Measurement of Water Clarity in Wisconsin Lakes Using Landsat TM

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Wisconsin Dept. of Natural Resources
Seventh National Monitoring Conference
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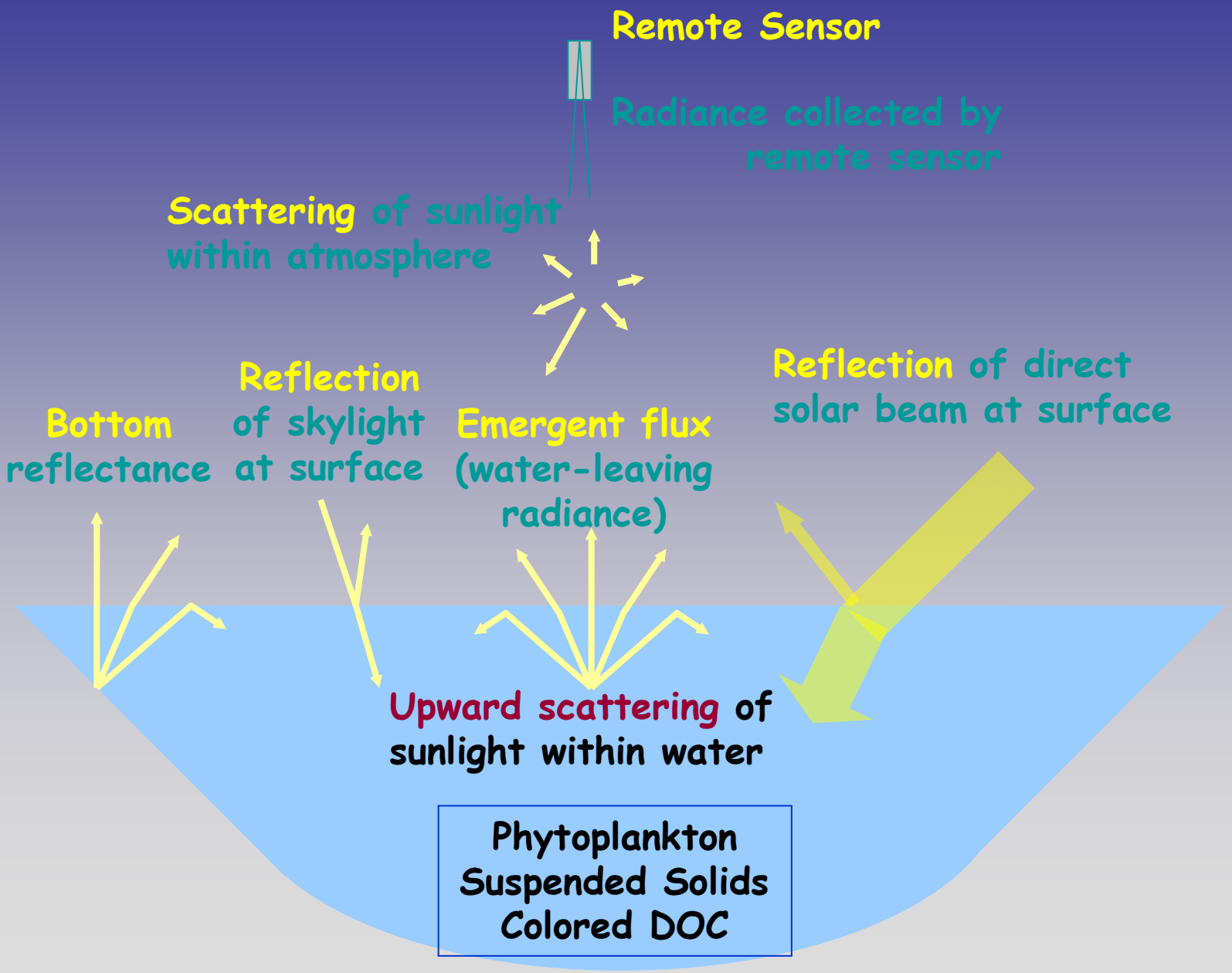
REMOTE SENSING OF FRESHWATERS



Water Quality Monitoring utilizing Remote Sensing

Advantages over conventional monitoring

- Spatial Coverage (Landsat 185 km x 185 km)
- Simultaneous sampling
- Lack of financial, institutional, technical resources for in situ monitoring, insufficient coverage
- Continuity of historical records/ political instability transboundary issues
- Quick dissemination/sharing of data

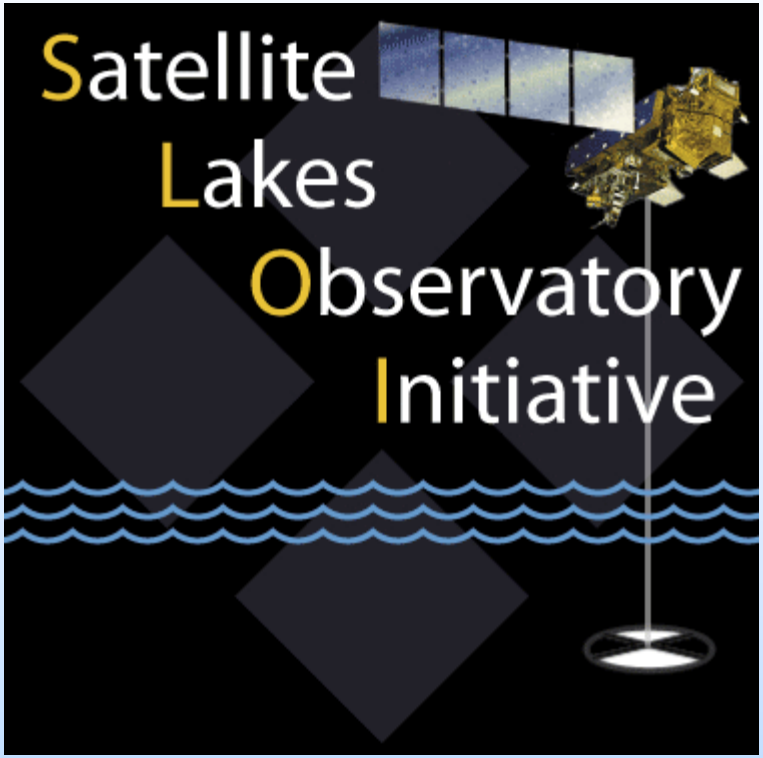
Disadvantages

- Freshwater is complex mixture, CPA's- algae, particulate,color.
- RS measure surface conditions, bottom visible in shallow
- Dynamic water quality changes
- Relatively small water body sizes
- Cloud cover over inland areas
- Can't monitor all parameters
- Laboratory analysis required for cal. and ver.

Potential Surface-Water Parameters via Remote Sensing for Limnological Investigations

- Water Clarity (Secchi depth)
- Surface Chlorophyll Conc.
- Floating Algal Accumulation (Toxicity issues)
- Macrophyte Abundance, Distribution, and Speciation
- Color, Humic Substances, Dissolved Organic Carbon
- Suspended Solids
- Surface Temperature

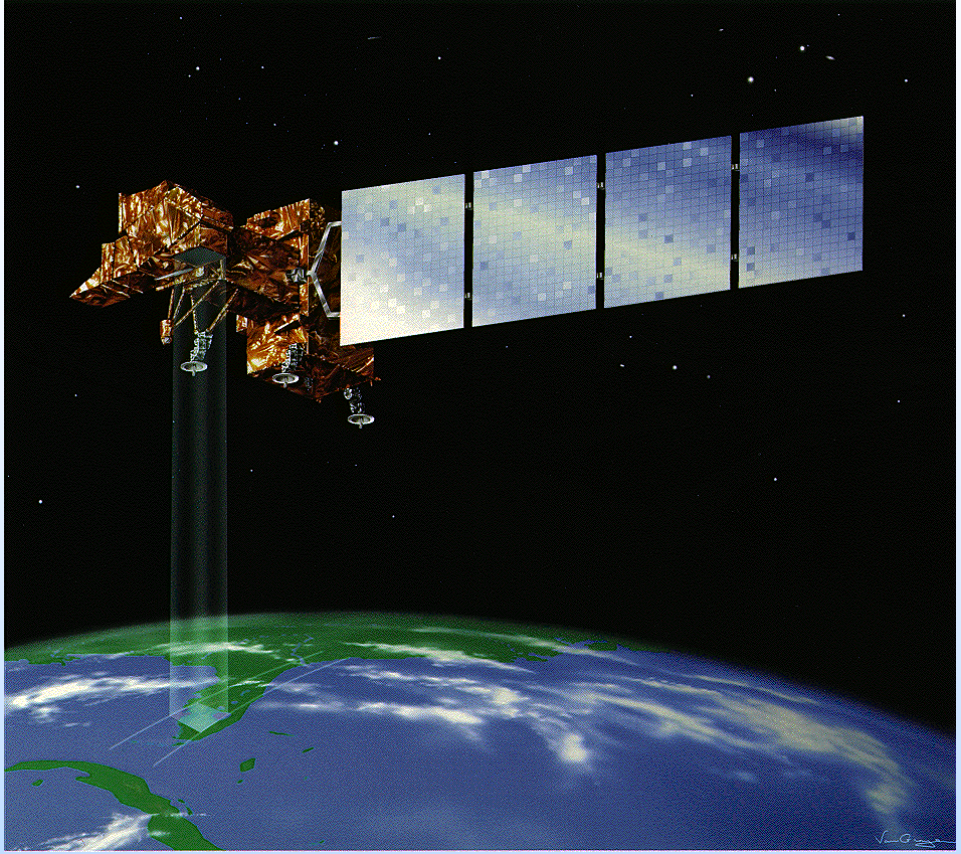
- Ice break-up and freezing dates
- Drainage Basin Land Use
- Benthic Type and Coverage
- Water Levels and Water body Morphology (size,shape)



A partnership between universities, state agencies and local citizens

SLOI is a project of the Upper Midwest Regional Earth Science Applications Center (RESAC) and it is supported by the NASA Affiliated Research Center (ARC) Program

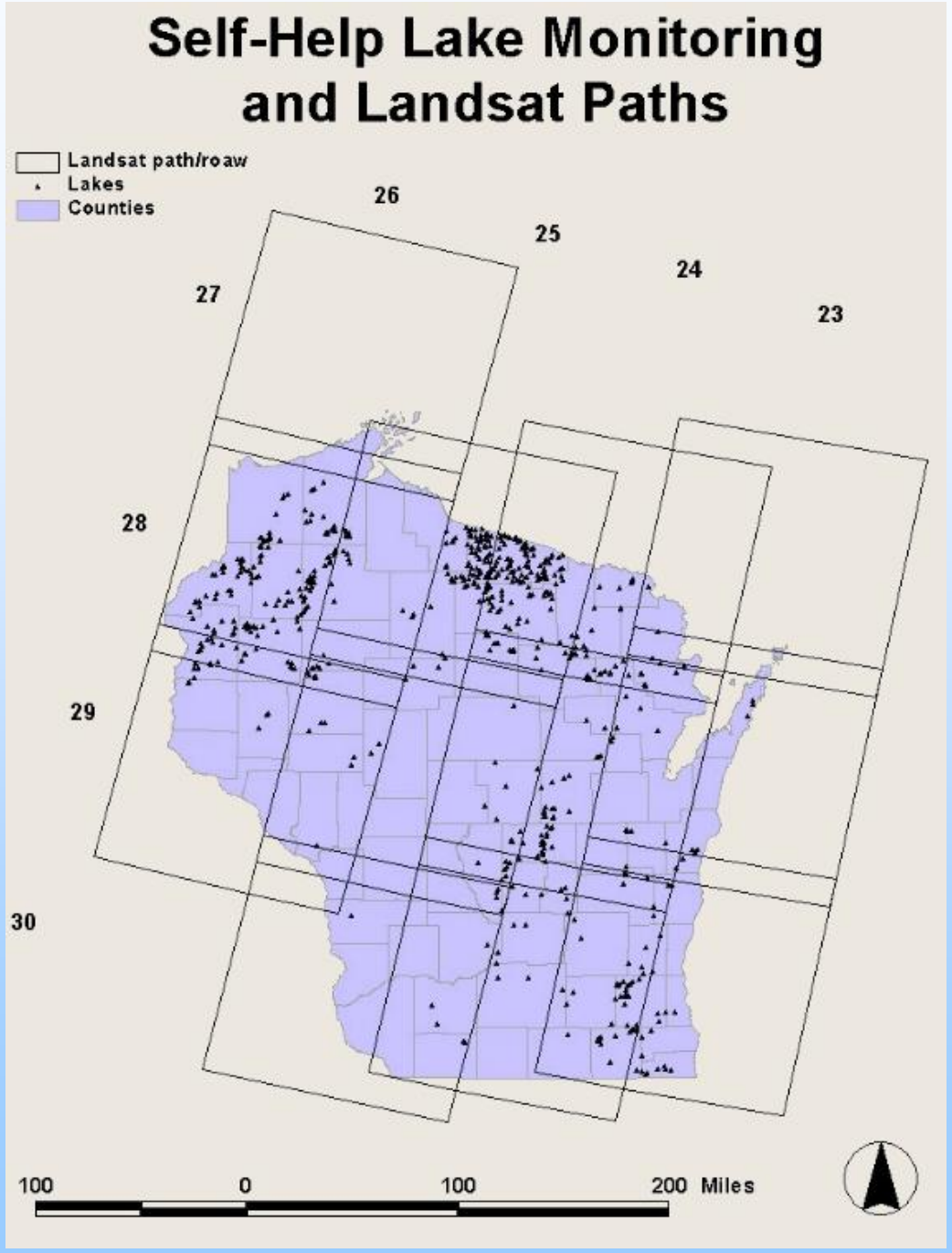
Landsat 5 & 7



Launched 1984 and 1999, resp.
Weight 4,800 lbs (2,200 kg)
Length14 ft (4.3 m)
Diameter 9 ft (2.8 m)
Orbit height 438 miles
Repeat coverage interval: 16 days (233 orbits)
Bands -8 total, 3 Vis, 4 IR, 1 Pan
Extremely cost effective!

Landsat Tracking-NASA - Science@NASA J-Track 3D and LIVE REAL TIME SATELLITE TRACKING: LANDSAT 5

Self-Help Lake Monitoring and Landsat Paths

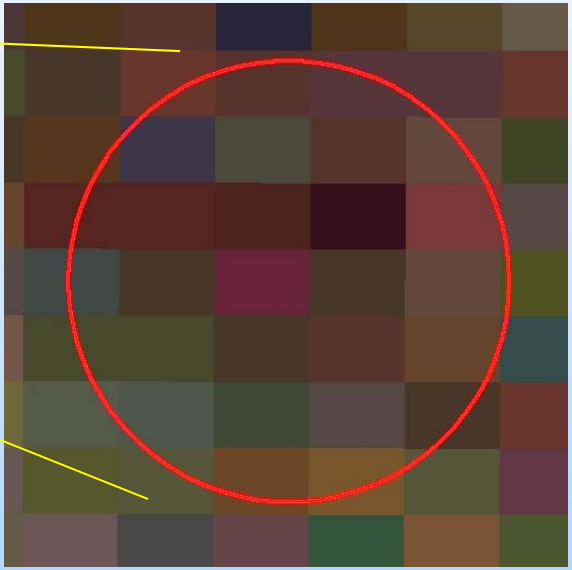


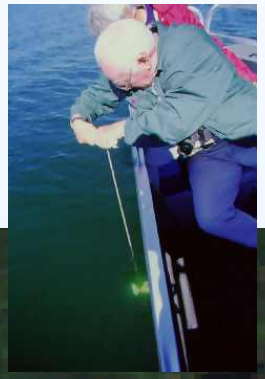
Quick review of how we measure Lake Water Clarity from Satellites

1.) Summer in-situ measurements from Citizen Lake Monitoring Network

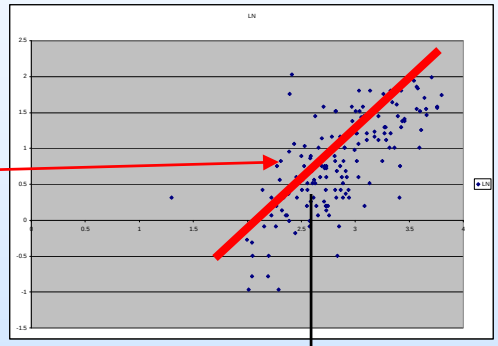
2.) Define a small buffer area where SD was measures

3.) Average the pixels





4.) Develop relationship between measured Secchi and pixel brightness



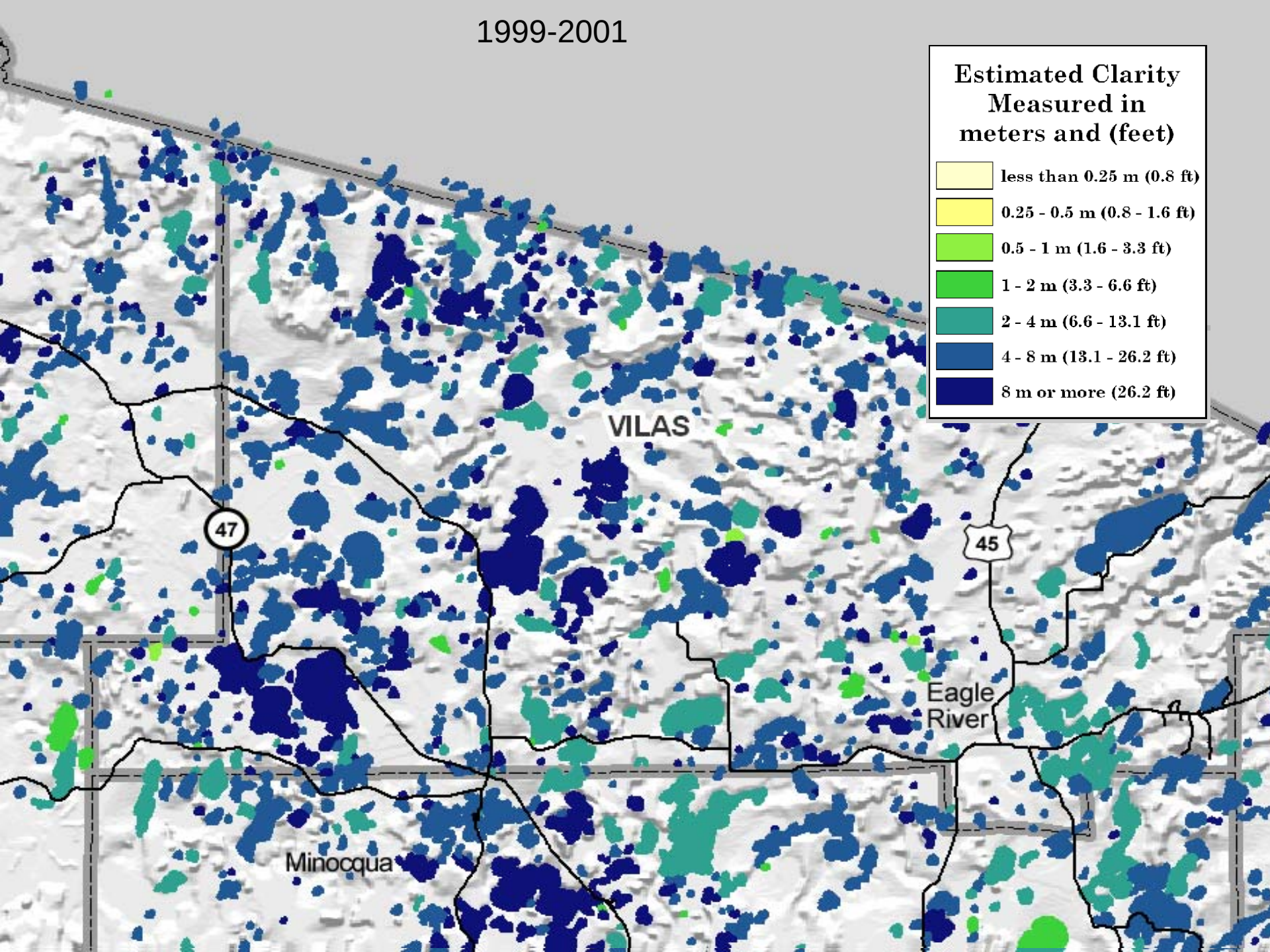
$$\ln(\text{Secchi}) = b_0 + b_1\left(\frac{TM1}{TM3}\right) + b_2(TM1)$$

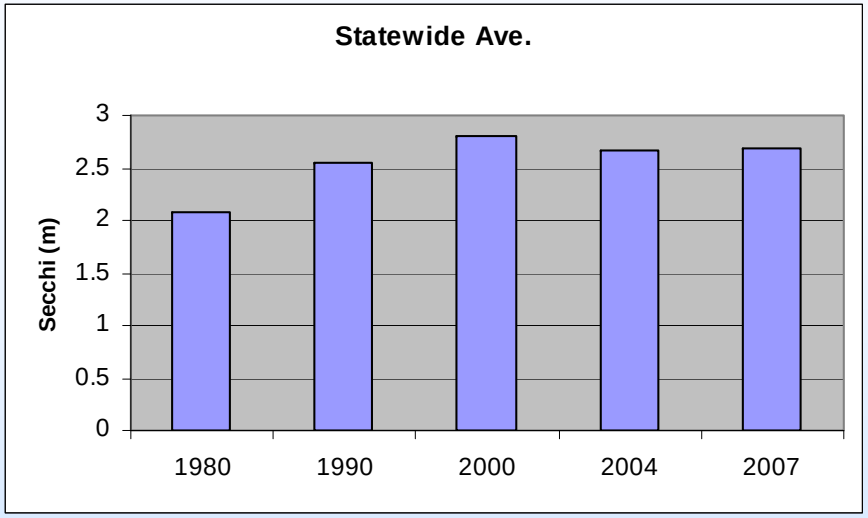
Statewide Lake SD data

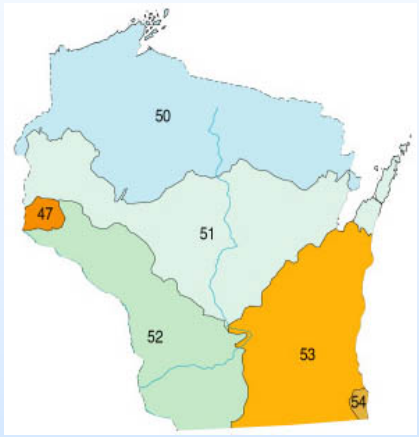
Approx. 8000 lakes

Six rounds completed

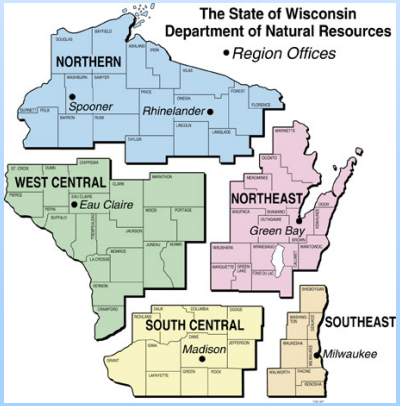
1980,1990,2000,2004,2007, 2008*

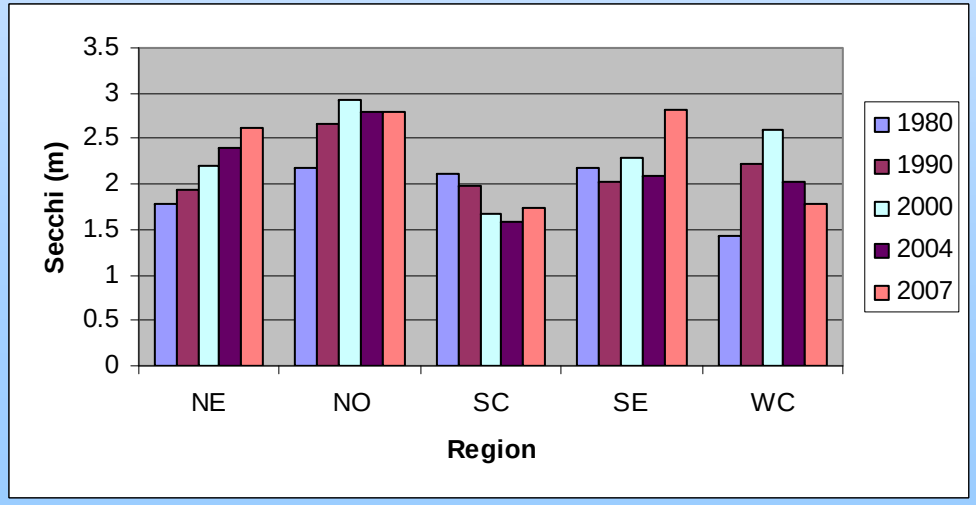

1999-2001
Estimated Clarity Measured in meters and (feet)
less than 0.25 m (0.8 ft)
0.25 - 0.5 m (0.8 - 1.6 ft)
0.5 - 1 m (1.6 - 3.3 ft)
1 - 2 m (3.3 - 6.6 ft)
2 - 4 m (6.6 - 13.1 ft)
4 - 8 m (13.1 - 26.2 ft)
8 m or more (26.2 ft)
VILAS
47
45
Eagle River
Minocqua

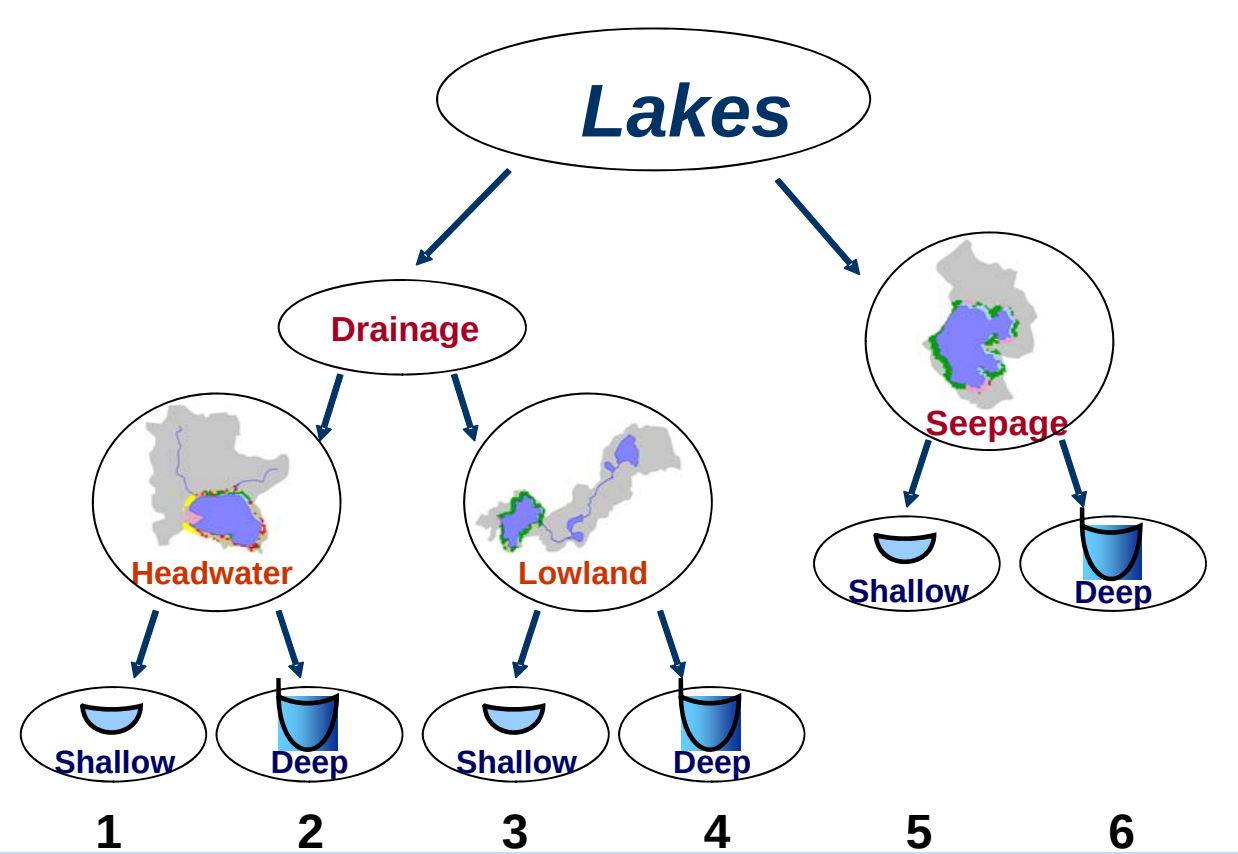




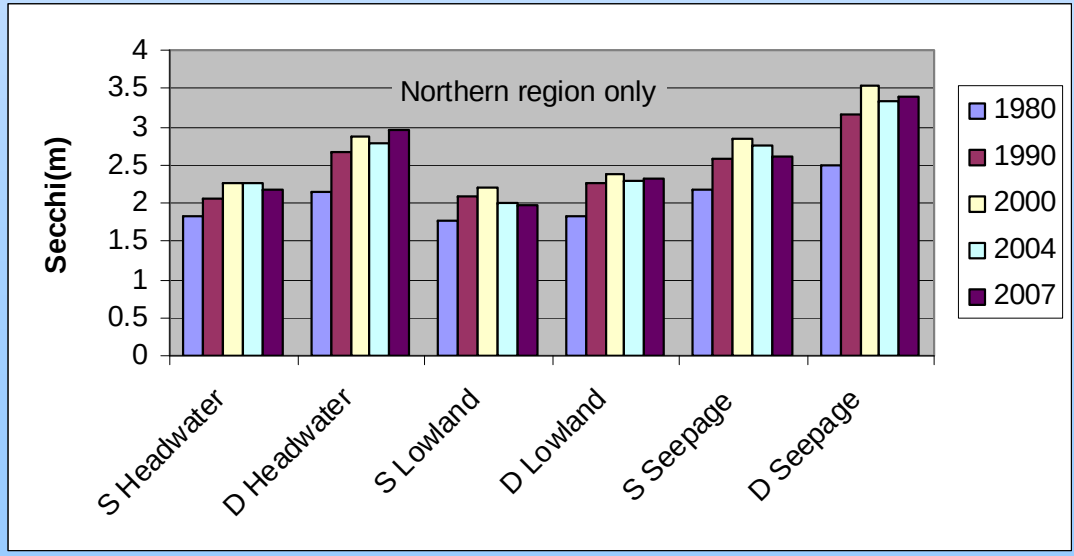
Partitioning Data






Lakes
Drainage
Seepage
Headwater
Lowland
Shallow
Deep
Shallow
Deep
Shallow
Deep
1
2
3
4
5
6

LAKE CLASS


Northern region only
Secchi(m)
4
3.5
3
2.5
2
1.5
1
0.5
0
S Headwater
D Headwater
S Lowland
D Lowland
S Seepage
D Seepage
1980
1990
2000
2004
2007

Calculate Lake Condition Assessments

$$TSI_{(secchi)} = 60-(14.41*\ln(SD))$$

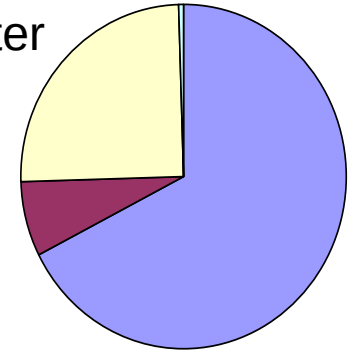
***Table 5. Trophic Status Index (TSI) Thresholds for Assessment of Lake Natural Communities.**

Condition Level	Shallow			Deep			
	Headwater	Lowland	Seepage	Headwater	Lowland	Seepage	Two-Story
Excellent	**< 45**	**< 49**	**< 39**	**< 47**	**< 46**	**< 44**	**< 44**
Good	**45 – 57**	**49 – 59**	**39 – 54**	**47 – 54**	**46 – 53**	**44 – 52**	**44 – 47**
Fair	**58 – 70**	**60 – 70**	**55 – 70**	**55 – 62**	**54 – 62**	**53 – 62**	**48 – 52**
Poor	**≥ 71**	**≥ 71**	**≥ 71**	**≥ 63**	**≥ 63**	**≥ 63**	**≥ 53**

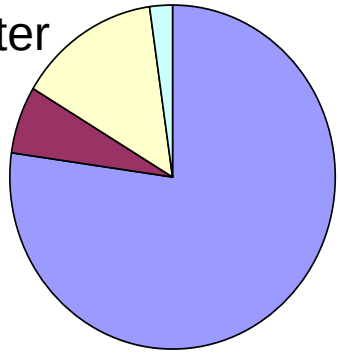
**From* "Guidance for the Classification, Monitoring, & Assessment of Wisconsin's Lakes, Rivers, and Streams Oct.2008(Draft)"

TSI Condition by Lake Class (state-wide)

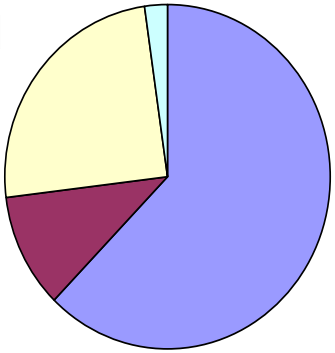
Headwater Shallow



Headwater Deep



Lowland Shallow



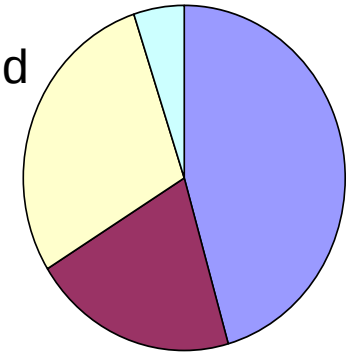
Excellent

Good

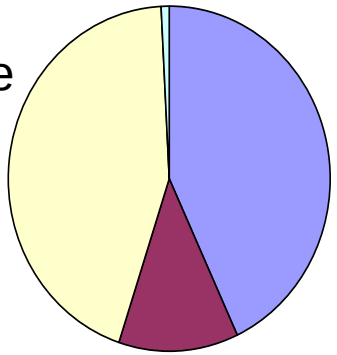
Fair

Poor

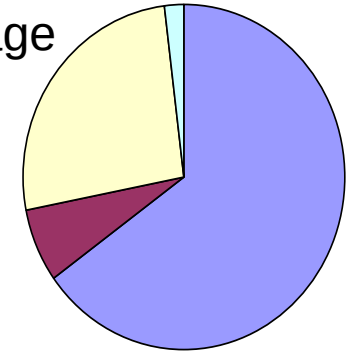
Lowland Deep



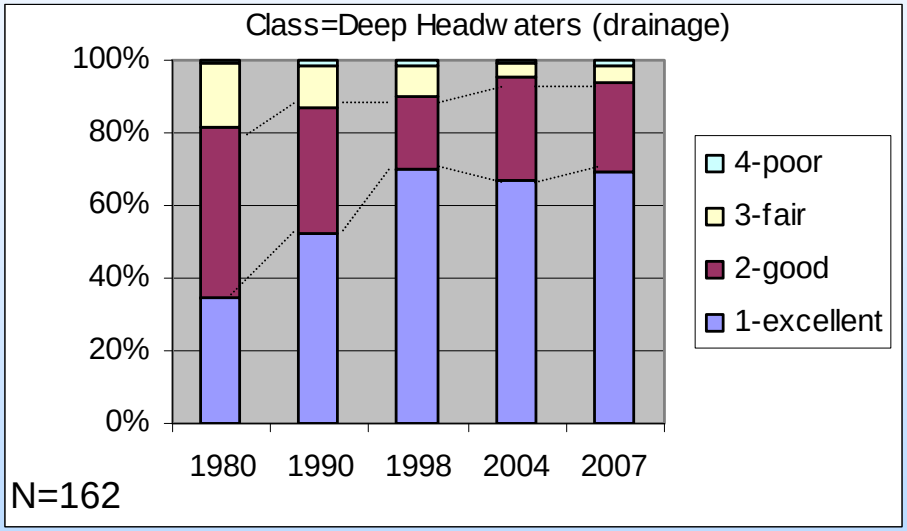
Seepage Shallow

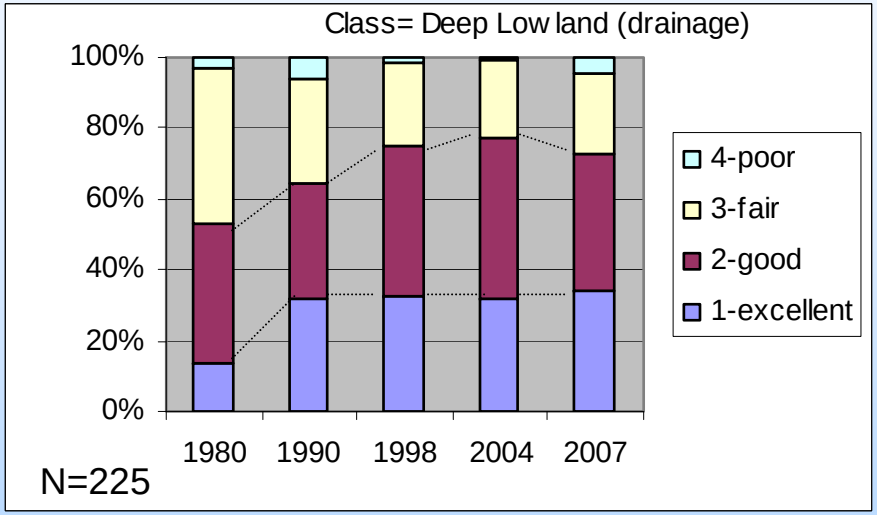


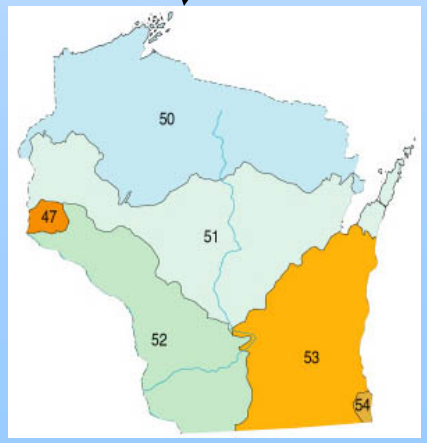
Seepage Deep



Example of Lake Class comparison (Ecoregion = Northern Lakes and Forests)







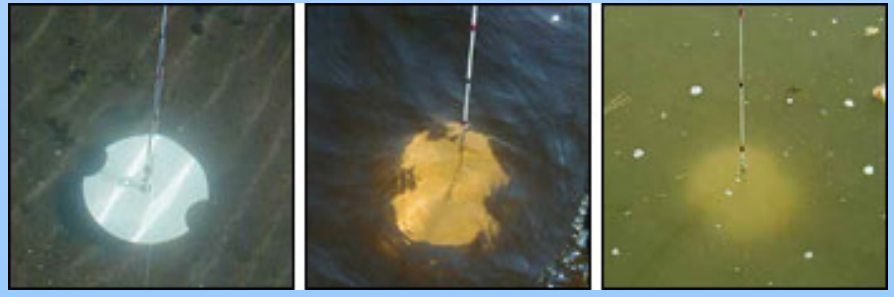
Future Activities

Environmental Drivers

What's influencing changes in lake trophic status (Temperature, Precip, landuse)

Consider New Approaches

Semi-Analytical Algorithms, Radiative Transfer Theory
Different Satellite Sensors
Additional Parameters (Chl-a, DOC, TSS)



Thank you!

GEOSS will yield a broad range of societal benefits, notably:

Reducing loss of life and property from natural and human-induced disasters;
Understanding environmental factors affecting human health and well-being,
Understanding, assessing, predicting, mitigating, and adapting to climate variability and change,
Improving water resource management through better understanding of the water cycle,
Improving weather information, forecasting and warning,
Improving the management and protection of terrestrial, coastal and marine ecosystems,
Supporting sustainable agriculture, and understanding, monitoring and conserving biodiversity.

GEO task WA-08-01g
Global Water Quality Monitoring

When complete, GEOSS will provide:

- a distributed system of systems,
- improved coordination,
- links between all observational platforms,
- more effective data exchange,
- gap analysis of our global capacities,
- improved abilities to address policy issues for Societal Benefit Areas (SBA)