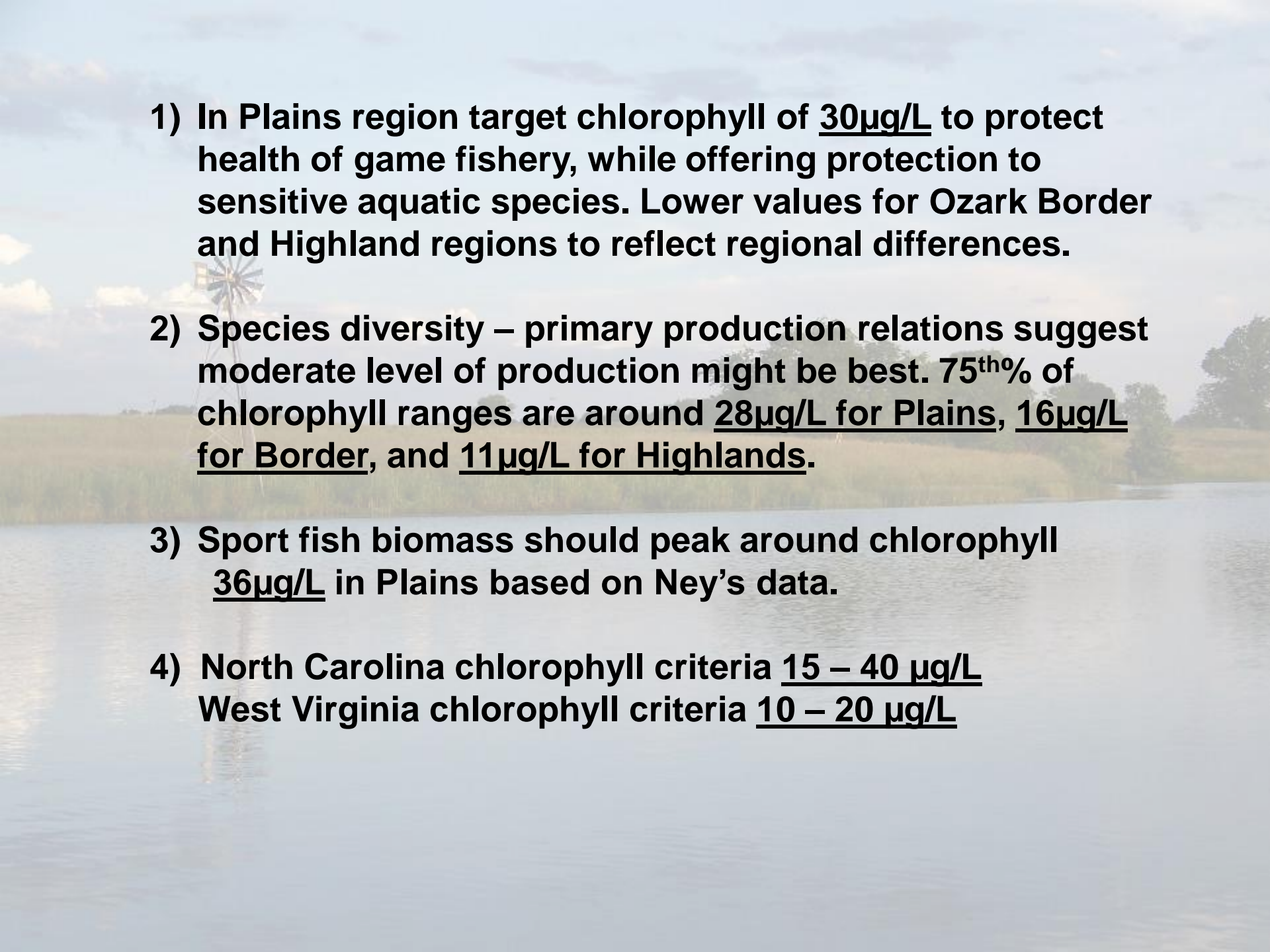
**The majority of North Carolina falls into Level III Ecoregion IX (same as MO Plains) and Ecoregion XI (same as Ozark Highlands). North Carolina has approved chlorophyll criteria of 15 – 40 µg/L.**

## Line of Evidence #4

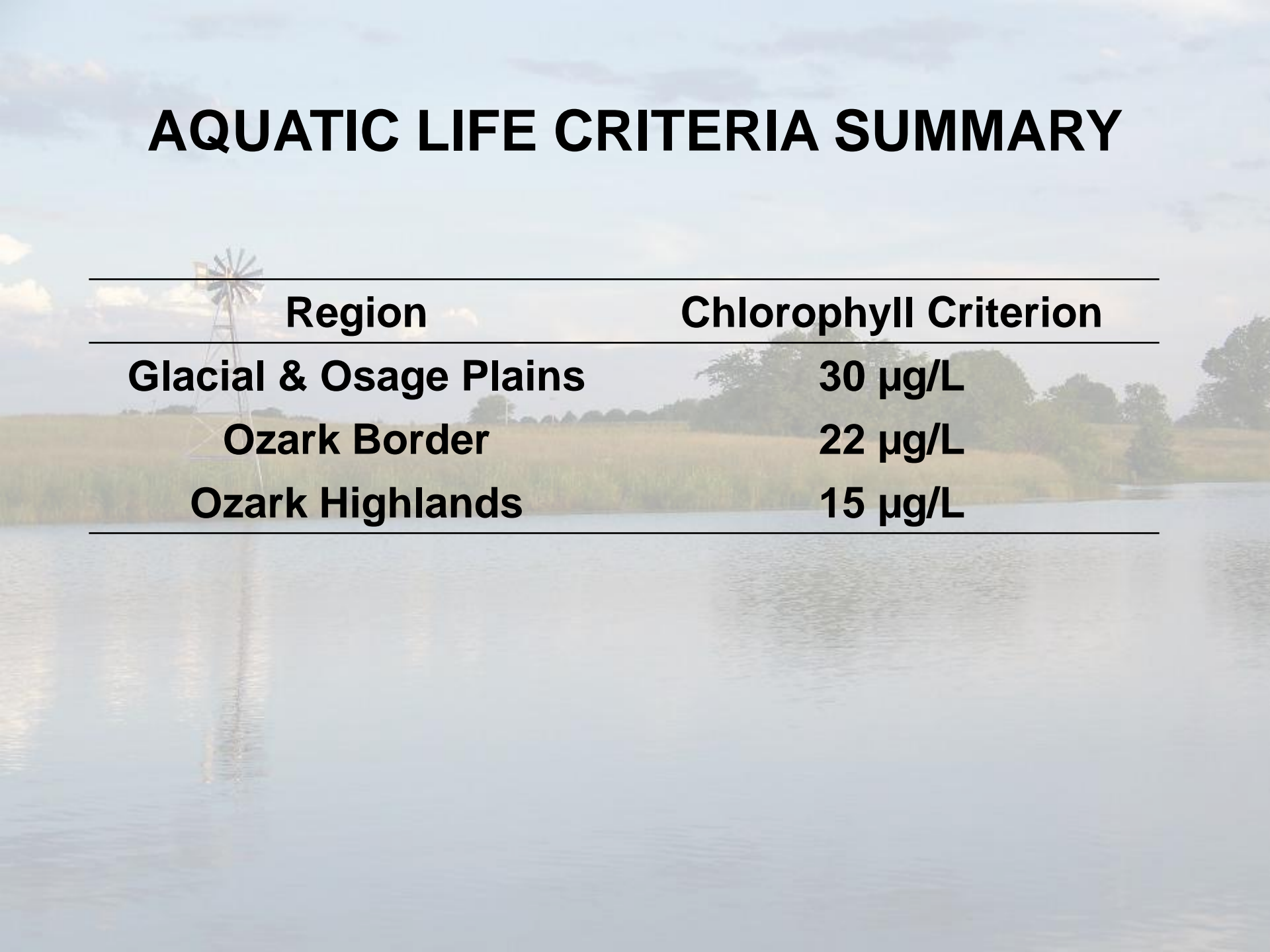
West Virginia is located in Ecoregion XI (same as Ozark Highlands). West Virginia has approved chlorophyll criteria of 10 – 20  $\mu\text{g/L}$ .





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- 1) In Plains region target chlorophyll of 30µg/L to protect health of game fishery, while offering protection to sensitive aquatic species. Lower values for Ozark Border and Highland regions to reflect regional differences.
  - 2) Species diversity – primary production relations suggest moderate level of production might be best. 75<sup>th</sup>% of chlorophyll ranges are around 28µg/L for Plains, 16µg/L for Border, and 11µg/L for Highlands.
  - 3) Sport fish biomass should peak around chlorophyll 36µg/L in Plains based on Ney's data.
  - 4) North Carolina chlorophyll criteria 15 – 40 µg/L  
West Virginia chlorophyll criteria 10 – 20 µg/L

# AQUATIC LIFE CRITERIA SUMMARY



Region	Chlorophyll Criterion
Glacial & Osage Plains	30 µg/L
Ozark Border	22 µg/L
Ozark Highlands	15 µg/L

# AQUATIC LIFE SCREENING VALUES

- 1) Chlorophyll is set at regional median value.
- 2) Phosphorus and nitrogen concentrations are back-calculated using regional regression formulas.

Region	Chlorophyll	Phosphorus	Nitrogen
Glacial & Osage Plains	18 µg/L	49 µg/L	843 µg/L
Ozark Border	13 µg/L	40 µg/L	733 µg/L
Ozark Highlands	6 µg/L	16 µg/L	401 µg/L

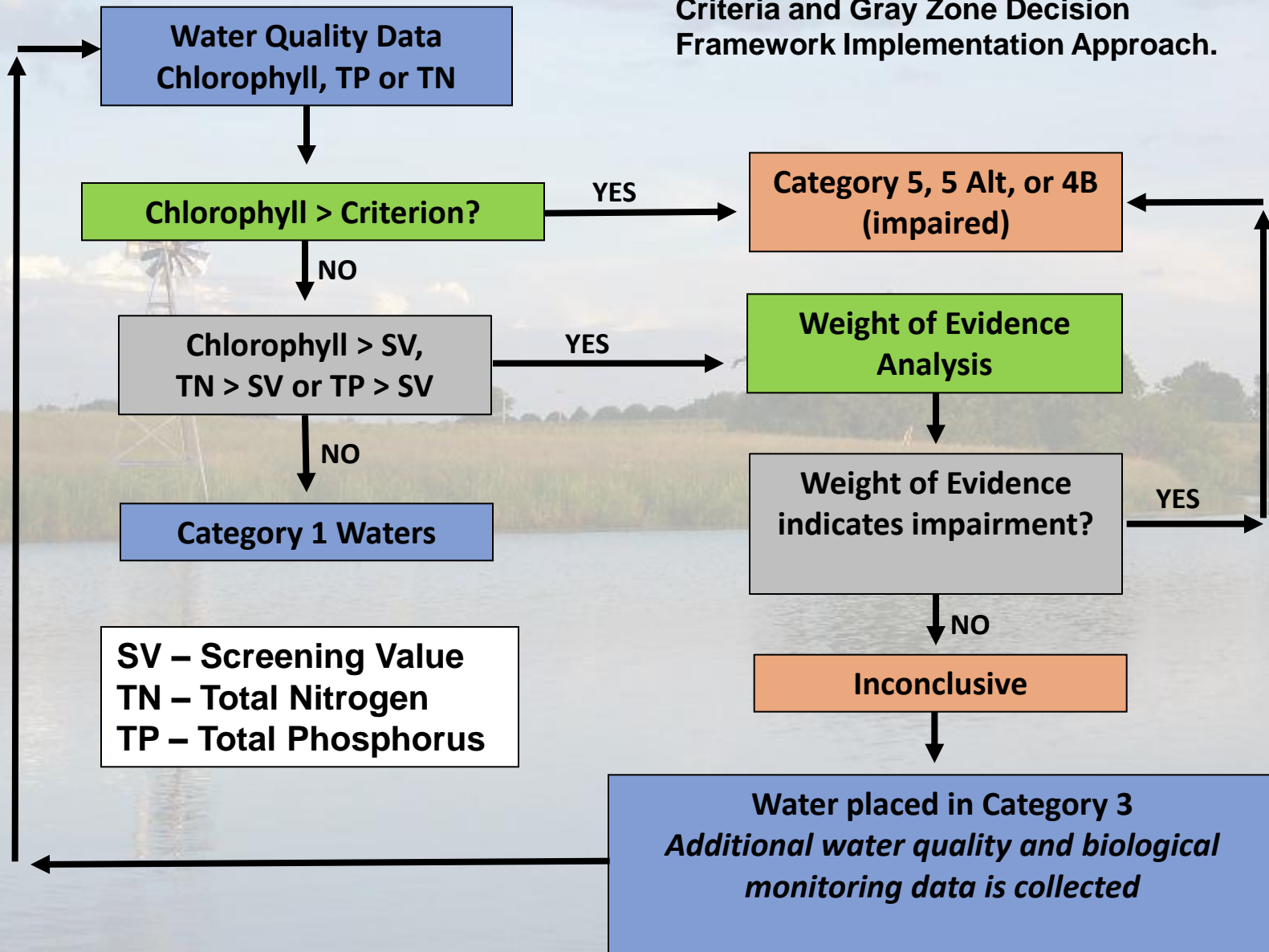
# CRITERIA AND SCREENING VALUE SUMMARY

USE	REGION	CHL CRITERIA	CHL SCREEN	TP SCREEN	TN SCREEN
AQL	Plains	30	18	49	843
	Border	22	13	40	733
	Highlands	15	6	16	401

All values are  $\mu\text{g/L}$



Figure 7-1. Missouri Chlorophyll Criteria and Gray Zone Decision Framework Implementation Approach.



A serene sunset scene over a calm body of water. The sun is low on the horizon, partially obscured by the silhouettes of trees. The sky is filled with soft, wispy clouds, and the water reflects the warm colors of the sunset. The overall mood is peaceful and contemplative.

**Questions?**