

# Integrating citizen science and satellite-based remote sensing for monitoring of Maine's lakes



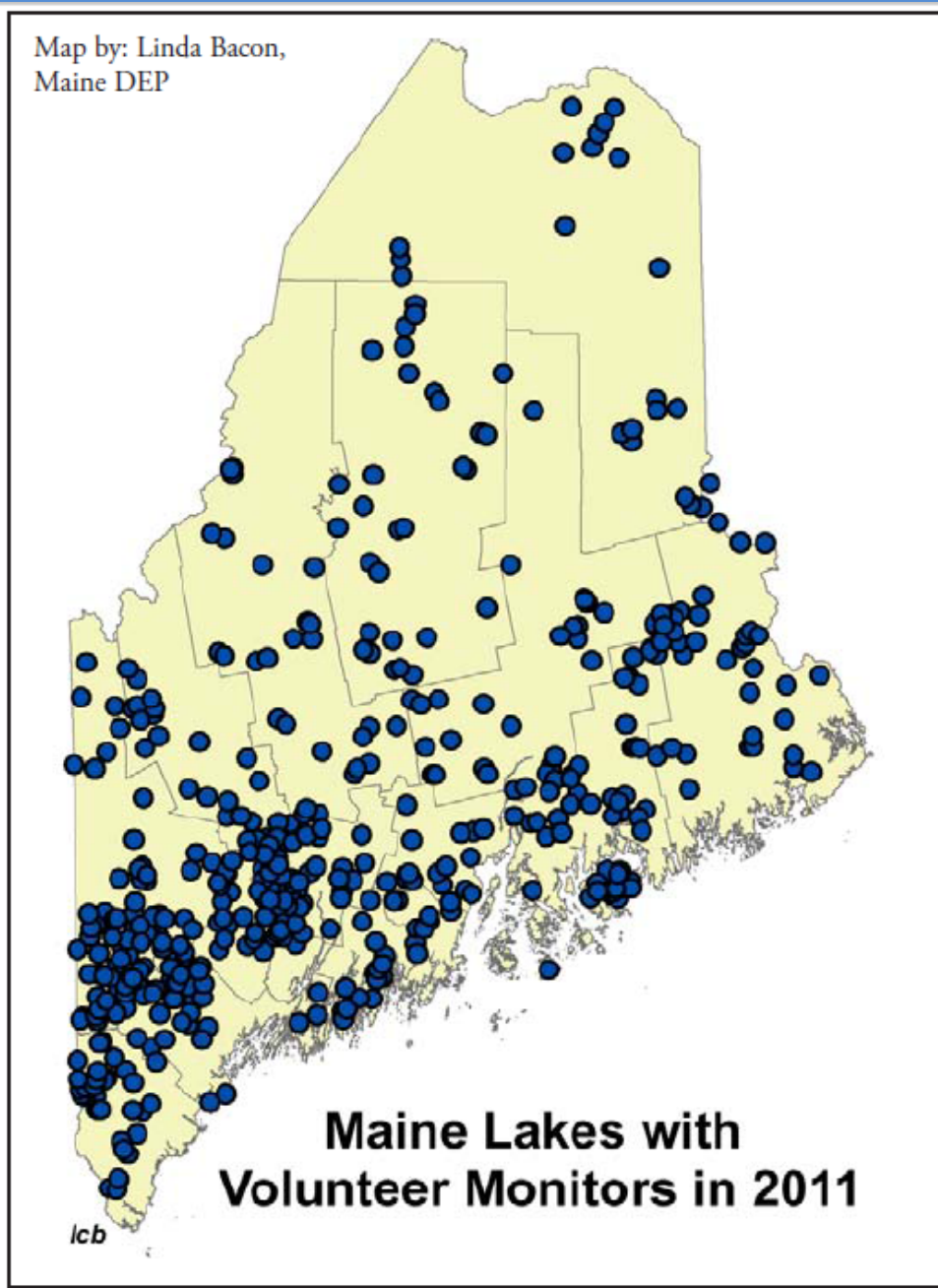
Ian McCullough, Cynthia Loftin and Steven Sader  
Maine VLMP Annual Conference: July 21, 2012

# A Landscape of Lakes

- 5,591 lakes > 1 ha
- 2,017 lakes > 8 ha

***How can we monitor  
thousands of lakes  
effectively and efficiently?***

Map by: Linda Bacon,  
Maine DEP



**Maine Lakes with  
Volunteer Monitors in 2011**

*lcb*

Source: 2011 Maine Lakes Report

## Physical assessments



Photo courtesy of Scott Williams

- Ice in/out
- Invasive species
- Secchi depth
- Temperature

## Chemical assessments



Photo of Ian's friend used without permission

- Alkalinity
- Chlorophyll-a
- Color
- Dissolved oxygen
- pH
- Specific conductance
- Total phosphorus

# Why Secchi depth?

- **Ecological Indicator**
  - Chlorophyll-a
  - Total phosphorus
  - Trophic status
  - Algae blooms (< 2 m)
- **Economic Indicator**
  - Waterfront property value
  - User-perception of water quality

***If we could know one thing about a lake, we should pick Secchi depth***



# Long Pond, Belgrade Lakes

July 2010



**Secchi = 0 m**



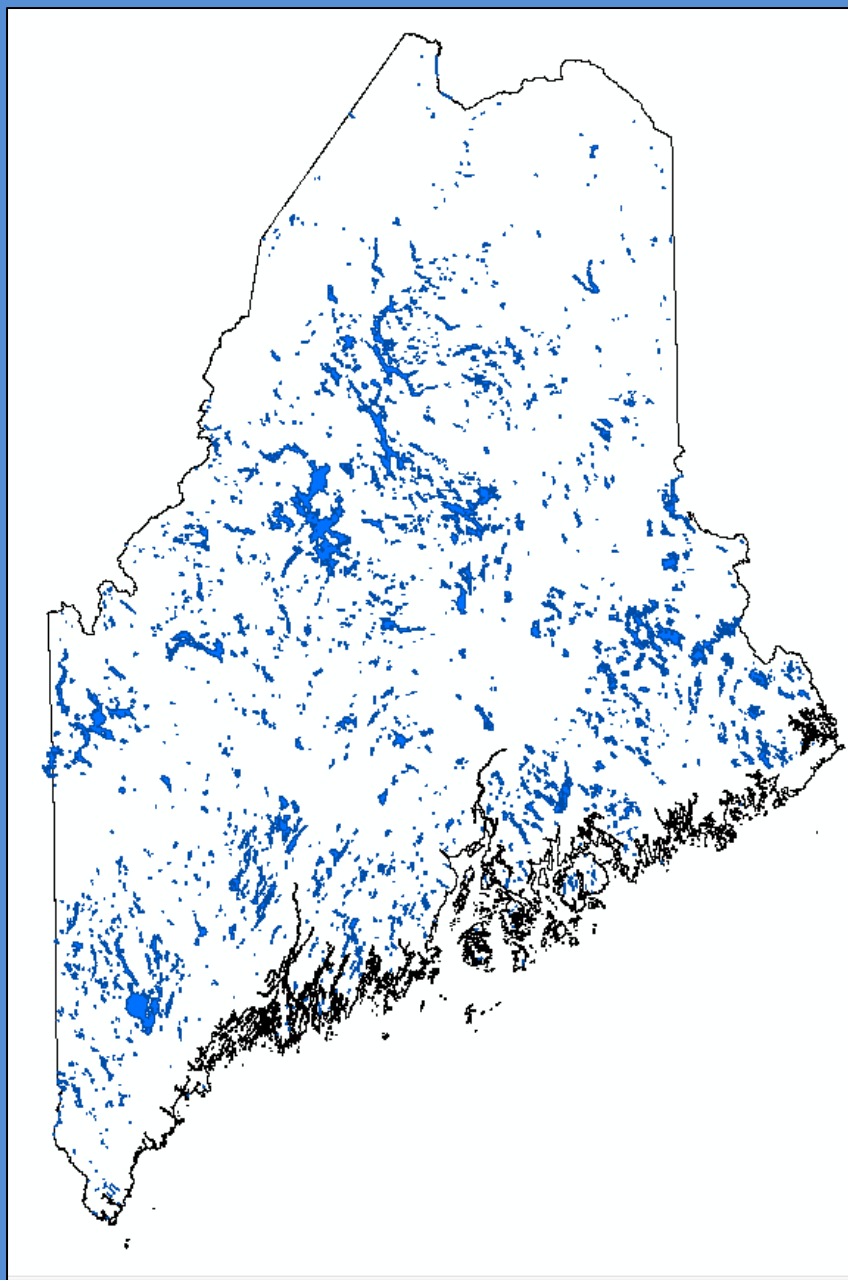
**Secchi = 6.5 m**



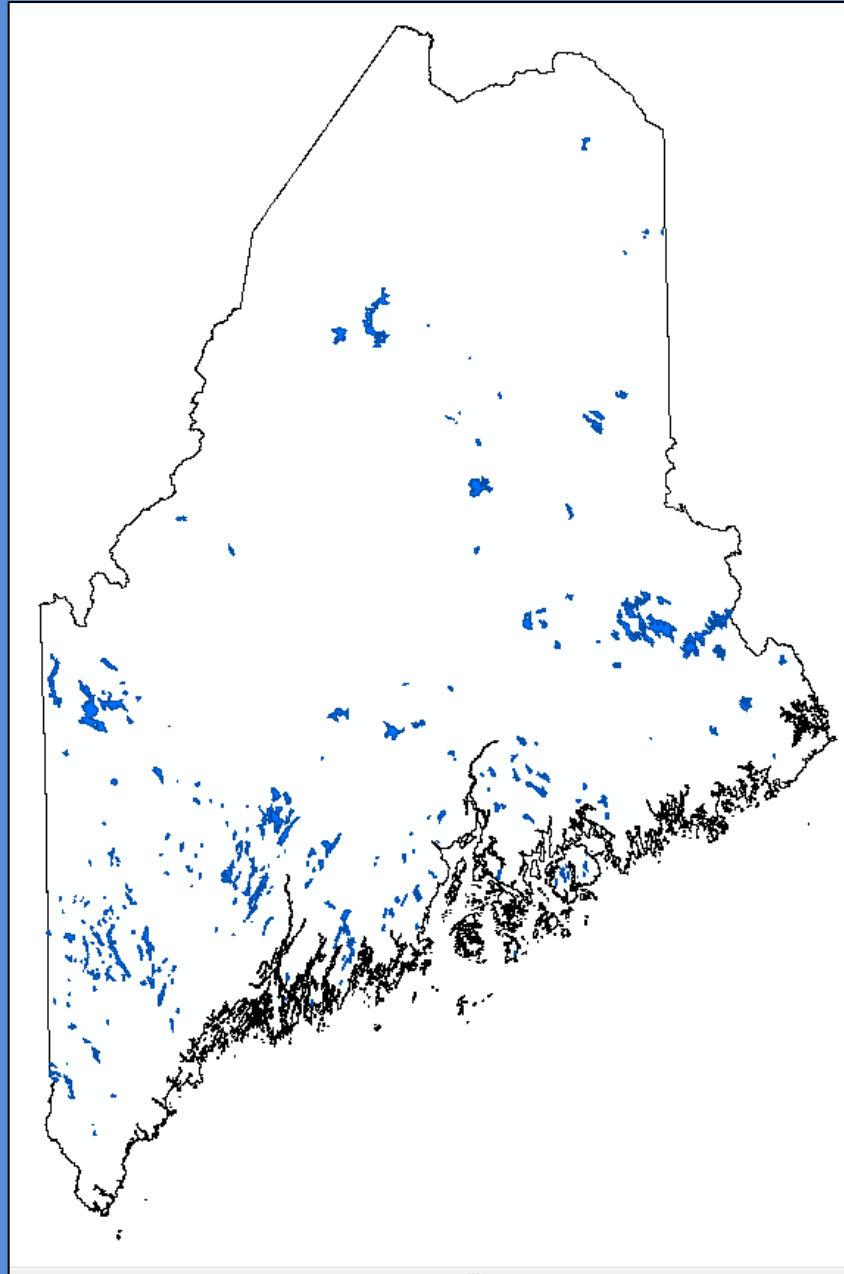
## Central Park, New York City

July 2011

# Lakes of Maine



Lakes with  
Secchi data  
in 2011



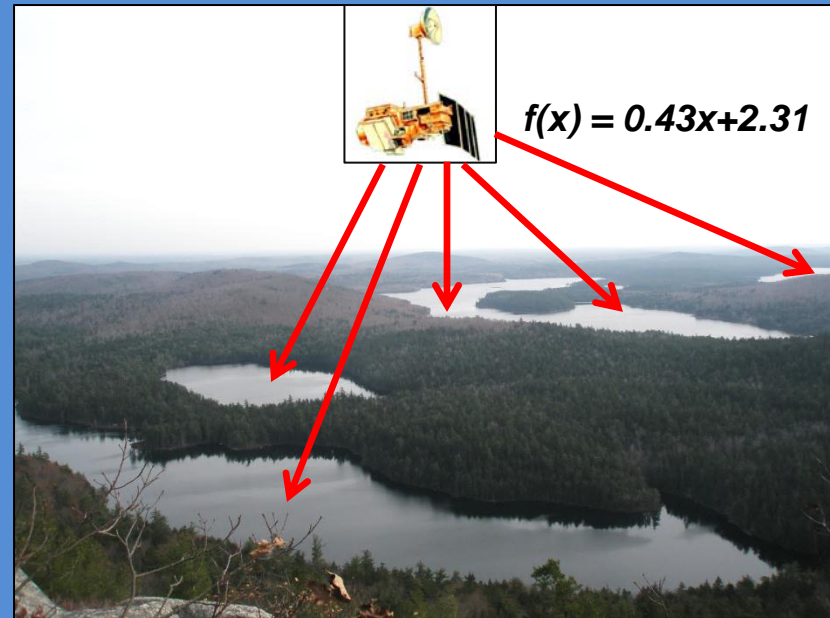
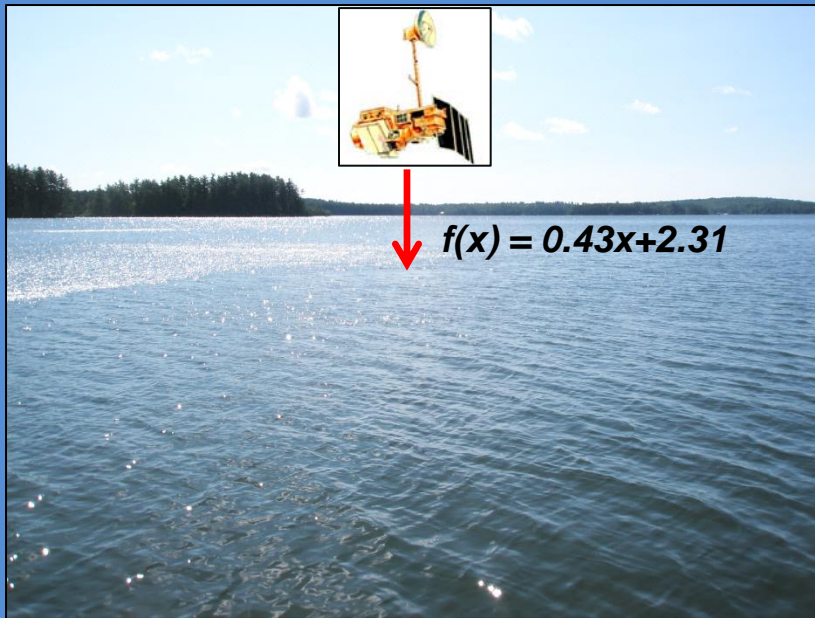
So, we have  
some good  
data already

But how can  
we fill in the  
gaps?

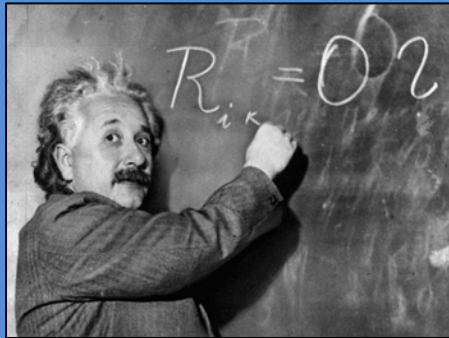


# Remote Sensing of Water Clarity

- Relate satellite image and Secchi disk data from roughly the same dates (fancy math - regression)
- Apply this relationship to estimate water clarity of unsampled lakes



# Can we do that in Maine?



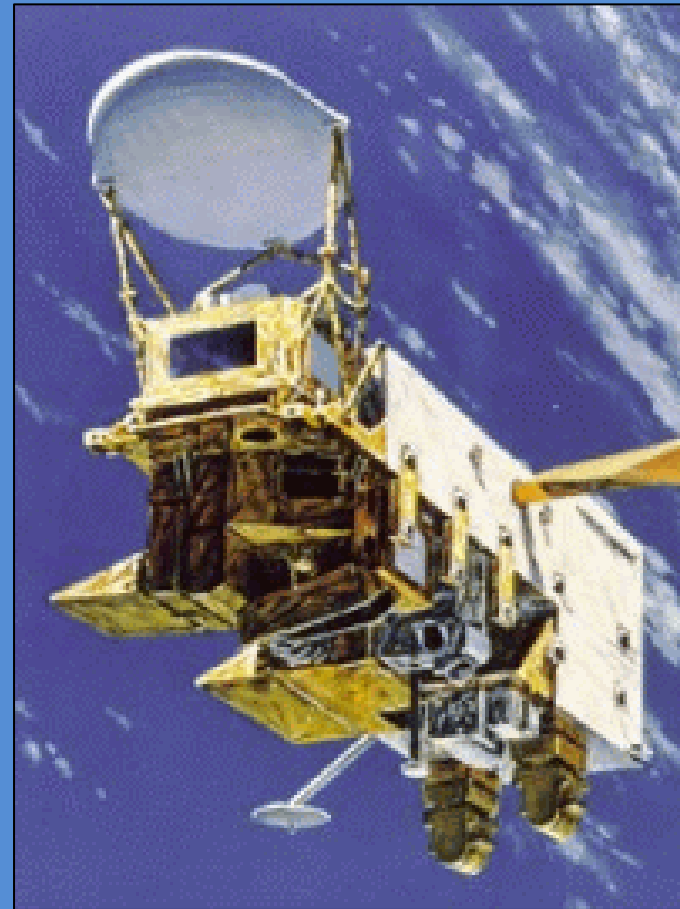
# The Satellites

## Landsat



[http://landsat.usgs.gov/images/squares/about\\_L5\\_1.jpg](http://landsat.usgs.gov/images/squares/about_L5_1.jpg)

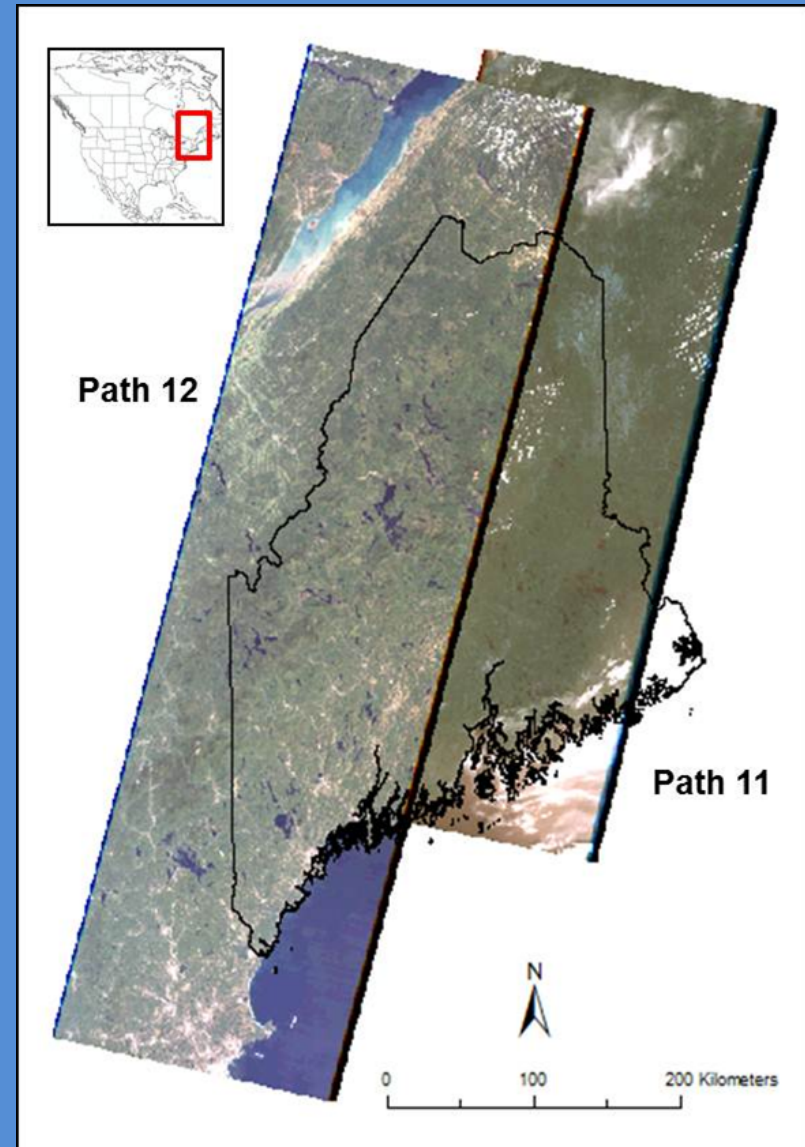
## MODIS Aqua/Terra



[http://polarmet.osu.edu/jbox/research/modis\\_in\\_space.gif](http://polarmet.osu.edu/jbox/research/modis_in_space.gif)

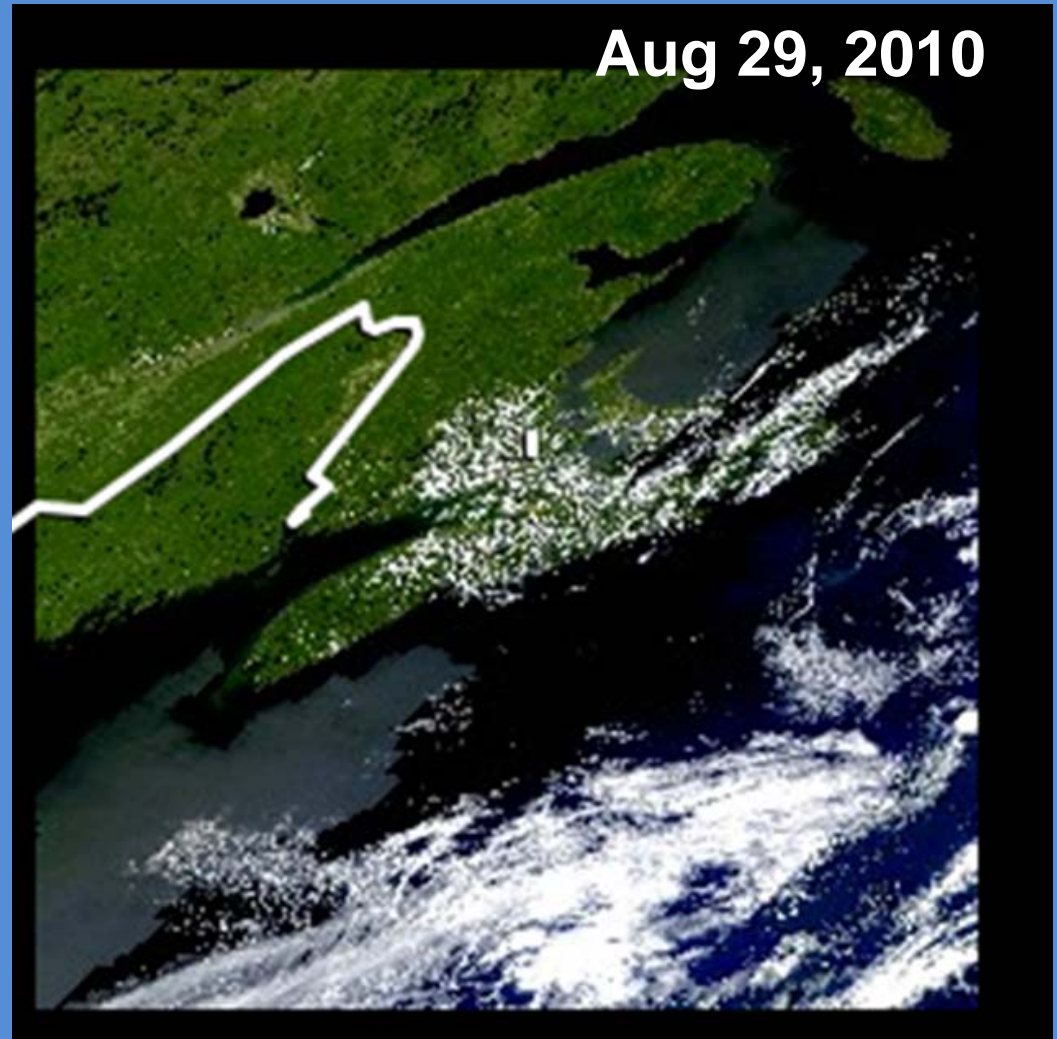
# Landsat

- Landsat 5, Landsat 7
- Near 40 year archive
- 30 m resolution
  - 1,511 lakes > 8 ha
- Returns every 16 days
- FREE

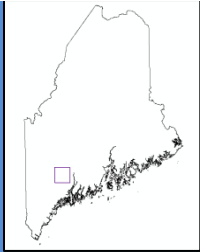


# MODIS

- Aqua, Terra
- Daily images since 1999
- 250 m resolution: 364 lakes > 100 ha
- 500 m resolution: 83 lakes > 400 ha
- FREE



# Methods



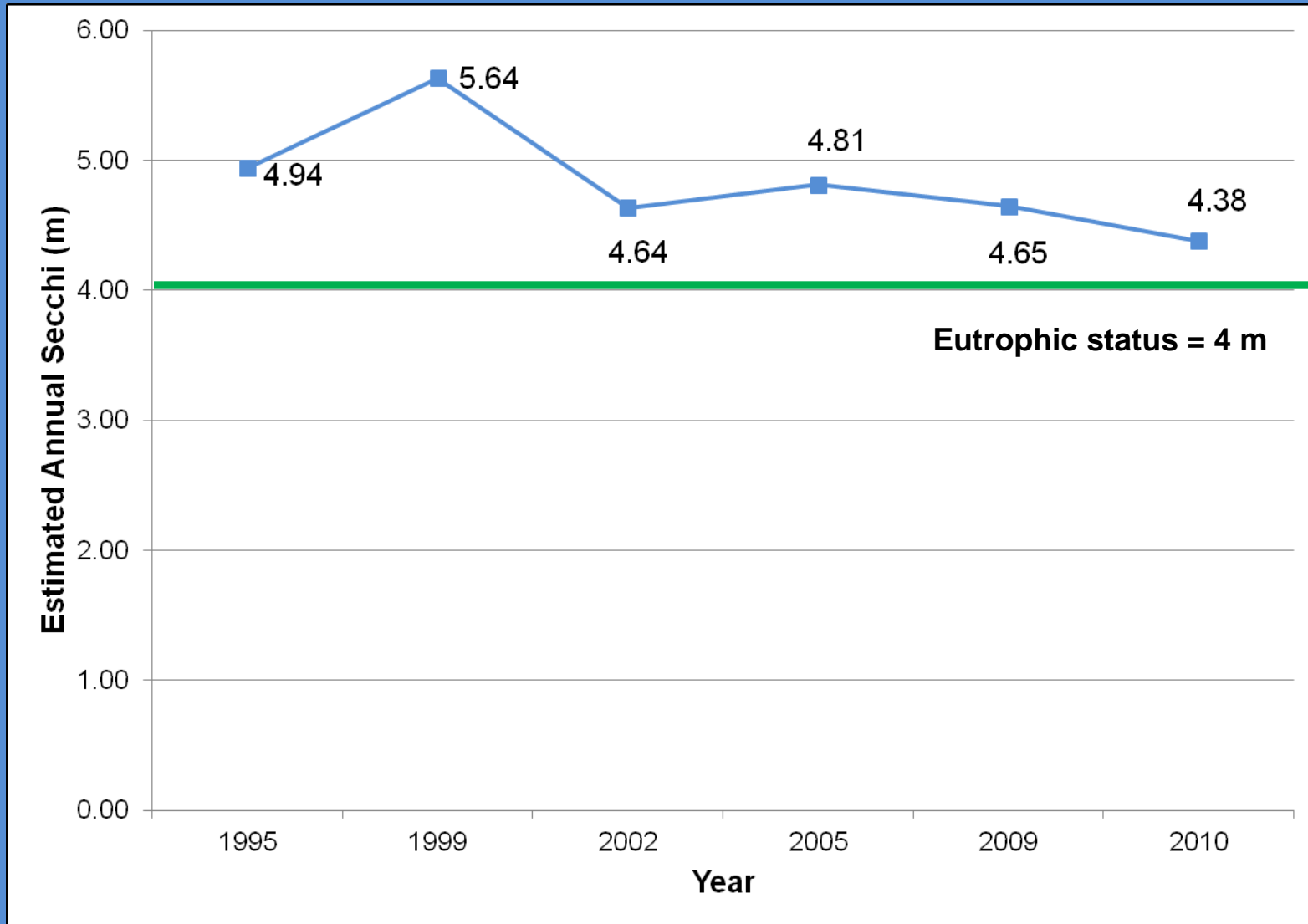
**1,511 lakes**

Androskoggin Lake

# Research Findings

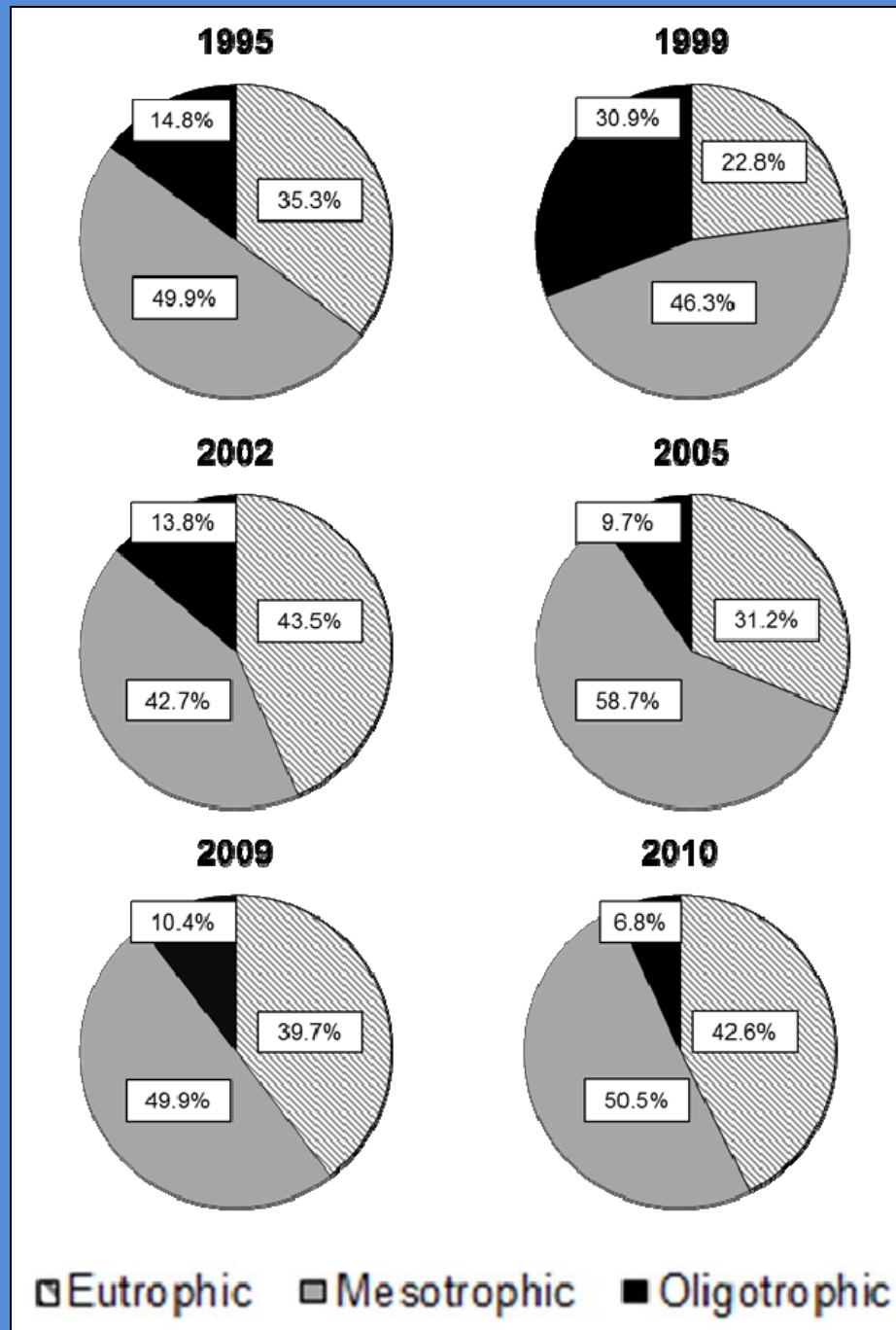


# Temporal trend in average Maine lake water clarity





## Shifting proportions of lake trophic states

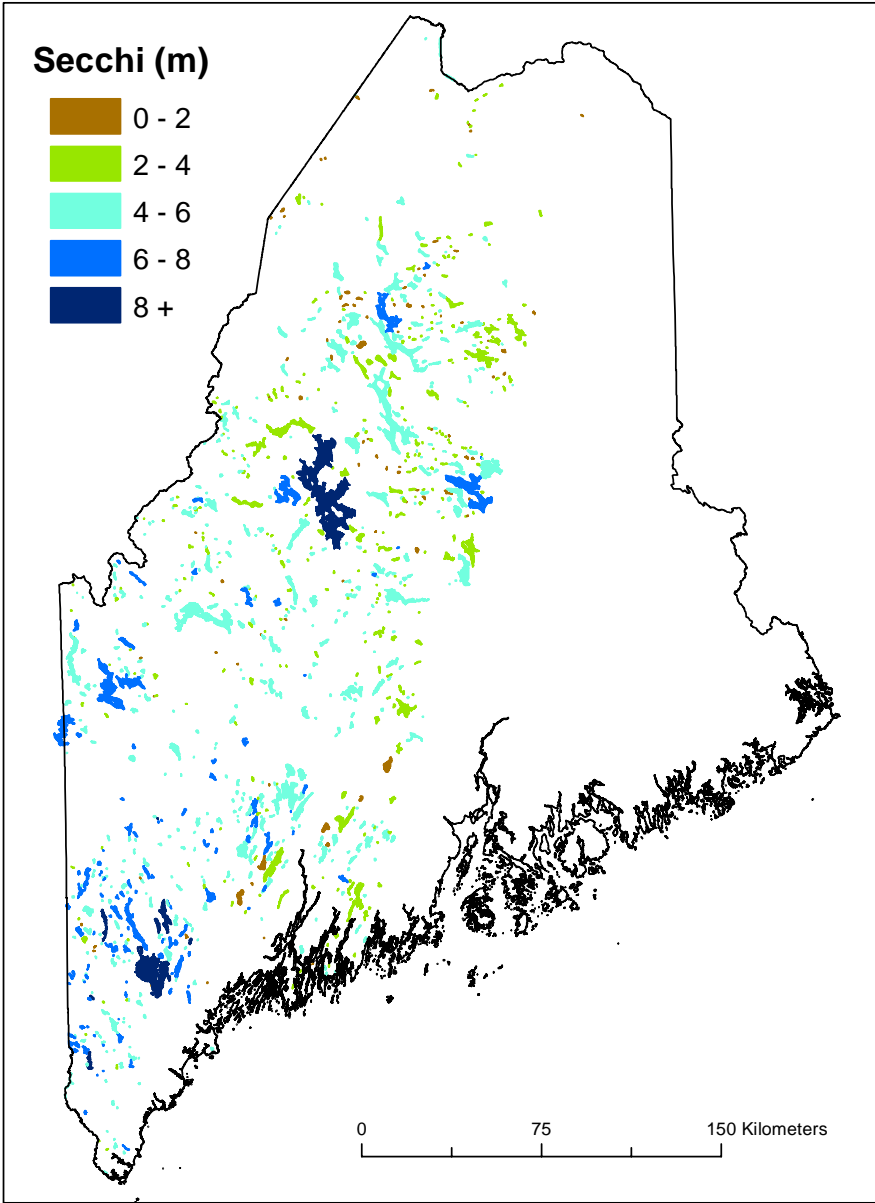


Oligotrophic lakes becoming mesotrophic

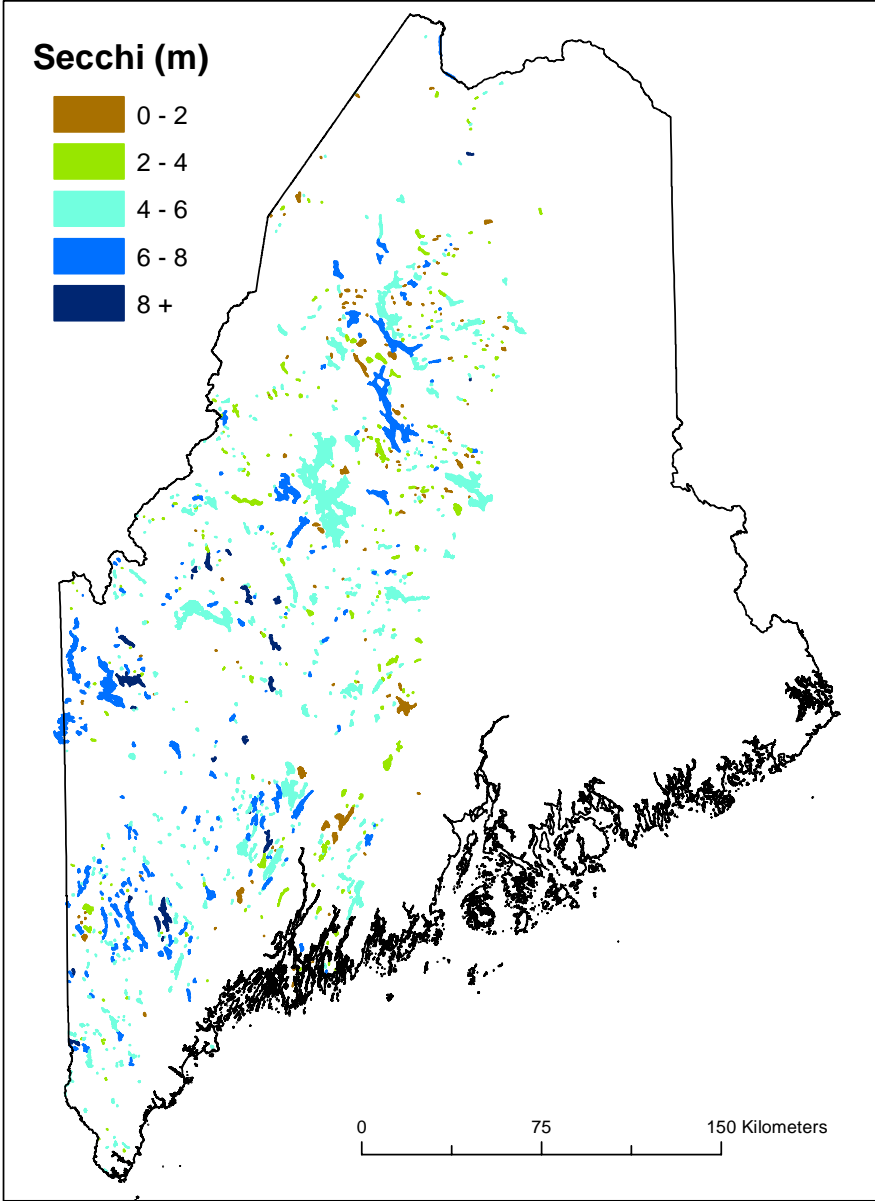
Mesotrophic lakes becoming eutrophic

Eutrophic: < 4 m  
Mesotrophic: 4-7 m  
Oligotrophic: > 7 m

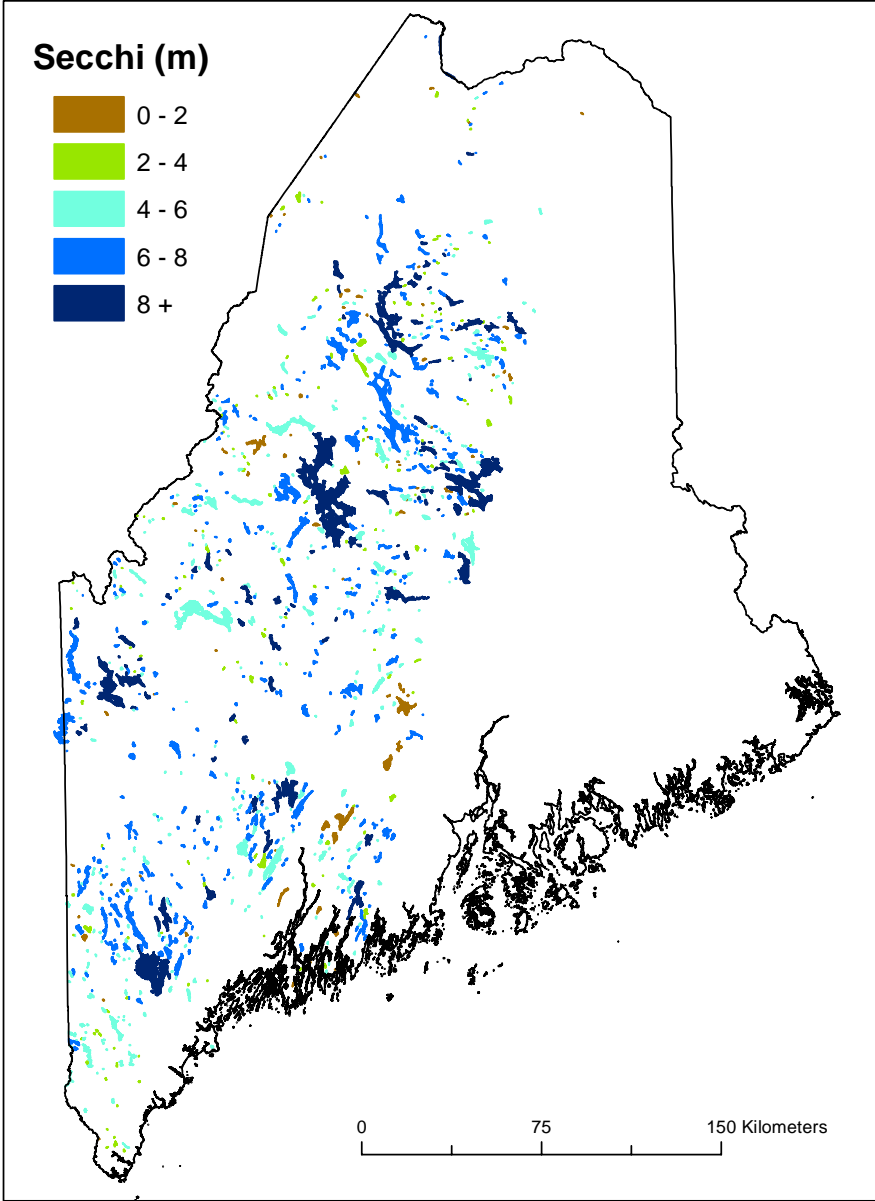
Sept 8, 1990



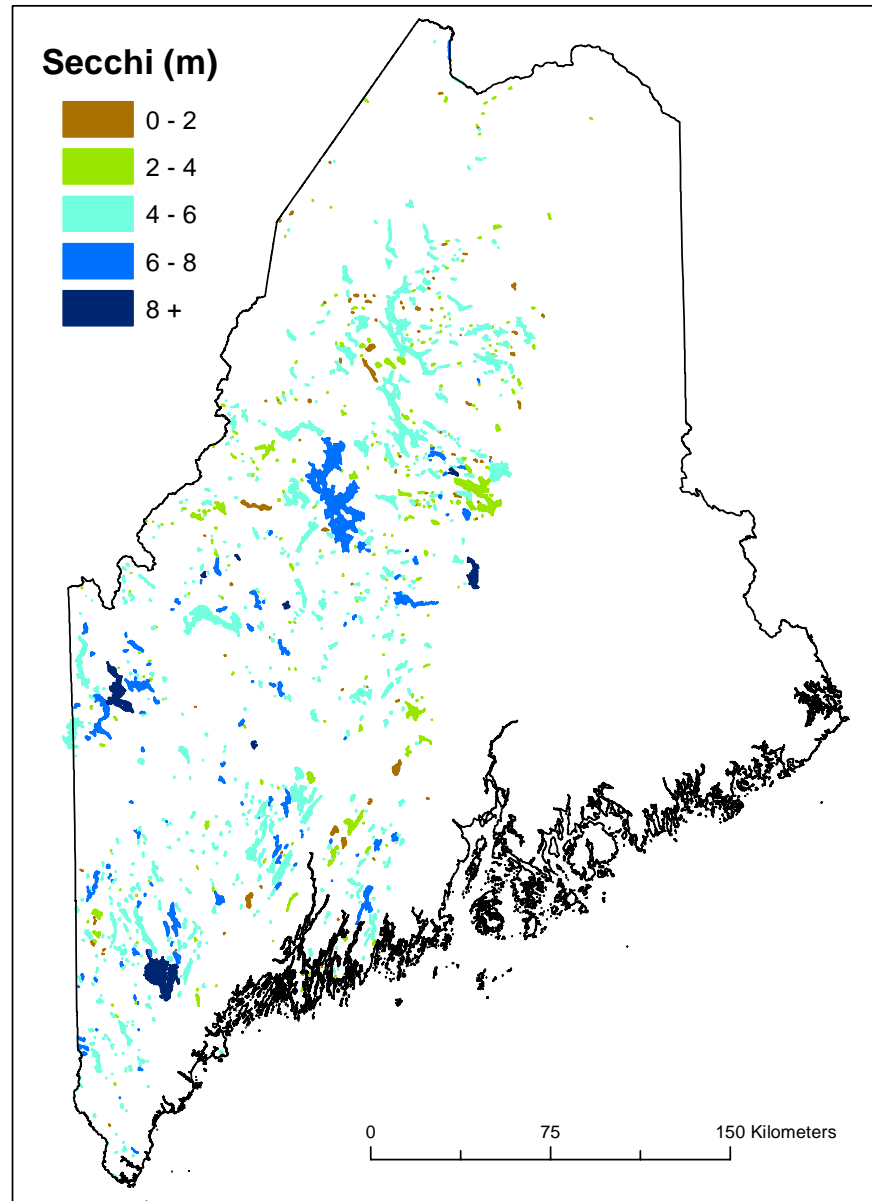
Sept 6, 1995



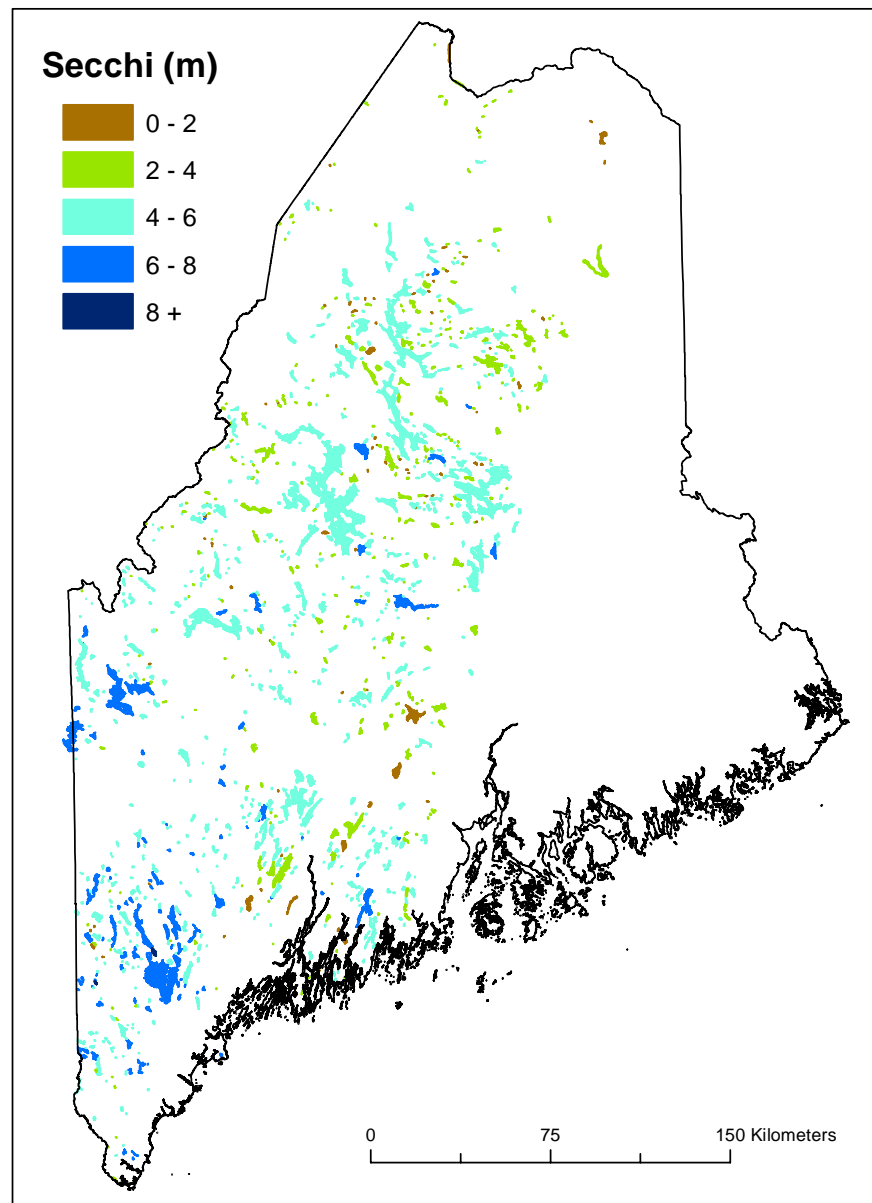
Sept 1, 1999



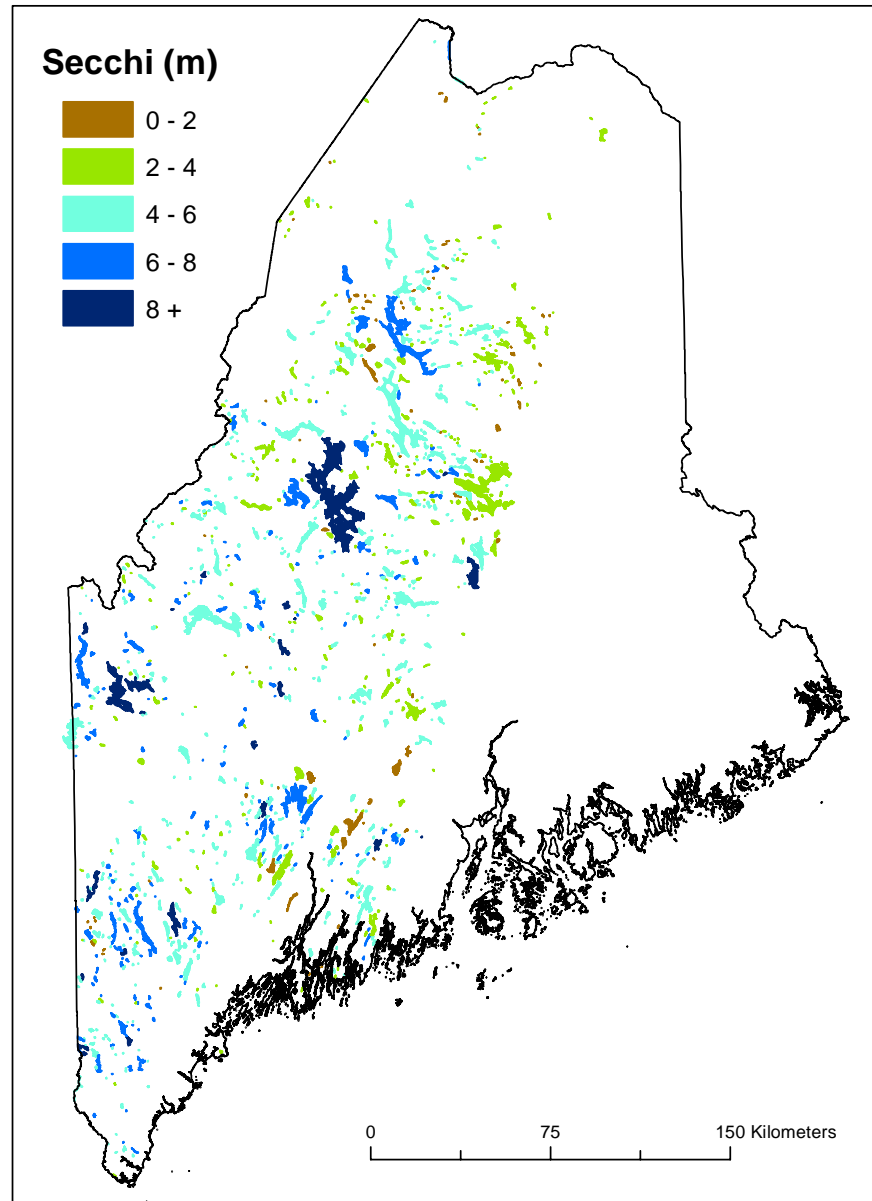
Aug 26, 2000



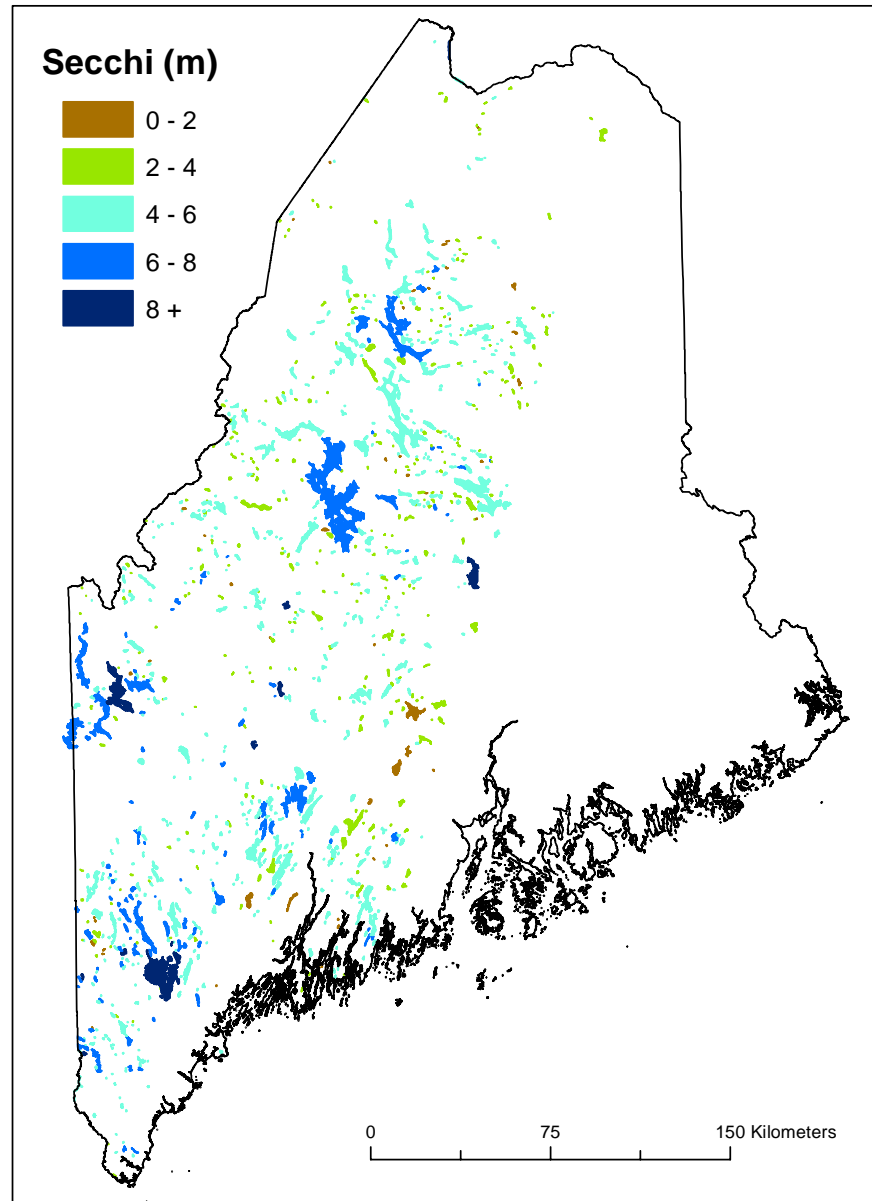
Sept 14, 2004



Aug 30, 2010

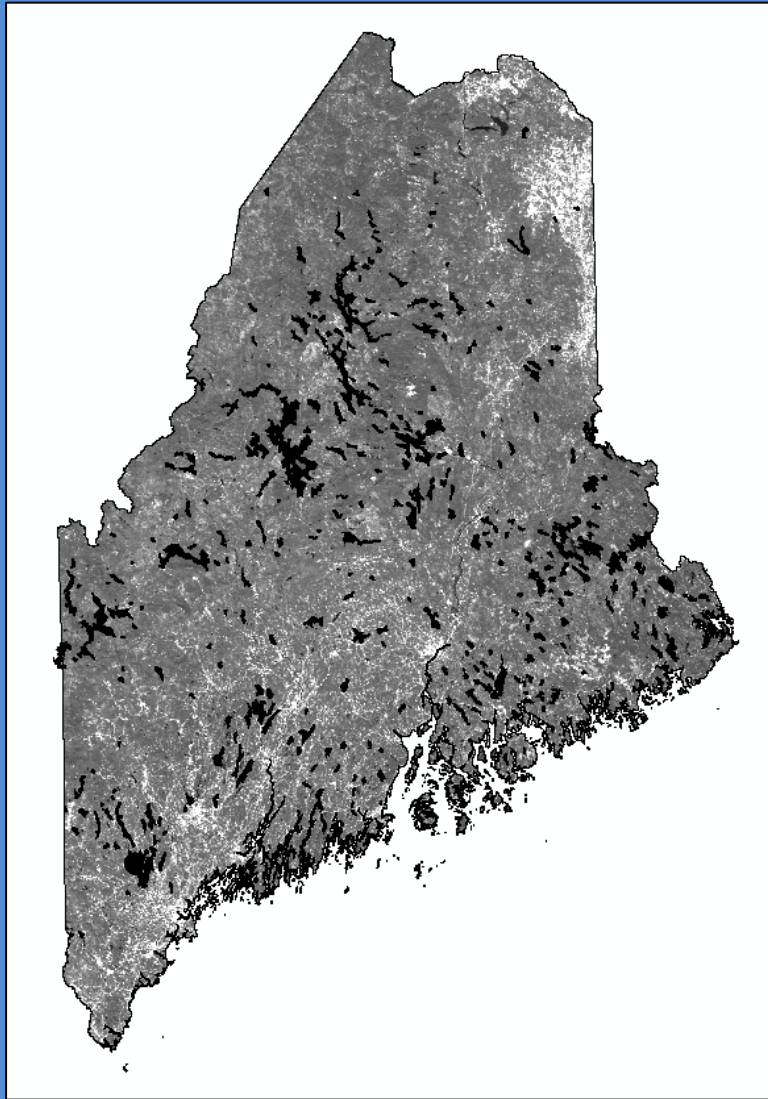


Aug 17, 2011

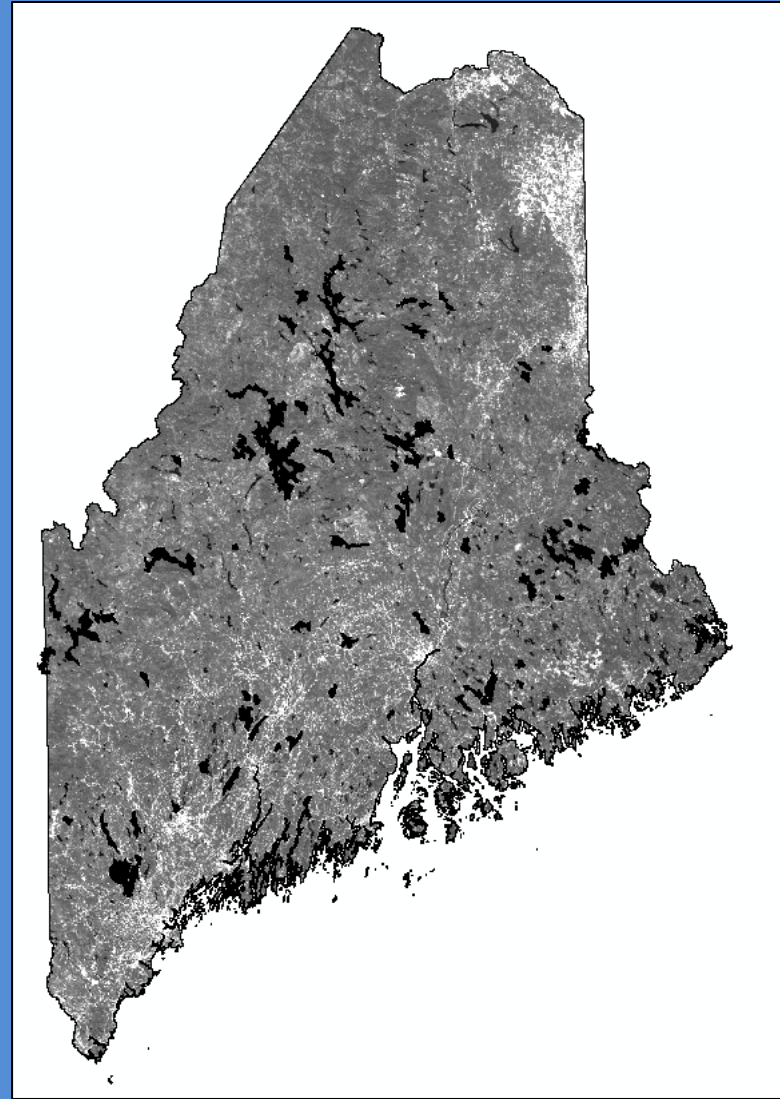




**MODIS 250 m - 364 lakes**



**MODIS 500 m - 83 lakes**





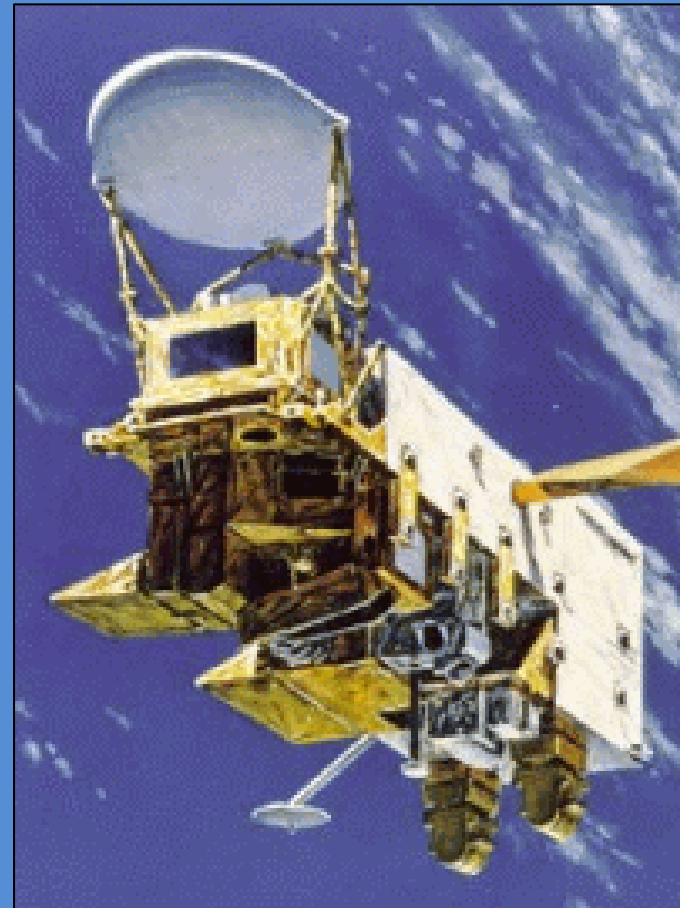
# Quite a 1-2 Punch?

**Landsat**



[http://landsat.usgs.gov/images/squares/about\\_L5\\_1.jpg](http://landsat.usgs.gov/images/squares/about_L5_1.jpg)

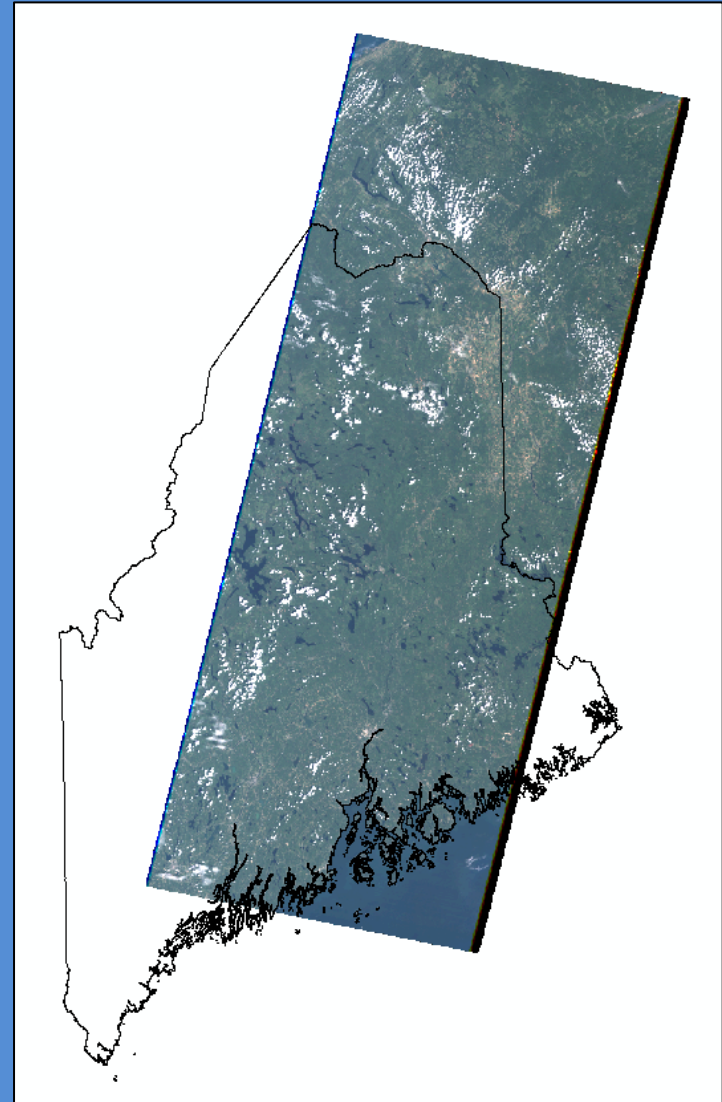
**MODIS Aqua/Terra**



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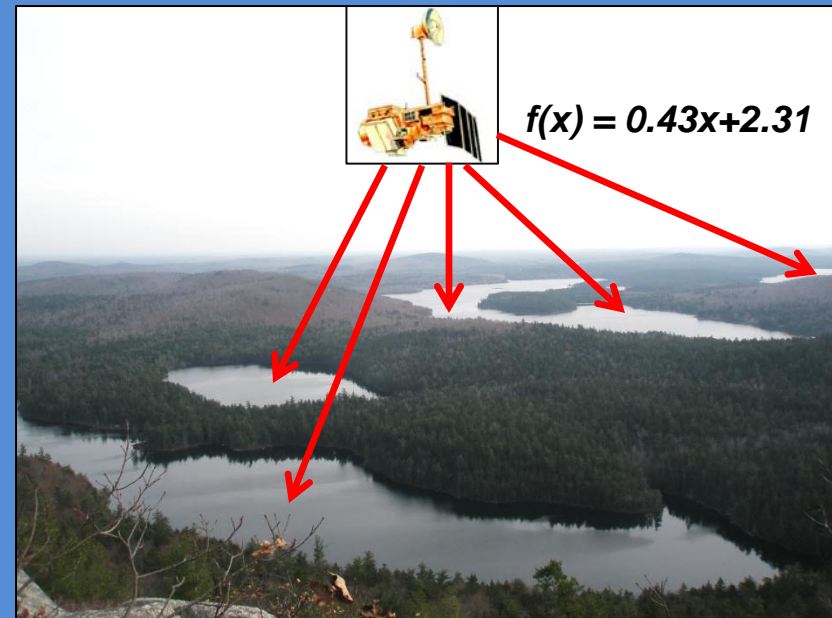
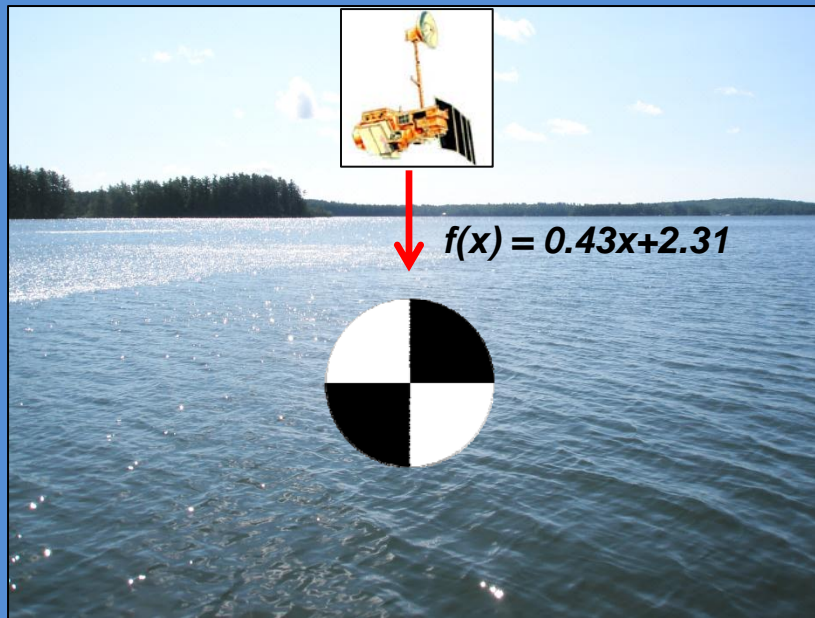
# Satellites have limitations

- Clouds, haze and fog
- Satellites can malfunction or wear out
- Would you trust yourself or a flying metal object 700 km in the sky?



# Wait a minute...

- Relate satellite image and Secchi disk data from roughly the same dates (fancy math - regression)
- Apply this relationship to estimate water clarity of unsampled lakes



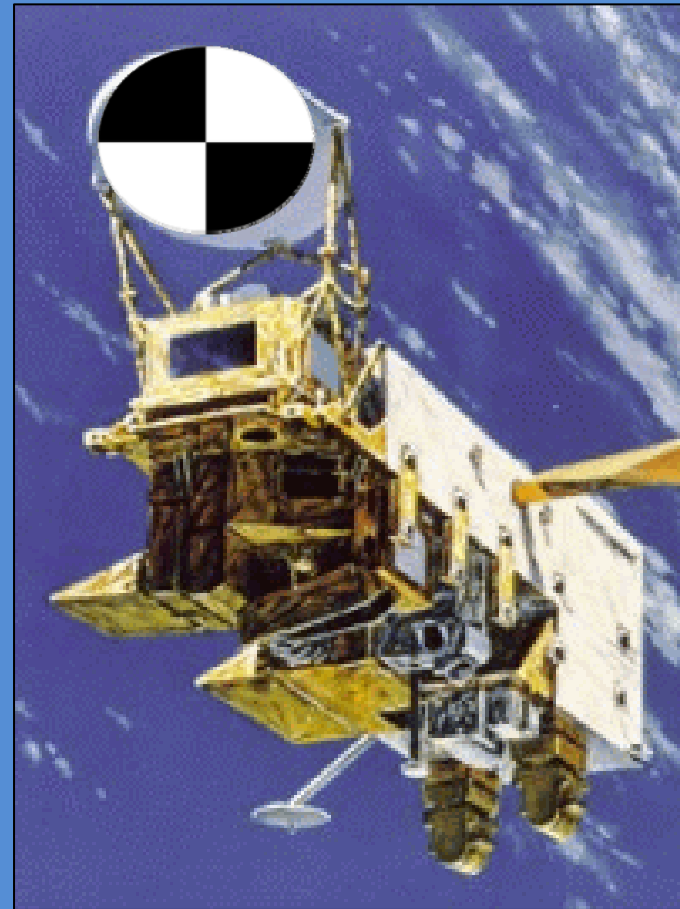
# Mere eyes in the sky

Landsat



[http://landsat.usgs.gov/images/squares/about\\_L5\\_1.jpg](http://landsat.usgs.gov/images/squares/about_L5_1.jpg)

MODIS Aqua/Terra



[http://polarmet.osu.edu/jbox/research/modis\\_in\\_space.gif](http://polarmet.osu.edu/jbox/research/modis_in_space.gif)

We need people to collect  
Secchi data in the field to  
“calibrate” the satellite imagery



**Maine Volunteer Lake Monitoring Program**

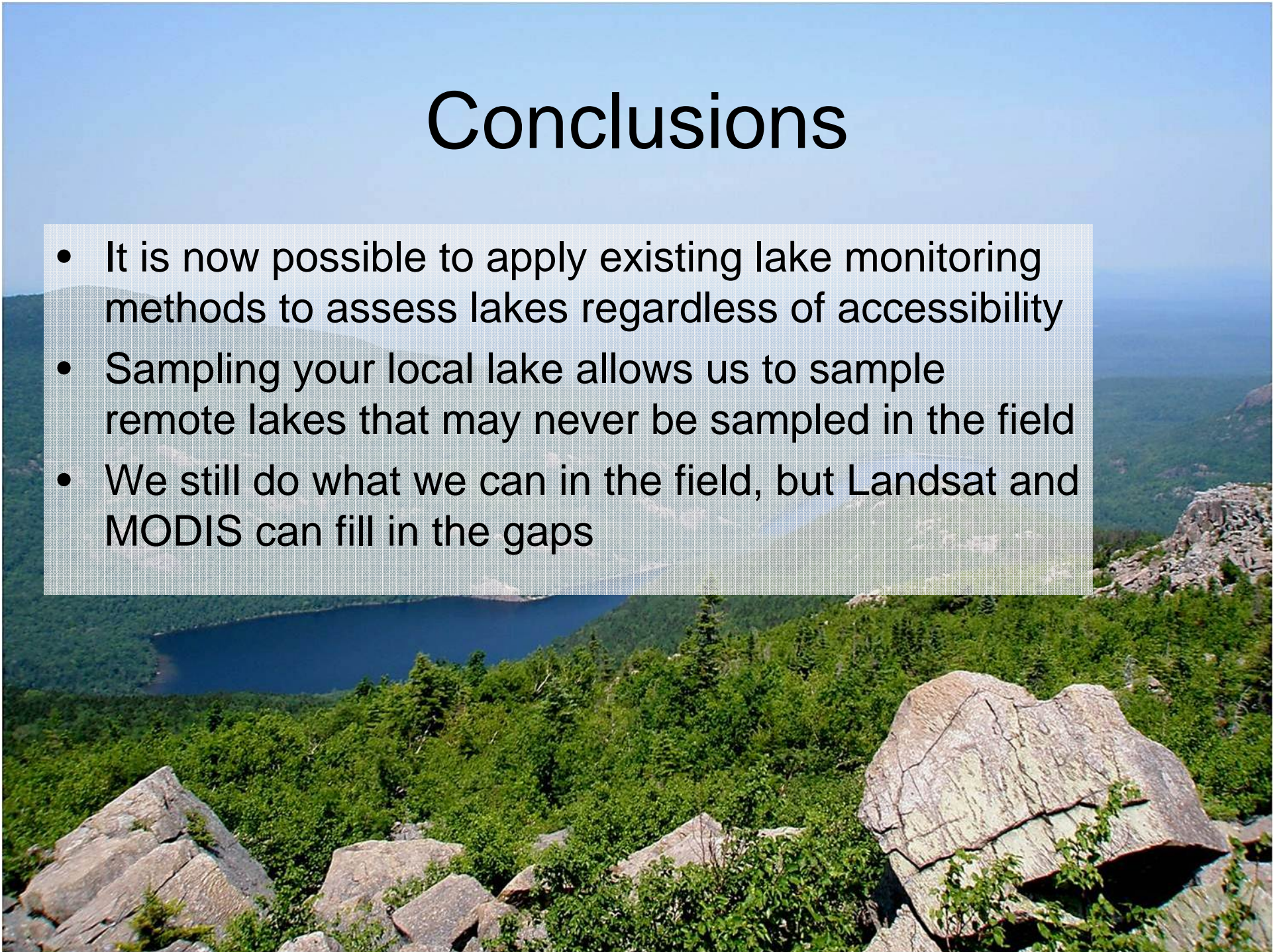
*Volunteers monitoring the health of Maine lakes since 1971*



Courtesy of Scott Williams

# Conclusions

- It is now possible to apply existing lake monitoring methods to assess lakes regardless of accessibility
- Sampling your local lake allows us to sample remote lakes that may never be sampled in the field
- We still do what we can in the field, but Landsat and MODIS can fill in the gaps





# Looking ahead...

- Keep up the good work!
- Keep an eye on Landsat dates (especially July-Sept)
- Enjoy and cherish your natural resources

**July: 26**

**August: 4, 11, 20, 27**

**September: 5, 12, 21**



# Acknowledgments



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## Co-advisors

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Wildlife Research Unit

## University of Maine

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## Colby College

Manuel Gimond



Maine Volunteer Lake  
Monitoring Program

## Photo Credits

Maine lakes

**Thank You**

