Water Quality Gradients in the A.R.M. Loxahatchee National Wildlife Refuge

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Introduction

- **The A.R.M. Loxahatchee National Wildlife Refuge (Refuge) developed as a system with waters low in inorganic ions.**

- **The Refuge has been impacted by intrusion of water with high nutrient and solute concentrations.**

- **In June 2004, the Refuge began a detailed water quality monitoring project to provide information to aid in water management decisions.**

Objectives

- Determine if water quality inflow from STA1 - West (agriculture) was different from water quality inflow from STA1 - East (agriculture and urban).

- Characterize how intrusion of water with high nutrient and solute concentrations has influenced water quality in the Refuge.

- Determine if a north - south water quality gradient exists in the Refuge.

Methods

- **Grab samples were collected monthly at 48 marsh and 5 canal sites from November, 2004 through August, 2007.**

- **Samples were stored on ice at 4 ^{o}C, filtered and analyzed within 4 hr of collection.**

- **Samples were analyzed using methods described in Standard Methods for the Examination of Water and Wastewater, American Public Health Association.**

Statistics

- **All dependent variables were tested for normality and then analyzed by GLM procedures for a completely random design with SAS programs.**

- **In each graph, bars with the same letter are not significantly different as determined by the least squares means test ($p \leq 0.05$, $n \geq 58$).**
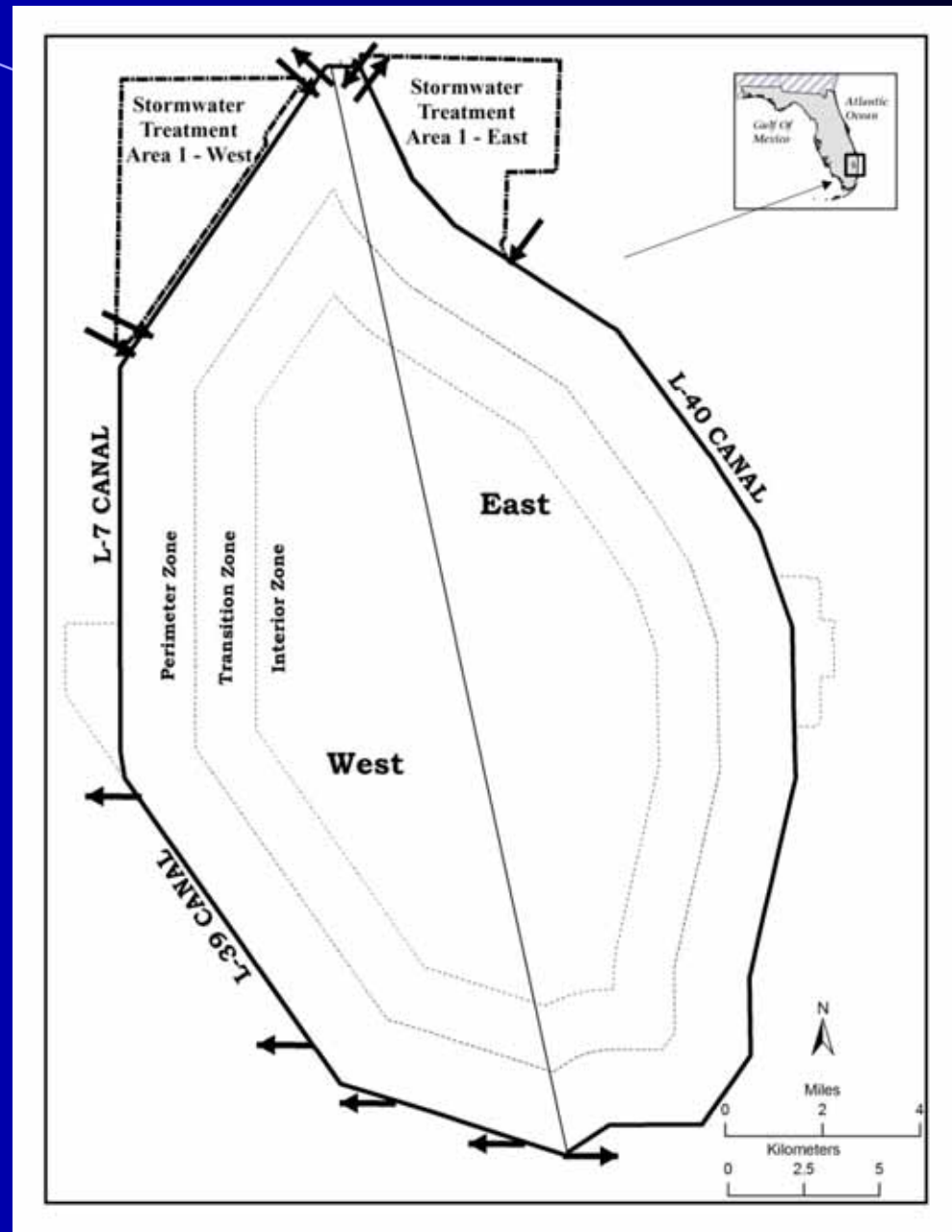
Zones:

Canal   0
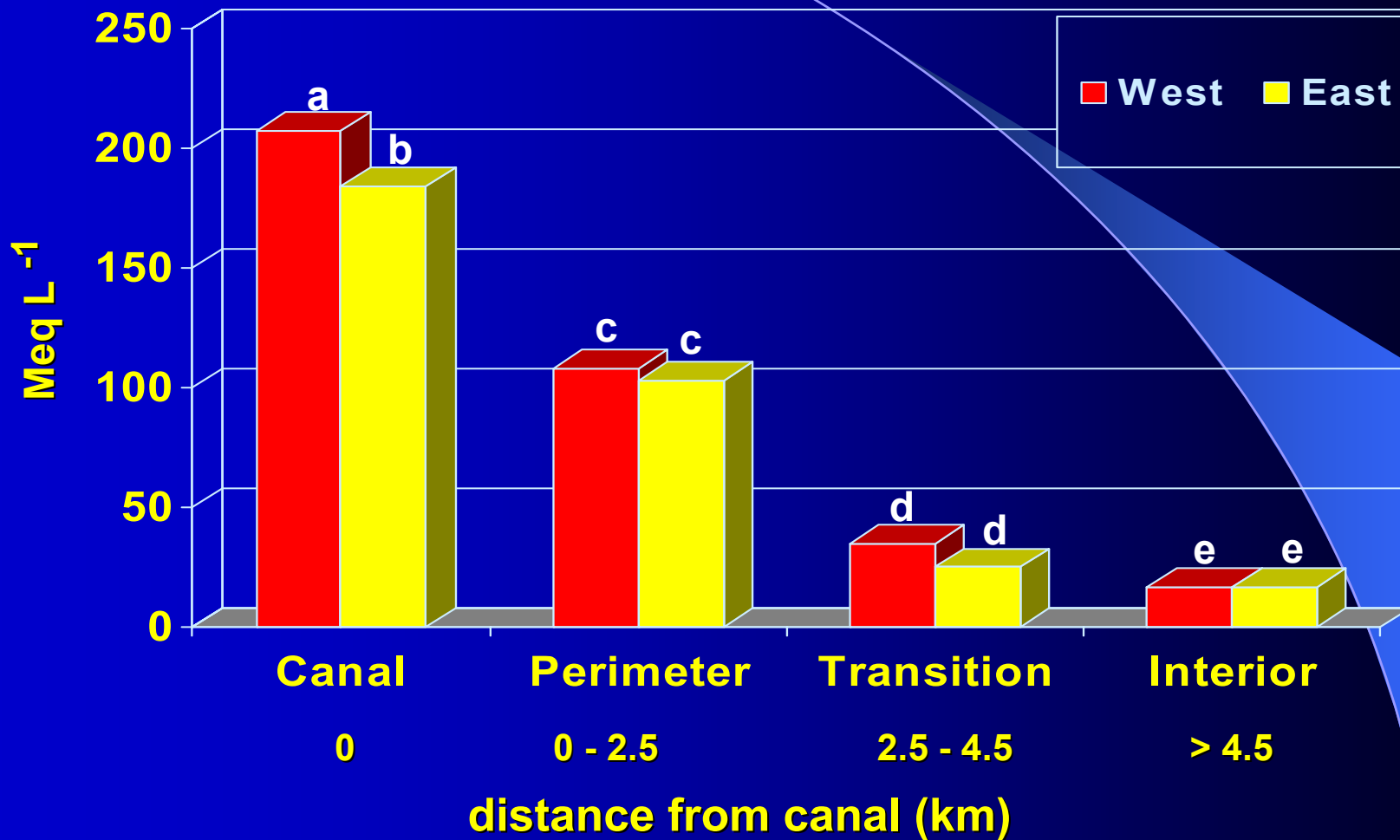**Perimeter   0 to 2.5   km**
Transition   2.5 to 4.5 km
Interior   > 4.5 km

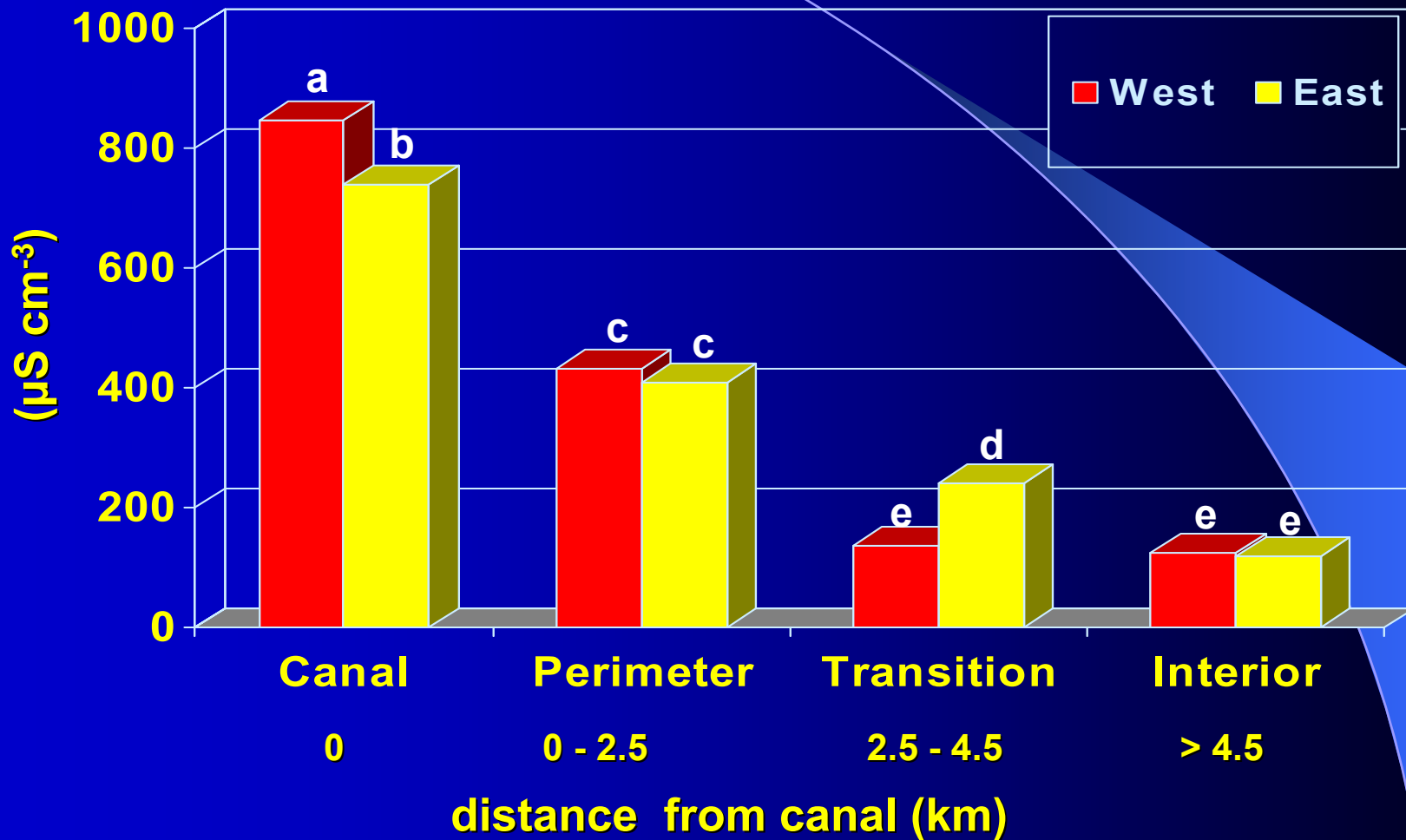**Stormwater Treatment Areas:**

STA1- West
STA1- East

Alkalinity

Values followed by the same letter are not significantly different as determined by the LS means test. p ≤ 0.05; n ≥ 58
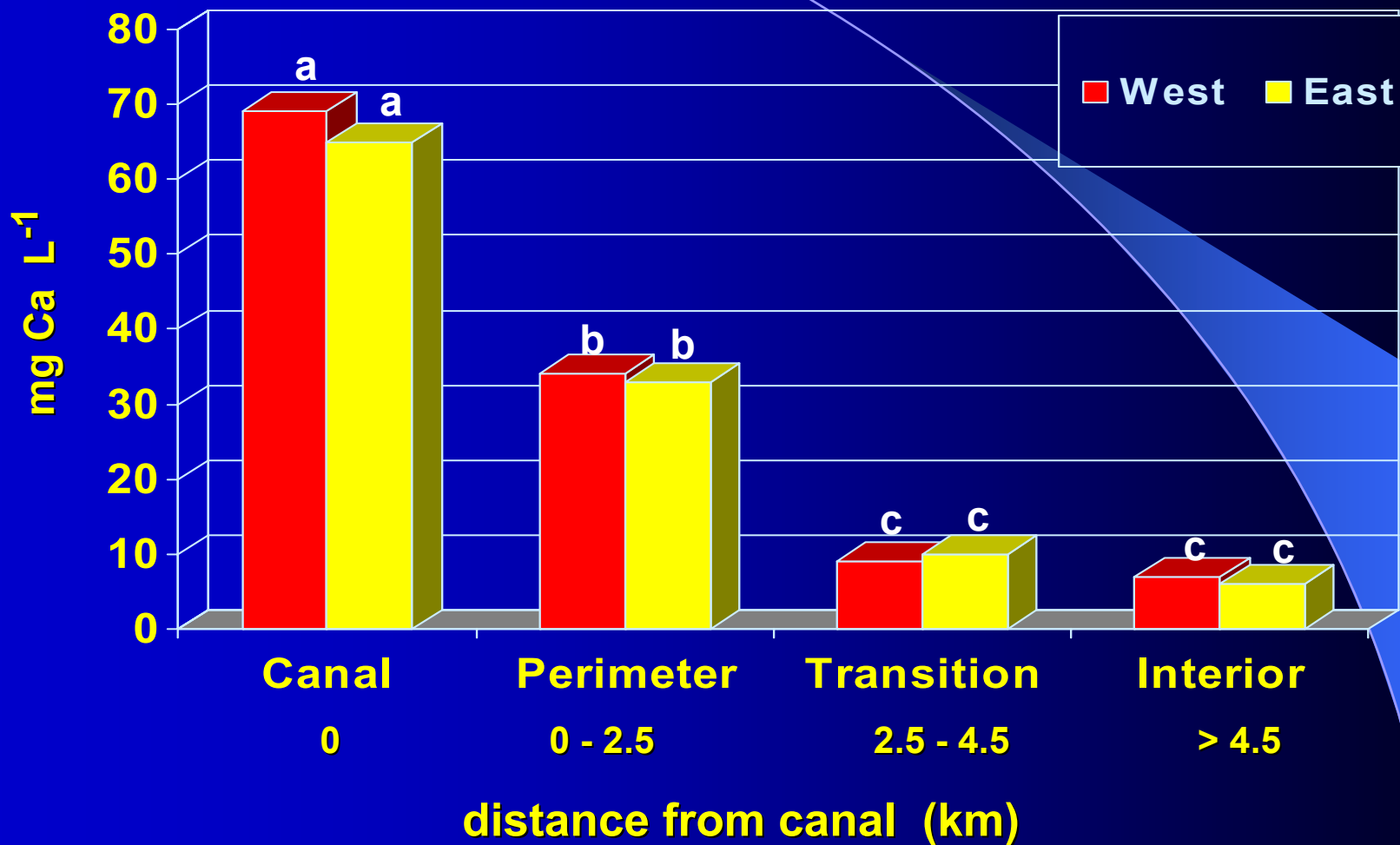
Conductivity

Values followed by the same letter are not significantly different as determined by the LS means test. p ≤ 0.05; n ≥ 58

Calcium

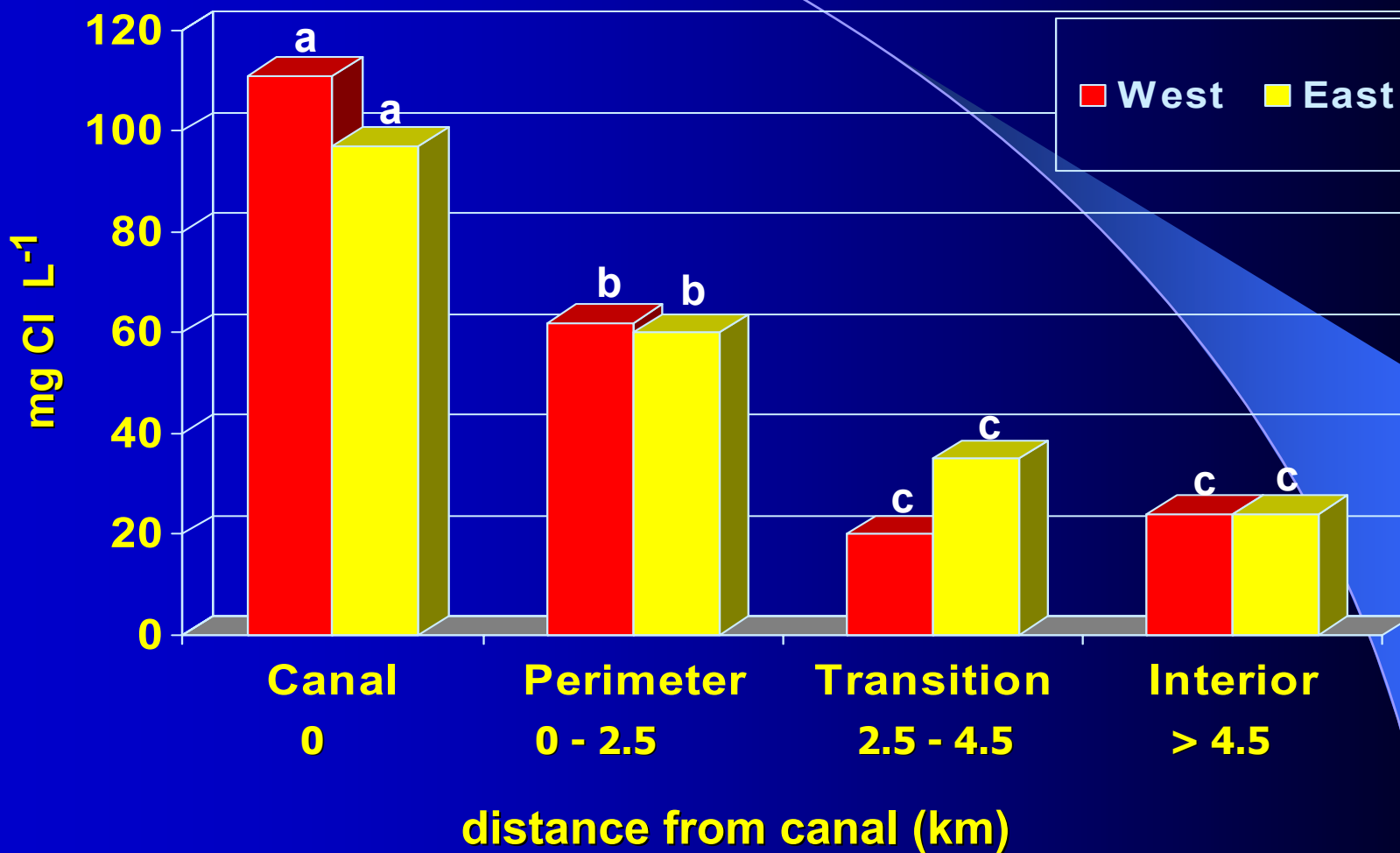Values followed by the same letter are not significantly different as determined by the LS means test. p ≤ 0.05; n ≥ 58

Chloride

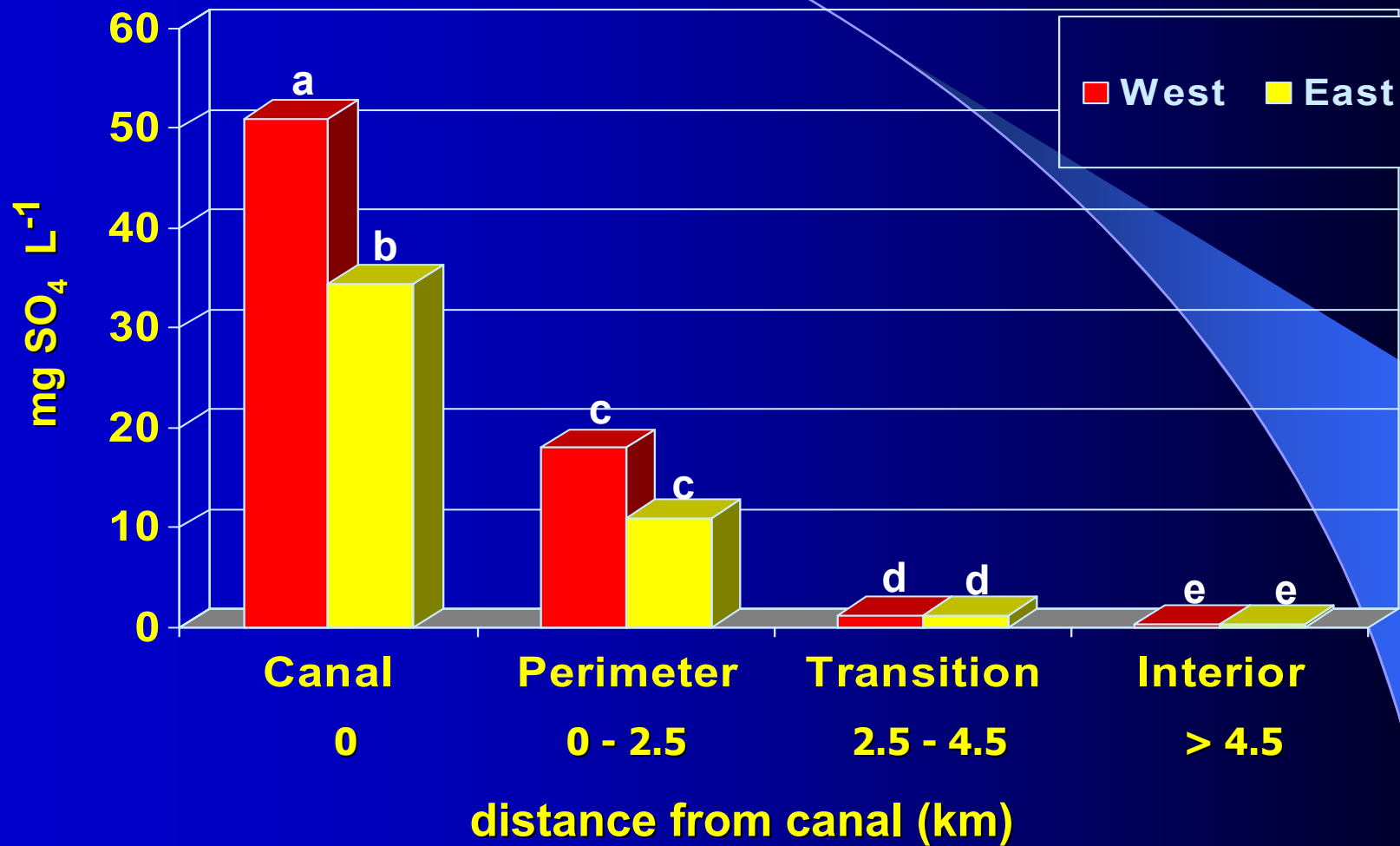Values followed by the same letter are not significantly different as determined by the LS means test. p ≤ 0.05; n ≥ 58
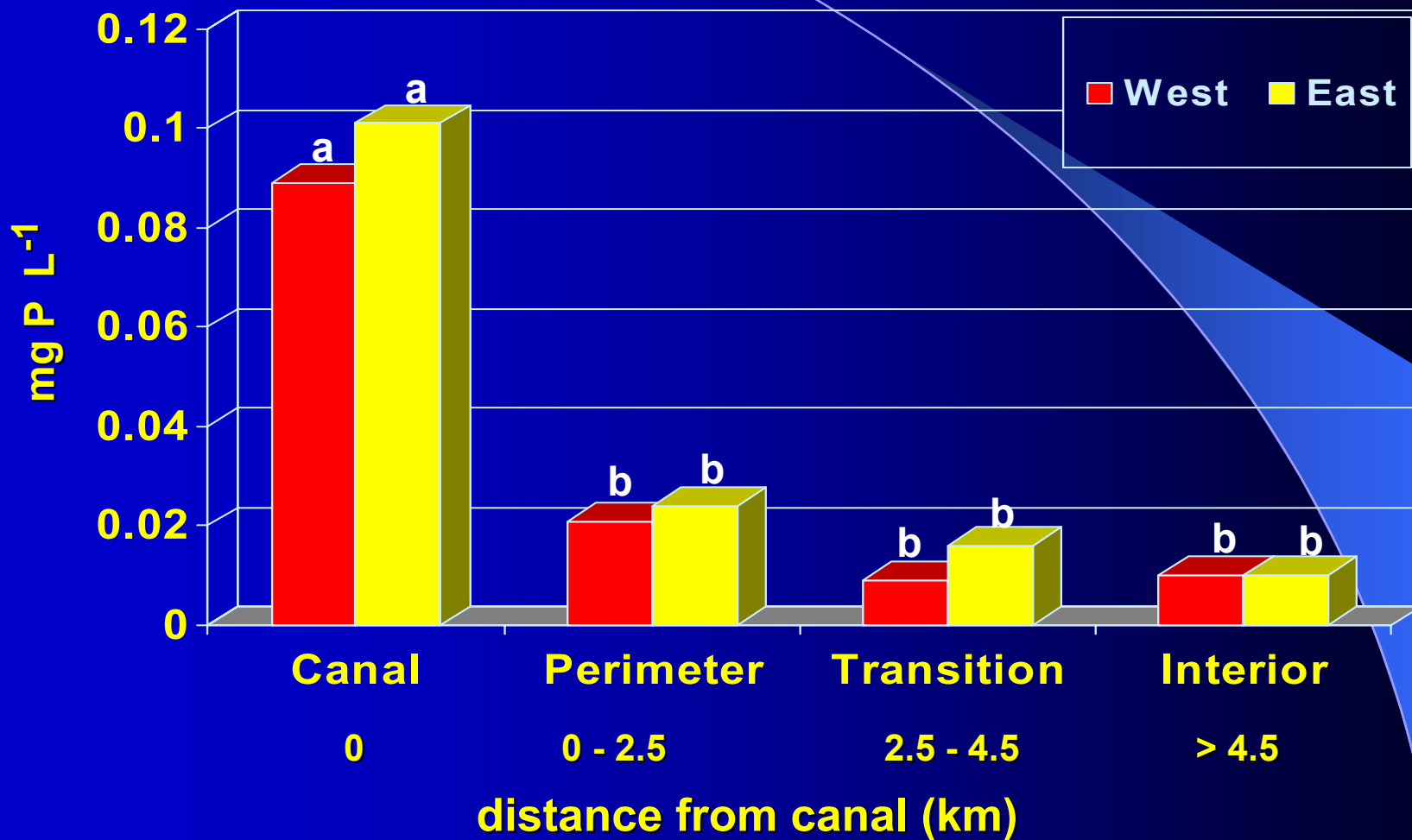
Sulfate

Values followed by the same letter are not significantly different as determined by the LS means test. p ≤ 0.05; n ≥ 58
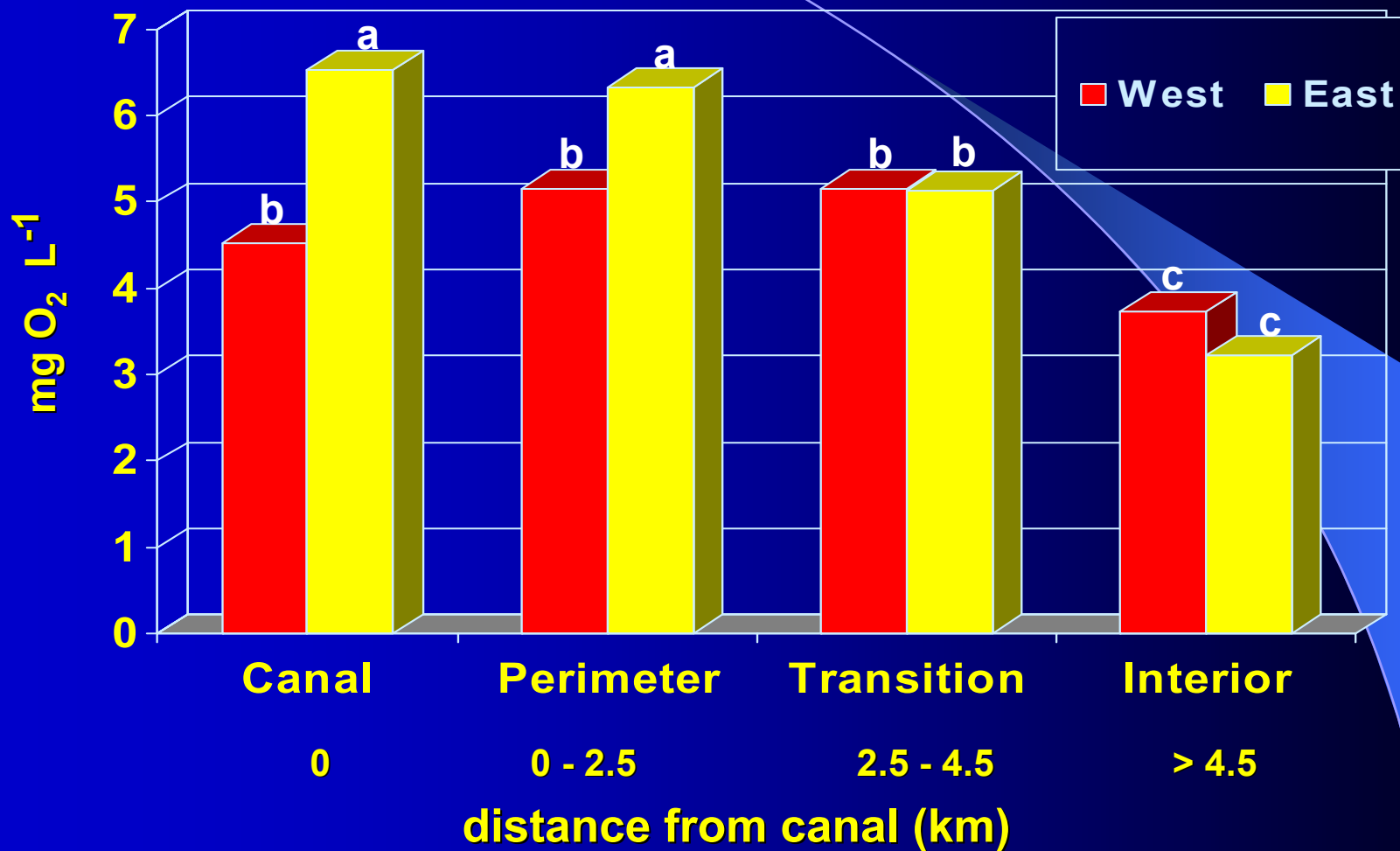
Total Phosphorus

Values followed by the same letter are not significantly different as determined by the LS means test. p ≤ 0.05; n ≥ 58

Dissolved Oxygen Deficit

distance from canal (km)

Values followed by the same letter are not significantly different as determined by the LS means test. p ≤ 0.05; n ≥ 58

Zones:

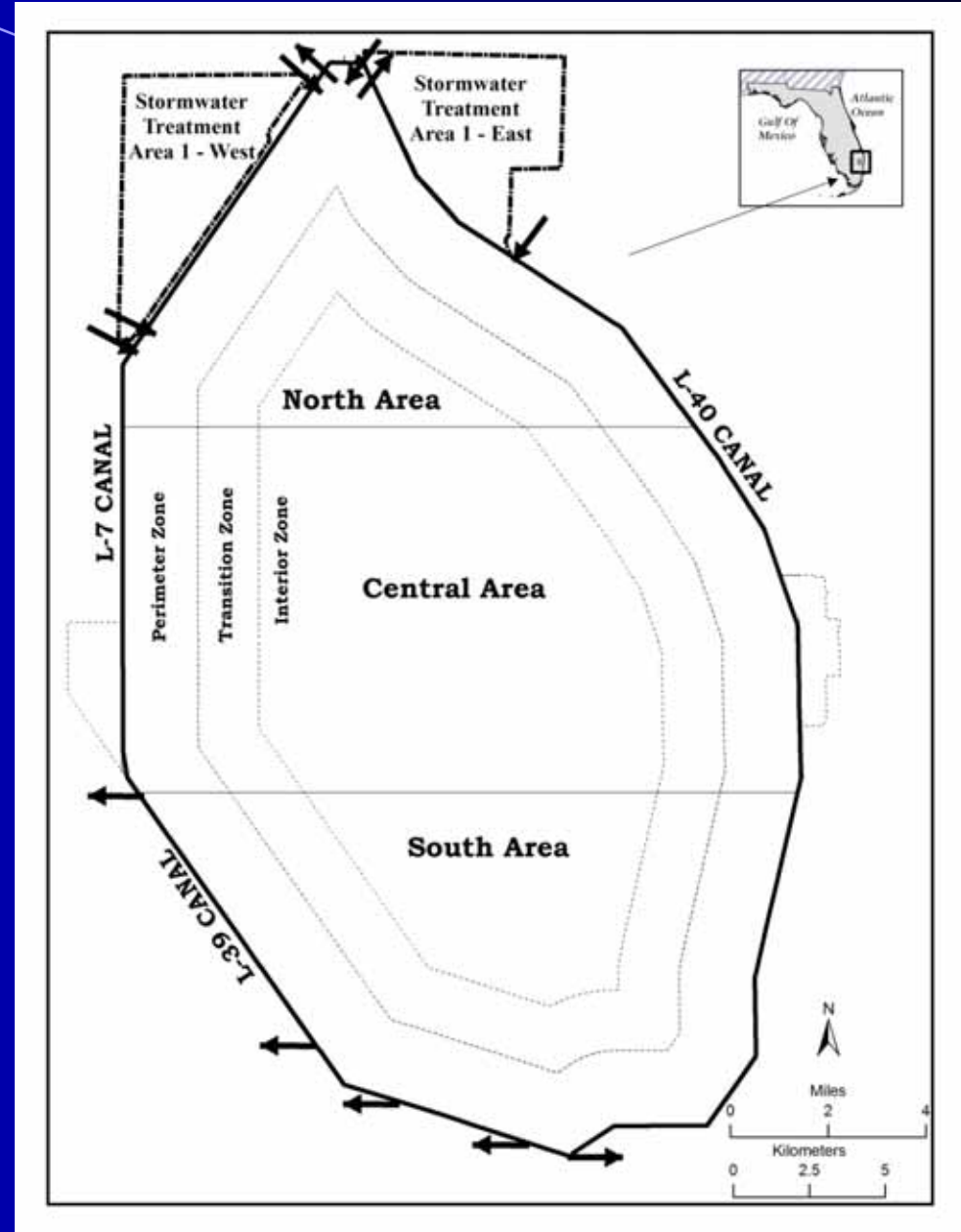|	
Canal	**0**
Perimeter	**0 to 2.5 km**
Transition	**2.5 to 4.5 km**
Interior	**> 4.5 km**

Areas:

North
Central
South

Alkalinity

Meq L^{-1}

North
Central
South

Canal	Perimeter	Transition	Interior
0	0 – 2.5	2.5 - 4.5	> 4.5

distance from canal (km)

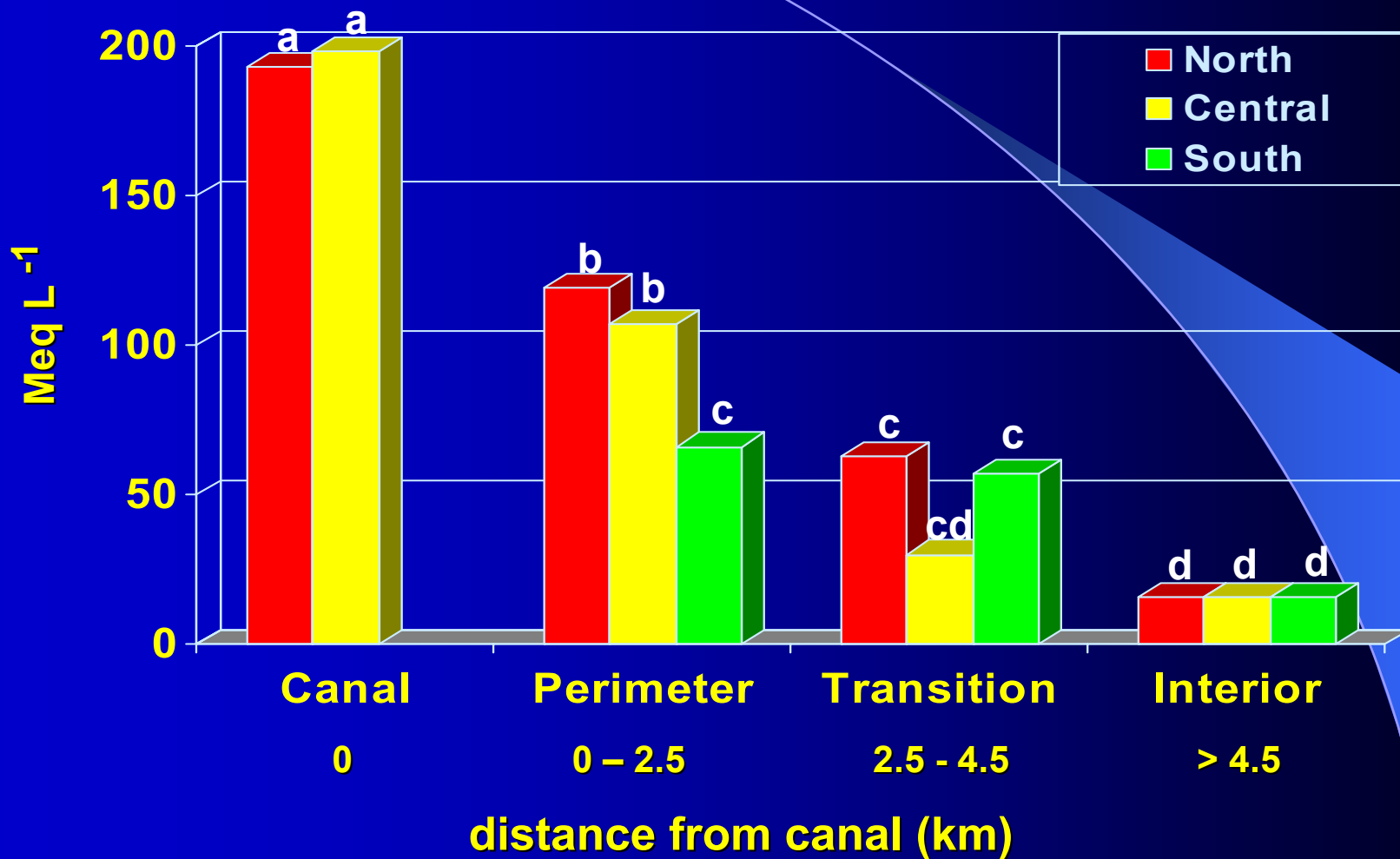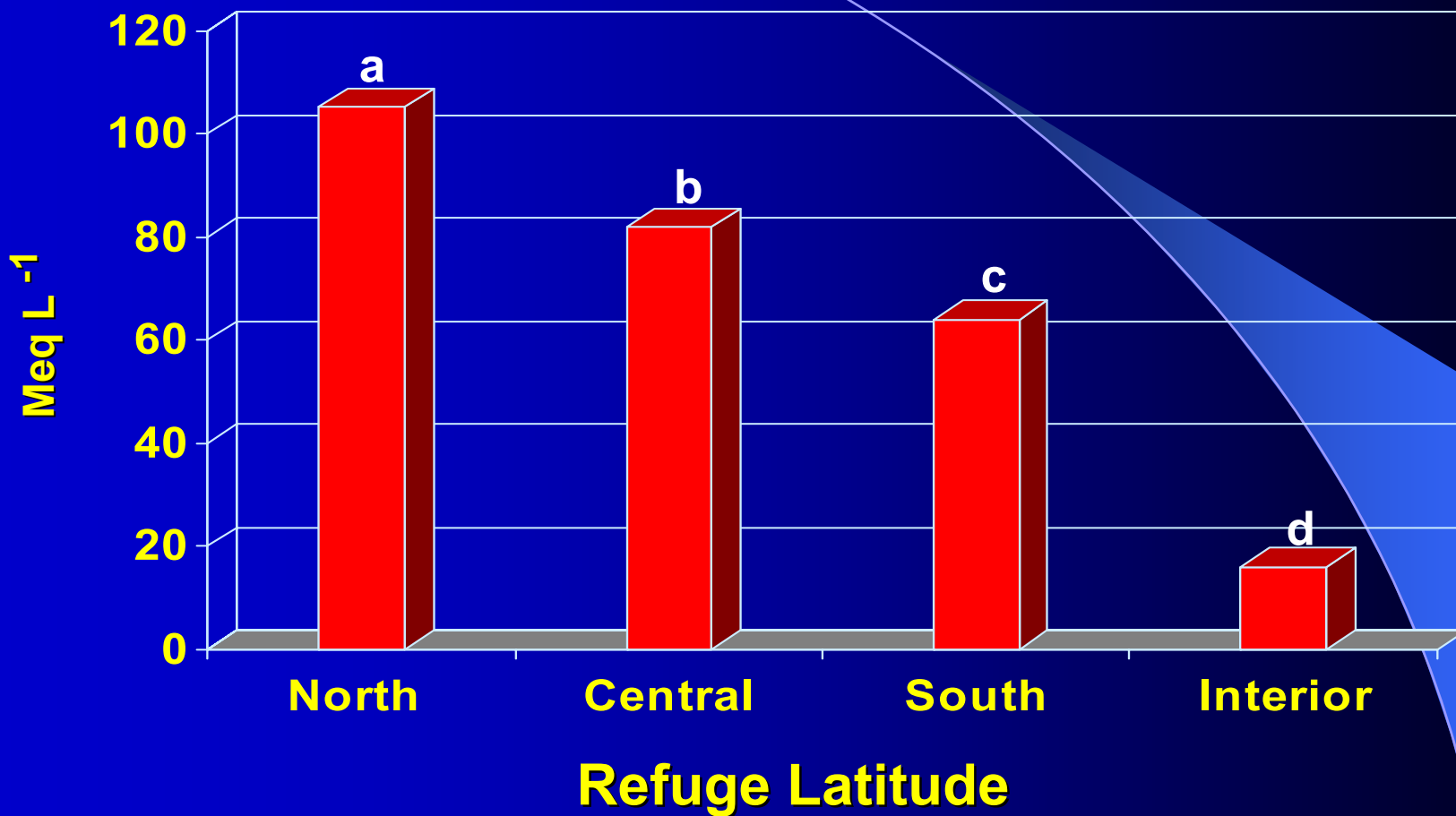Values followed by the same letter are not significantly different as determined by the LS means test. p ≤ 0.05; n ≥ 58

Alkalinity
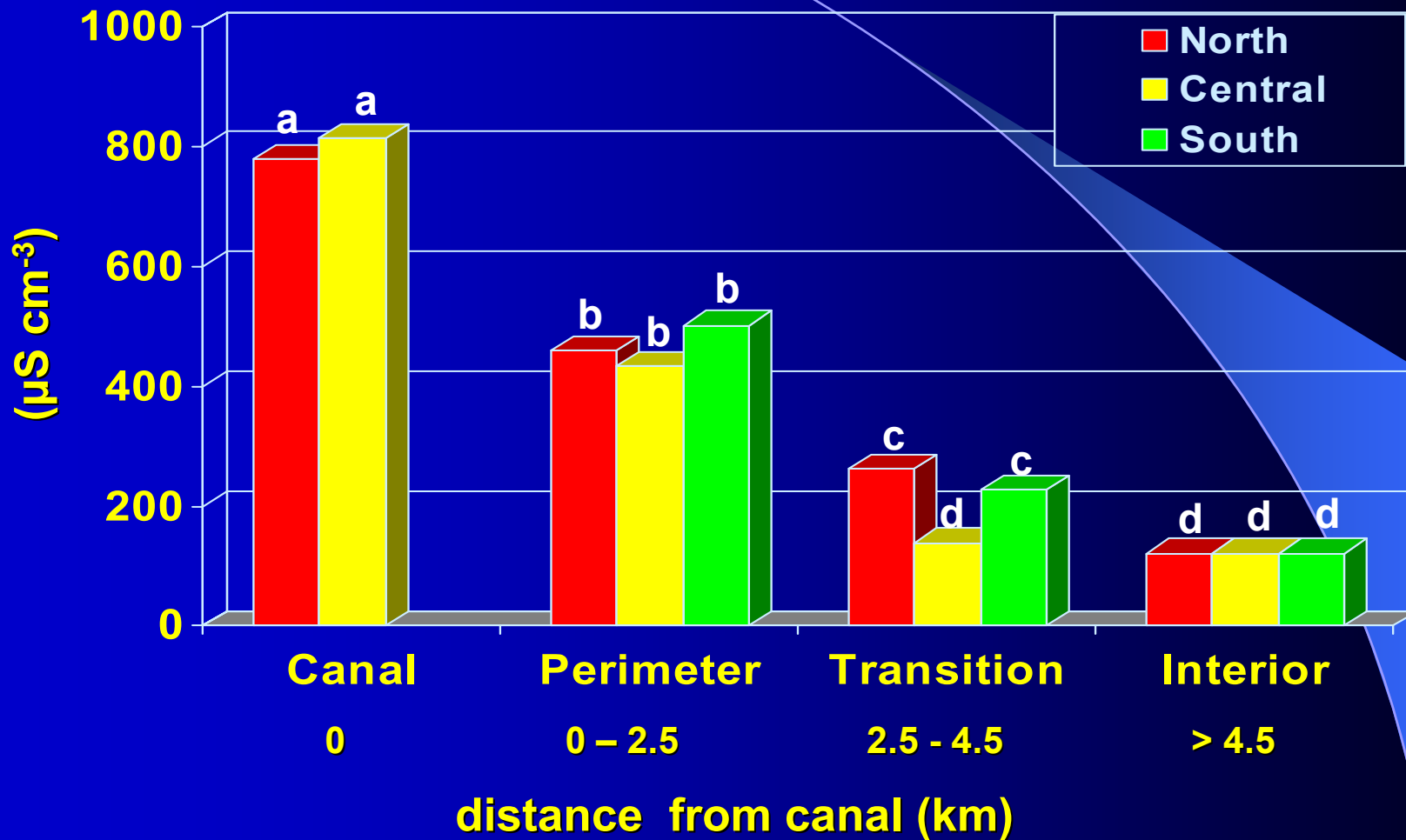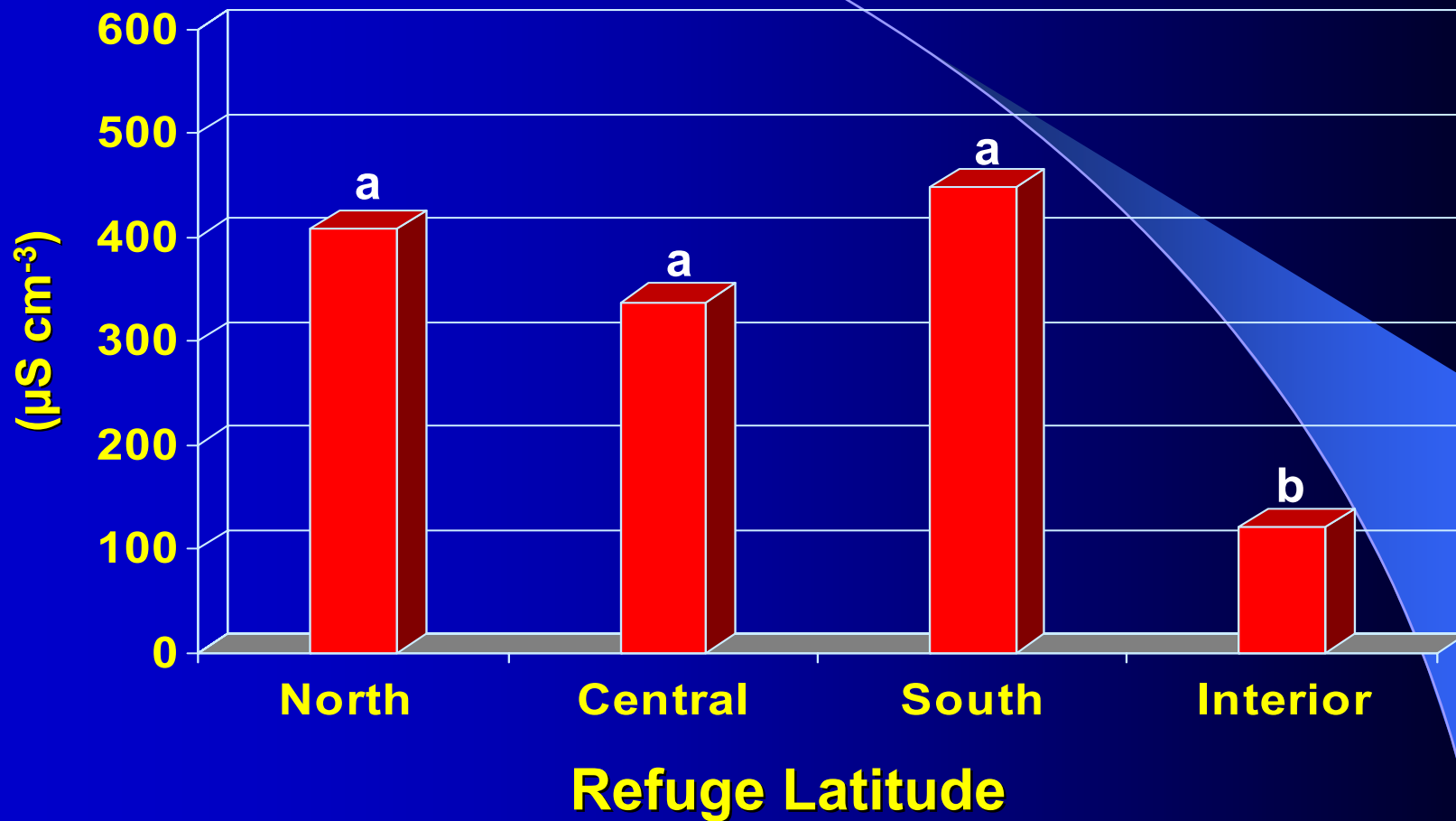

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Conductivity

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Conductivity

Refuge Latitude — (µS cm^{-3})

North: a (~400)
Central: a (~330)
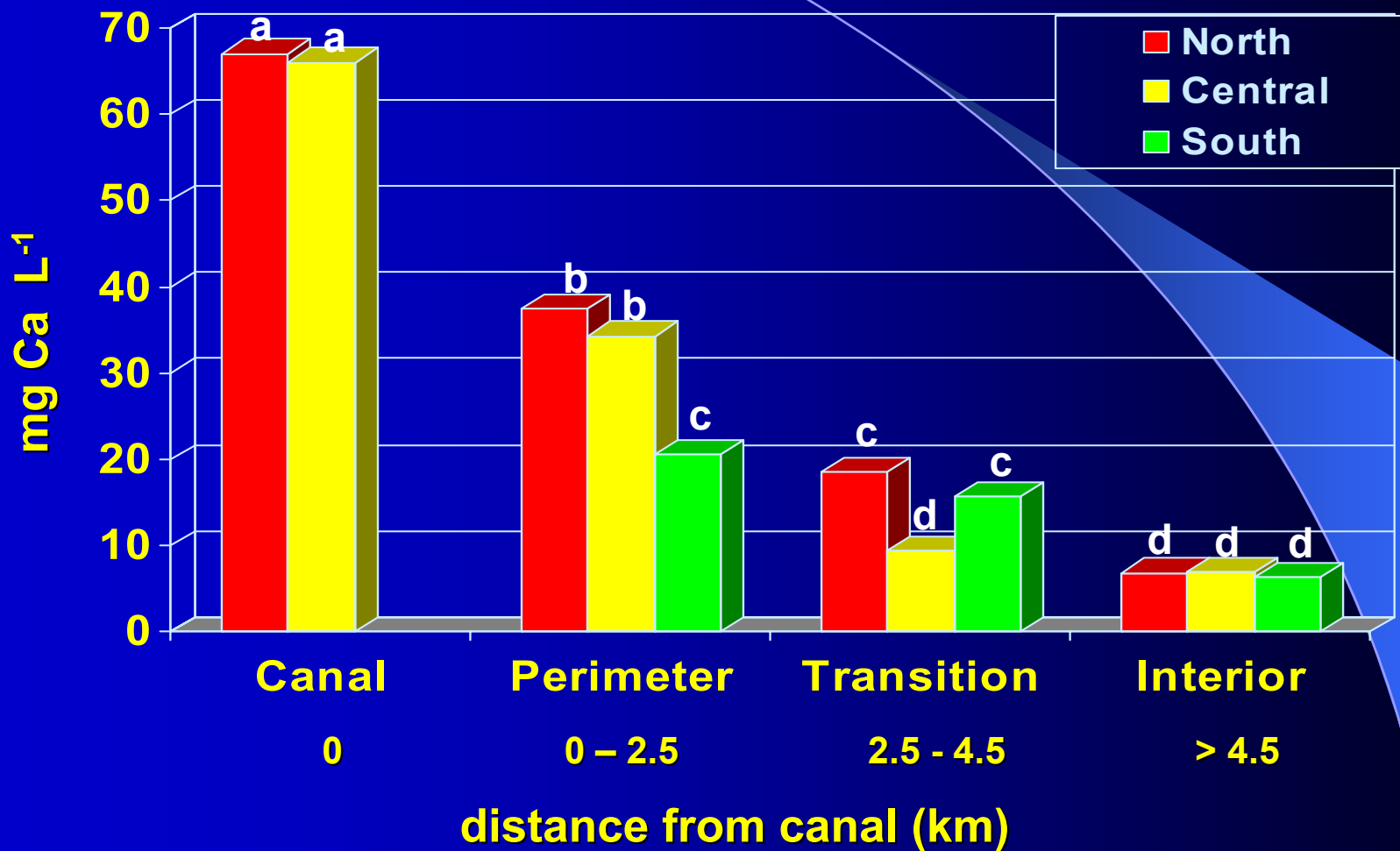South: a (~450)
Interior: b (~110)

Values followed by the same letter are not significantly different as determined by the LS test. $p \leq 0.05$; $n \geq 58$

Calcium

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Calcium

Refuge Latitude (x-axis) vs **mg Ca L^{-1}** (y-axis)

- North: a
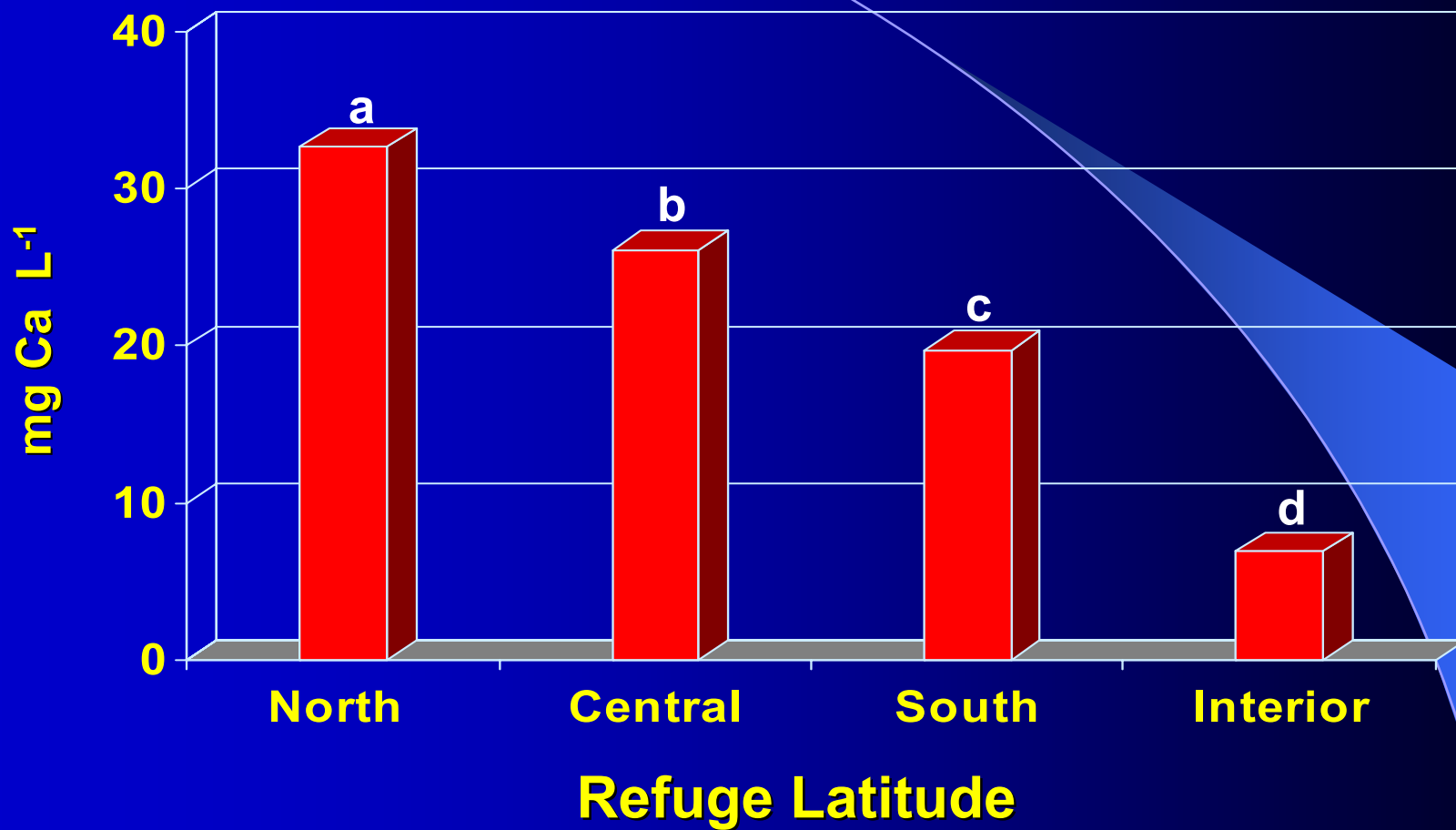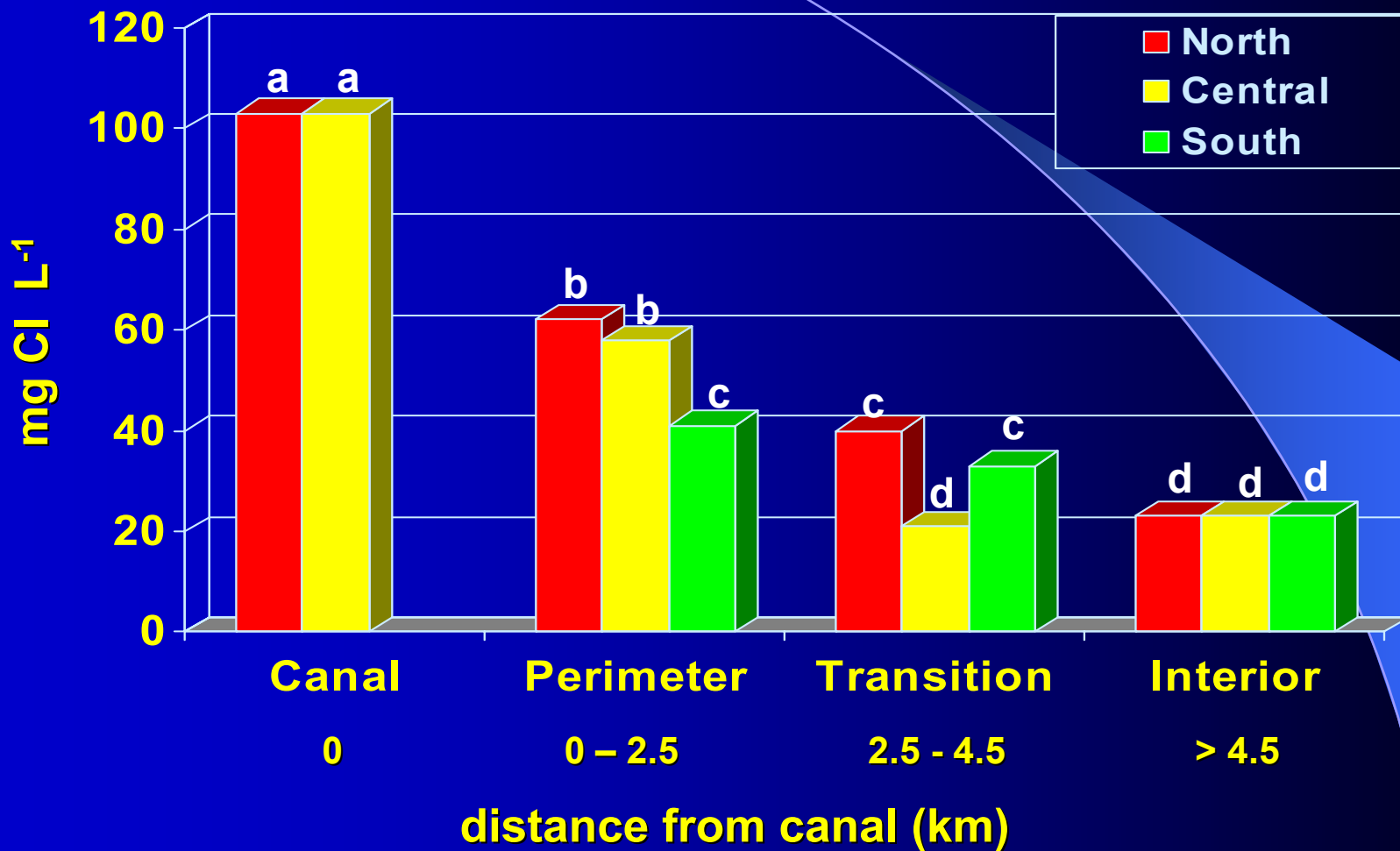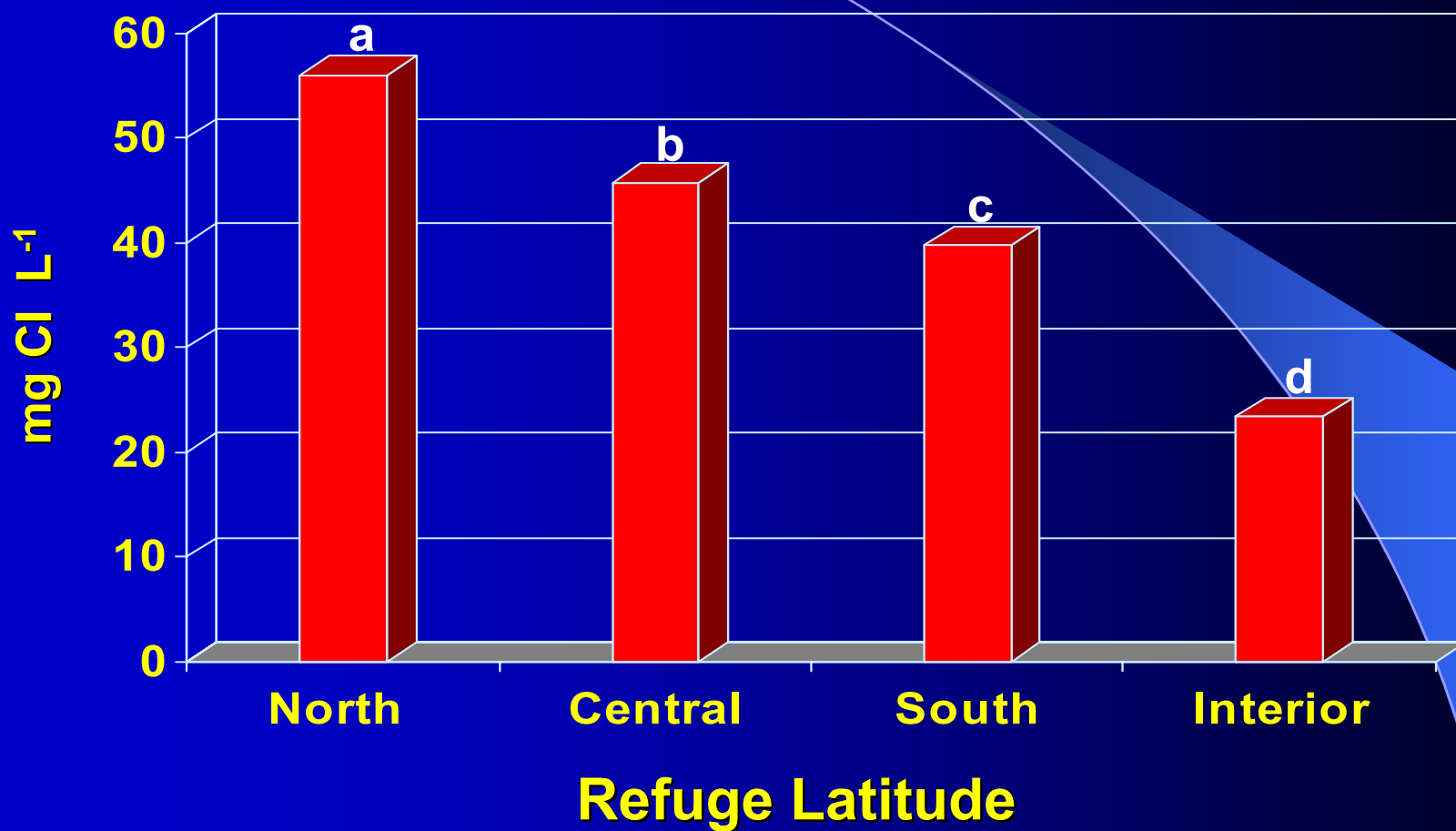- Central: b
- South: c
- Interior: d

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Chloride

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Chloride

Chart showing mg Cl L⁻¹ by Refuge Latitude:
- North: ~55 (a)
- Central: ~45 (b)
- South: ~39 (c)
- Interior: ~23 (d)

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Sulfate

mg SO$_4$ L^{-1} vs distance from canal (km)

Legend: North (red), Central (yellow), South (green)

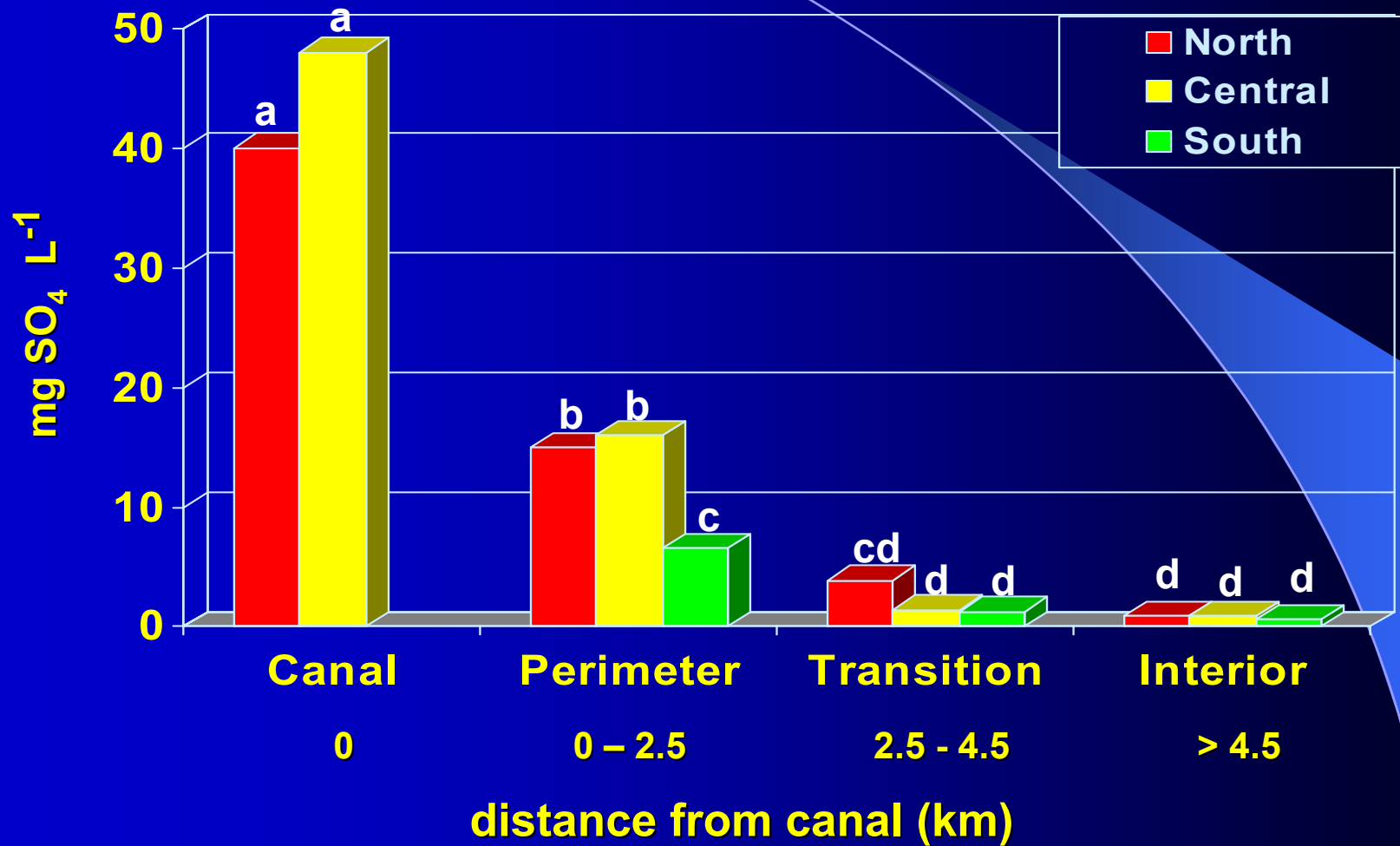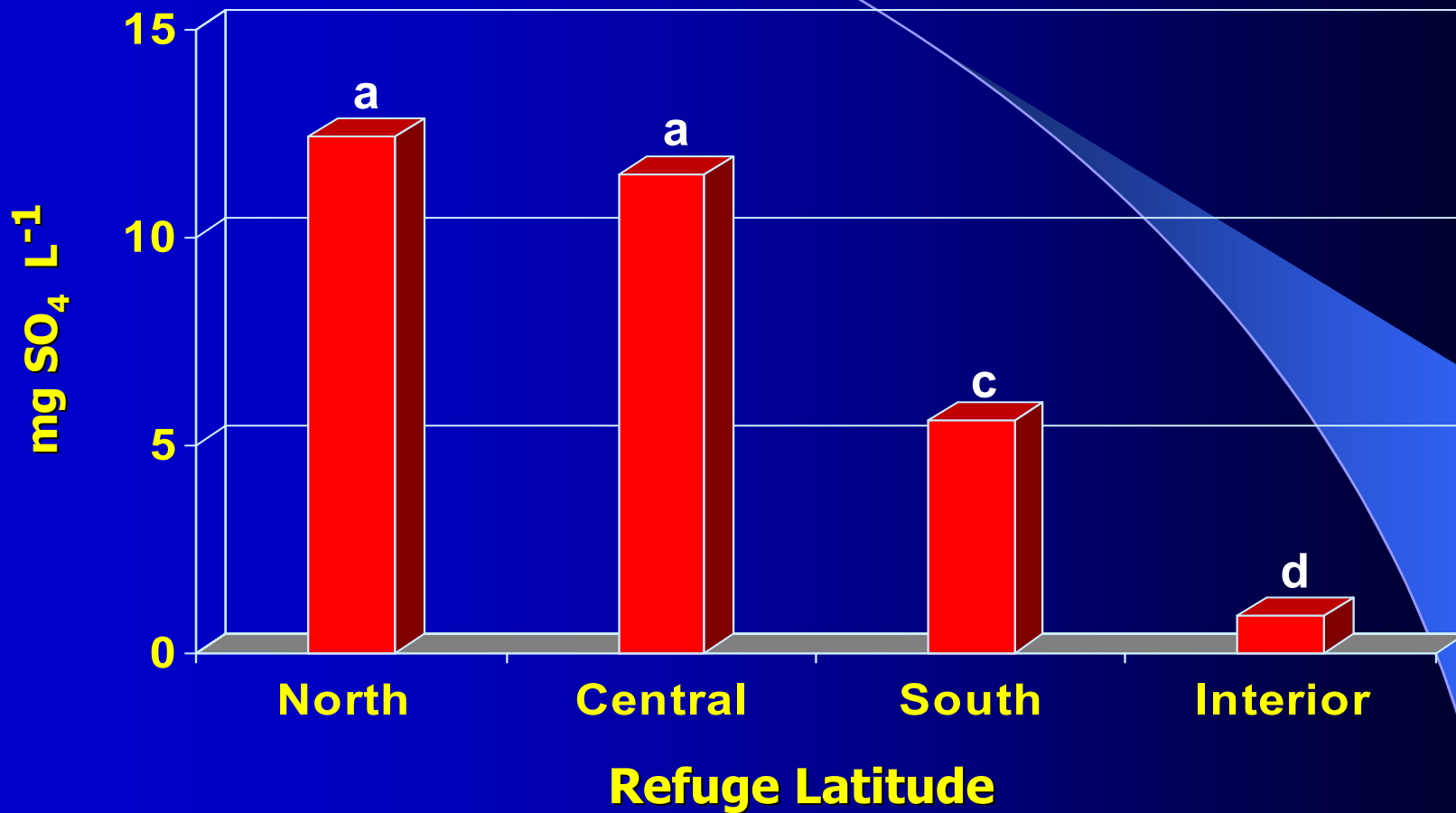| Location	distance from canal (km)
Canal	0
Perimeter	0 – 2.5
Transition	2.5 - 4.5
Interior	> 4.5

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Sulfate

Refuge Latitude

mg SO$_4$ L^{-1}
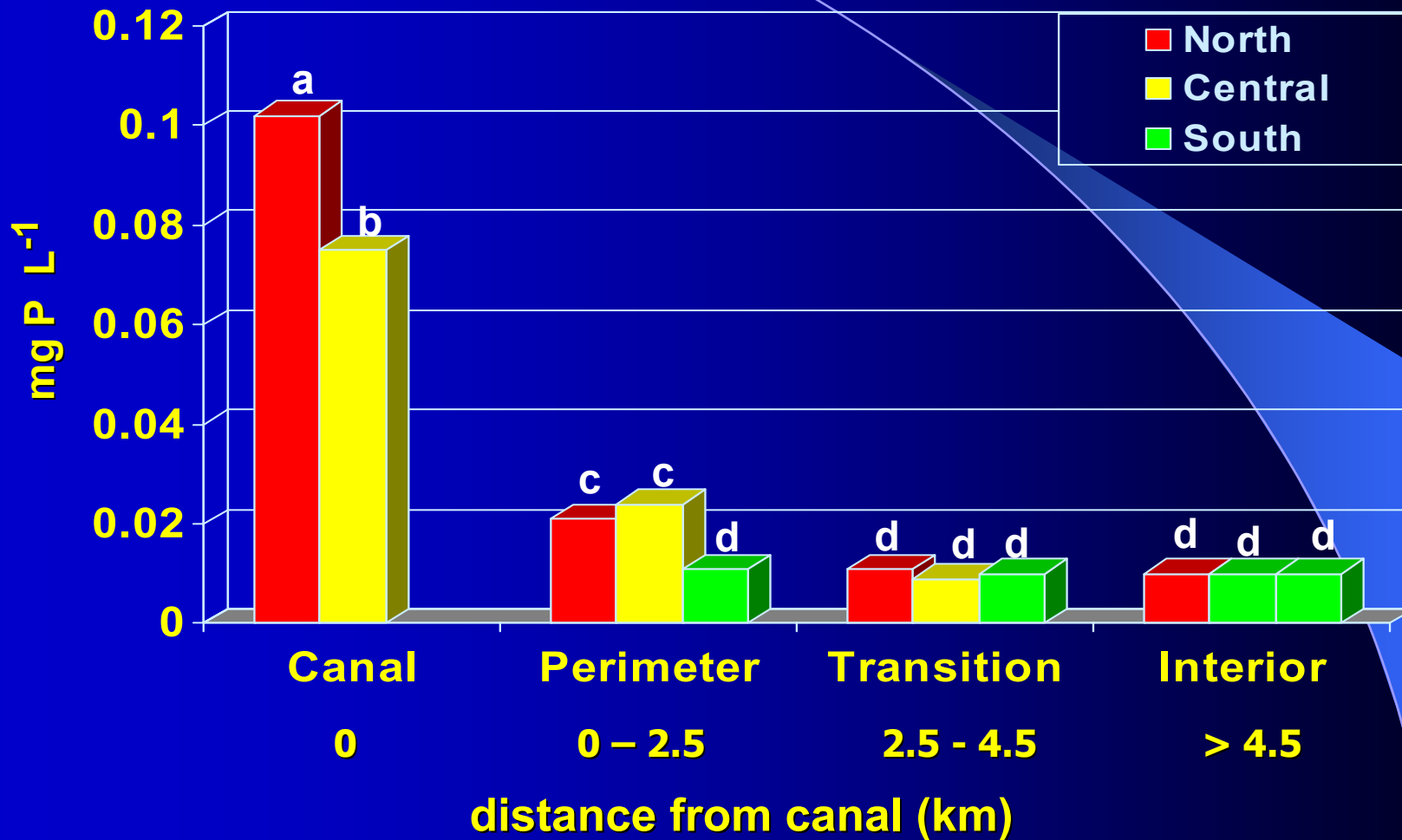
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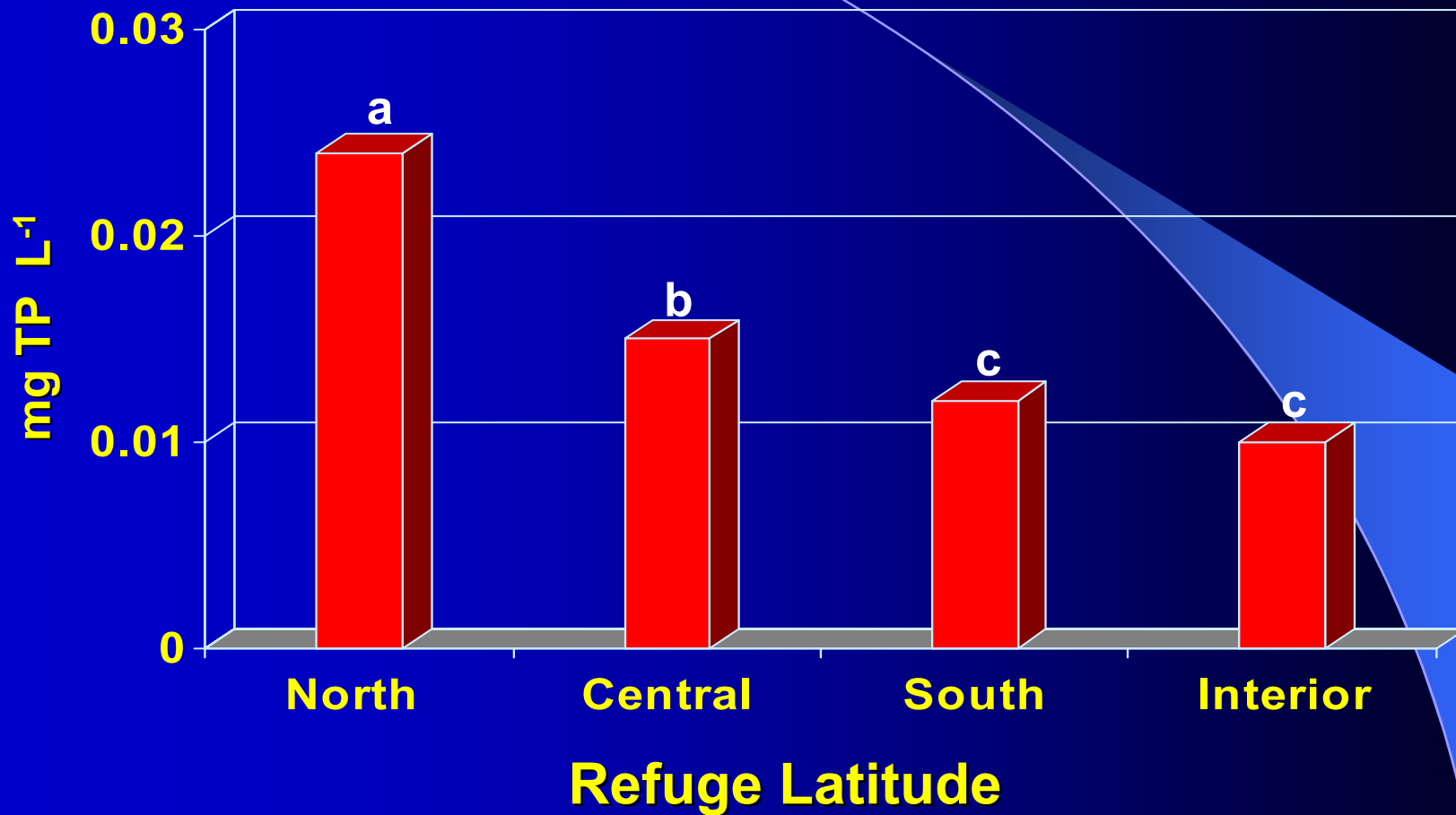
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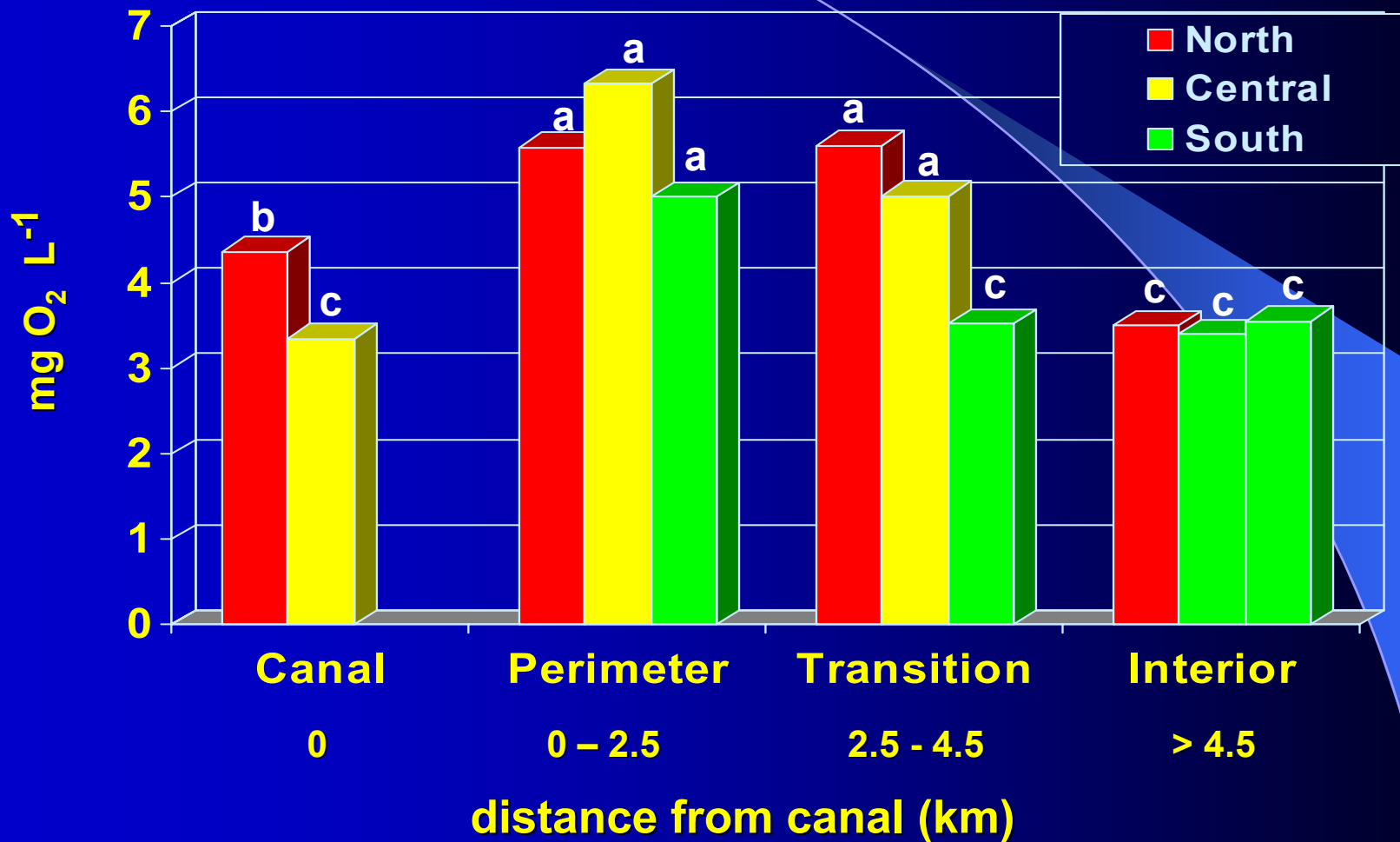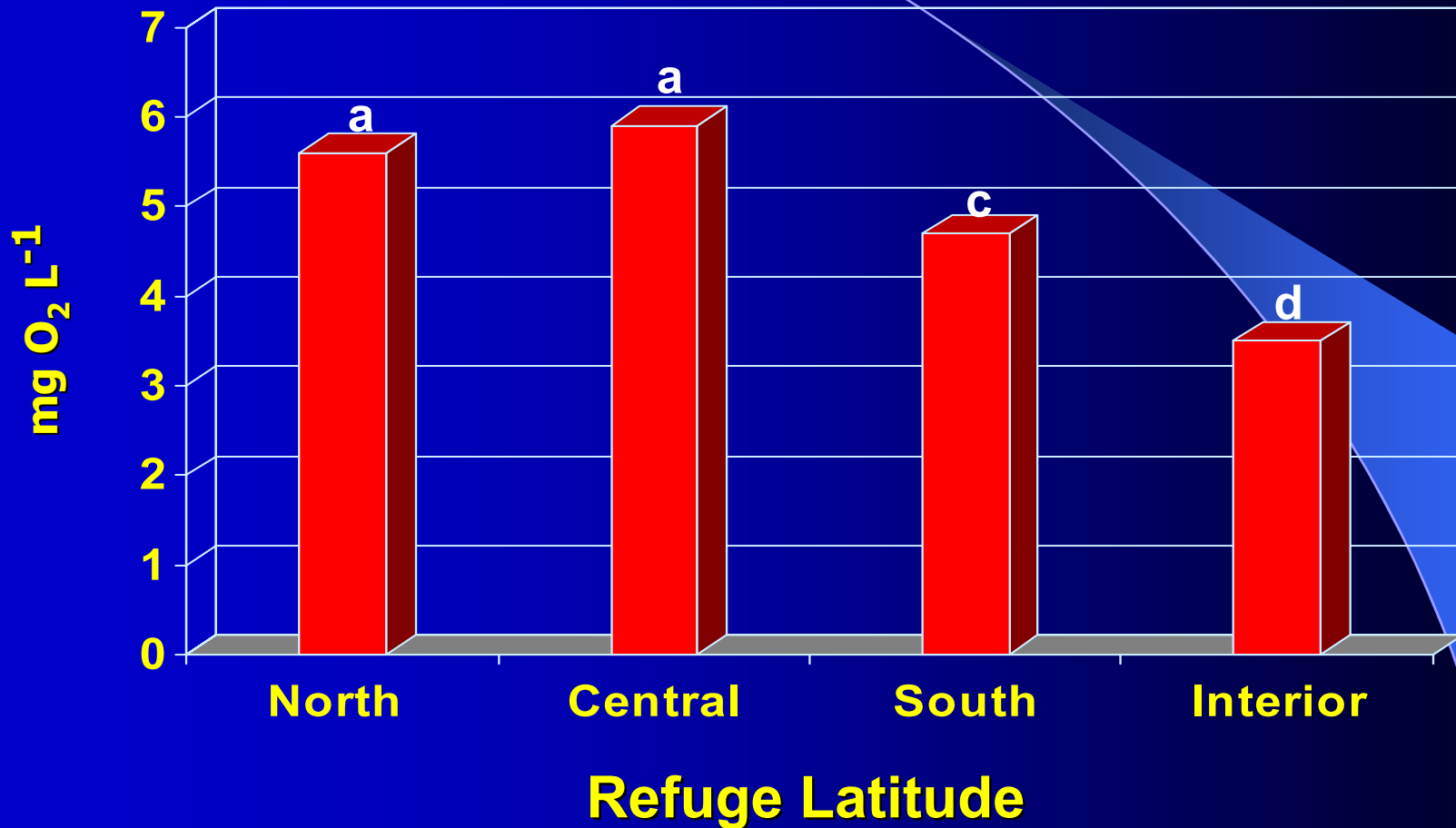
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Discussion

- **Inflow from STA1-West (Agriculture) has higher ALK, SpC, SO_4, and DO deficits than inflow from STA1-East (Agricultural + Urban).**

- **We found that a large area of the Refuge was affected by agricultural or urban stormwater.**

- **In the northern and central areas, the perimeter zone has higher ALK, SpC, Ca, Cl, SO_4, and DO deficit relative to the interior zone.**

- **In the northern and central areas, the transition zone has higher ALK, SpC, SO_4, and DO deficit relative to the interior zone.**

Discussion

- **Decreasing ALK, SpC, Ca, Cl, and SO$_4$ gradients from the canal to the Refuge interior.**

- **Distance from the canal towards the Refuge interior is the most important variable affecting water nutrient and solute concentrations.**

- **Decreasing north to south ALK, SpC, Cl, TP, SO$_4$, and DO deficit gradients in the perimeter and transition zones.**

- **We did not find a north to south gradient for any water quality parameter in the interior zone.**