Valuing Water Quality in Midwestern Lake Ecosystems

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Iowa Lakes Valuation Project

- Collaborative project involving economists and ecologists studying Iowa lakes
  - Builds off of existing 5 year study of the ecological conditions of 132 lakes in Iowa (2000-2004)
  - Some lake conditions changing rapidly during this period
- Downing's team measures water clarity, chlorophyll, nitrogen and phosphorus, pH, suspended solids, dissolved organic carbon, etc.
- EPA Star grant augments work begun with Iowa DNR funding and CARD support – 4 year project

Project Overview

- A four-year panel data set of survey responses will be collected involving
  - Actual trip behavior and future expected trips, years 2001-2006
  - 2nd through 4th year survey will contain water quality scenarios measuring WTP for quality improvements
  - Knowledge and perceptions regarding lake quality
- Estimate demand for and value of improved water quality in Iowa's lakes

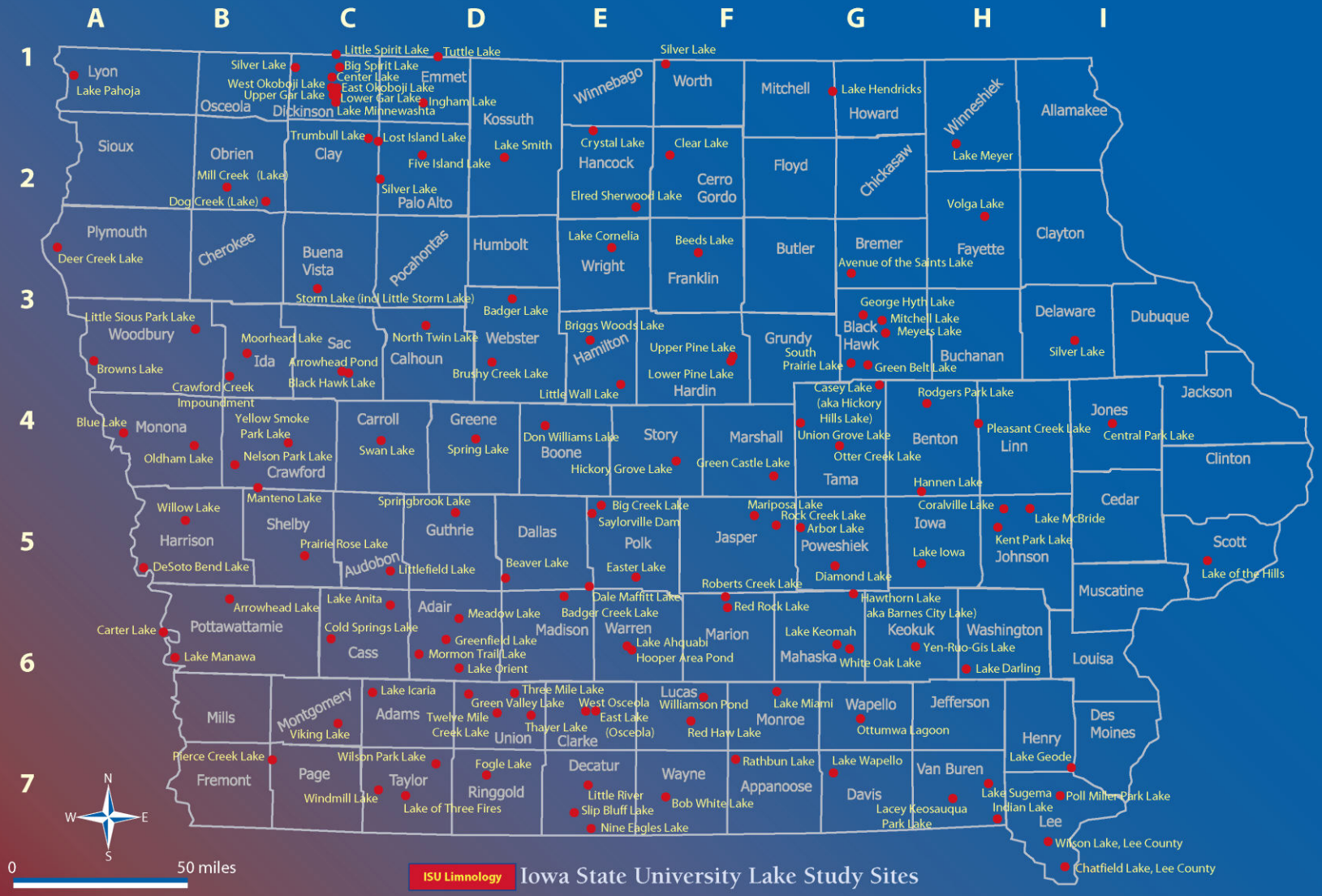
Measuring Benefits of Iowa Lakes

- Maximum Willingness to Pay

  Represents maximum amount an individual will pay for a certain level of water quality improvement, representing the value of goods willing to forgo for more of this "commodity"
- We want to quantify the tradeoffs people are willing to make to get improved water quality and compare these to the tradeoffs required
- Don't observe market transactions to measure value (as with farmland), rather gather non-market data to value public good
  - Revealed Preference data (observed use of the lakes and substitute sites) - estimate demand for lake and infer WTP values
  - Stated Preference data - directly elicit WTP for water quality gains
- Local economic impact does not measure these tradeoffs, useful for other purposes, but not cost-benefit assessments

Baseline Survey

- First of four mail surveys
- 8000 Iowa residents selected at random
- Survey collected
  - trip data for 132 lakes
    - 2001 and 2002 actual trips
    - 2003 anticipated trips
  - attitudes regarding lake quality
  - Socio-demographic data
- 62.1% response rate


A
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Lyon
Lake Pahoja
Silver Lake
Little Spirit Lake
Tuttle Lake
Big Spirit Lake
Center Lake
West Okoboji Lake
East Okoboji Lake
Upper Gar Lake
Lower Gar Lake
Ingham Lake
Lake Minnewashta
Osceola
Dickinson
Emmet
Kossuth
Winnebago
Worth
Silver Lake
Mitchell
Lake Hendricks
Howard
Winneshiek
Lake Meyer
Allamakee
Sioux
Obrien
Mill Creek (Lake)
Dog Creek (Lake)
Trumbull Lake
Lost Island Lake
Five Island Lake
Silver Lake
Palo Alto
Clay
Lake Smith
Crystal Lake
Hancock
Elred Sherwood Lake
Clear Lake
Cerro Gordo
Floyd
Chickasaw
Volga Lake
Fayette
Clayton
Plymouth
Deer Creek Lake
Cherokee
Buena Vista
Storm Lake (incl Little Storm Lake)
Pocahontas
Humbolt
Lake Cornelia
Wright
Beeds Lake
Franklin
Butler
Bremer
Avenue of the Saints Lake
Little Sioux Park Lake
Woodbury
Browns Lake
Crawford Creek Impoundment
Moorhead Lake
Ida
Sac
Arrowhead Pond
Black Hawk Lake
Calhoun
Badger Lake
North Twin Lake
Webster
Brushy Creek Lake
Briggs Woods Lake
Hamilton
Little Wall Lake
Upper Pine Lake
Lower Pine Lake
Hardin
Grundy
South Prairie Lake
George Hyth Lake
Mitchell Lake
Meyers Lake
Black Hawk
Green Belt Lake
Buchanan
Delaware
Silver Lake
Dubuque
Blue Lake
Monona
Oldham Lake
Yellow Smoke Park Lake
Nelson Park Lake
Crawford
Carroll
Swan Lake
Greene
Spring Lake
Don Williams Lake
Boone
Hickory Grove Lake
Story
Green Castle Lake
Marshall
Casey Lake (aka Hickory Hills Lake)
Union Grove Lake
Otter Creek Lake
Tama
Rodgers Park Lake
Benton
Pleasant Creek Lake
Linn
Jones
Central Park Lake
Jackson
Clinton
Willow Lake
Harrison
DeSoto Bend Lake
Manteno Lake
Shelby
Prairie Rose Lake
Springbrook Lake
Guthrie
Audobon
Littlefield Lake
Dallas
Beaver Lake
Big Creek Lake
Saylorville Dam
Polk
Easter Lake
Mariposa Lake
Rock Creek Lake
Arbor Lake
Jasper
Poweshiek
Diamond Lake
Hannen Lake
Coralville Lake
Iowa
Lake Iowa
Lake McBride
Kent Park Lake
Johnson
Cedar
Scott
Lake of the Hills
Muscatine
Arrowhead Lake
Carter Lake
Pottawattamie
Lake Manawa
Lake Anita
Cold Springs Lake
Cass
Adair
Meadow Lake
Greenfield Lake
Mormon Trail Lake
Lake Orient
Madison
Dale Maffitt Lake
Badger Creek Lake
Warren
Lake Ahquabi
Hooper Area Pond
Marion
Red Rock Lake
Roberts Creek Lake
Lake Keomah
Mahaska
Hawthorn Lake (aka Barnes City Lake)
Keokuk
Yen-Ruo-Gis Lake
White Oak Lake
Washington
Lake Darling
Louisa
Mills
Montgomery
Viking Lake
Lake Icaria
Adams
Twelve Mile Creek Lake
Green Valley Lake
Three Mile Lake
Union
West Osceola
East Lake (Osceola)
Thayer Lake
Clarke
Lucas
Williamson Pond
Red Haw Lake
Monroe
Lake Miami
Wapello
Ottumwa Lagoon
Jefferson
Henry
Lake Geode
Des Moines
Pierce Creek Lake
Fremont
Page
Windmill Lake
Wilson Park Lake
Taylor
Lake of Three Fires
Fogle Lake
Ringgold
Decatur
Little River
Slip Bluff Lake
Nine Eagles Lake
Wayne
Bob White Lake
Rathbun Lake
Appanoose
Lake Wapello
Davis
Van Buren
Lacey Keosauqua Park Lake
Lake Sugema
Indian Lake
Poll Miller Park Lake
Lee
Wilson Lake, Lee County
Chatfield Lake, Lee County
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50 miles
ISU Limnology
Iowa State University Lake Study Sites

Figure 1: Percentage of respondents who took at least one trip

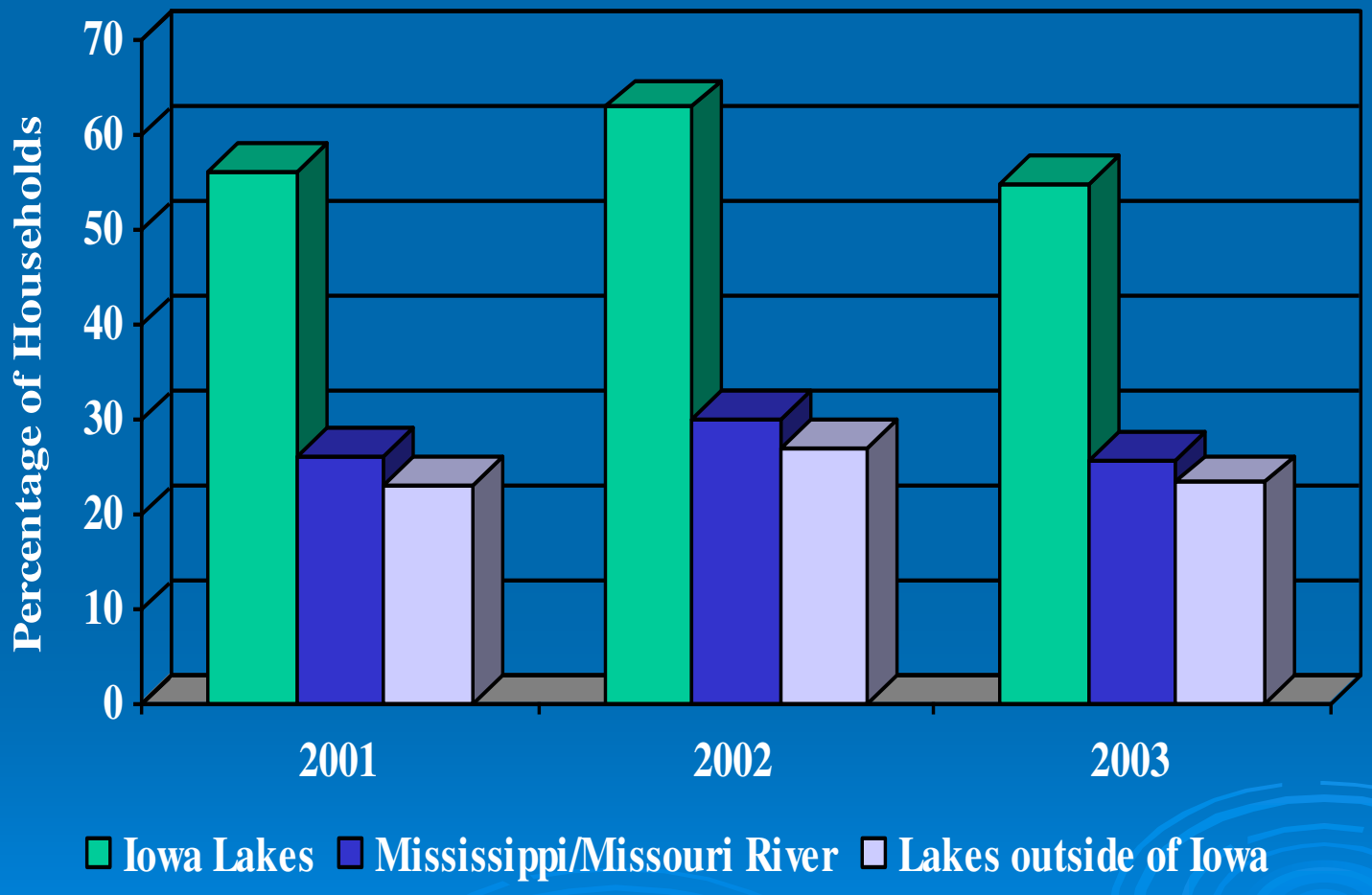


Figure 2: Average number of day trips

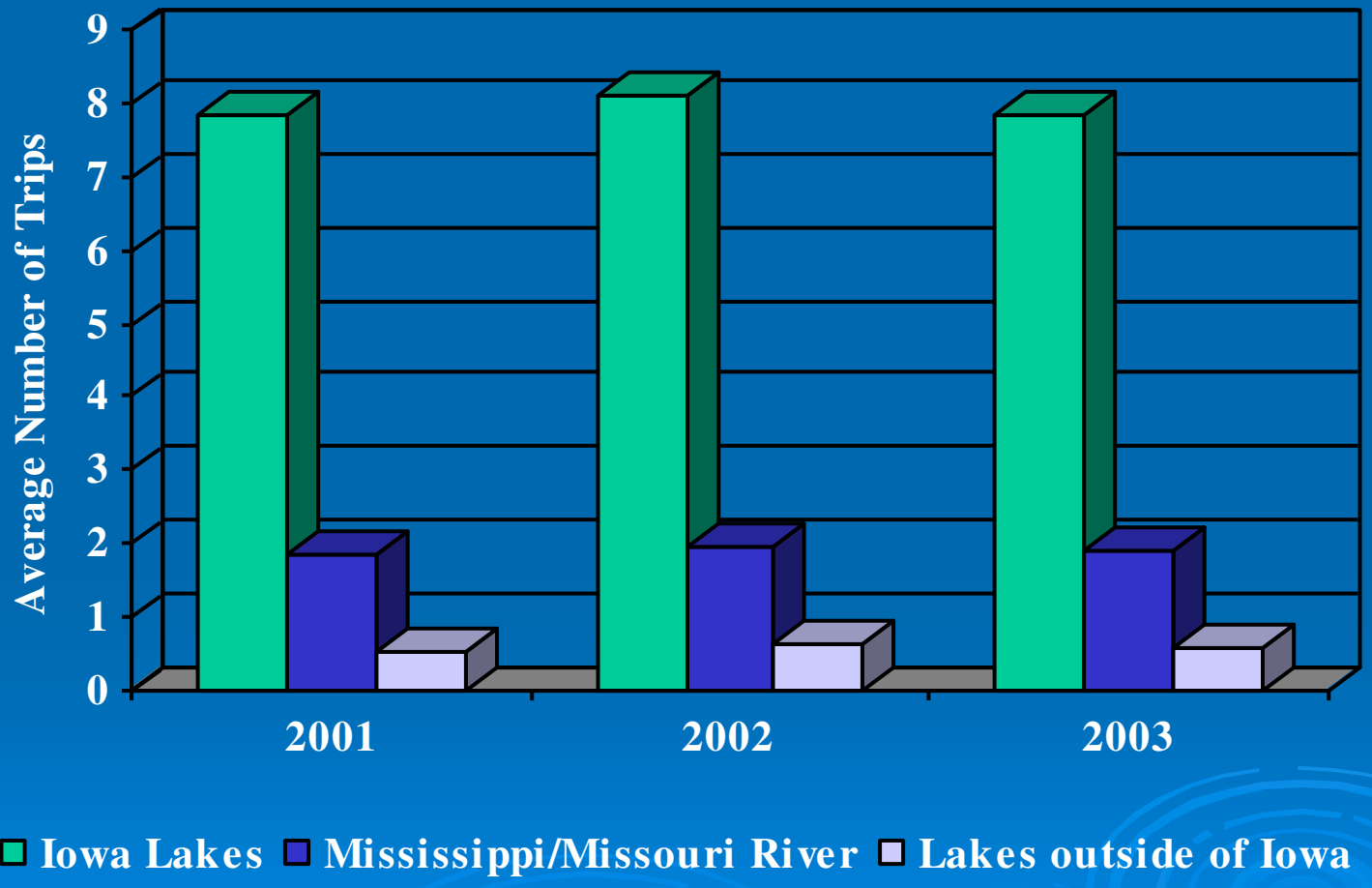


Figure 3: Activities engaged in by respondents

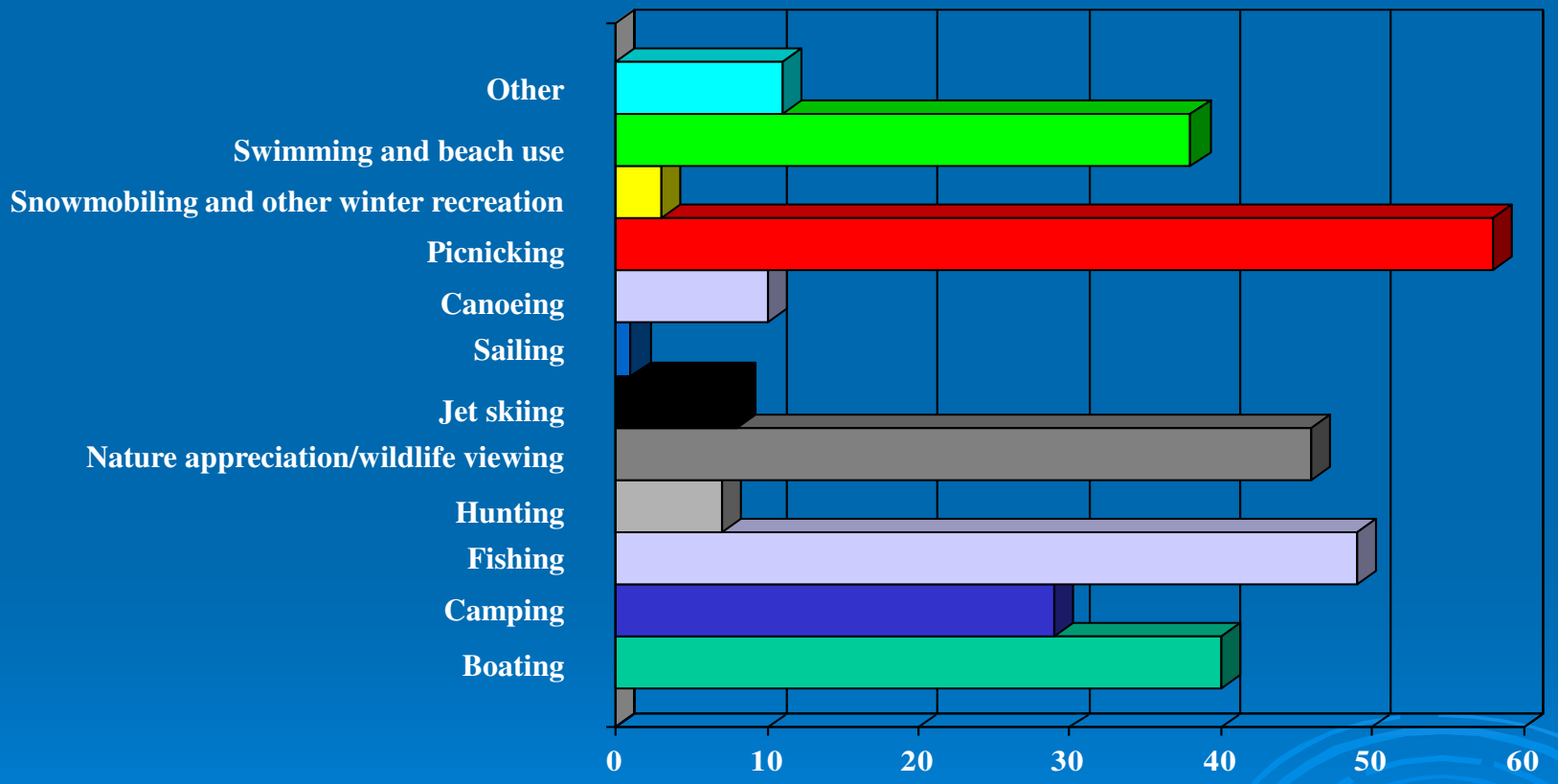


Figure 4: Average allocation of importance points to factors important in choosing a lake for recreation

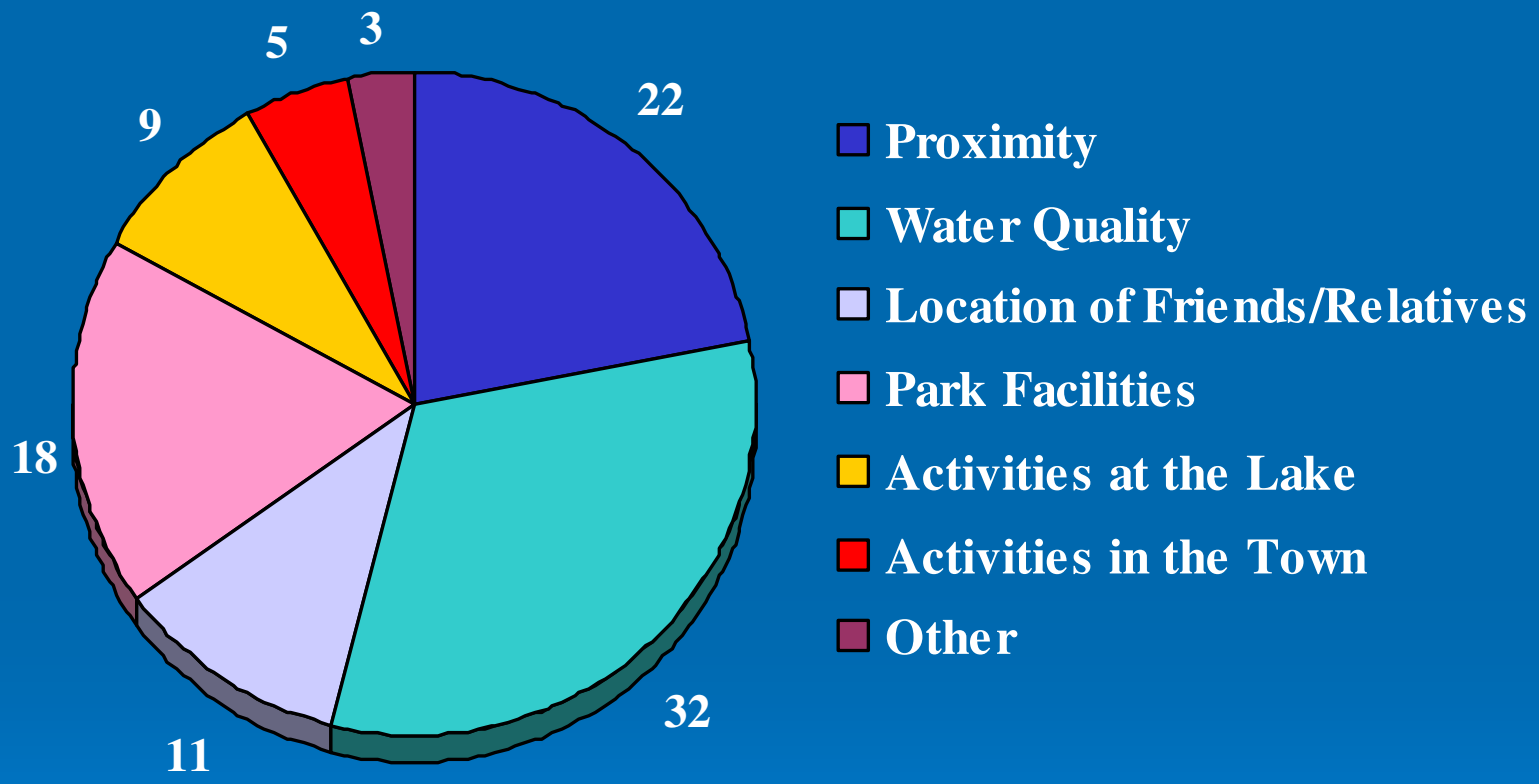
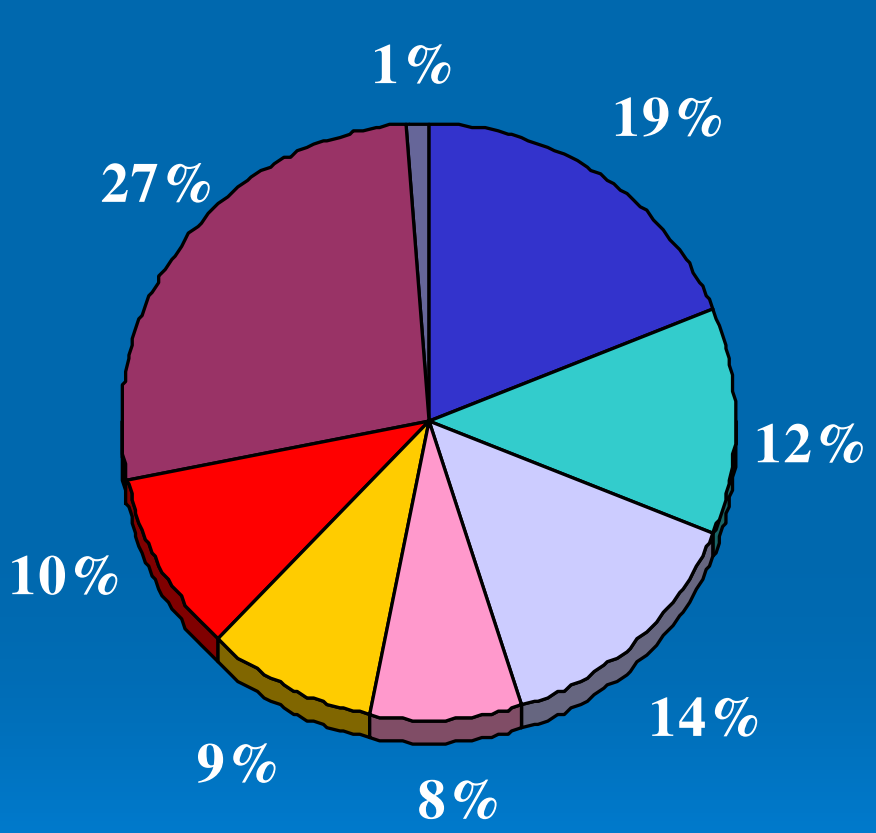


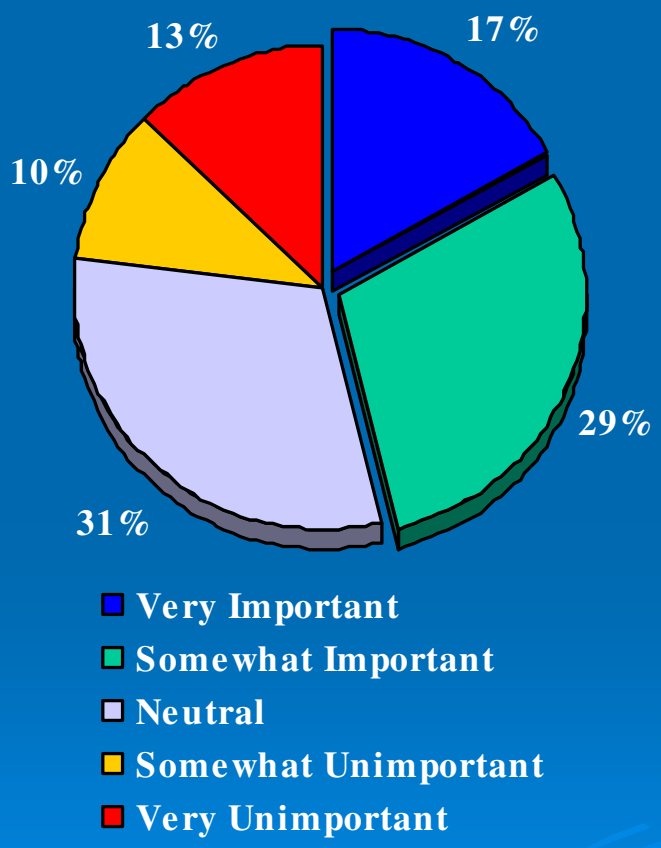
Figure 5: Average allocation of importance points to lake characteristics



- Water clarity
- Hard, clean, sandy bottom in swimming area
- Lack of water odor
- Diversity of wildlife
- Diversity of fish species/habitat
- Quantity of fish caught
- Safety from Bacteria contamination/health advisories
- Other

Figure 6: How important is the presence of the lake nearest your permanent residence to the economic vitality of your community?

Current Conditions



If Significantly Improved

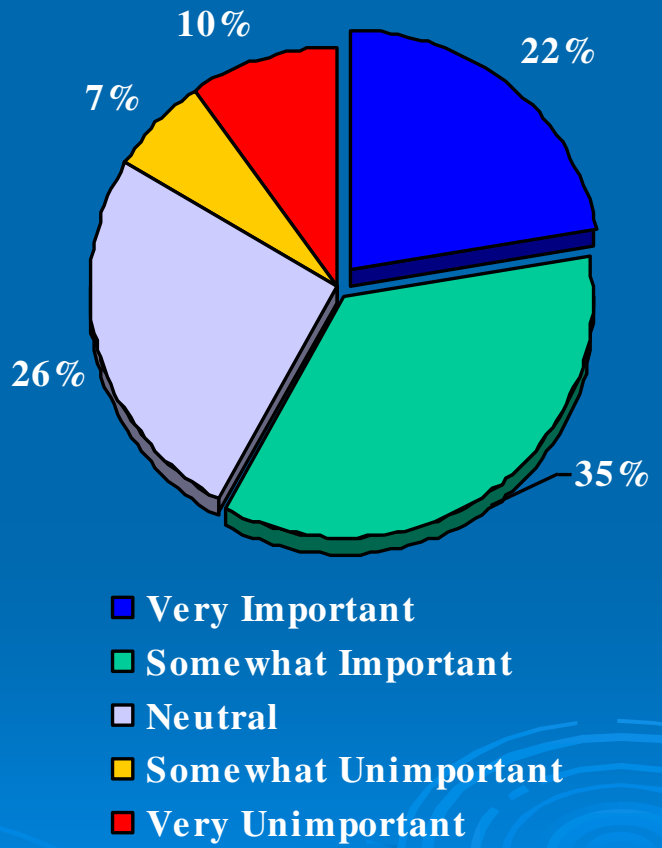


Figure 8: How important is the presence of the lake nearest your permanent residence to retaining the interest of young people to remain in your community or in attracting prospective residents to your area?

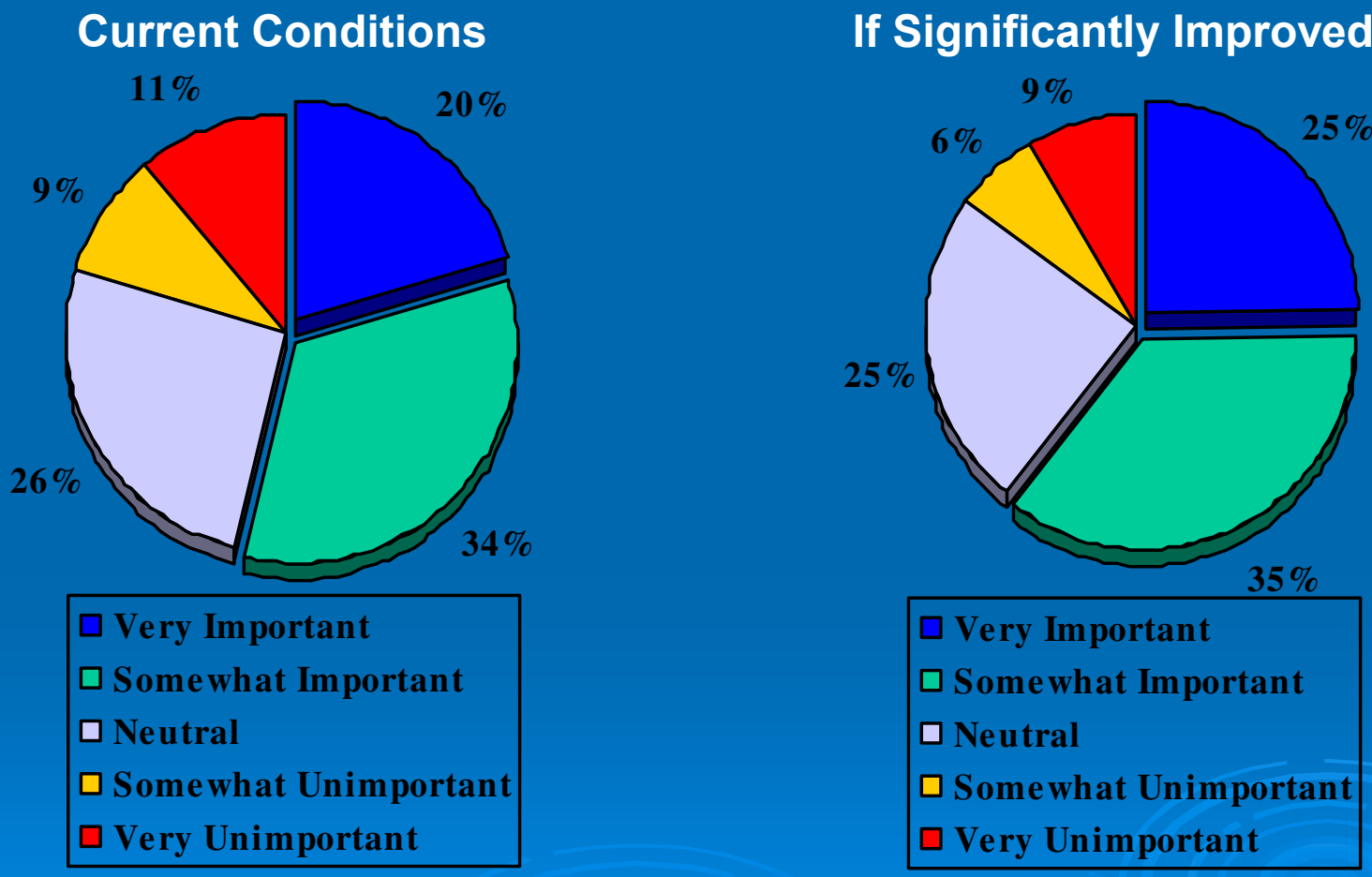
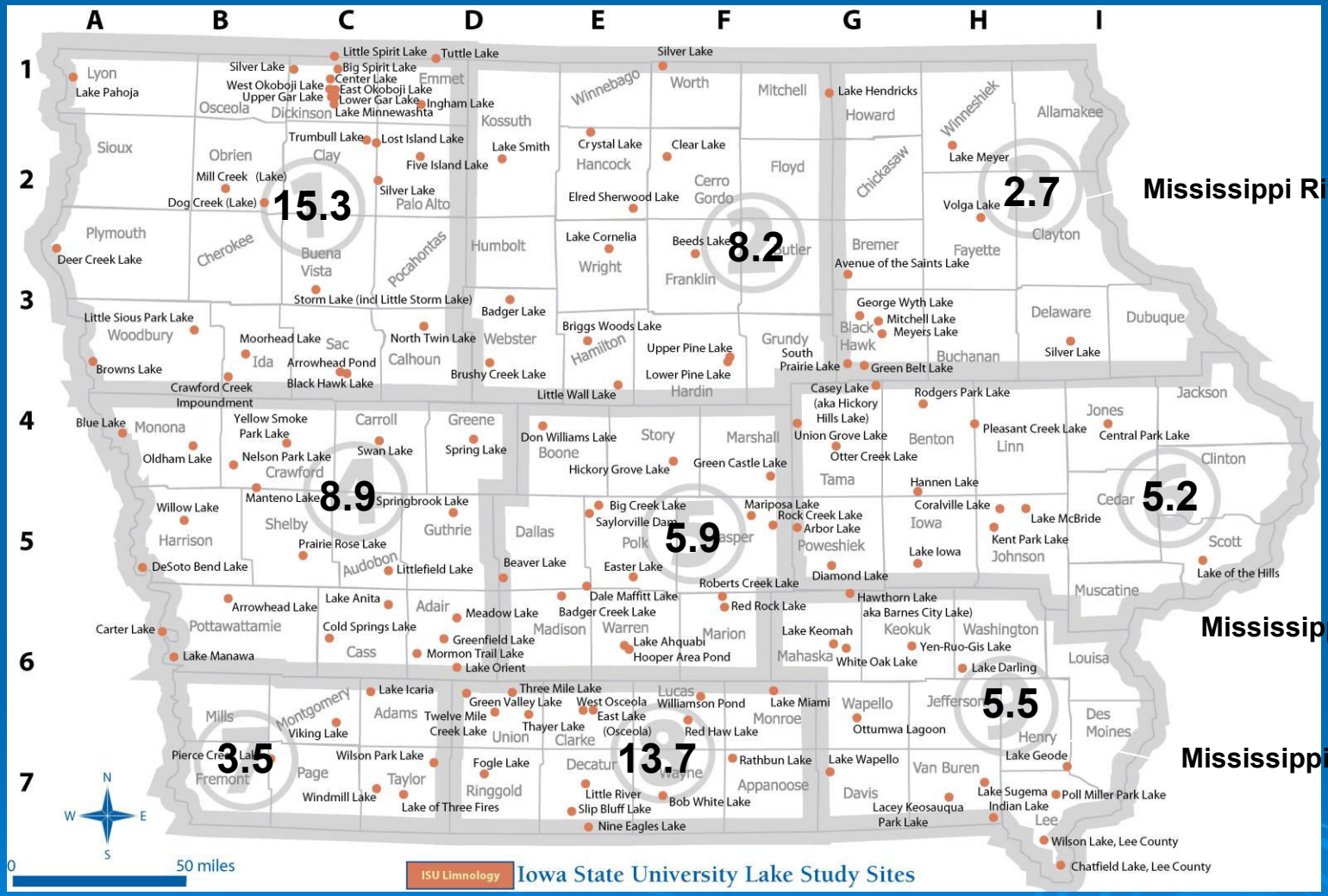


Figure 10: Lake zones



Relationship between Recreation Trips and Physical Water Quality Measures: 2002 Data

Zone 3 Lakes	Average Trips within Zone 3	Secchi Depth (m)	Chlorophyll (ug/l)	Total Phosphorous (ug/l)	Total Suspended Solids (mg/l)
George Wyth Lake	1.28	1.1	17	50	7.2
Silver Lake	0.02	0.2	177	246	27.9

Summary Statistics

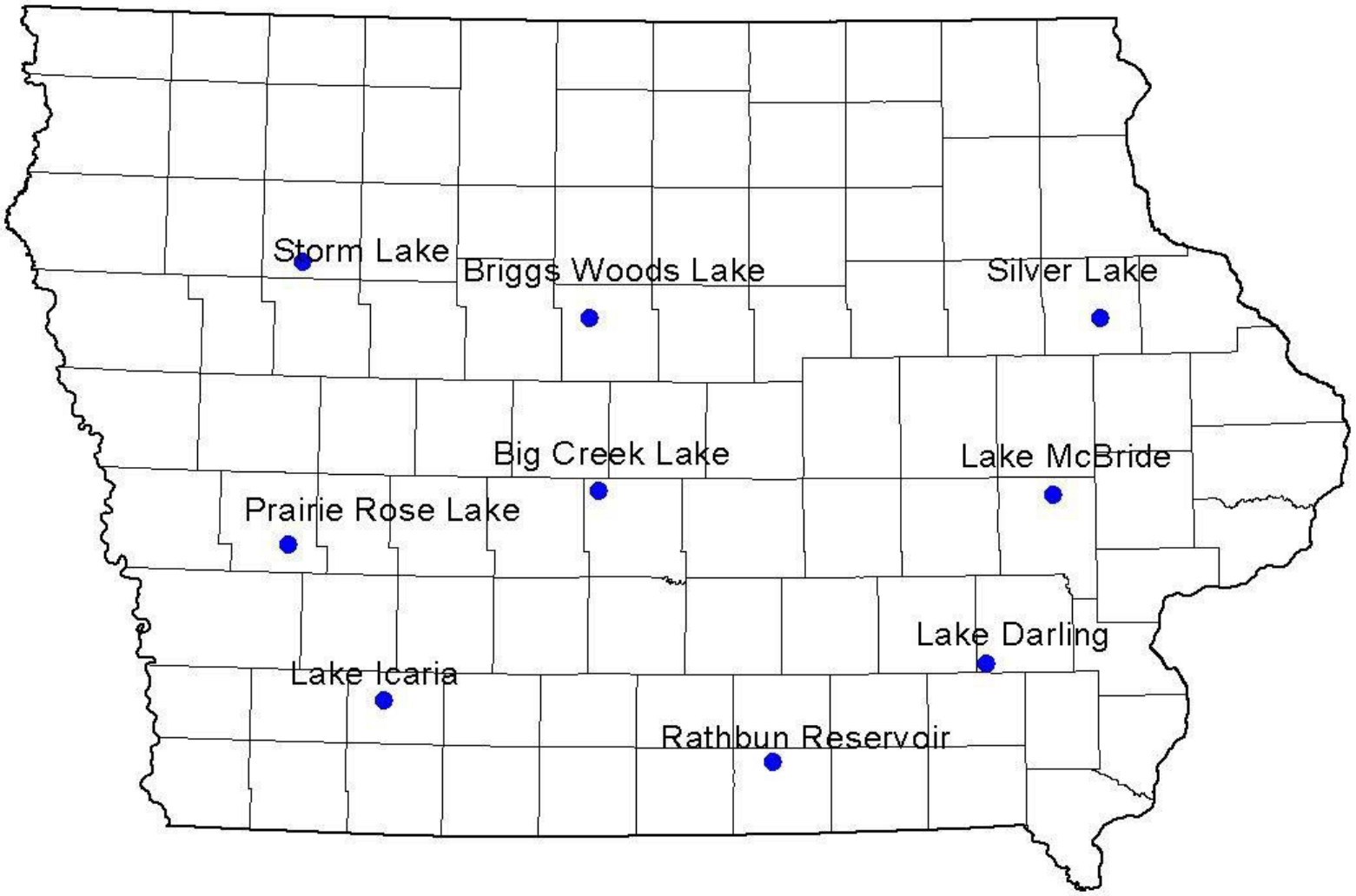
Table 3. Physical Water Quality Summary Statistics				
Variable	Mean	Std. Dev.	Minimum	Maximum
Secchi Depth (m)	1.17	0.92	0.09	5.67
Chlorophyll (ug/l)	40.93	38.02	2.45	182.92
NH_3+NH_4 (ug/l)	292.15	158.57	72	955.34
NO_3+NO_2 (mg/l)	1.20	2.54	0.07	14.13
Total Nitrogen (mg/l)	2.20	2.52	0.55	13.37
Total Phosphorus (ug/l)	105.65	80.61	17.10	452.55
Silicon (mg/l)	4.56	3.24	0.95	16.31
pH	8.50	0.33	7.76	10.03
Alkalinity (mg/l)	141.80	40.98	73.83	286.17
Inorganic SS (mg/l)	9.43	17.87	0.57	177.60
Volatile SS (mg/l)	9.35	7.93	1.64	49.87

Coefficient Results

Variable	Qualitative Sign
Price (Travel Cost)	-
Log(Acres)	+
Ramp	+
State Park	+
Facilities	+
Wake	+

Variable	Qualitative Sign
Secchi Depth	+
Chlorophyll	+
Total Nitrogen	+
Total Phosphorus	-
Inorganic SS	-
Volatile SS	-

FOCUS LAKES


Storm Lake
Briggs Woods Lake
Silver Lake
Big Creek Lake
Lake McBride
Prairie Rose Lake
Lake Darling
Lake Icaria
Rathbun Reservoir

Comparing Water Quality across Lakes

	West Okoboji Lake	Averages of the other 128 Lakes	Averages of the Nine Focus Lakes	Rathbun Lake	Averages of the 31 Impaired Lakes
Secchi Depth (m)	5.67	1.13	1.23	0.90	0.70
Chlorophyll	2.63	41.29	40.13	6.55	56.76
Total Nitrogen	0.86	2.22	3.64	1.10	2.77
Total Phosphorus	21.28	106.03	91.11	43.87	153.70
Inorganic Suspended Solids	1.00	9.49	9.52	5.42	20.42
Volatile Suspended Solids	1.79	9.43	8.42	3.62	15.49

Silver Lake

Rathbun Lake

West Okoboji Lake

Willingness to Pay Estimates

Annual WTP	All 129 Lakes Improved to West Okboboji	Nine Focus Lakes Improved to West Okboboji	31 Impaired Lakes Improved to Rathbun
Avg WTP per Iowa household	$208.68	$39.71	$4.87
Avg WTP for all Iowans	$240,649,000	$45,788,092	$5,612,219
Predicted Trips per household (9.80 currently)	11.18	10.06	9.83

- 19.0% of WTP value is achieved from improving 7.0% of the lakes
- An average focus lake improved to the physical water quality of West Okoboji Lake is valued about equally to the 31 impaired lakes improved to Lake Rathbun

Conclusions

- Recreator's trip behavior is responsive to physical measures of Water Quality
  - Better water clarity increases recreational trips
  - Nutrients decrease recreational trips
- Allows consumer surplus measures to directly be linked to physical water quality improvements
  - Iowans value more highly a few lakes with superior water quality over all recreational lakes at an adequate level
- Findings allow prioritization for clean-up activities to generate the greatest recreation benefits for a given expenditure
  - Rank which lakes and in what order and most efficient levels of improvement

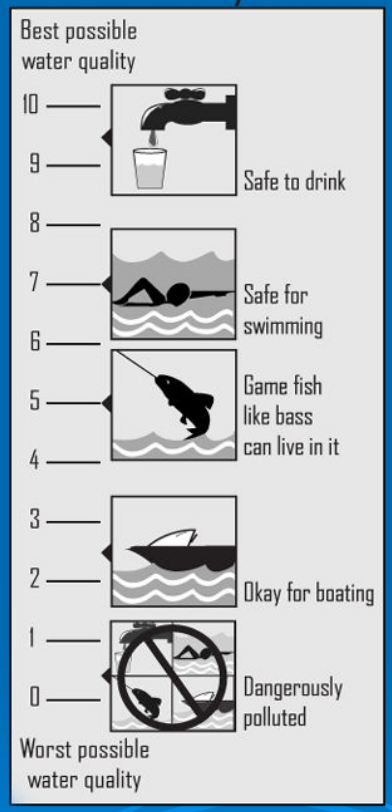
Next Stage of Project: Year 2

- Collect Visitation Data from all 132 lakes
- Augment with Water Quality Perceptions via Water Quality Ladder
- Collect Willingness to pay for Water Quality Improvements at Eight Focus Lakes


Iowa Lakes
Survey 2003
CARD
Center for Agricultural and Rural Development
Resource and Environmental Policy Division
IOWA STATE UNIVERSITY
DEPARTMENT OF ECONOMICS

Name of Lake (County)	Check if you have ever considered visiting this lake	Number of visits (January-December) in 2003		Water Quality Assessment
		Single-Day	Over-night	
Arbor Lake (Poweshiek)				
Arrowhead Lake (Pottawattamie)				
Arrowhead Pond (Sac)				
Avenue of the Saints Lake (Bremer)				
Badger Creek Lake (Madison)				
Badger Lake (Webster)				
Beaver Lake (Dallas)				
Beeds Lake (Franklin)				
Big Creek Lake (Polk)				
Big Spirit Lake (Dickinson)				
Black Hawk Lake (Sac)				
Blue Lake (Monona)				
Bob White Lake (Wayne)				
Woods Lake (Hamilton				

Water Quality Ladder



Current conditions of Storm Lake can be summarized as:

Water Clarity:	objects distinguishable 8 inches to 3 feet under water
Algae blooms:	2 to 5 per year
Water color:	brown to green
Water odor:	mild to strong odor
Bacteria:	possible short-term swim advisories
Fish:	low diversity

photograph showing water color and clarity

Improved conditions of Storm Lake can be summarized as:

Water Clarity:	objects distinguishable 6 to 8 feet under water
Algae blooms:	Rarely more than 1 per year
Water color:	green to blue
Water odor:	usually fresh
Bacteria:	rare swim advisories (most years none)
Fish:	high diversity

photograph showing water color and clarity