Effects of Wildfires on Nutrients, Primary Productivity, and Wildlife of Boreal Lakes – A Multi-trophic Perspective

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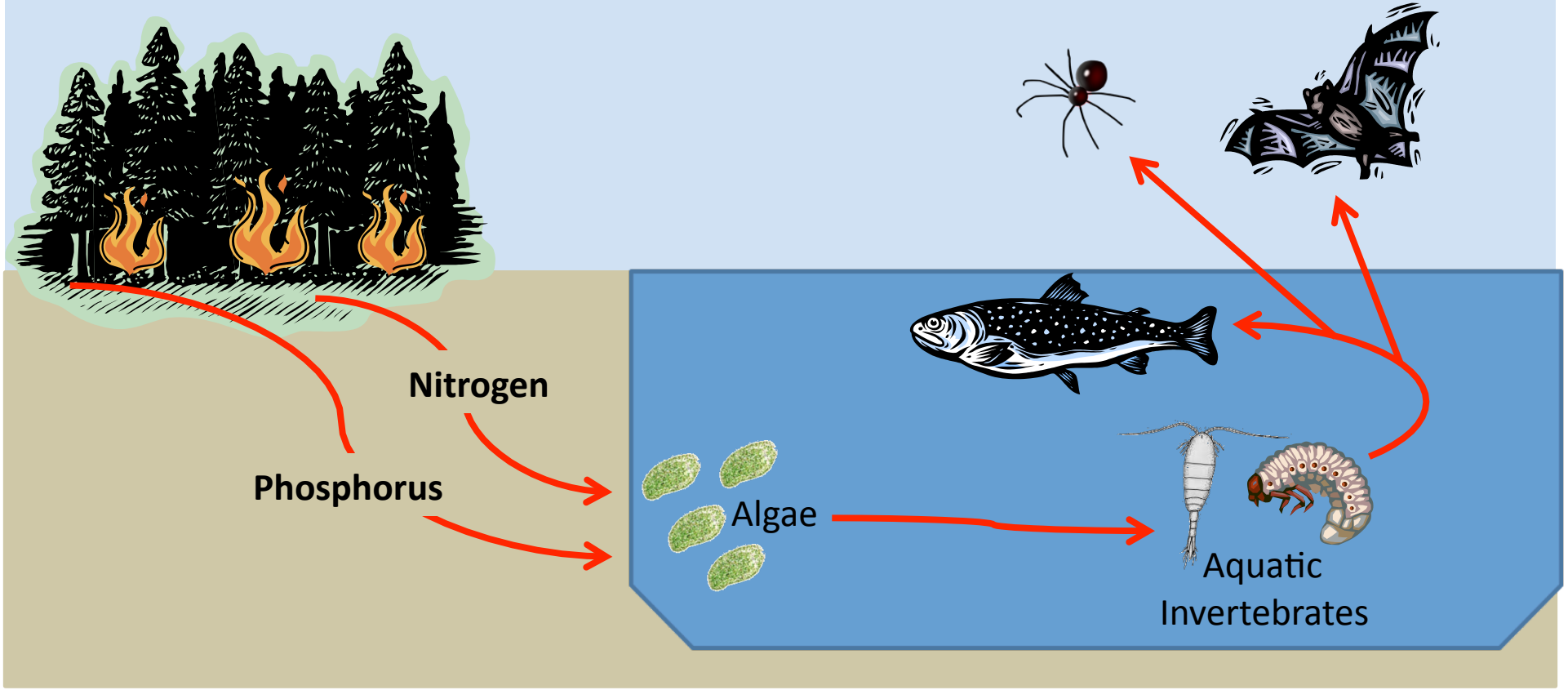
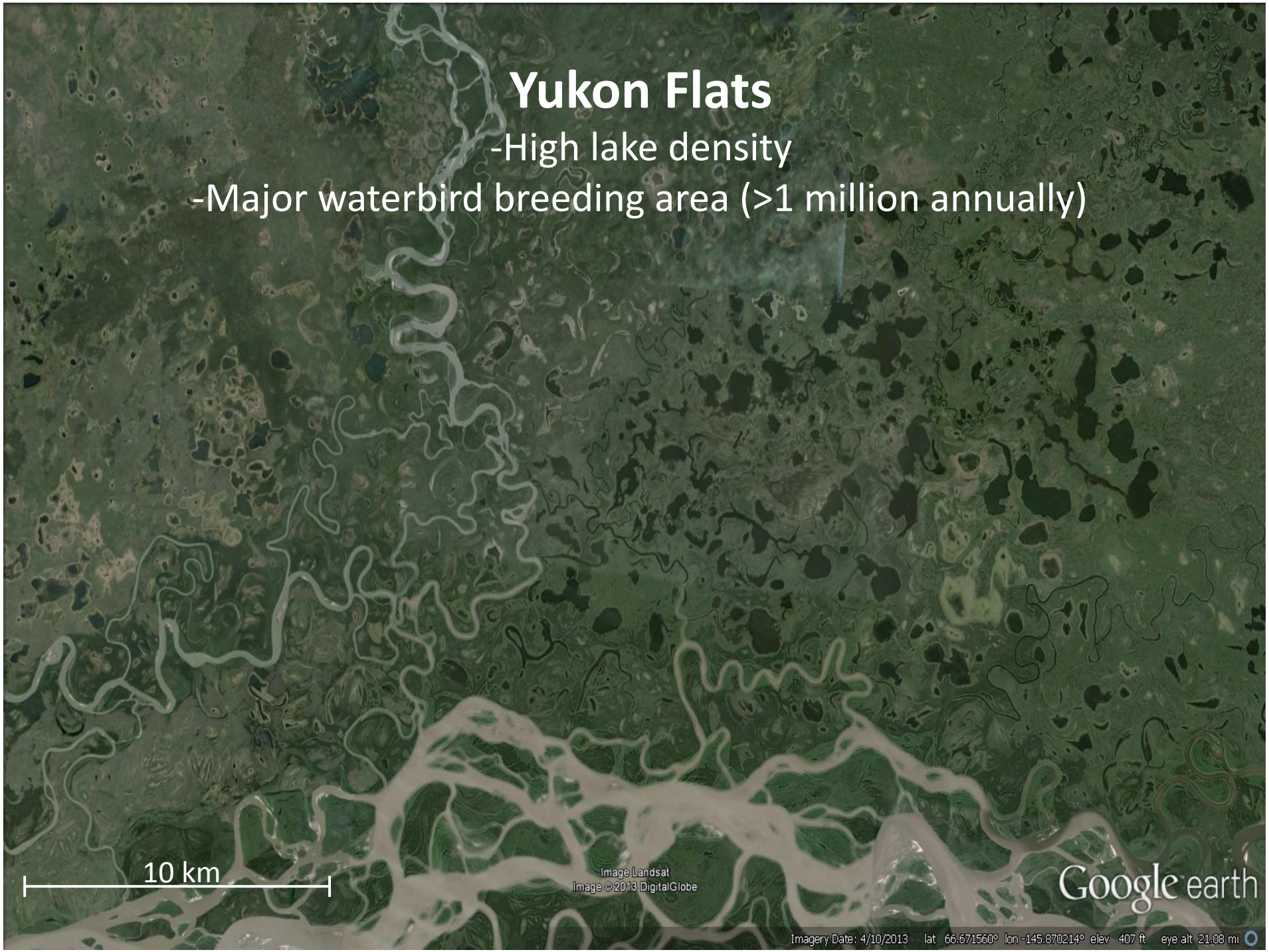
Fire-derived nutrients in aquatic ecosystems:

1) Fires unlock terrestrial nutrients for transport to aquatic systems
2) Elevated aquatic nutrients stimulate primary production
3) Increased primary production produces more aquatic invertebrates
4) Aquatic invertebrates provide increased food for predators




Yukon Flats
-High lake density
-Major waterbird breeding area (>1 million annually)
10 km
Image Landsat
Image © 2013 DigitalGlobe
Google earth
Imagery Date: 4/10/2013 lat 66.671560° lon -145.870214° elev 407 ft eye alt 21.08 mi

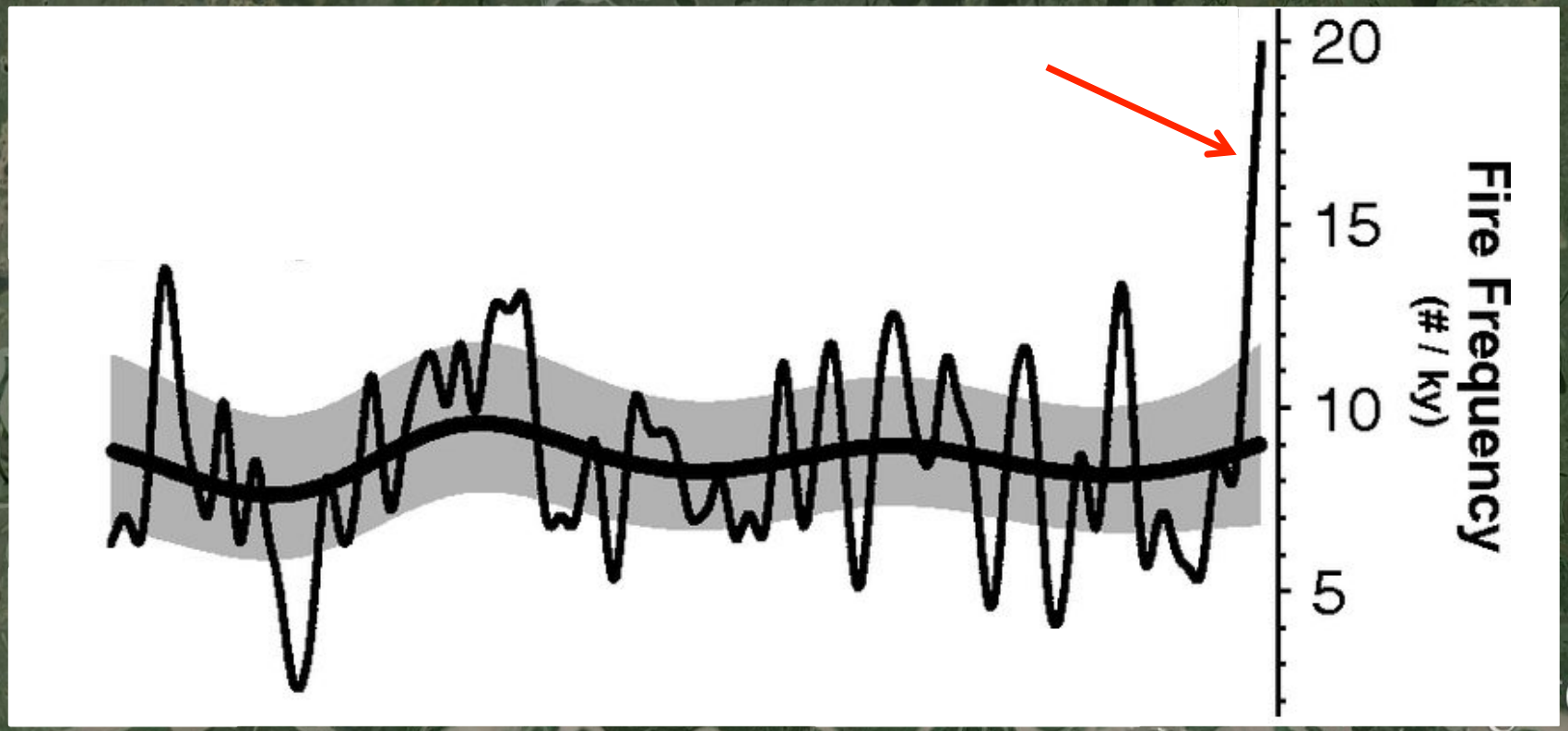
Yukon Flats

-High lake density

-Major waterbird breeding area (>1 million annually)

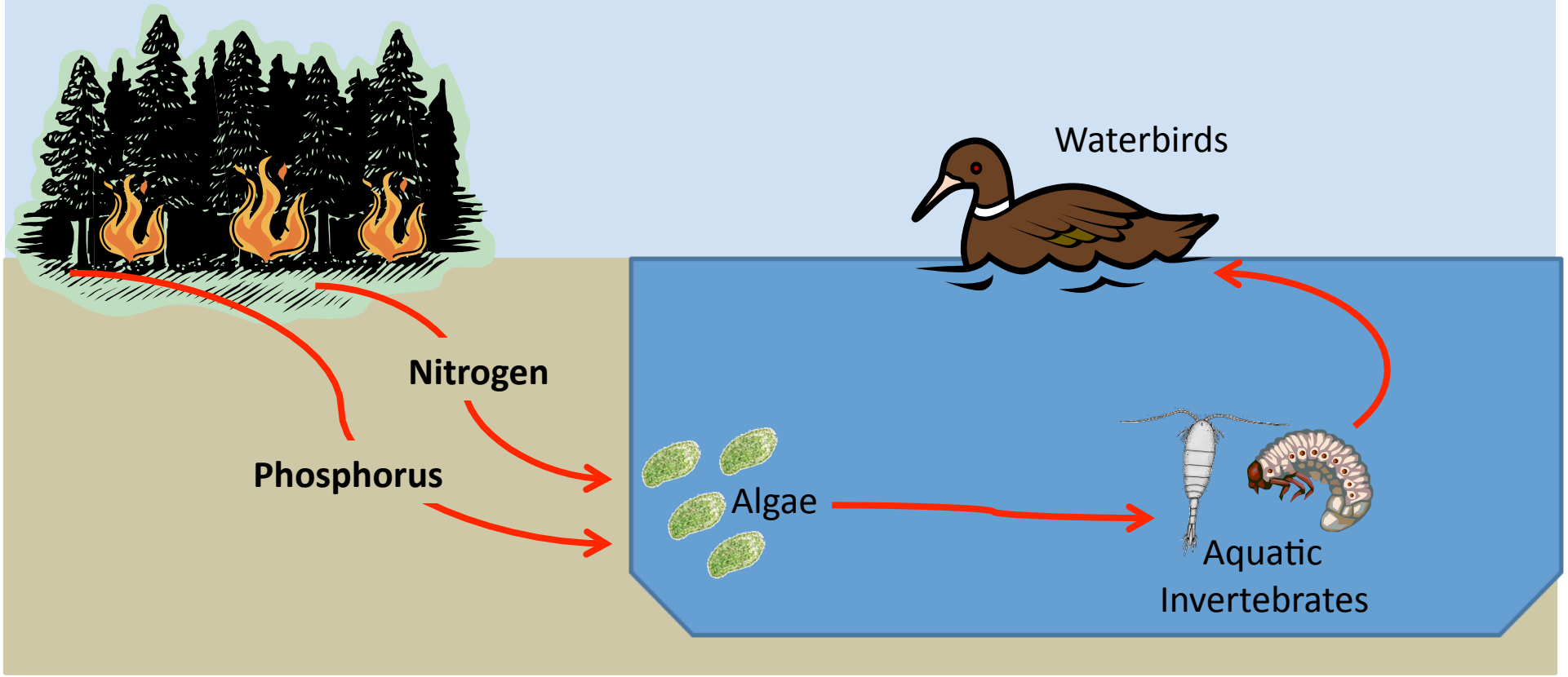
-Among highest fire frequency in NA boreal forest

-Current fire activity highest in 10,000 yr record



Hypothesis:

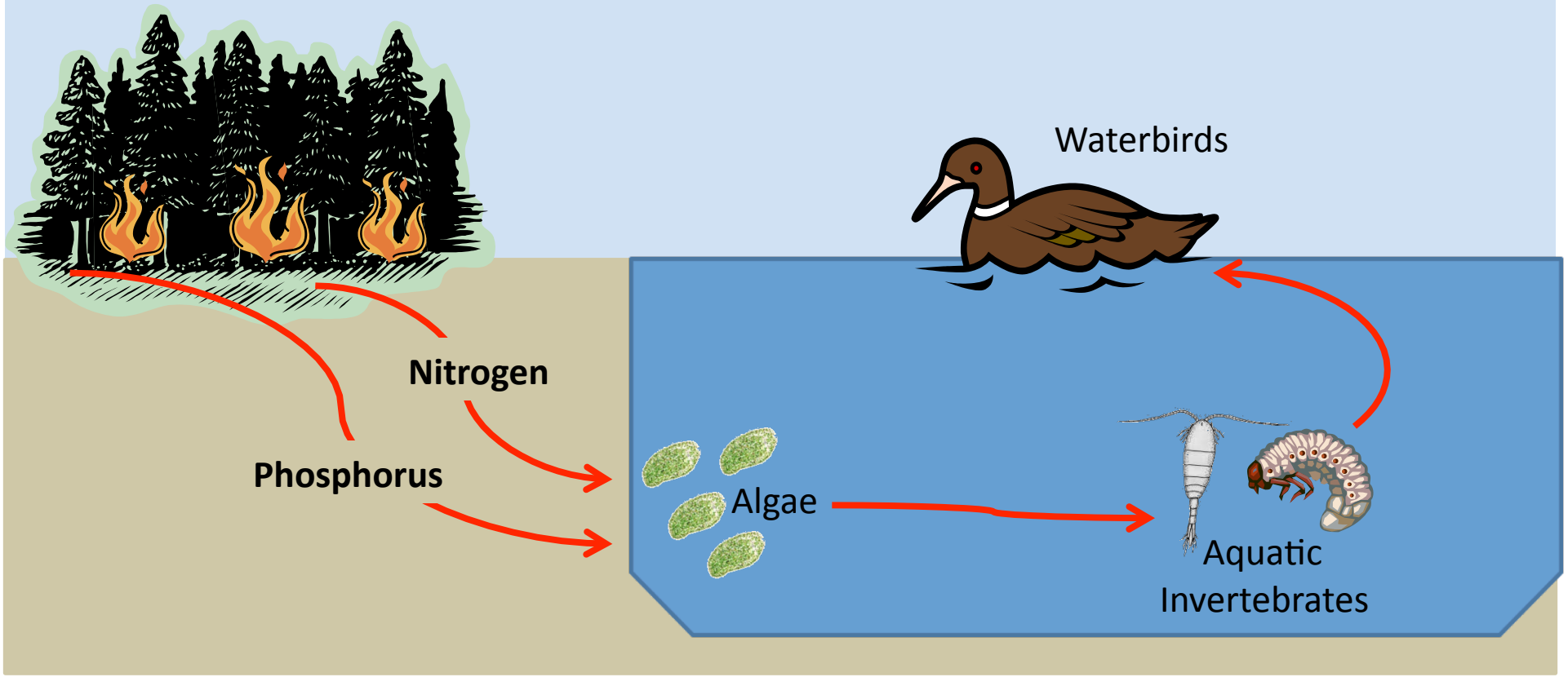
Terrestrial nutrients released by fires are transported to lakes, stimulating increased primary productivity, which may radiate through multiple trophic levels.



We Measured:

1) Total nitrogen & total phosphorus concentration
2) Chlorophyll *a* concentration
3) Aquatic invertebrate density
4) Abundance of waterbird chicks

(waterbirds = ducks, loons, grebes)

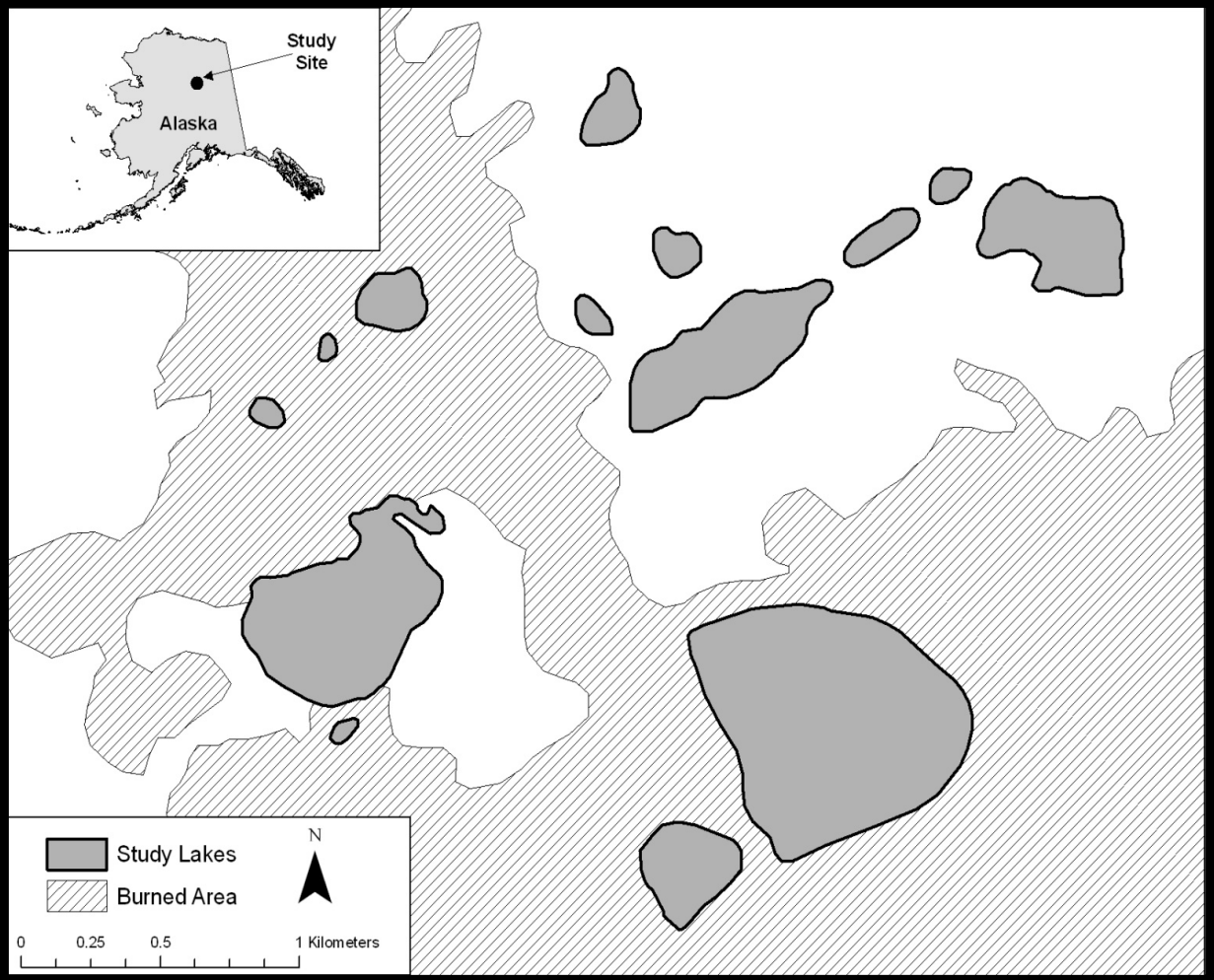


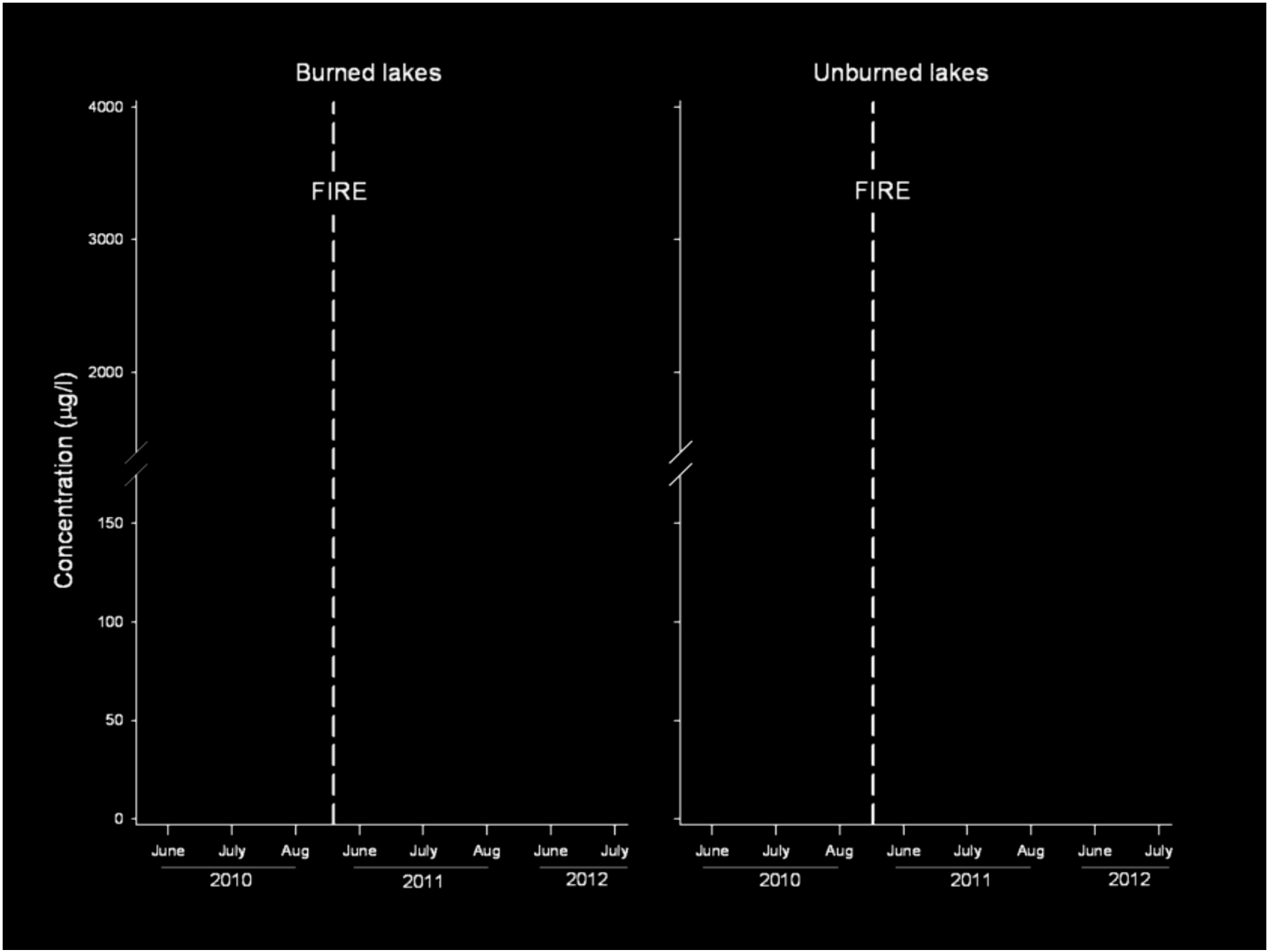
Before: 1 year pre-fire data

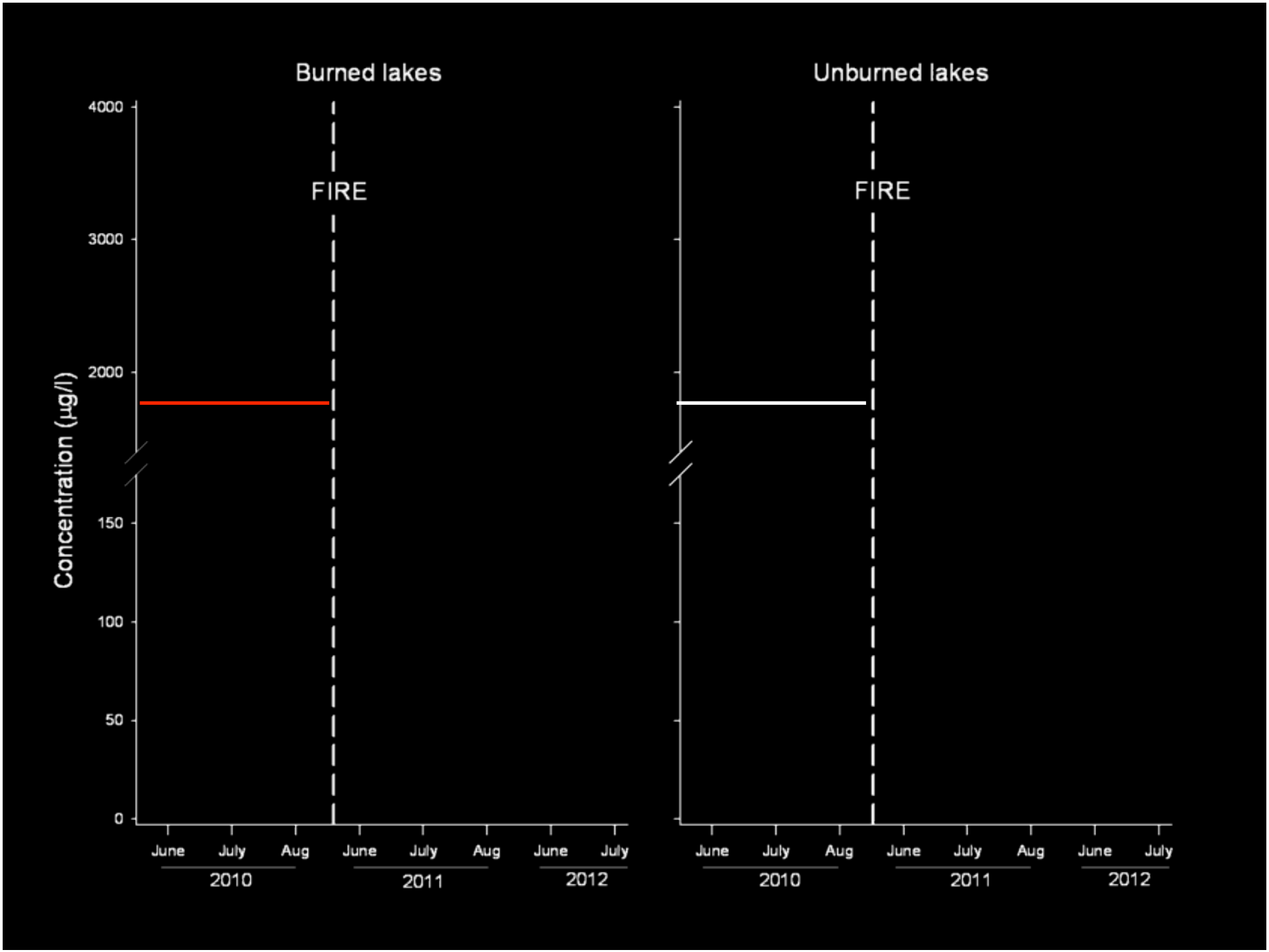
After: 2 years post-fire data

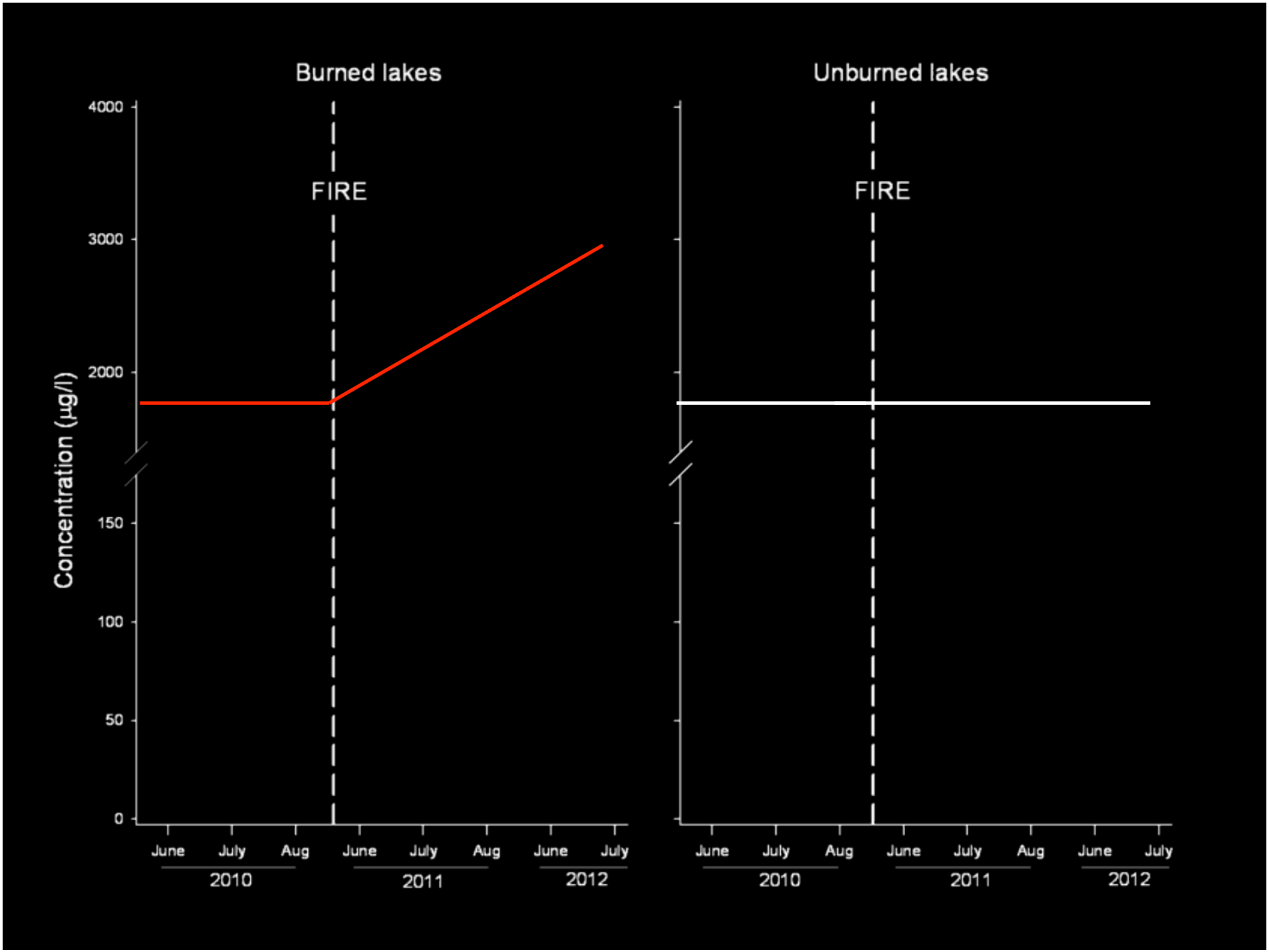
Control: 7 unburned lakes

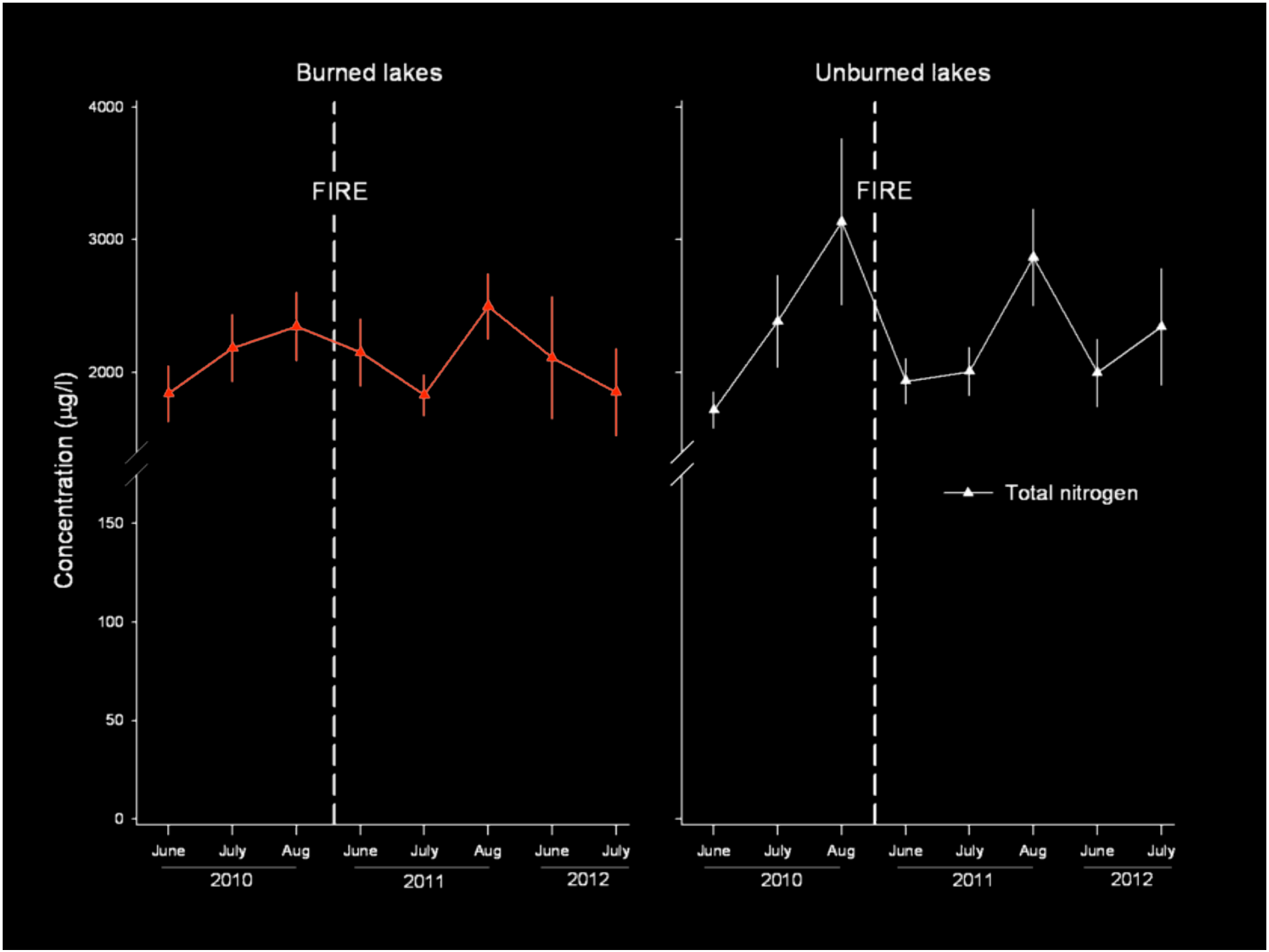
Impact: 7 burned lakes

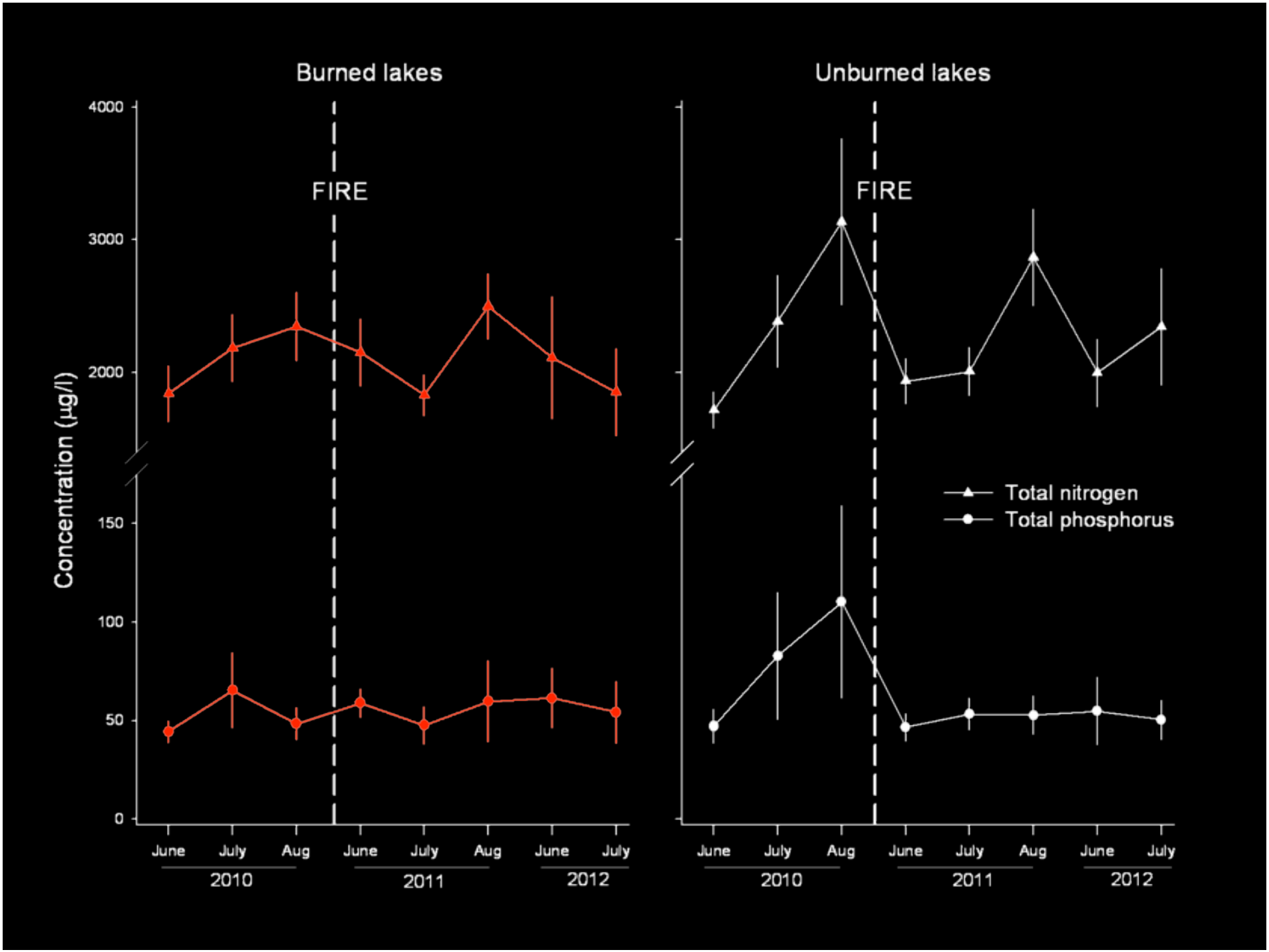


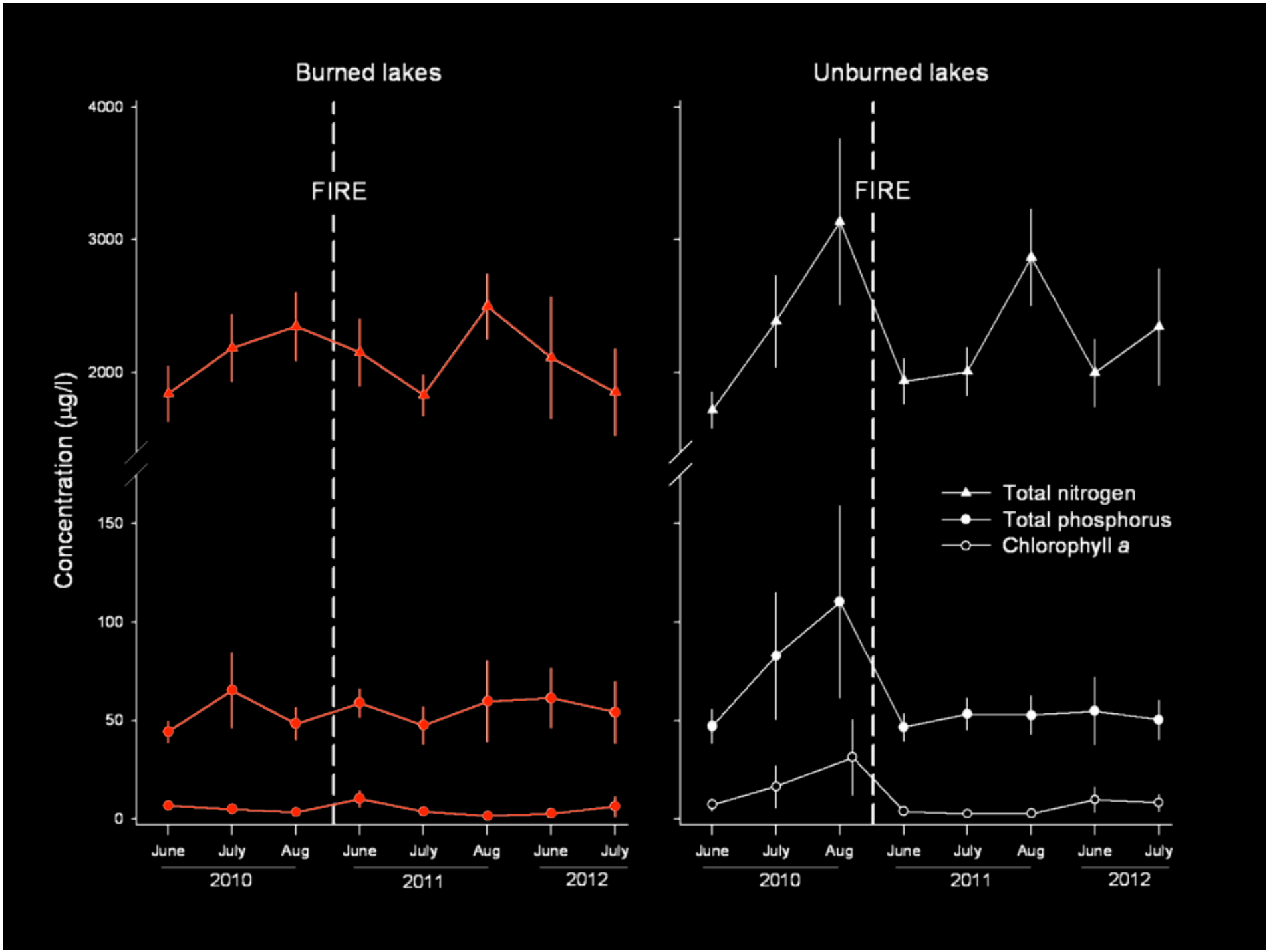

Burned lakes
Unburned lakes
FIRE
FIRE
Concentration (µg/l)
4000
3000
2000
150
100
50
0
June
July
Aug
June
July
Aug
June
July
2010
2011
2012
June
July
Aug
June
July
Aug
June
July
2010
2011
2012

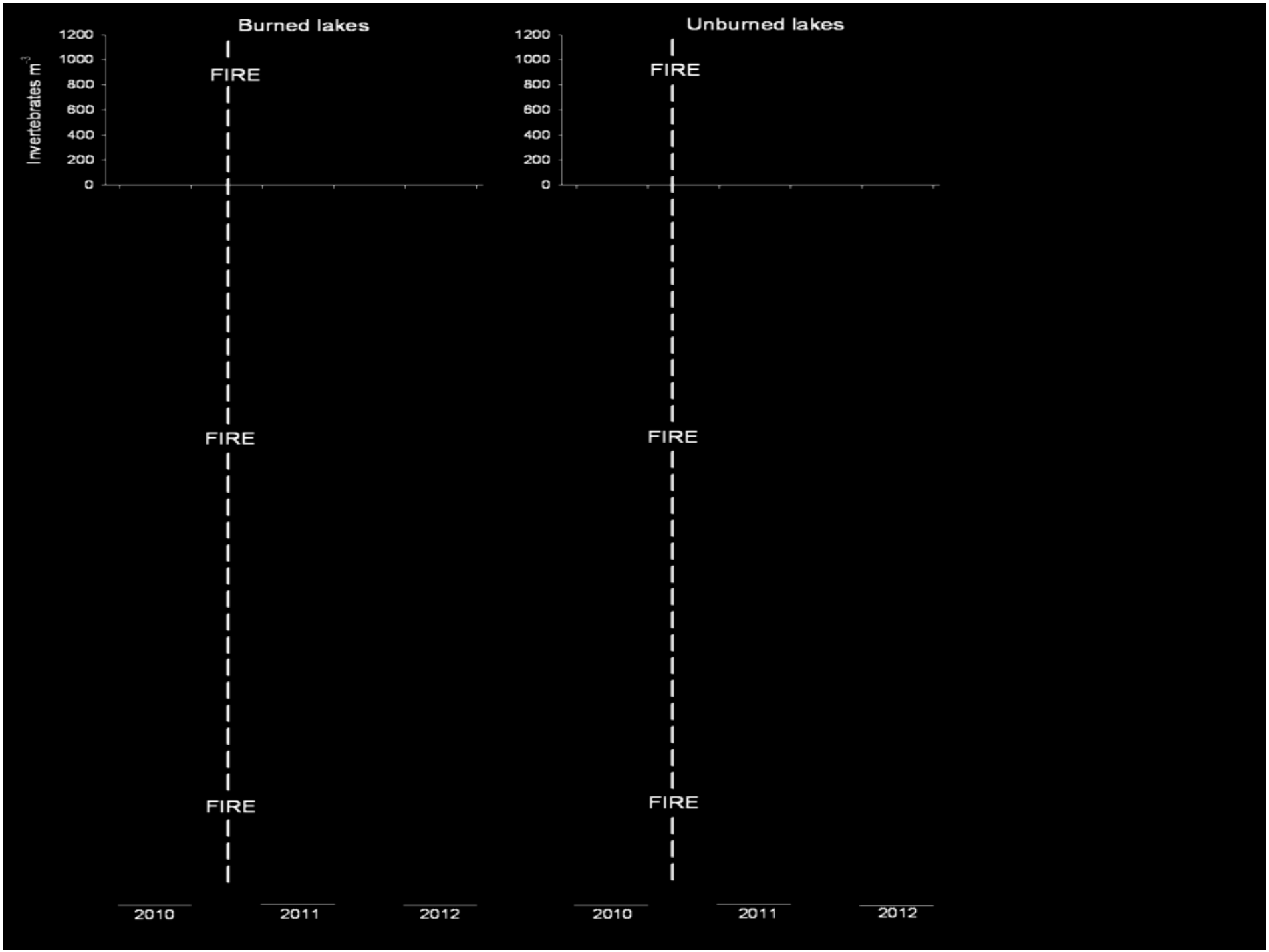

Burned lakes
Unburned lakes
FIRE
FIRE
Concentration (µg/l)
4000
3000
2000
150
100
50
0
June
July
Aug
June
July
Aug
June
July
2010
2011
2012
June
July
Aug
June
July
Aug
June
July
2010
2011
2012

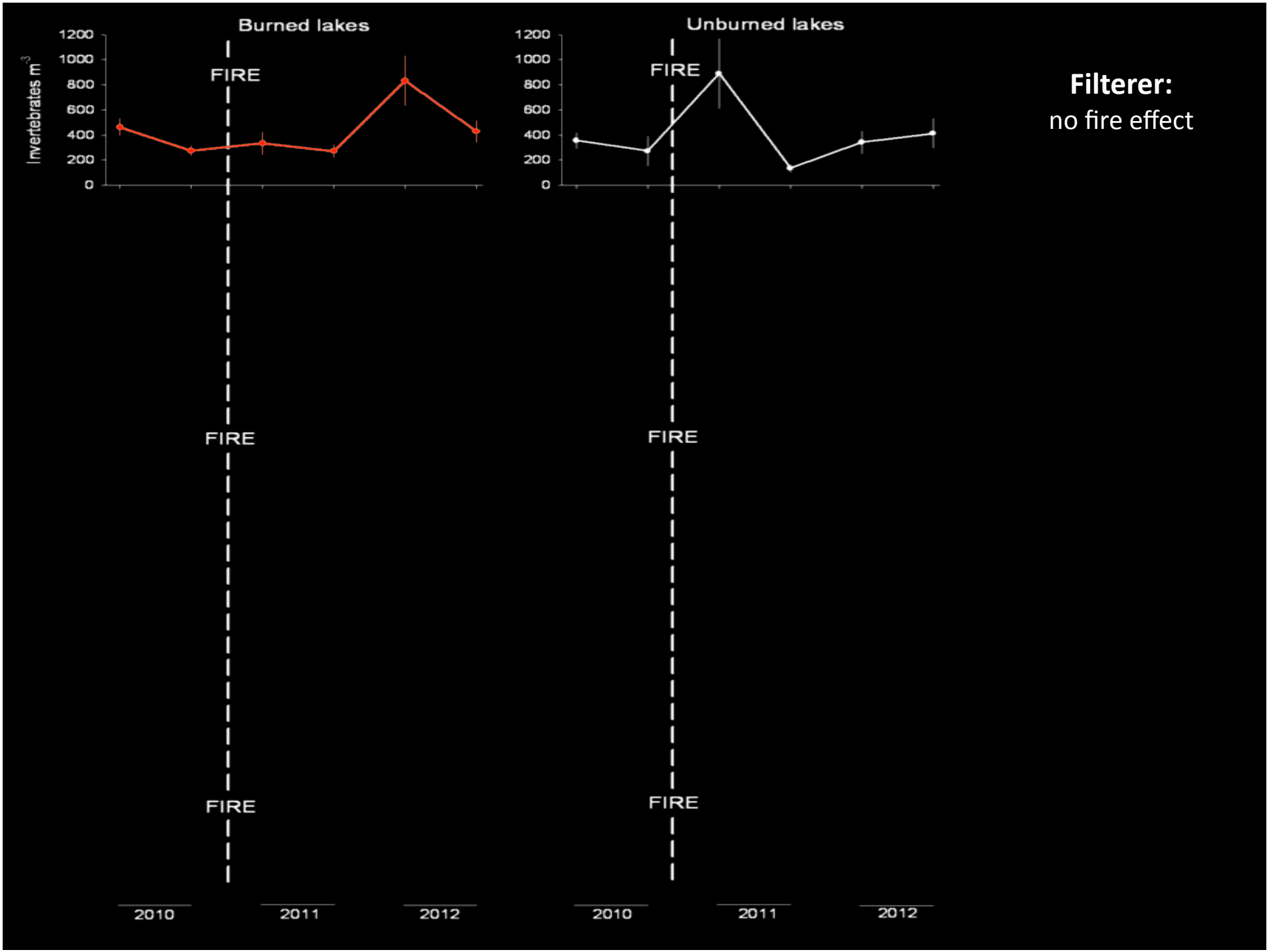

Burned lakes
Unburned lakes
FIRE
FIRE
Concentration (µg/l)
4000
3000
2000
150
100
50
0
June
July
Aug
June
July
Aug
June
July
2010
2011
2012
June
July
Aug
June
July
Aug
June
July
2010
2011
2012


Burned lakes
Unburned lakes
FIRE
FIRE
Concentration (µg/l)
4000
3000
2000
150
100
50
0
Total nitrogen
June
July
Aug
June
July
Aug
June
July
2010
2011
2012
June
July
Aug
June
July
Aug
June
July
2010
2011
2012

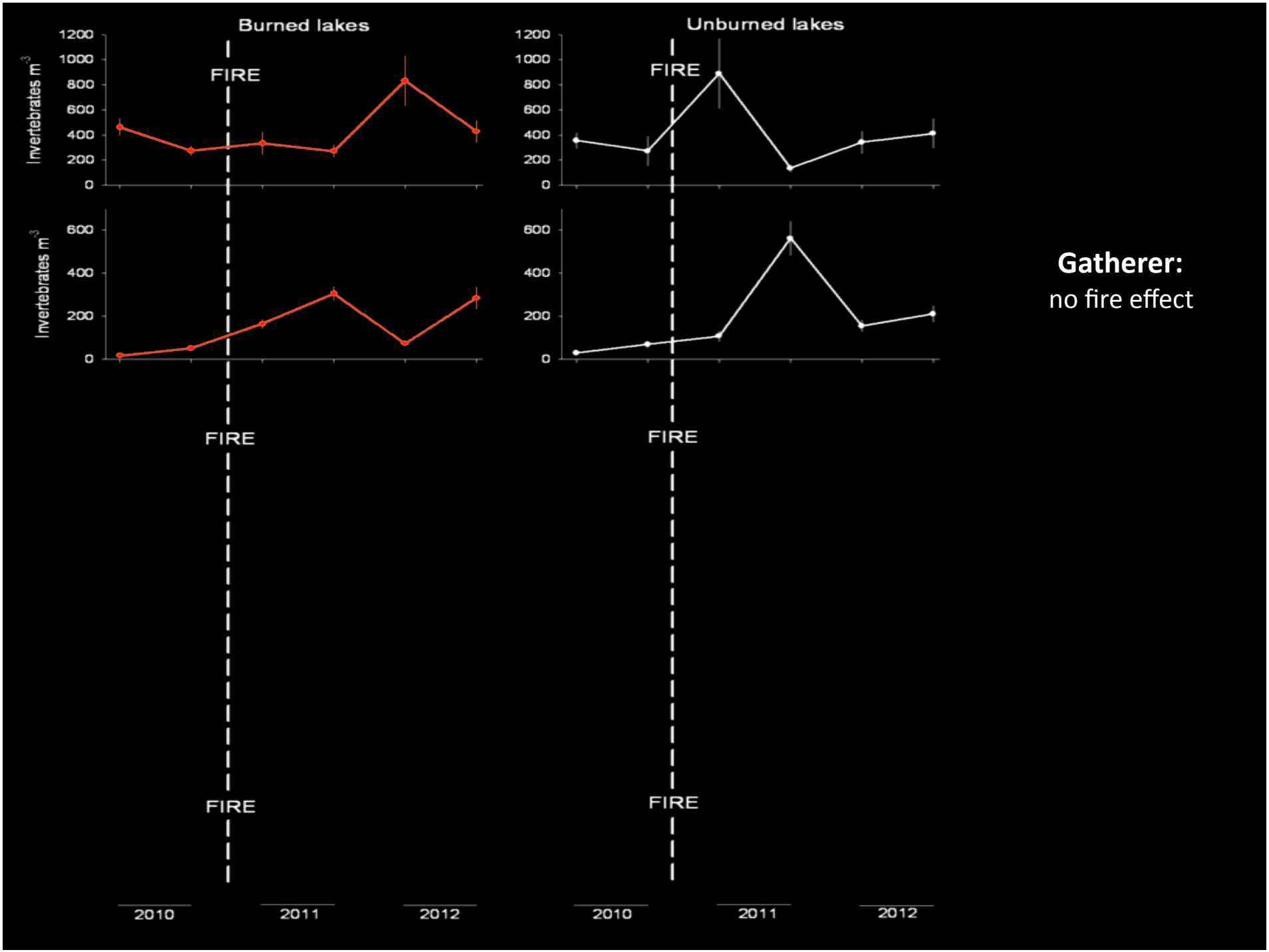

Burned lakes
Unburned lakes
FIRE
FIRE
Concentration (µg/l)
4000
3000
2000
150
100
50
0
Total nitrogen
Total phosphorus
June
July
Aug
June
July
Aug
June
July
2010
2011
2012
June
July
Aug
June
July
Aug
June
July
2010
2011
2012


Burned lakes
Unburned lakes
FIRE
FIRE
Concentration (µg/l)
4000
3000
2000
150
100
50
0
Total nitrogen
Total phosphorus
Chlorophyll a
June
July
Aug
June
July
Aug
June
July
2010
2011
2012
June
July
Aug
June
July
Aug
June
July
2010
2011
2012

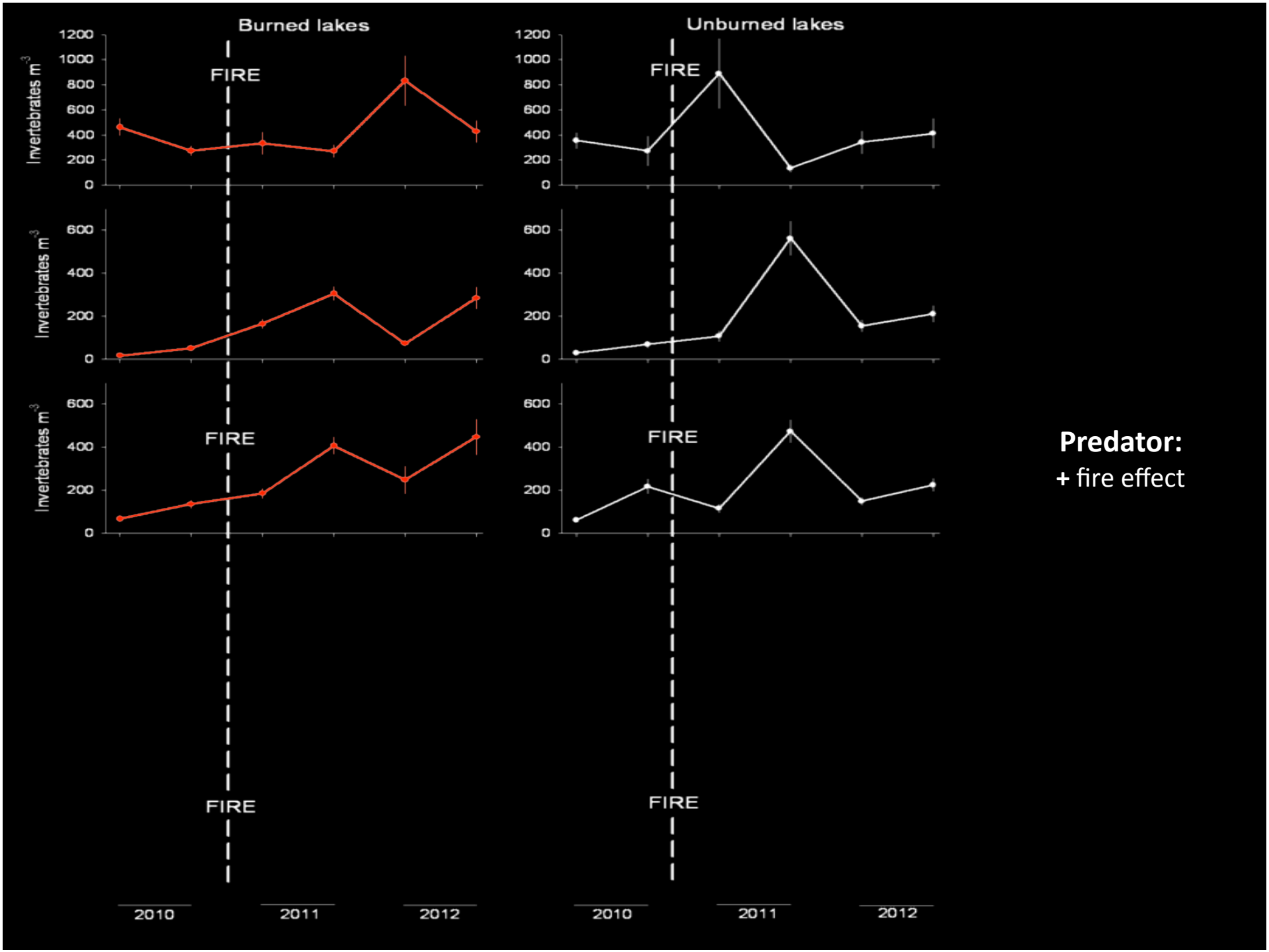

Burned lakes
Unburned lakes
Invertebrates m-3
1200
1000
800
600
400
200
0
FIRE
FIRE
FIRE
FIRE
FIRE
FIRE
2010
2011
2012
2010
2011
2012



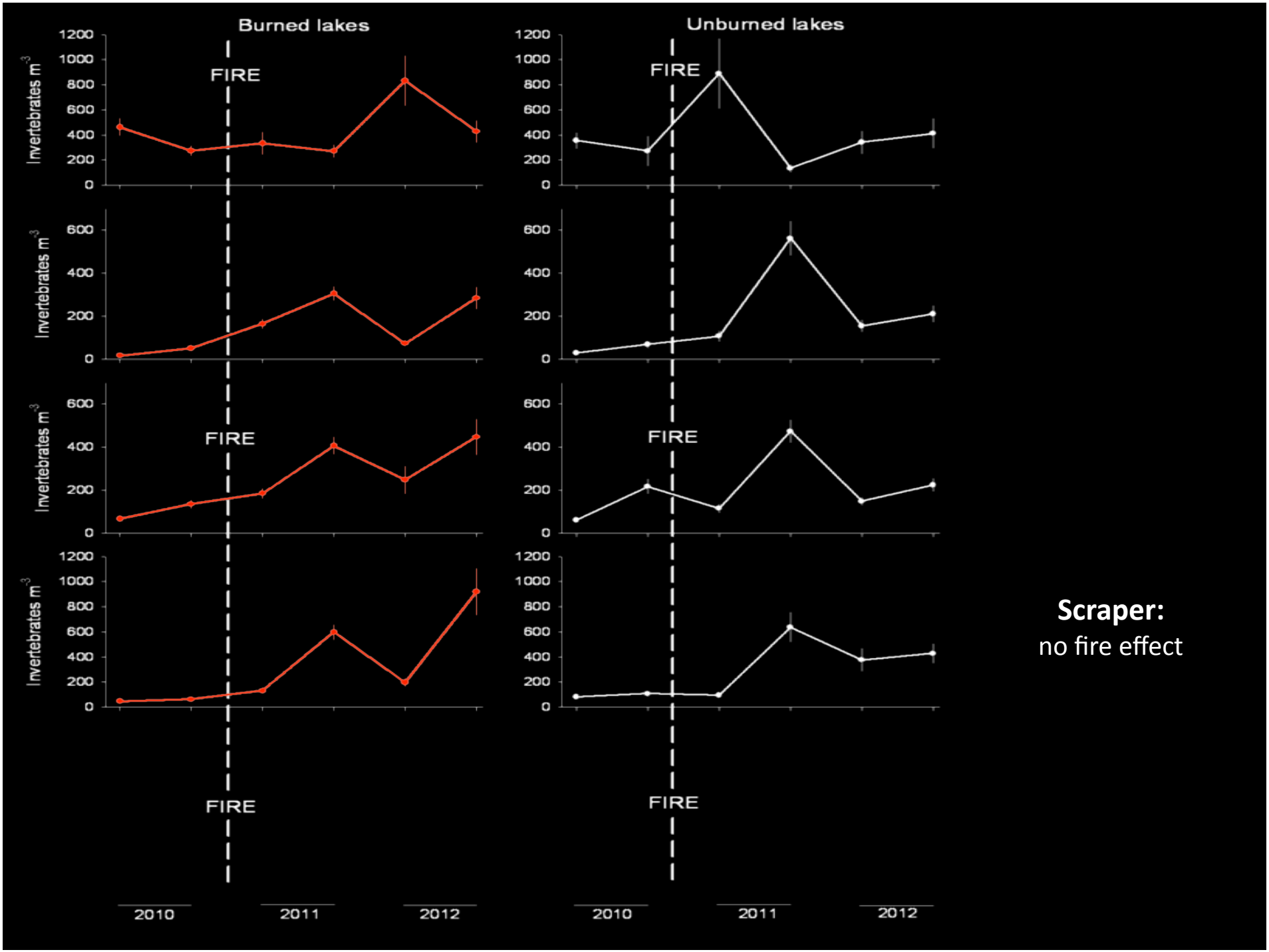
Filterer:
no fire effect

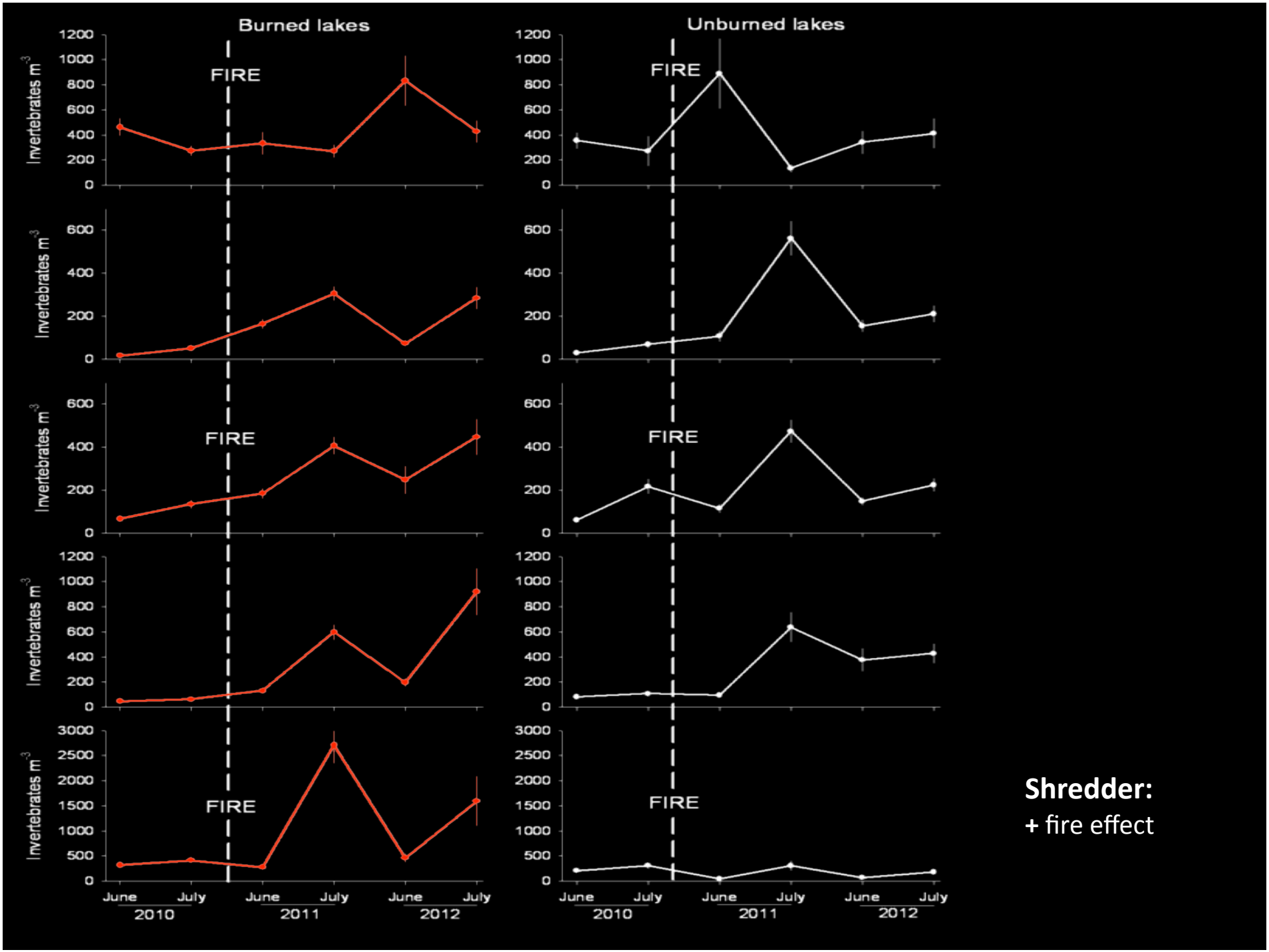


Gatherer:
no fire effect



Predator:
+ fire effect

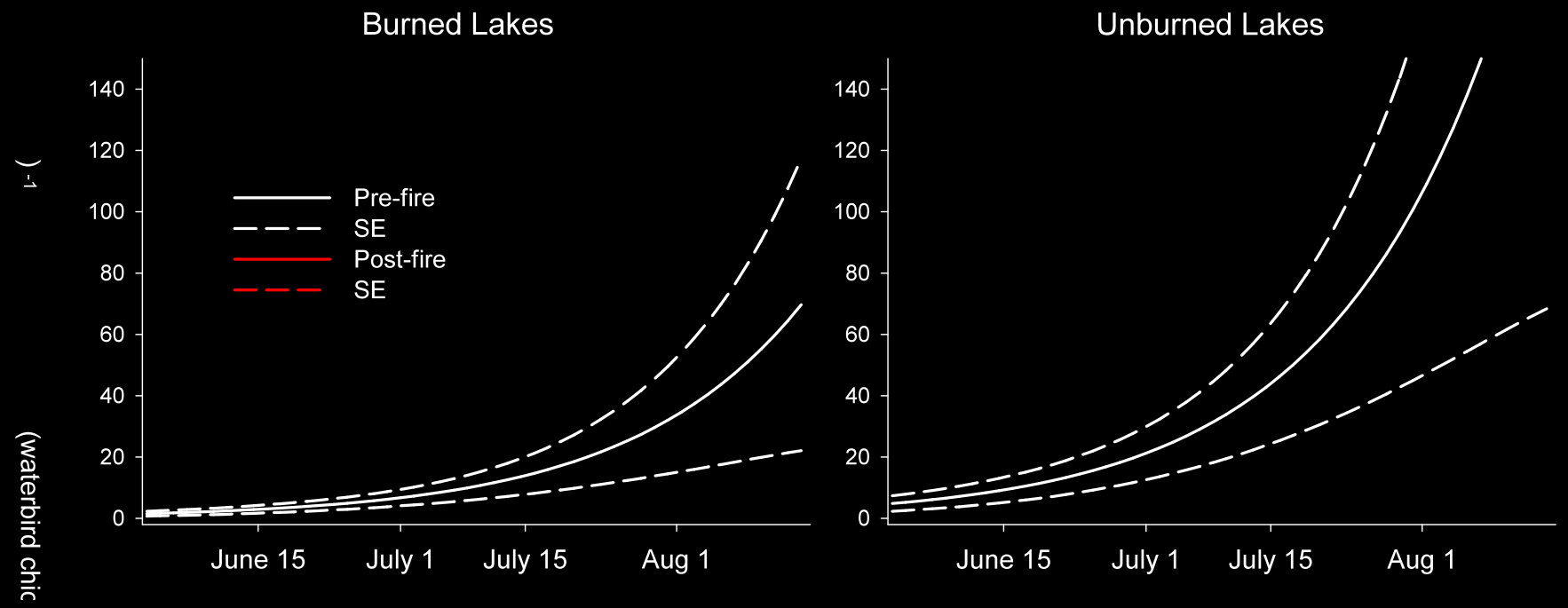

Burned lakes
Unburned lakes
Invertebrates m-3
FIRE
2010
2011
2012
Scraper:
no fire effect


Burned lakes
Unburned lakes
FIRE
Invertebrates m-3
June
July
2010
2011
2012
Shredder:
+ fire effect

Expected abundance of waterbird chicks

-N-mixture models

- Accounts for imperfect detection



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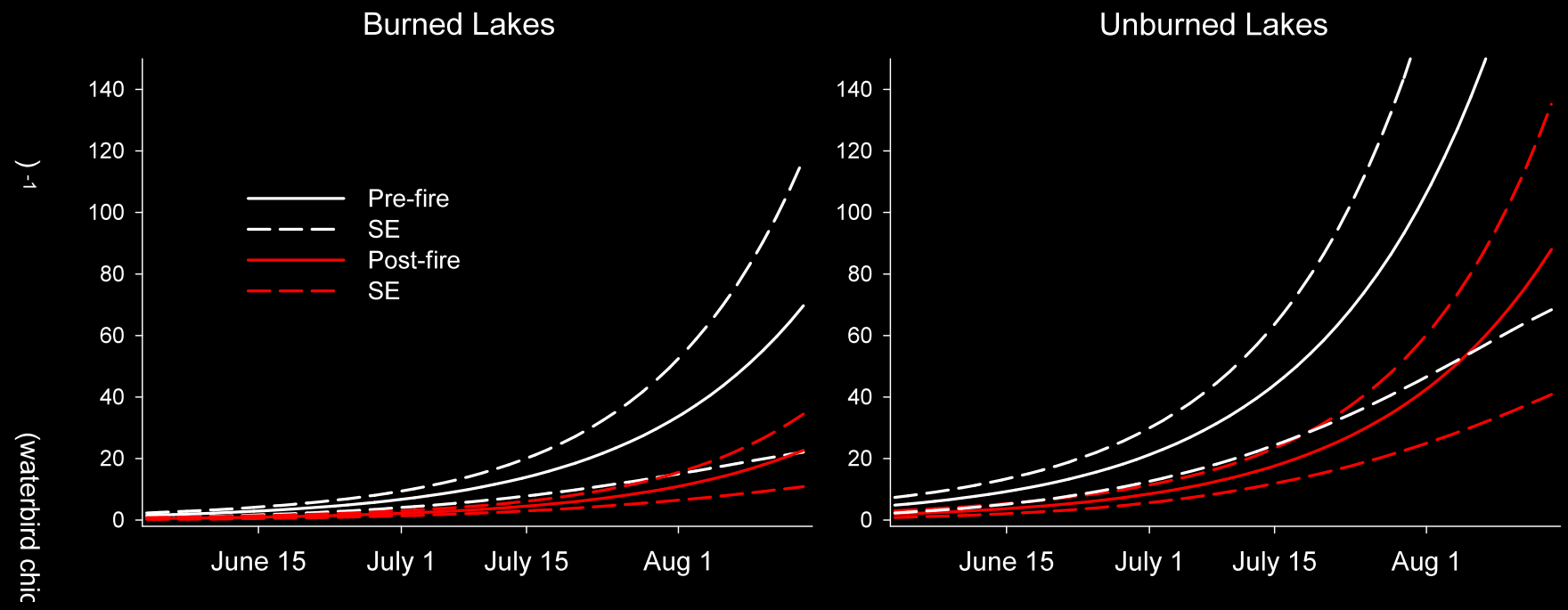

Why were there no fire-induced changes in aquatic nutrients?

1) **Naturally Eutrophic Lakes**
- Dampens impact of nutrient input

Our Yukon Flats Lakes	**Mackenzie Delta Lakes**	**Canadian Shield Lakes**
Total Nitrogen = 2199 μg/l	TN = 1000 μg/l	TN = 280 μg/l
Total Phosphorus = 59 μg/l	TP = 17 μg/l	TP = 12 μg/l

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3) Permafrost

- Restricts subsurface flow and nutrient transport

Why did shredder and predator invertebrates increase?

- 98% of shredders were amphipods
- amphipods are generalists that respond well to disturbances

- Predators responded to increased amphipods
- Amphipods were most numerous invert

Why did abundance of waterbird chicks decrease on both burned and unburned lakes after the fire?

1) **From waterbird perspective, fire adversely impacted entire study area**
   - Loss of nesting habitat


Lesser Scaup nest

2) **Not related to fire; caused by factors operating at large spatial scales**
   - E.g., predators, poor weather, poor winter conditions

Multi-trophic Resilience of Boreal Lakes

Effects of Fire

1) No change in nitrogen, phosphorus, and chlorophyll concentrations

2) No change in densities of filterers, gatherers, and scrapers

3) Increased density of shredders and predators

4) No change in abundance of waterbird chicks

Yukon Flats lakes, and similar boreal lakes (small catchments, high nutrients), are largely resilient to forest fires

Thanks…

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