Siltcoos Lake, Oregon: a limnological case study

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Portland State UNIVERSITY

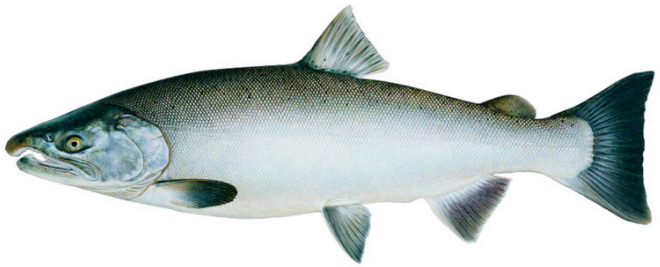
Outline

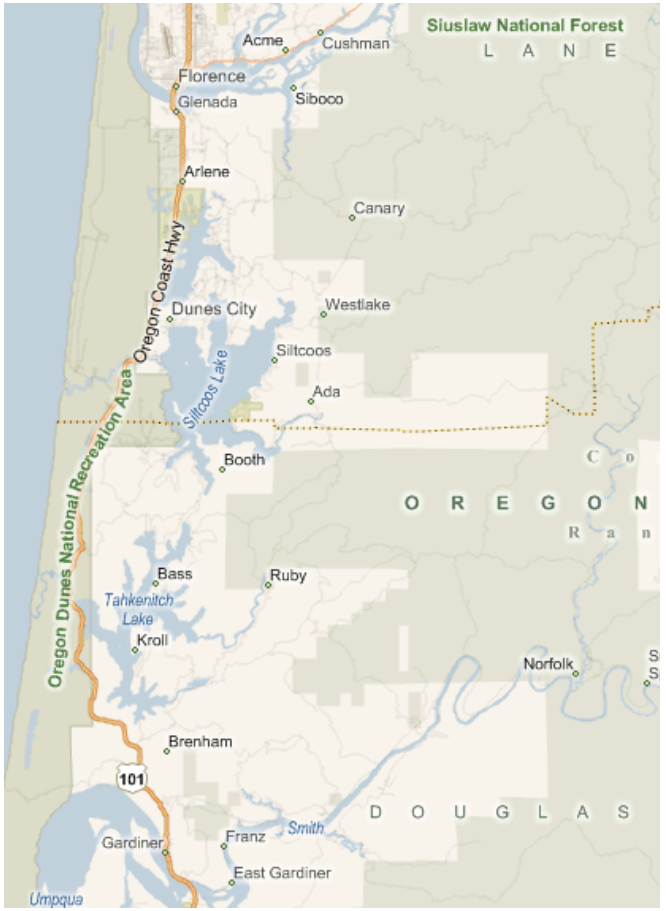
- Siltcoos Lake background
  - Origin and natural conditions
  - Anthropogenic influences
- Water quality problems and management
  - Designated beneficial uses
  - Water quality impairments
- 2008-2009 limnological studies
  - Bathymetry
  - Aquatic macrophytes
  - Water quality/nutrient loading

Origin and natural conditions

- Submersed valley dammed by sand dunes
- ~1300 ha, ? m deep

  Current 6m max depth + wind = no thermal stratification
- Water quality?
- Coho, cutthroat trout

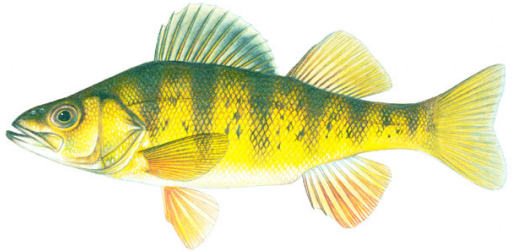




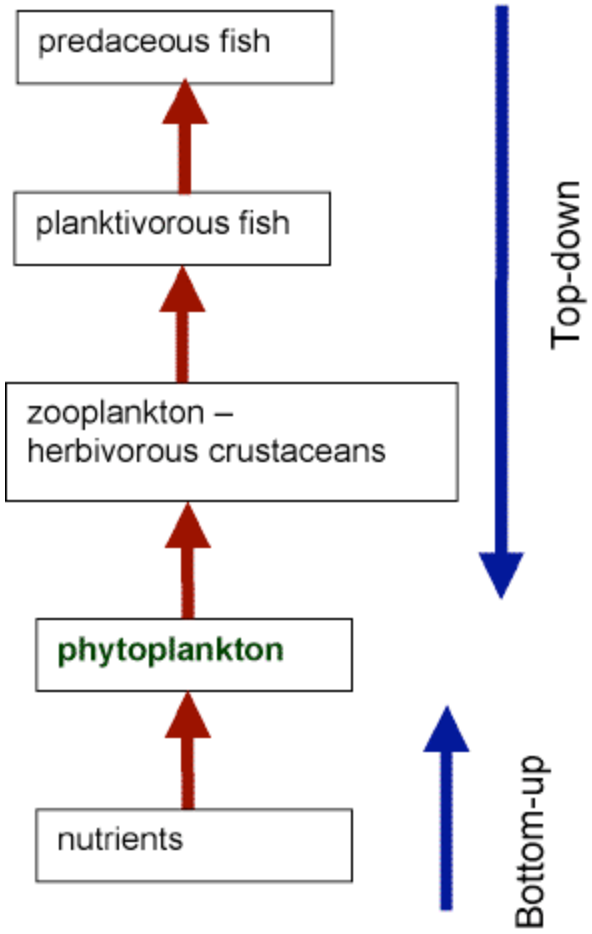
Anthropogenic influences

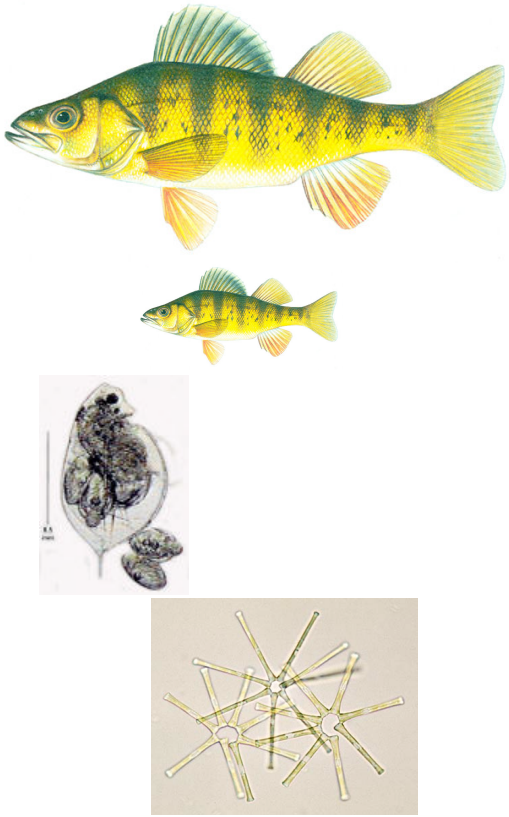
- Water level control
  - I.P. dam (1-2.4 MASL)
- Land use (inc.nutrient loading)
  - Forestry
  - Agriculture (channelization)
  - Residential (septics, etc)
- Introduced flora and fauna
  - Warmwater fish ~1920
  - *Egeria densa* < 1947

Photo: Tenmile Lakes Basin Partnership



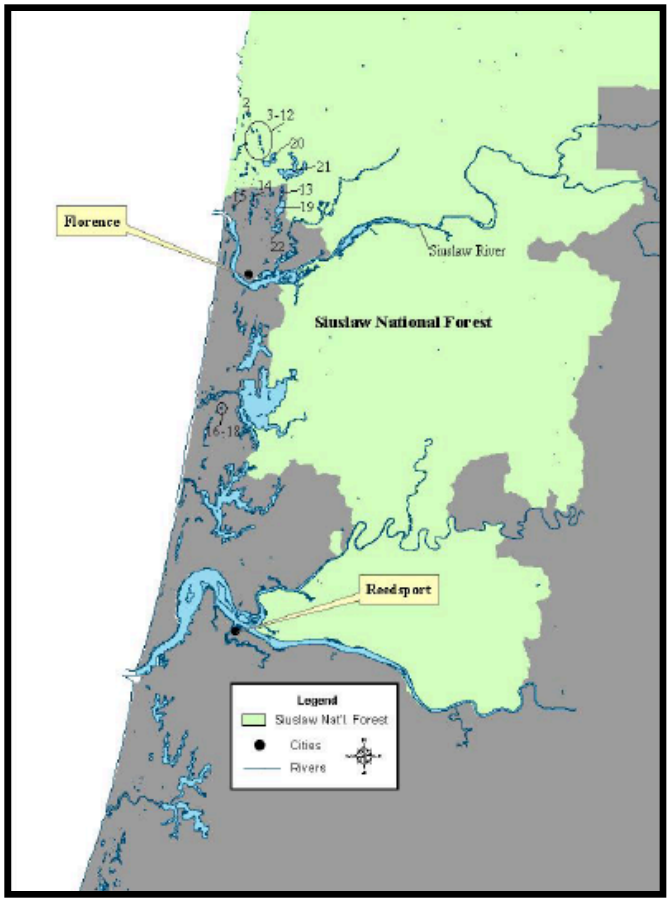
Top down / bottom up?





Nitrogen and phosphorus loading

Boats as vectors for aquatic weeds



Siuslaw NF Lakes	2003	2004
Percent of boat ramp equipped lakes with invasive weeds	100	100
Percent of **non-boat ramp** equipped lakes with invasive weeds	24	27
Mean number of invasive weeds in ramp lakes	2	2
Mean number of invasive weeds in **no-ramp** lakes	<1	<1

Sytsma and Pfauth 2005

Designated beneficial uses from OAR's

- Domestic water supply
- Water contact recreation
- Fishing
- Boating
- Salmon and trout rearing and migration

Beneficial Uses	Estuaries & Adjacent Marine Waters	Fresh Waters
Public Domestic Water Supply[1]		X
Private Domestic Water Supply[1]		X
Industrial Water Supply	X	X
Irrigation		X
Livestock Watering		X
Fish & Aquatic Life[2]	X	X
Wildlife & Hunting	X	X
Fishing	X	X
Boating	X	X
Water Contact Recreation	X	X
Aesthetic Quality	X	X
Hydro Power		X
Commercial Navigation & Transportation	X	
[1] With Adequate pretreatment (filtration & disinfection) and natural quality to meet drinking water standards.		
[2] See also Figures 220A and 220B for fish use designations for this basin.		

Table produced November, 2003

Water quality impairments

- CWA Section 305(b) requires a report from DEQ on the overall condition of Oregon's waters.
- CWA Section 303(d) requires identifying waters that do not meet water quality standards where a Total Maximum Daily Load (TMDL*) needs to be developed.

Watershed **4th Field HUC** **Record ID**	Name **LLID** **River Mile**	Parameter	Season	Criteria	**Beneficial Uses**	**Status**	**Assessment: Year Action**	**[Data Source] Supporting Data**
SILTCOOS 17100207 2773	Siltcoos Lake / Siltcoos Lake 1241131438816 / 1240882438766 0 to 2.3	Aquatic Weeds Or Algae	Undefined	The development of fungi or other growths having a deleterious effect on stream bottoms, fish or other aquatic life, or which are injurious to health,recreation or industry may not be allowed.	Aesthetics Fishing Water contact recreation	303(d)	1998 Added to database	Previous Data: Atlas of Oregon Lakes (PSU, 1985): Extensive growth of Elodea densa, a non-native aquatic plant and a "B" designated weed (ODA), dominates the macrophyte assemblage and interferes with beneficial uses.

More problems

- Frequent potentially toxigenic cyanobacteria blooms
- Health advisory if > 100,000 cells/ml; unless *Microcystis* or *Planktothrix* (>40,000 cells/ml)
- Advisories issued for 54 days during the fall of 2008 and 93 days during the fall/winter of 2009
- 125 Dunes City households draw water directly from the lake

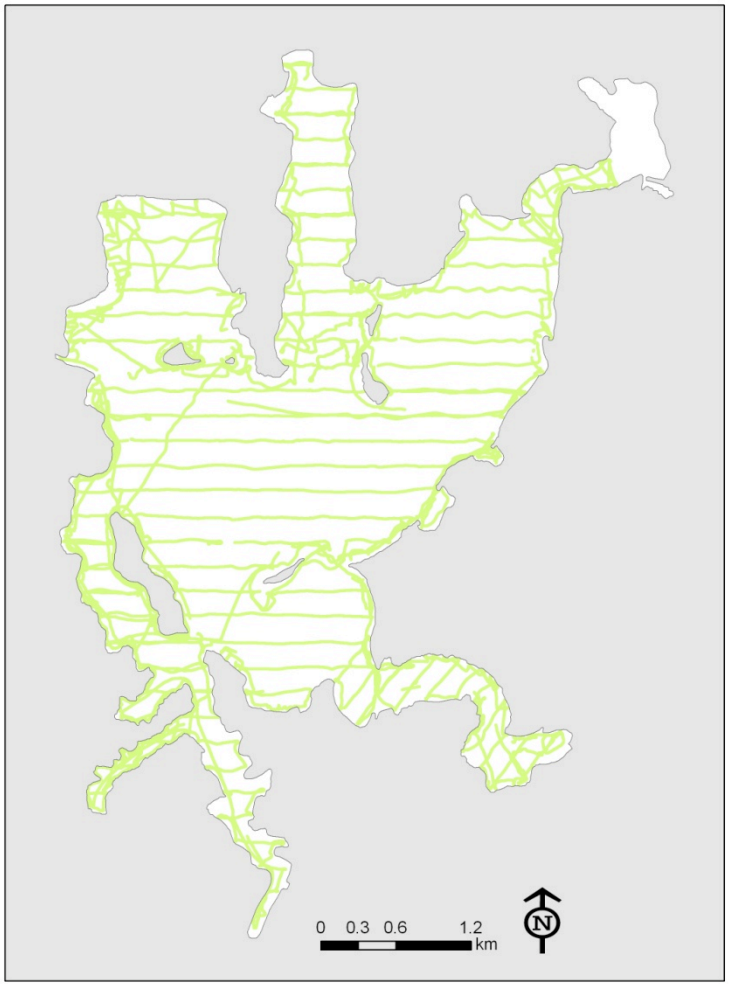
Anabaena sp. bloom. Photo by Stephen Hager

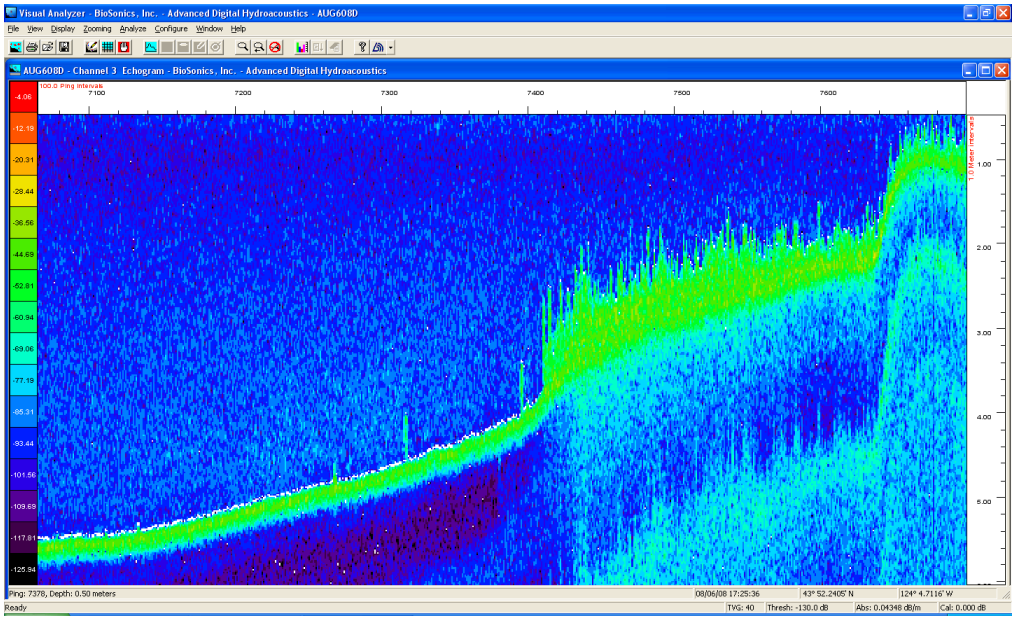
2008-2009 research by CLR

- Funded by DEQ/EPA 319 grant program
- Create bathymetric map
- Determine the coverage, composition, and depth distribution of macrophytes
- Document water quality conditions
- Document nutrient loading from tributaries

Data can be used by DEQ for TMDL purposes

Hydroacoustics

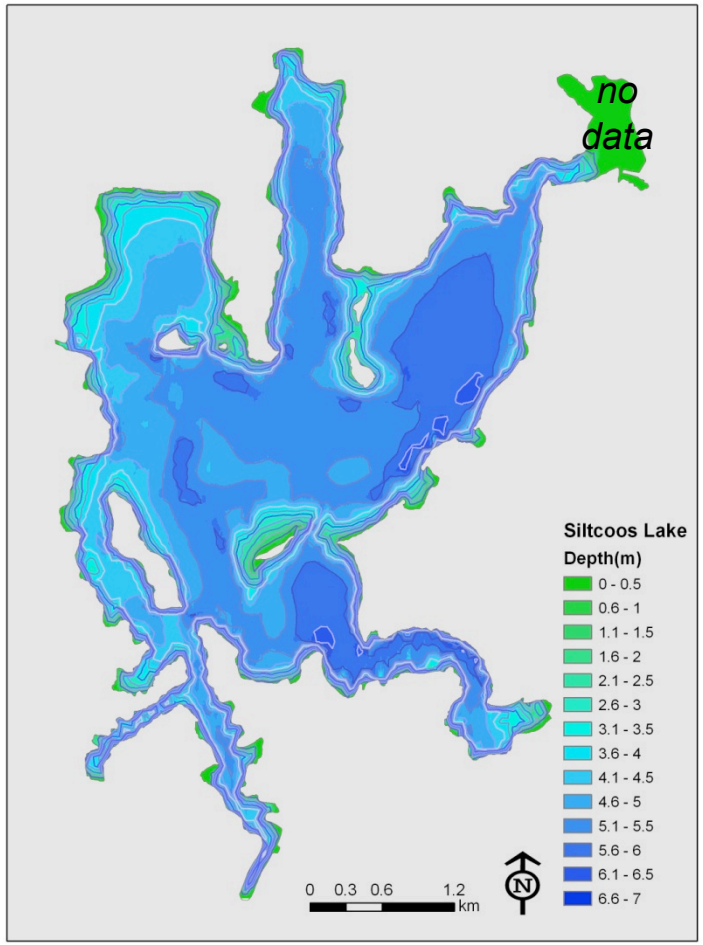




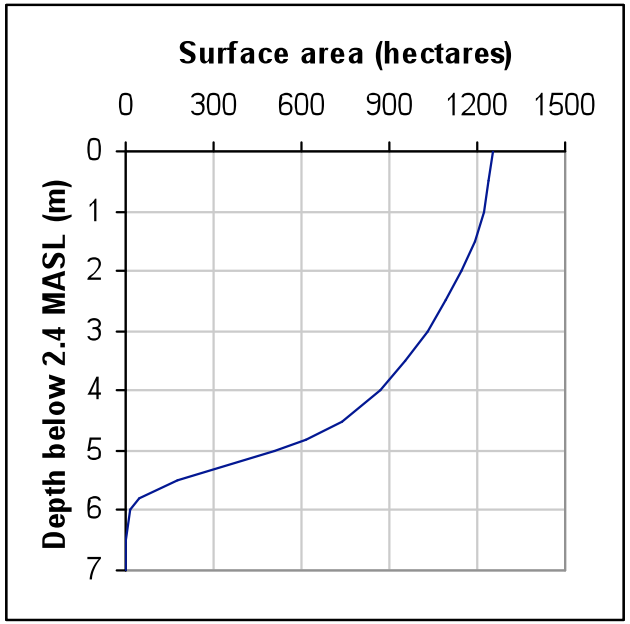
- Transects spaced ~ 200m apart
- 420 kHz transducer and differential GPS
- Data processed to:
  - bottom depth
  - macrophyte canopy height

Bathymetry

Essential data for hydrologic and macrophyte modeling



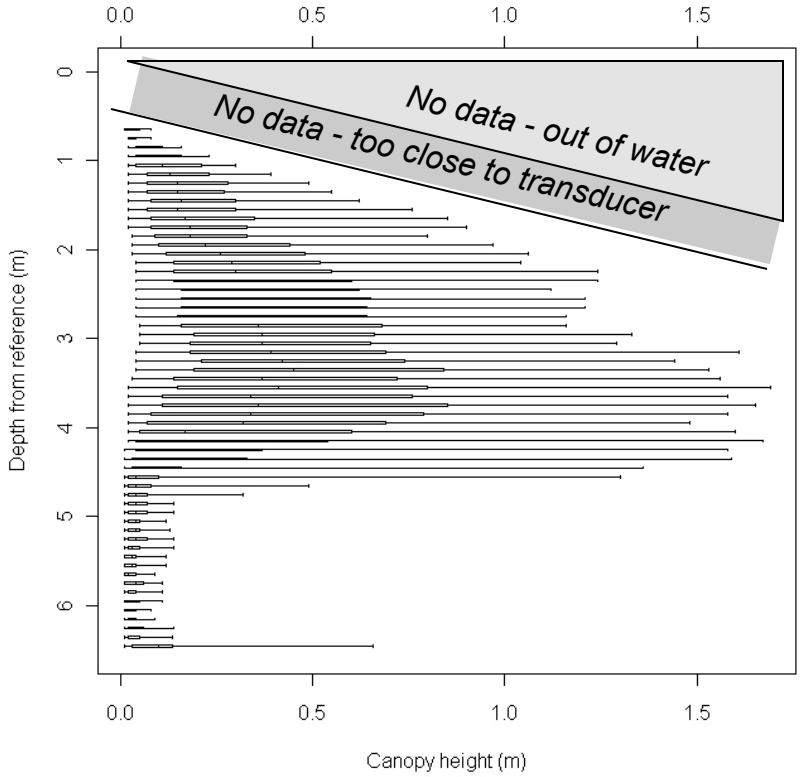
- Interpolated surface from acoustic data
- Maximum depth of 6.5m at WSEL of 2.4m
- Volume = 53.9 cubic hectometers
- Surface area = 1254 hectares

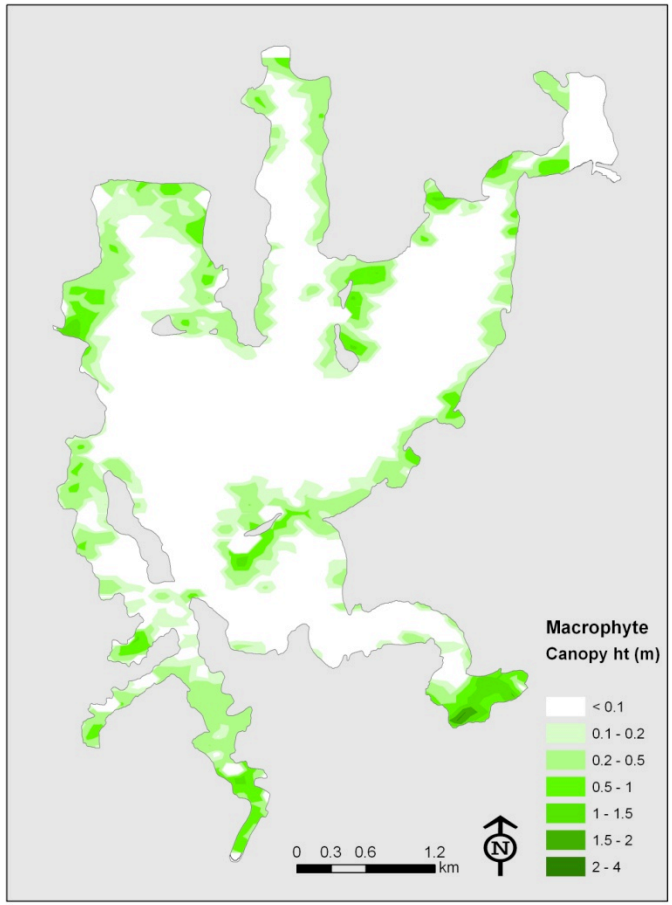


Macrophyte coverage, composition, and distribution

- Methods
  - Hydroacoustic data
  - Grab samples
- Results can be used for
  - Define extent of problem
  - Baseline for long-term monitoring
  - Modeling effects of management scenarios

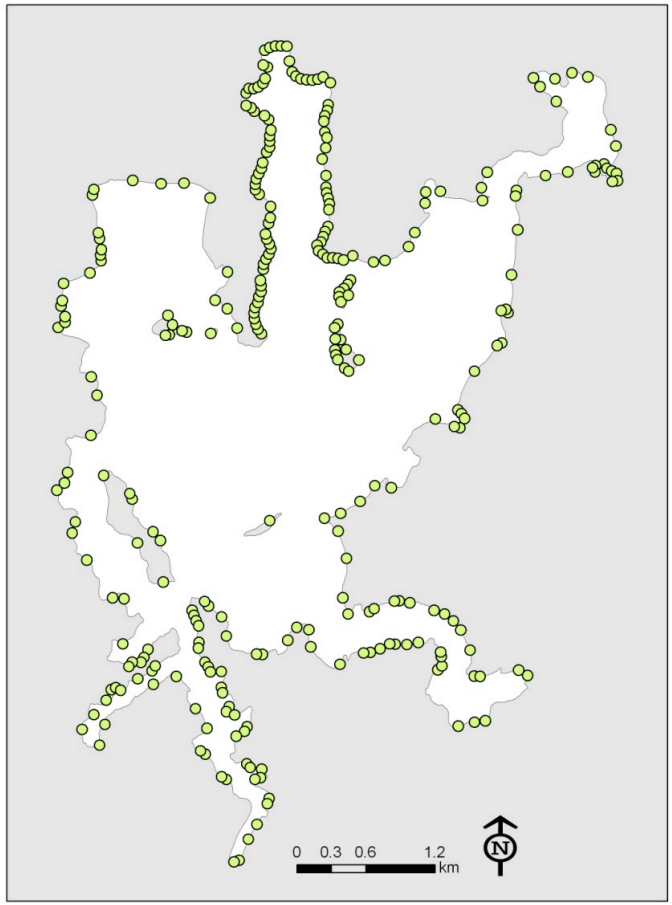
Macrophyte canopy height from acoustic data





Maximum depth of colonization ~ 4.8m

Species composition from grab samples



- 300 random points evenly distributed from 0.5 to 5 m
- Presence/absence and wet weight by species
- Macrophytes present at 80% of sites between 0.5-5m

Macrophyte species (n=26, 4NN)

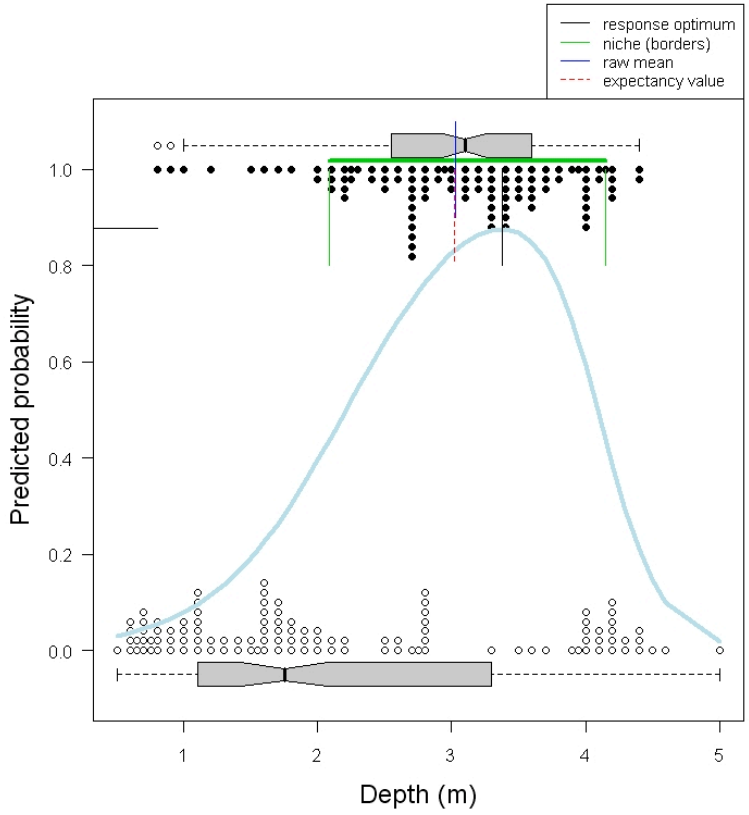
ITIS code	Scientific name	Common names	Native status	Uncertain taxonomy?
18370	*Brasenia schreberi*	water shield	Native	no
32057	*Callitriche hermaphroditica*	autumn water starwort	Native	no
18403	*Ceratophyllum demersum*	coontail, common hornwort	Native	no
38972	*Egeria densa*	Brazilian elodea	Non-native	no
40010	*Eleocharis sp.*	spikerush	Unknown	no
38937	*Elodea canadensis*	common waterweed	Native	no
38081	*Megalodonta beckii*	Beck's watermarigold	Native	no
503904	*Myriophyllum aquaticum*	parrotfeather milfoil	Non-native	no
27044	*Myriophyllum heterophyllum*	Variable leaf water milfoil	Non-native	no
38996	*Najas flexilis*	slender water nymph	Native	no
9467	*Nitella sp.*	brittlewort	Unknown	no
517578	*Nuphar lutea polysepala*	yellow pond lilly, splatterdock	Native	no
39021	*Potamogeton amplifolius*	bigleaf pondweed	Native	no
39019	*Potamogeton foliosus*	leafy pondweed	Native	yes
39008	*Potamogeton natans*	floating leaf pondweed	Native	no
39042	*Potamogeton praelongus*	white stemmed pondweed	Native	no
39017	*Potamogeton pusillus*	small pondweed	Native	yes
504558	*Potamogeton richardsonii*	Richardson's pondweed	Native	no
504559	*Potamogeton robbinsii*	fern-leaf pondweed	Native	no
39005	*Potamogeton sp.*	unknown pondweed	Unknown	no
39055	*Potamogeton zosteriformis*	flatstem pondweed	Native	no
521154	*Scirpus tabernaemontani*	softstem bulrush	Native	yes
40238	*Scirpus subterminalis*	water bulrush	Native	no
757504	*Stuckenia pectinata*	sago pondweed	Native	no
34456	*Utricularia macrorhiza*	*U. vulgaris*, bladderwort	Native	no
38951	*Vallisneria americana*	tape grass, wild celery	Non-native	no

Species distribution factors

- Within a lake
  - Depth/light
  - Sediment quality
  - Competition between species
  - Wave energy

Egeria densa. Photo by Toni Pennington

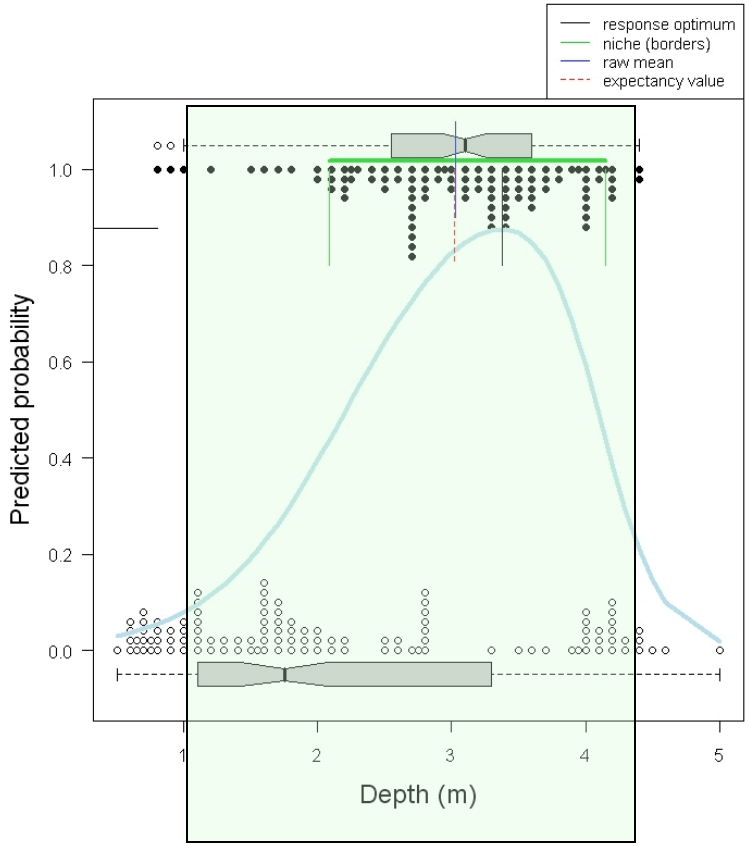
Presence/absence probability model based on depth



$$\mu = \frac{1}{1+\exp(a+bx)} \cdot \frac{1}{1+\exp(c-dx)}$$

- Present w/> 5% prob.
- Absent
- Depth of max. prob.
- Niche (½ max. prob.)

Presence/absence probability model



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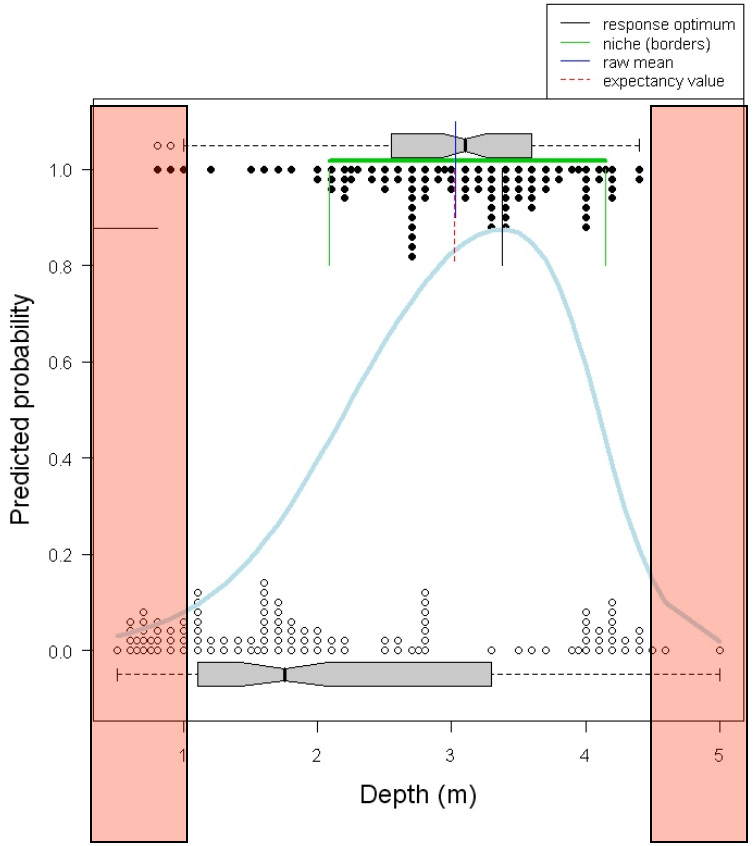

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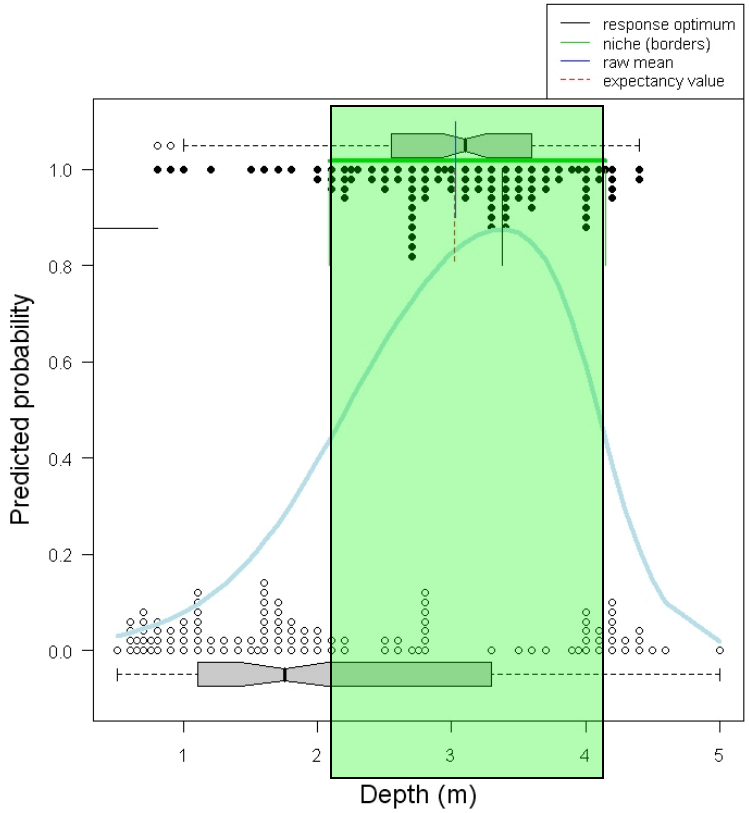

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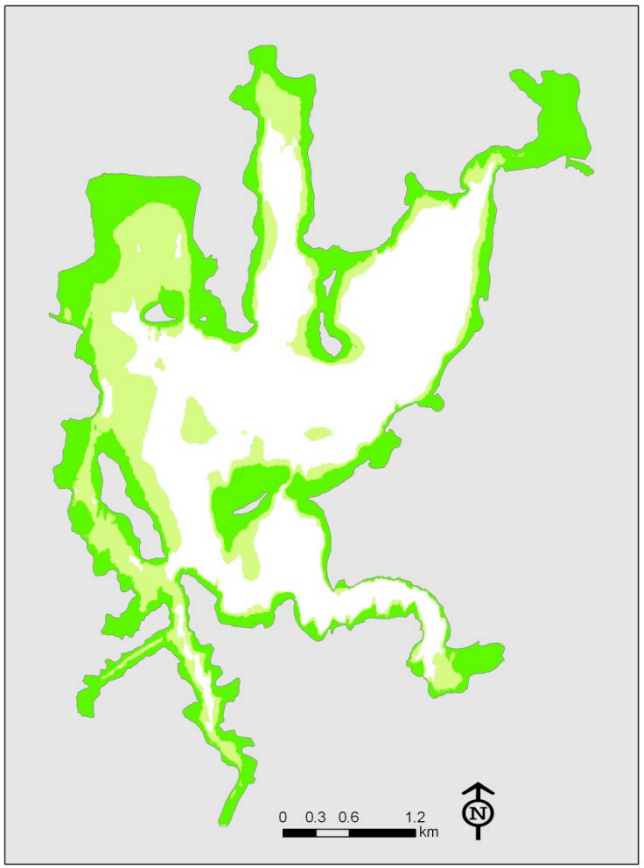
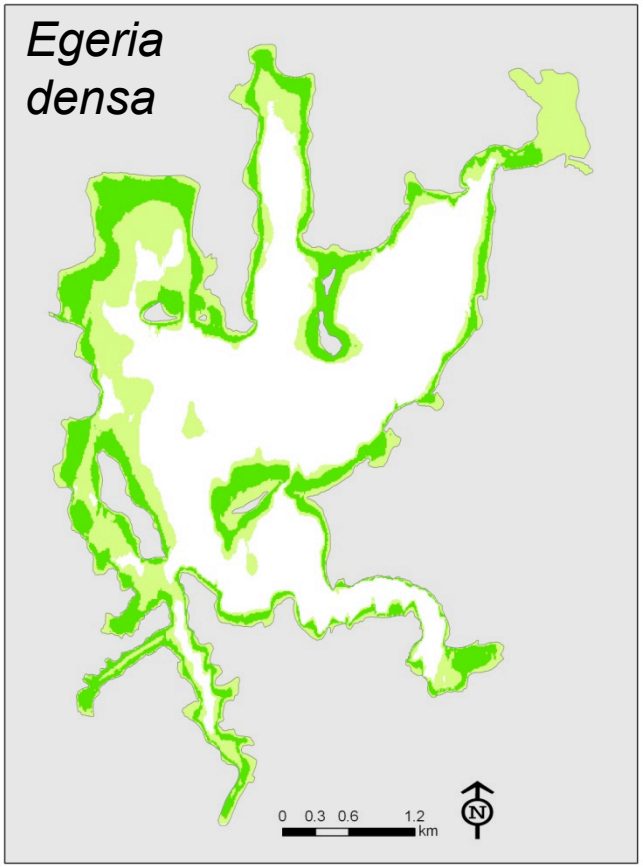
- Present w/> 5% prob.
- Absent
- Depth of max. prob.
- Niche (½ max. prob.)

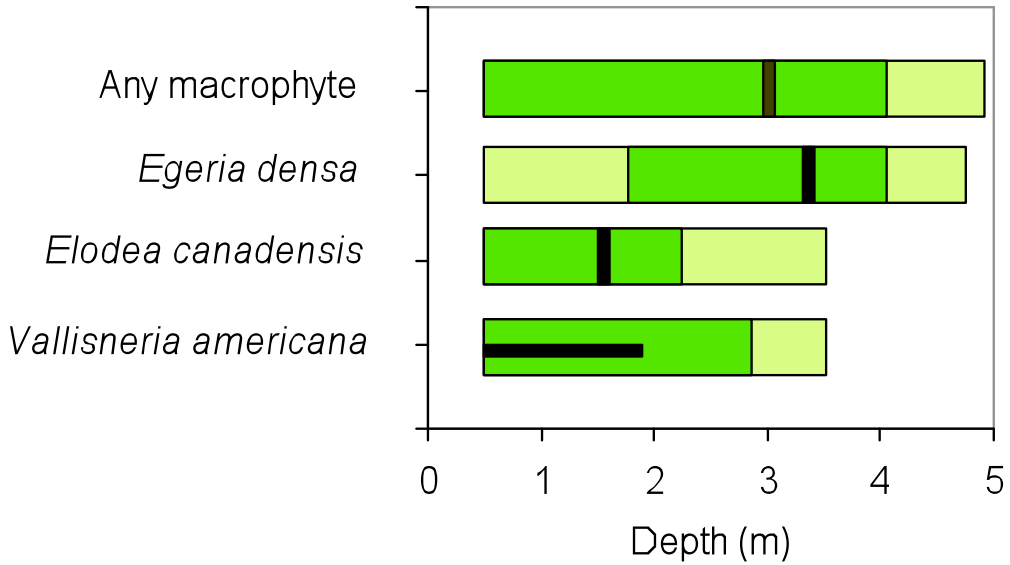
Macrophyte presence/absence model applied to the bathymetic map



- Predicts 51% of the surface area has > 5% probability of macrophyte coverage
- Max. (90%) probability of occurrence at 3.0 m
- >5% probability from 0.5-4.9 m
- <5% probability > 4.9m
- Niche from 0.5-4.1 m

Distribution of individual species



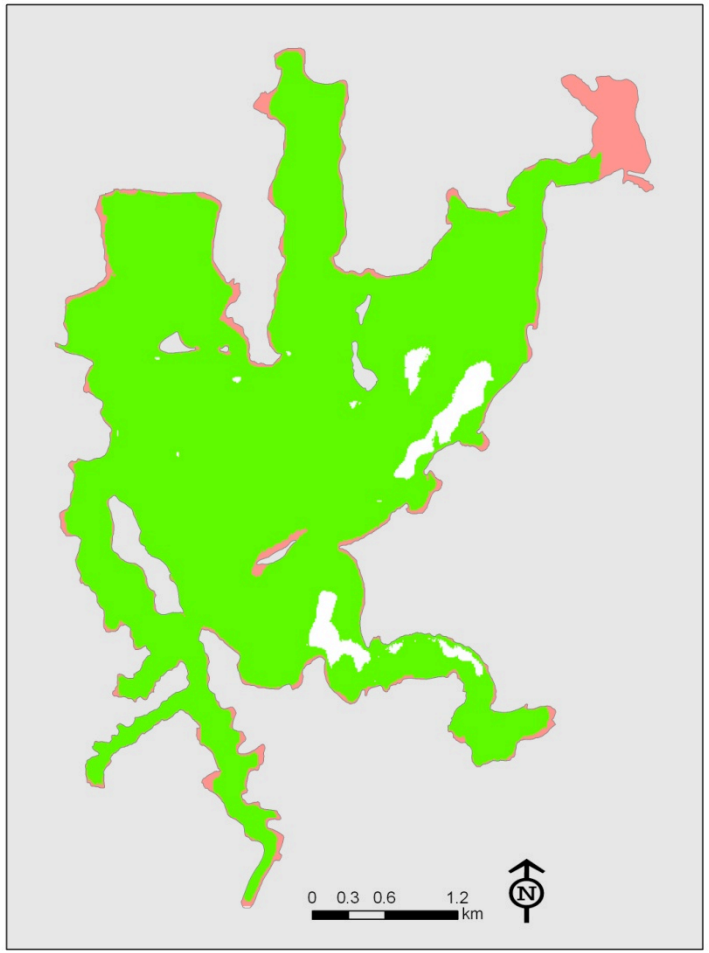


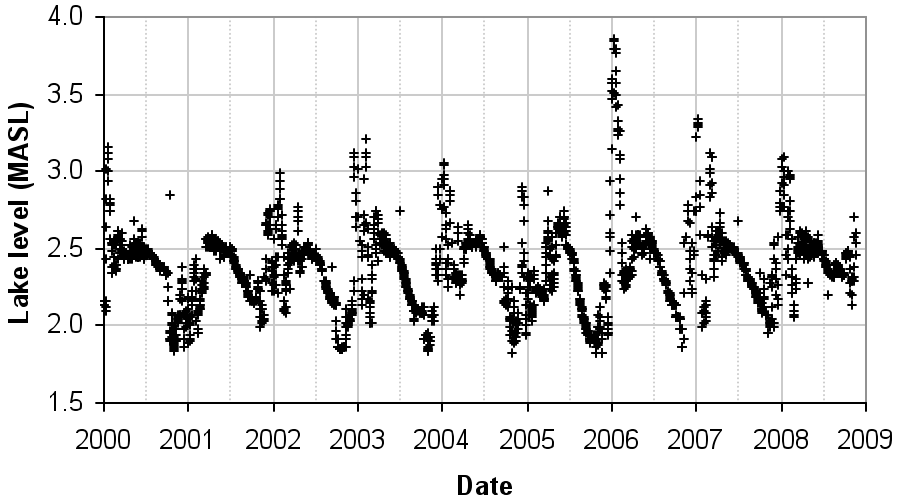
Myriophyllum heterophyllum not present at enough random sites to create a depth distribution model

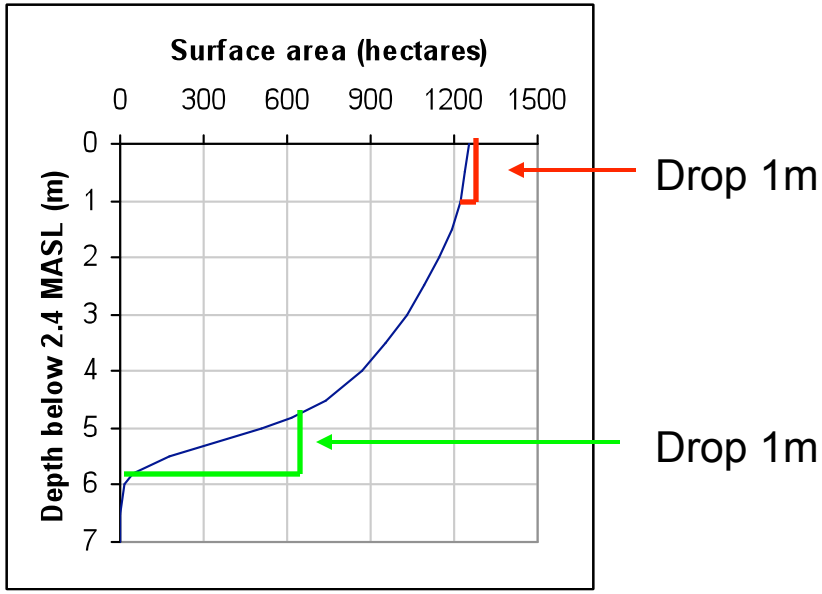
How is this information useful?

- Baseline data is necessary for tracking natural and managed changes
- Simulation of management scenarios

Δ Water level







Aquatic weed management options

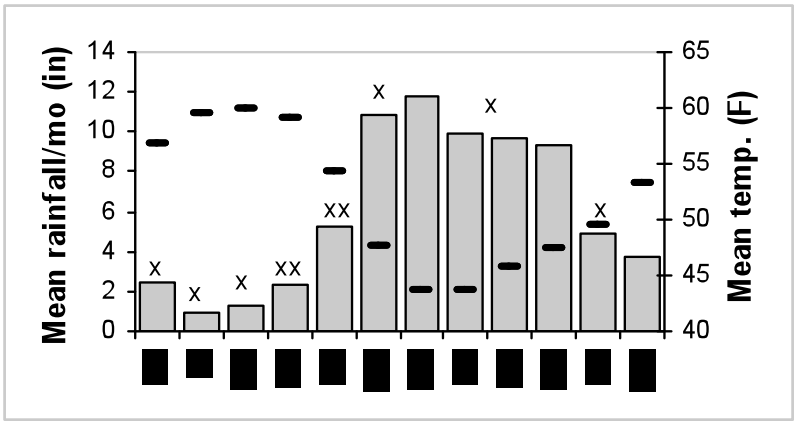
- Herbicides
- Biomanipulation
- Harvest
- Bottom barriers
- Dredging
- Water levels
- Water clarity

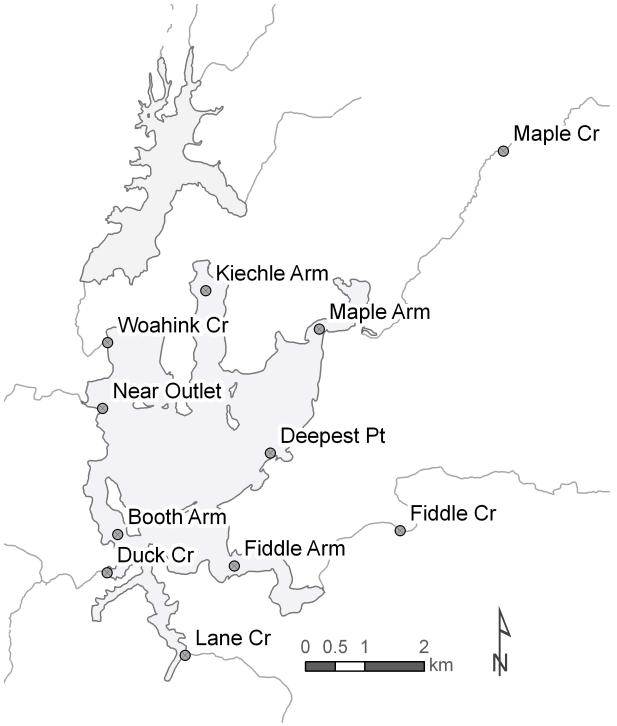
Unintended consequences of macrophyte management

- Less macrophytes leads to more algae?
- Habitat loss for fish and aquatic invertebrates

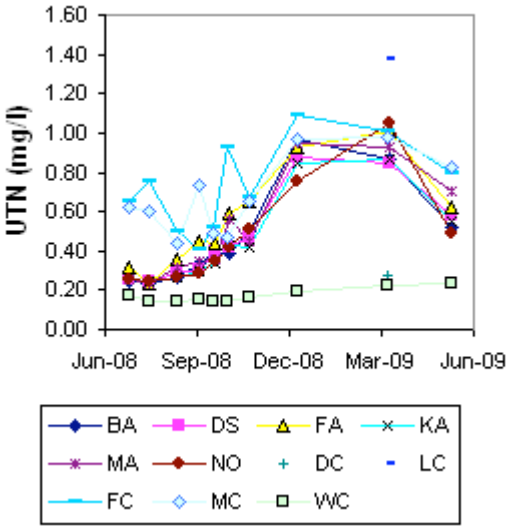
Water quality monitoring

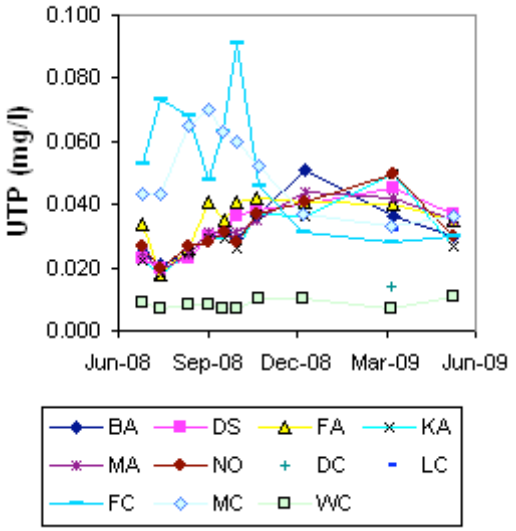
- Six lake, five stream sites
- Ten sampling events
- Nutrients, chlorophyll, phytoplankton, zooplankton, clarity, temperature, oxygen, pH, etc.

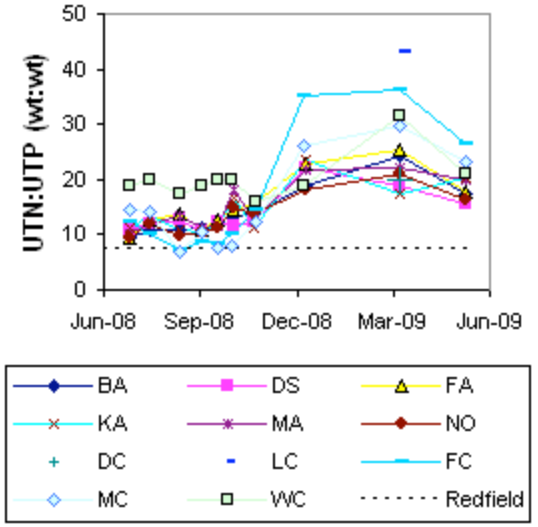




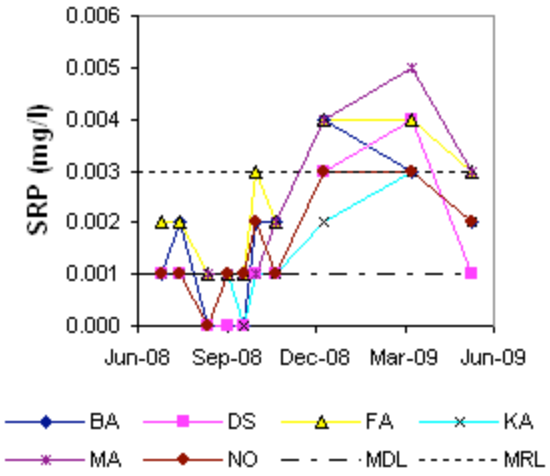
Total phosphorus and nitrogen

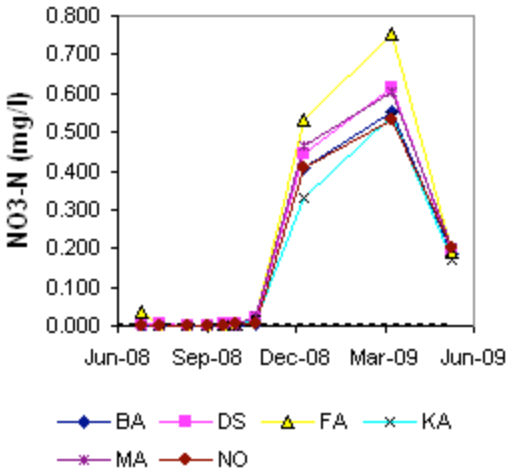


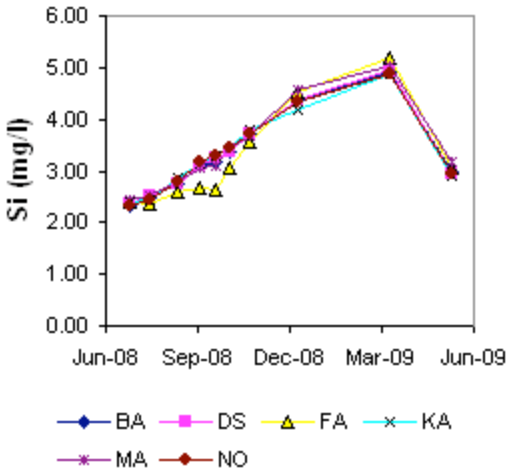




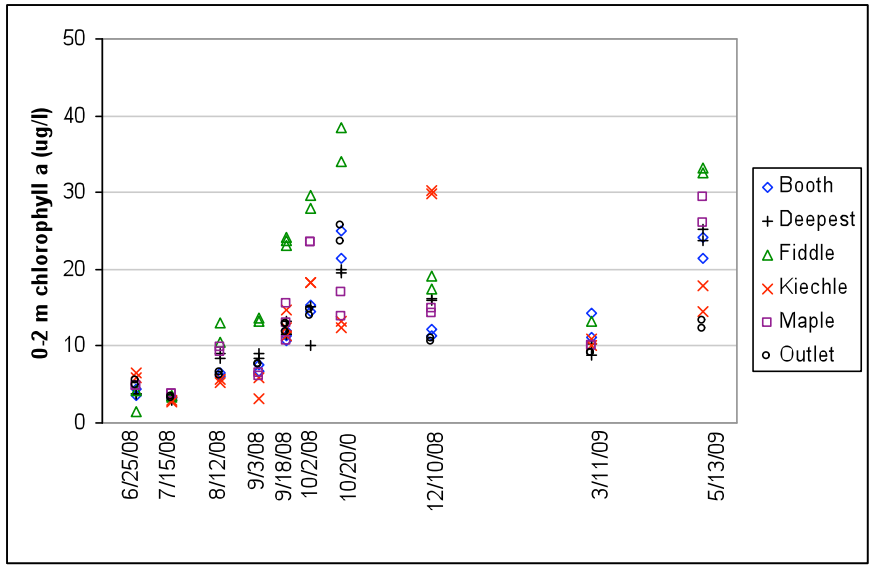
Dissolved nutrients

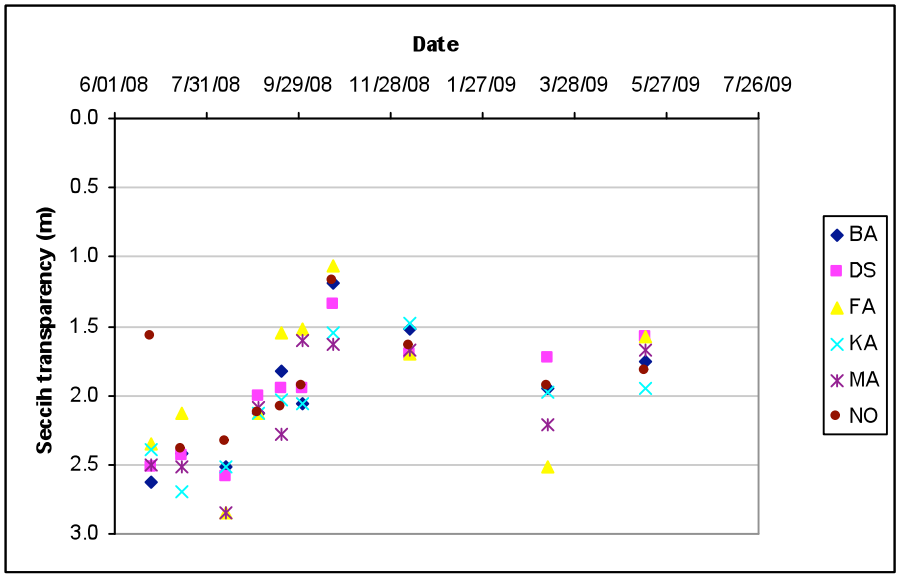






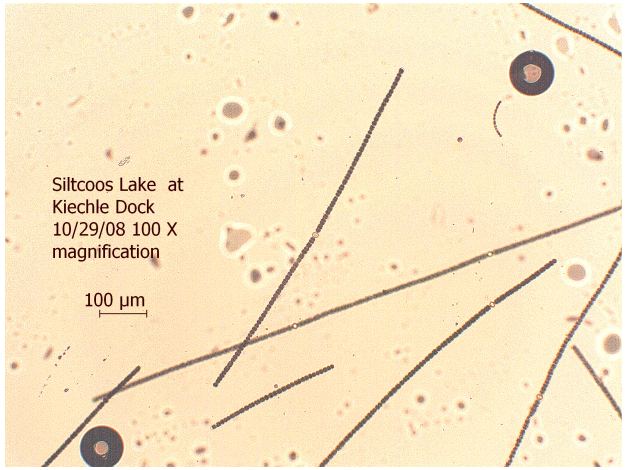
Chlorophyll and Secchi trans.





Phytoplankton and zooplankton

- Cyanobacteria present in every sample and dominant in most samples
  - Several *Anabaena sp.*
  - *Gloeotrichia echi*
  - *Aphanizomenon flos aquae*
- Some nitrogen fixers
- Herbivorous zooplankton (*Daphnia sp*. and copepods)



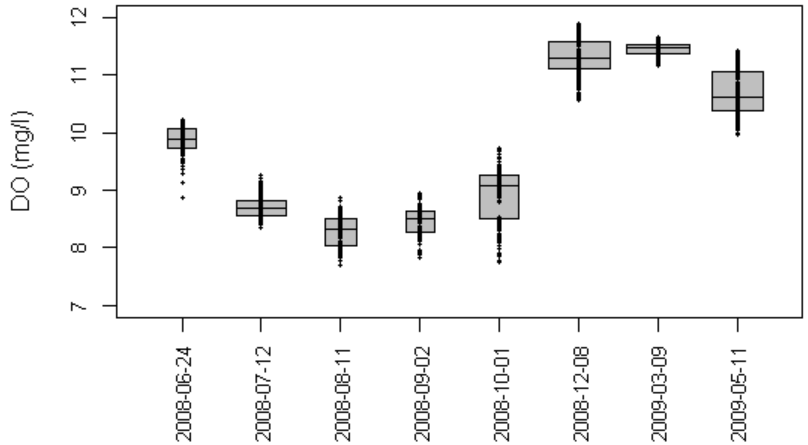
Metabolic balance and diel shifts

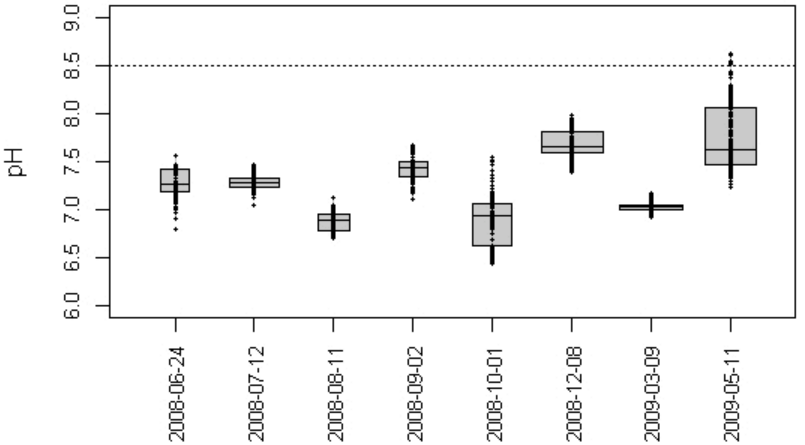
Photosynthesis

$$6CO_2 + 12H_2O + light \rightarrow C_6H_{12}O_6 + 6H_20 + 6O_2$$

Respiration

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_20 + energy$$





Hydrologic model

- GIS based with slope, soil type, and land use as factors
- Driven by daily precipitation and temperature
- "Back of the envelope" (no gaged watersheds for model verification)