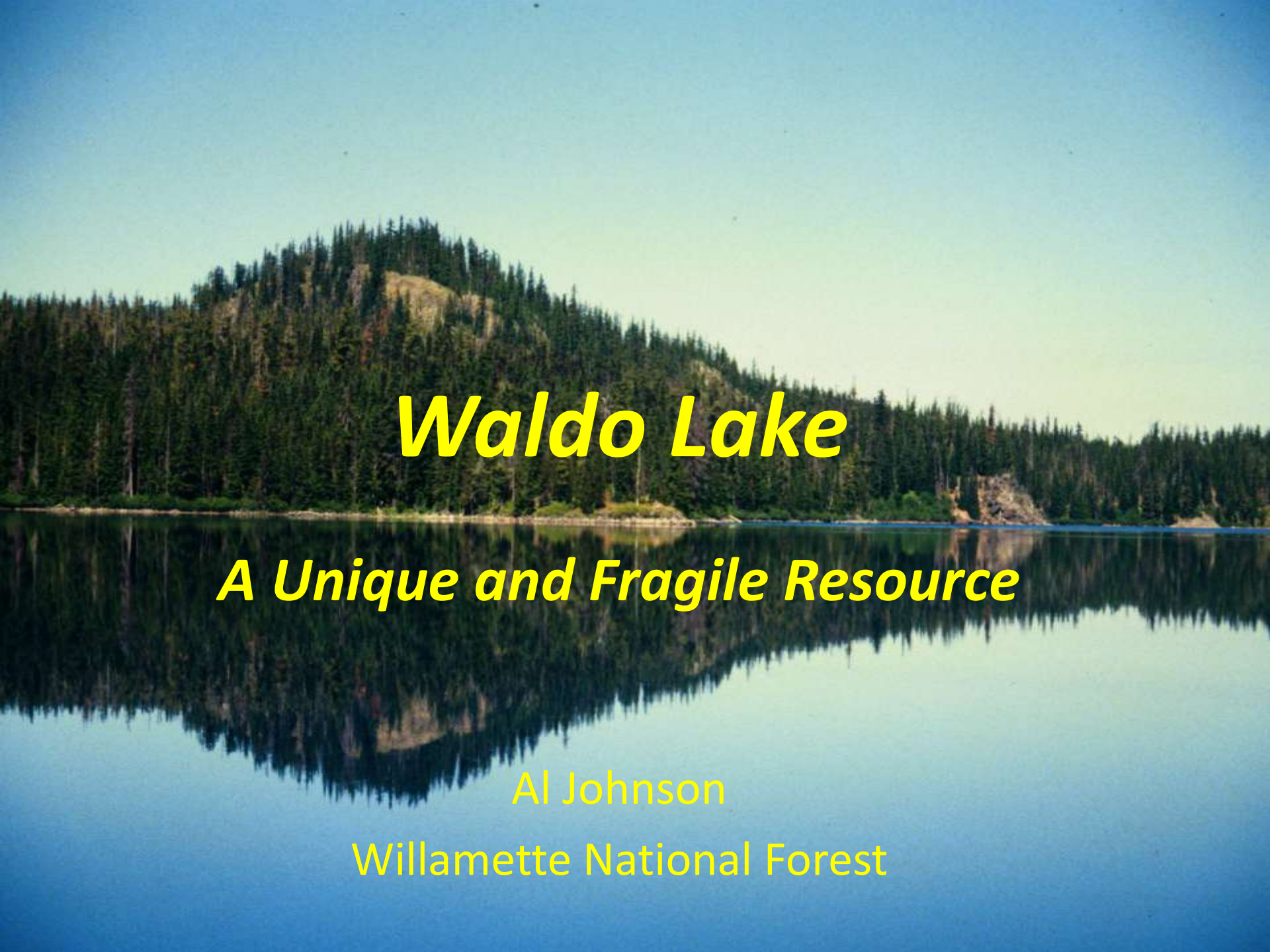
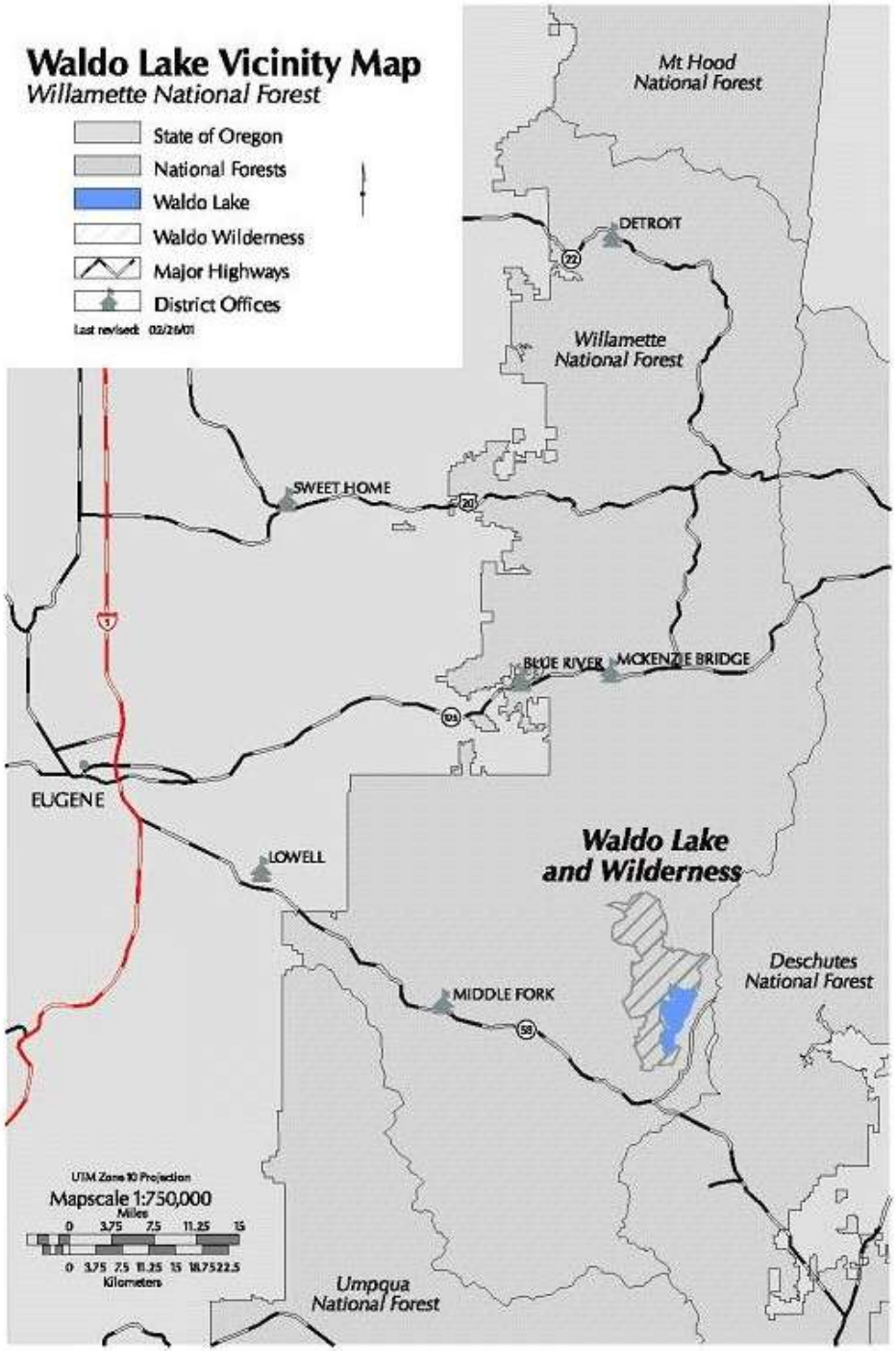


# *Waldo Lake*

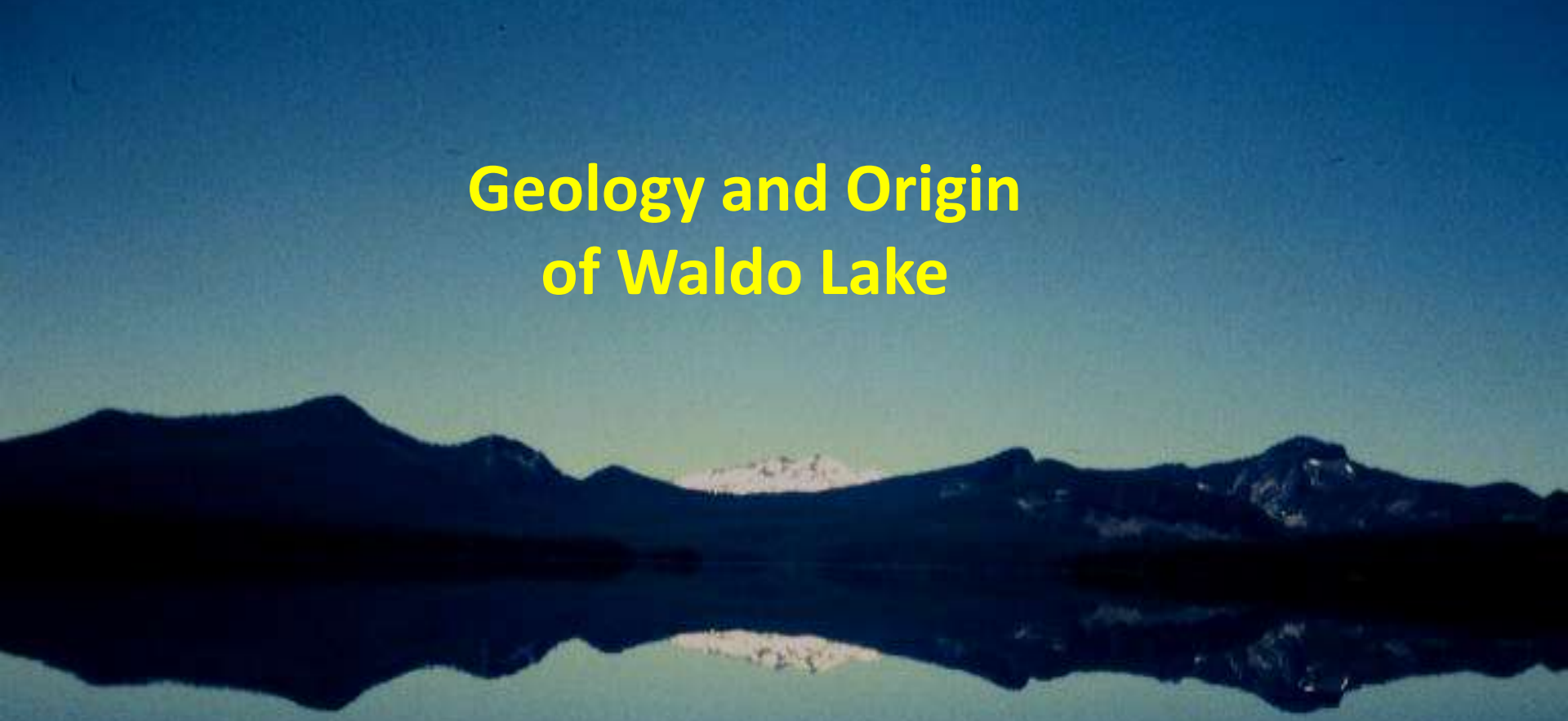
## *A Unique and Fragile Resource*

Al Johnson

Willamette National Forest

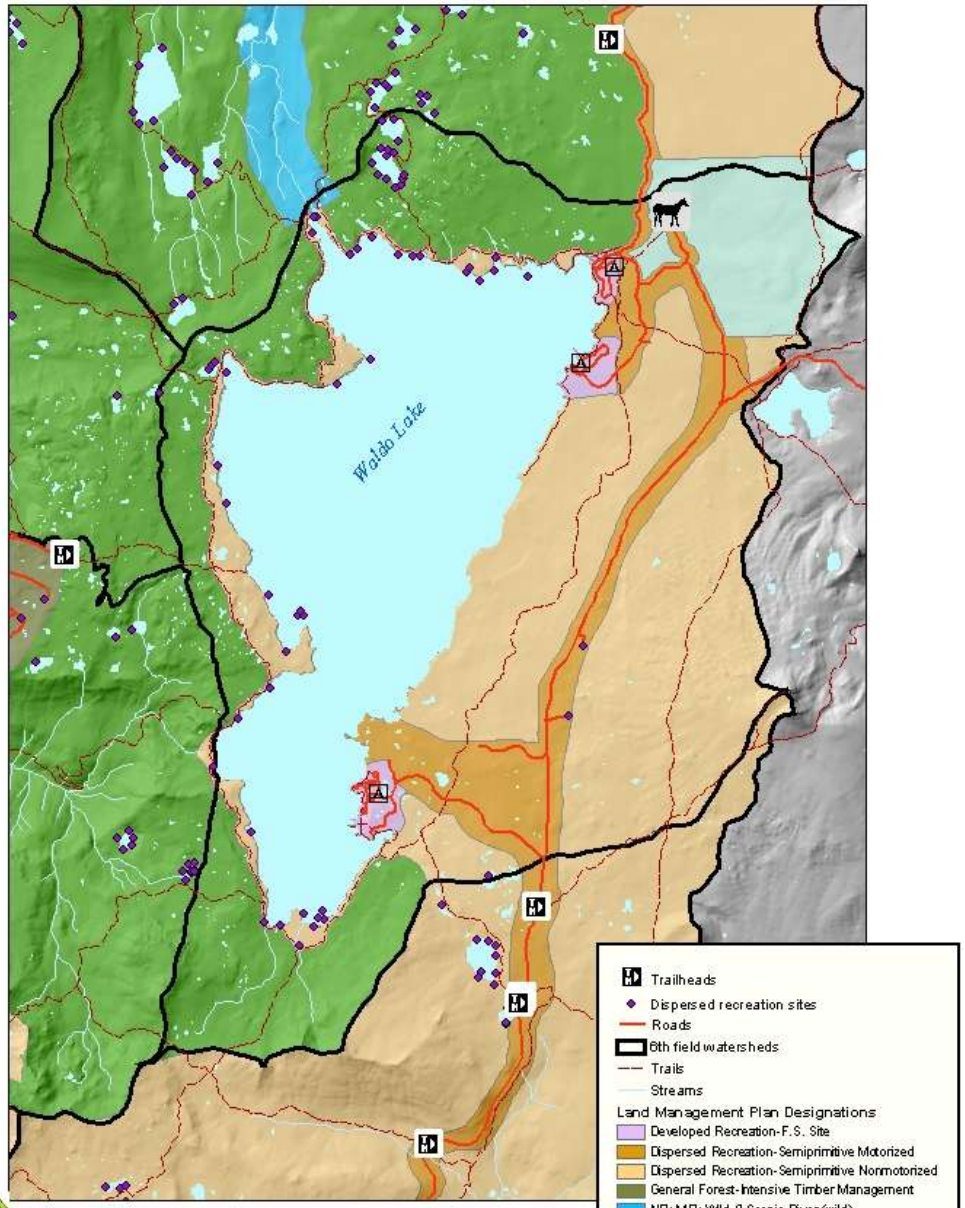

Waldo Lake Vicinity Map
Willamette National Forest
State of Oregon
National Forests
Waldo Lake
Waldo Wilderness
Major Highways
District Offices
Last revised: 02/26/01
Mt Hood National Forest
DETROIT
Willamette National Forest
SWEET HOME
BLUE RIVER
MCKENZIE BRIDGE
EUGENE
LOWELL
Waldo Lake and Wilderness
Deschutes National Forest
MIDDLE FORK
UTM Zone 10 Projection
Mapscale 1:750,000
Miles
0 3.75 7.5 11.25 15
0 3.75 7.5 11.25 15 18.75 22.5
Kilometers
Umpqua National Forest

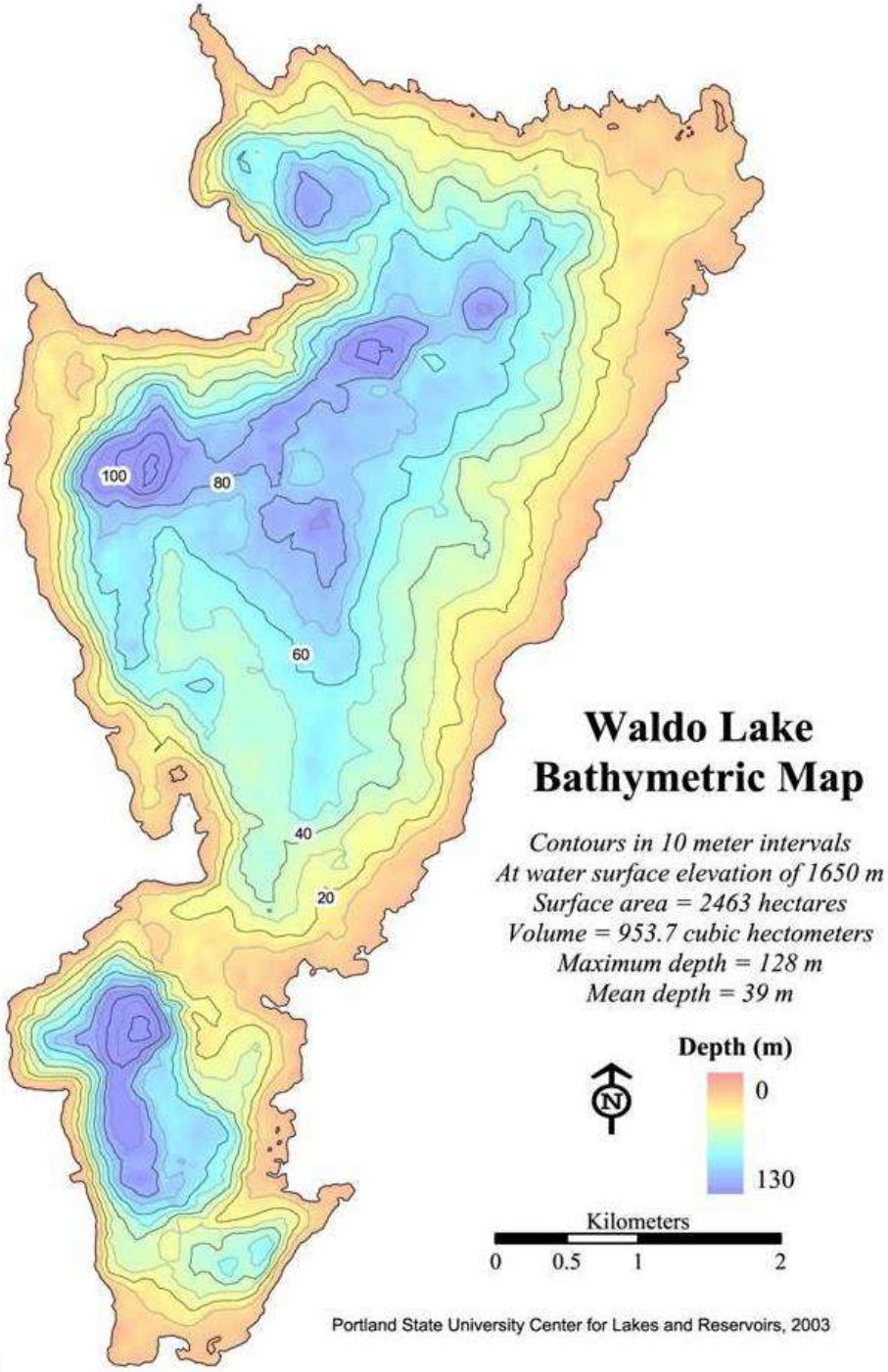
# Geology and Origin of Waldo Lake



- 10,000 to 12,000 years old
- Carved by a northward moving glacier
- Location probably controlled by a north-south down to the east trending fault
- Bedrock consists of fractured basalt lava flows

# Waldo Lake
# Land Management Plan and Uses




100
80
60
40
20
Waldo Lake
Bathymetric Map
Contours in 10 meter intervals
At water surface elevation of 1650 m
Surface area = 2463 hectares
Volume = 953.7 cubic hectometers
Maximum depth = 128 m
Mean depth = 39 m
Depth (m)
0
130
N
Kilometers
0
0.5
1
2
Portland State University Center for Lakes and Reservoirs, 2003

# Waldo Lake Water Chemistry

Acid neutralizing capacity is very low indicating the lake is weakly buffered and highly susceptible to acidification from acidic deposition

| Parameter | n | range | mean |
|---|---|---|---|
| Specific conductance (μmhos·cm$^{-1}$) | 155 | 2.9-3.8 | 3.29 |
| Total alkalinity (mg·L$^{-1}$ as $CaCO_3$) | 150 | 1.64-2.96 | 2.45 |
| Total dissolved solids (mg·L$^{-1}$) | 135 | <1.0-16.0 | 5.14 |
| Silica, dissolved (μg·L$^{-1}$) | 153 | 0.12-0.34 | |
| Total carbon (mg·L$^{-1}$) | 5 | 0.95-5.41 | 1.88 |
| Dissolved carbon (mg·L$^{-1}$) | 5 | 0.60-5.02 | 1.67 |
| Total organic carbon (mg·L$^{-1}$) | 5 | 0.58-3.99 | 1.31 |
| Dissolved organic carbon (mg·L$^{-1}$) | 5 | 0.50-3.40 | 1.12 |
| Bicarbonate (mg·L$^{-1}$) | 150 | 0.39-0.71 | 0.59 |
| Nitrite/nitrate (μg·L$^{-1}$) | 159 | <1.0-3.0 | |
| Ammonium (μg·L$^{-1}$) | 155 | <1-19 | |
| Total phosphorus (μg·L$^{-1}$) | 152 | <1-13 | |
| Orthophosphate (μg·L$^{-1}$) | 150 | <1-7 | |

Water samples were collected by Salinas and Larson between 1986 and 1995 and analyzed by the Cooperative Chemical Analytical Laboratory, Department of Forest Science, Oregon Sate University

# Primary Production

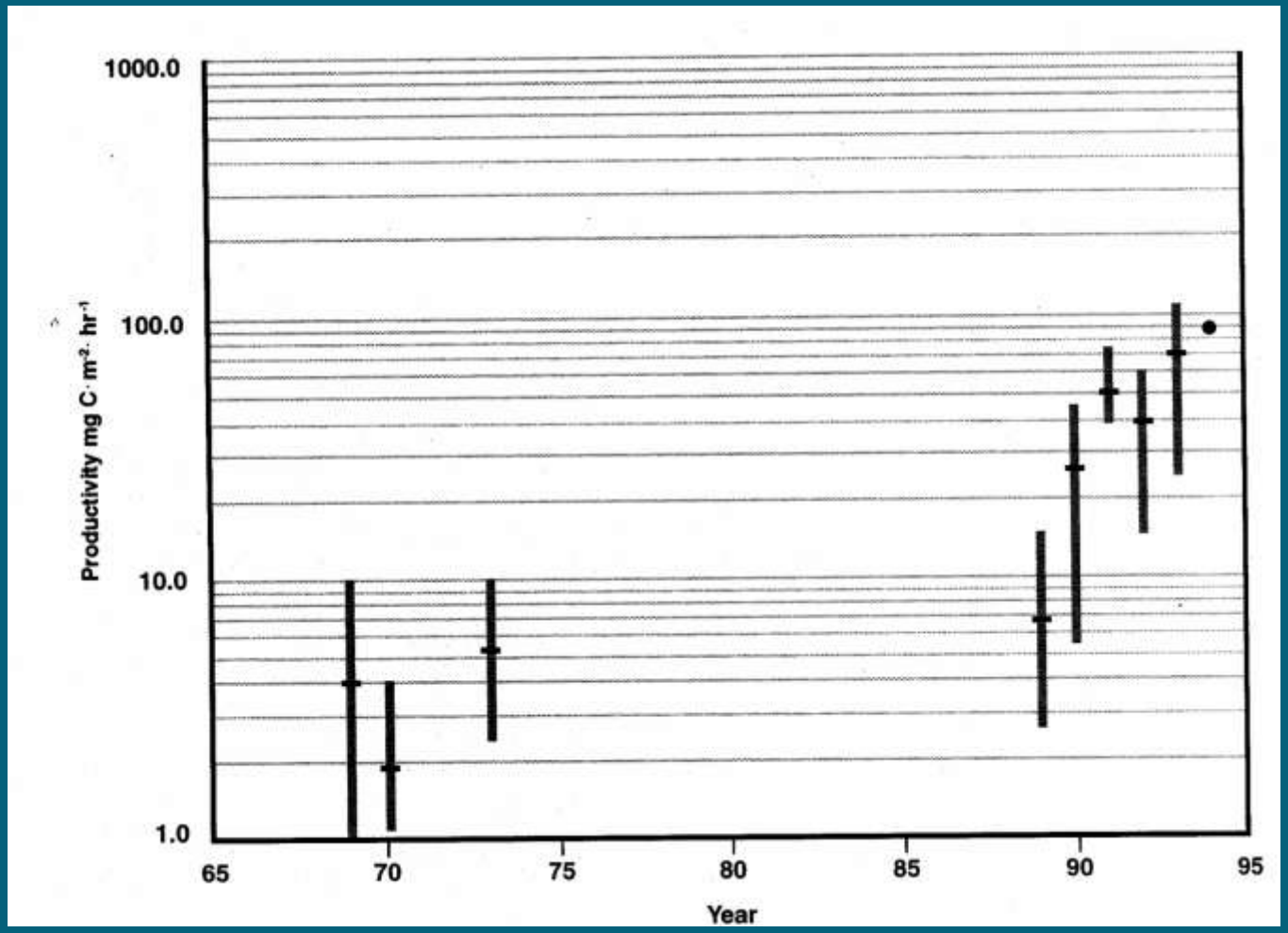
- Observed rates of phytoplankton primary production are among the lowest ever measured in a large freshwater lake anywhere in the world

- Most of the primary production likely occurs in the benthic region of the lake

# Conclusions of Larson and Salinas, 1995

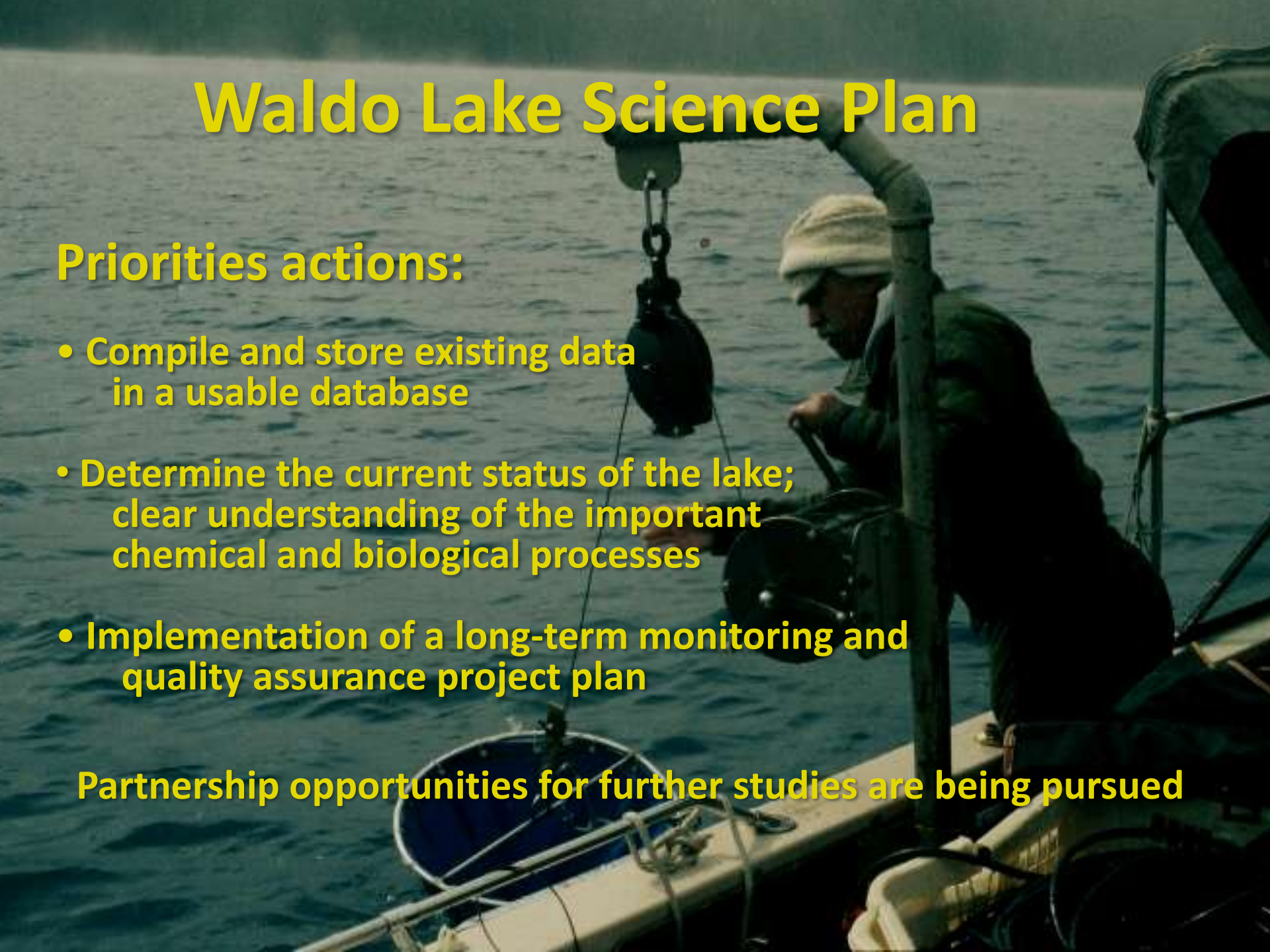
- Zooplankton many times more abundant and species composition changed entirely
- Increase in phytoplankton primary production (20-fold increase since 1969)
- Reduced penetration of blue light

# Phytoplankton Primary Production




Larson and Salinas 1995

# Waldo Lake Science Plan



## Priorities actions:

- Compile and store existing data in a usable database
- Determine the current status of the lake; clear understanding of the important chemical and biological processes
- Implementation of a long-term monitoring and quality assurance project plan

Partnership opportunities for further studies are being pursued

# Waldo Lake Science Plan Partners





**USDA- Forest Service**

**Willamette National Forest**

# Waldo Lake Long-Term Monitoring Parameters

**Multi-parameter probe measurements**
Temperature,
Dissolved oxygen,
pH,
Turbidity,
Redox potential,
Conductivity,
Depth

| Parameter | Method |
|---|---|
| Transparency | Secchi disk |
| Photosynthetically Active Radiation | Spherical radiation sensor |
| Penetration of solar radiation | Photometer |
| Absorbed light at 660 nm | transmissometer |

**Water chemistry**
Total phosphorus (TP)
Orthophosphate (OP)
Total nitrogen (persulfate TN method)
alkalinity, pH, conductivity, and dissolved, silica

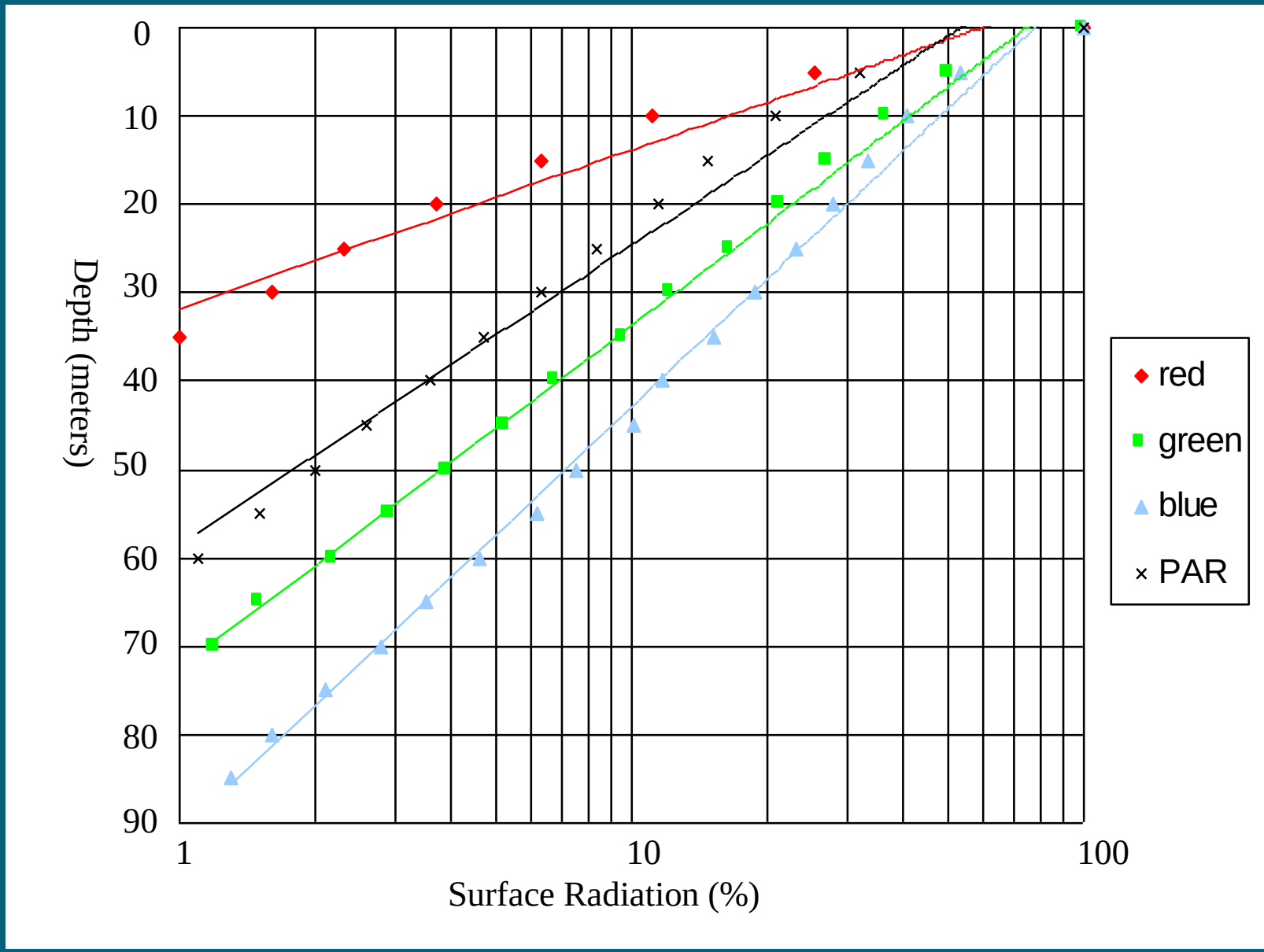
**Biological Parameters**
Phytoplankton
Zooplankton Chlorophyll
Primary Productivity


Waldo Mountain
Charlton Butte
Cupit Mary Mountain
Gerdine Butte
The Twins
Mount Ray
Fuji Mountain
Shadow Bay Campground
N
W
E
S

Secchi transparency ranged from 20 to 45.5 m from 1990 through 2003 (20 cm disk)

Mean Secchi transparency from 1998 through 2003 was 35.7 m

# Photometer Data – Sept. 9, 2001



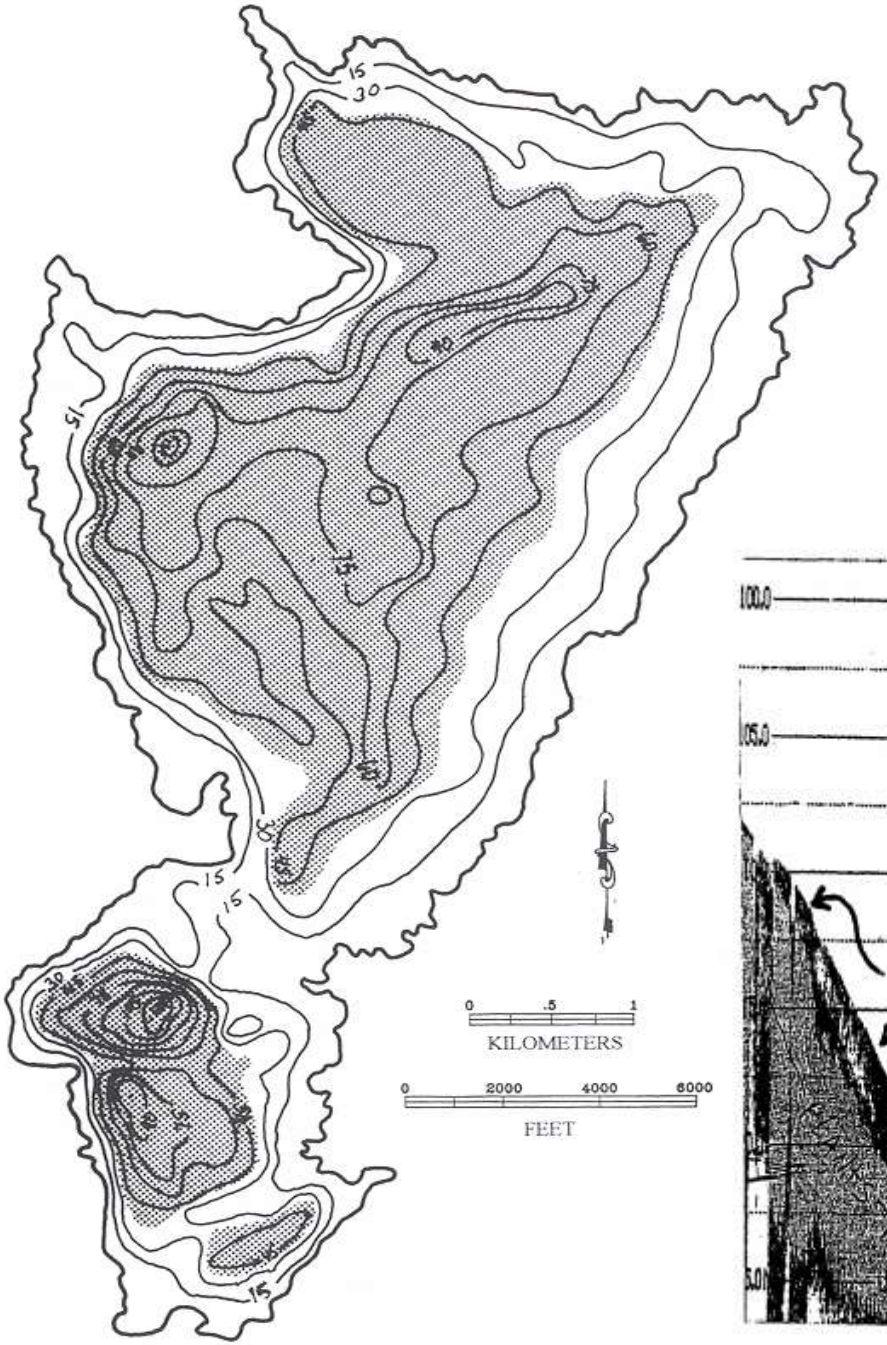
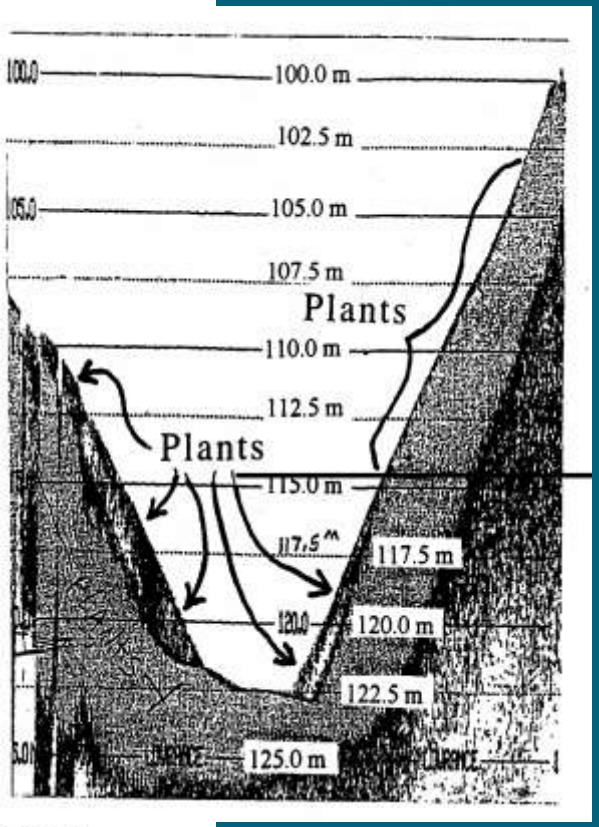



Figure 6.–Maximum potential distribution of bryophytes in Waldo Lake, Oregon.



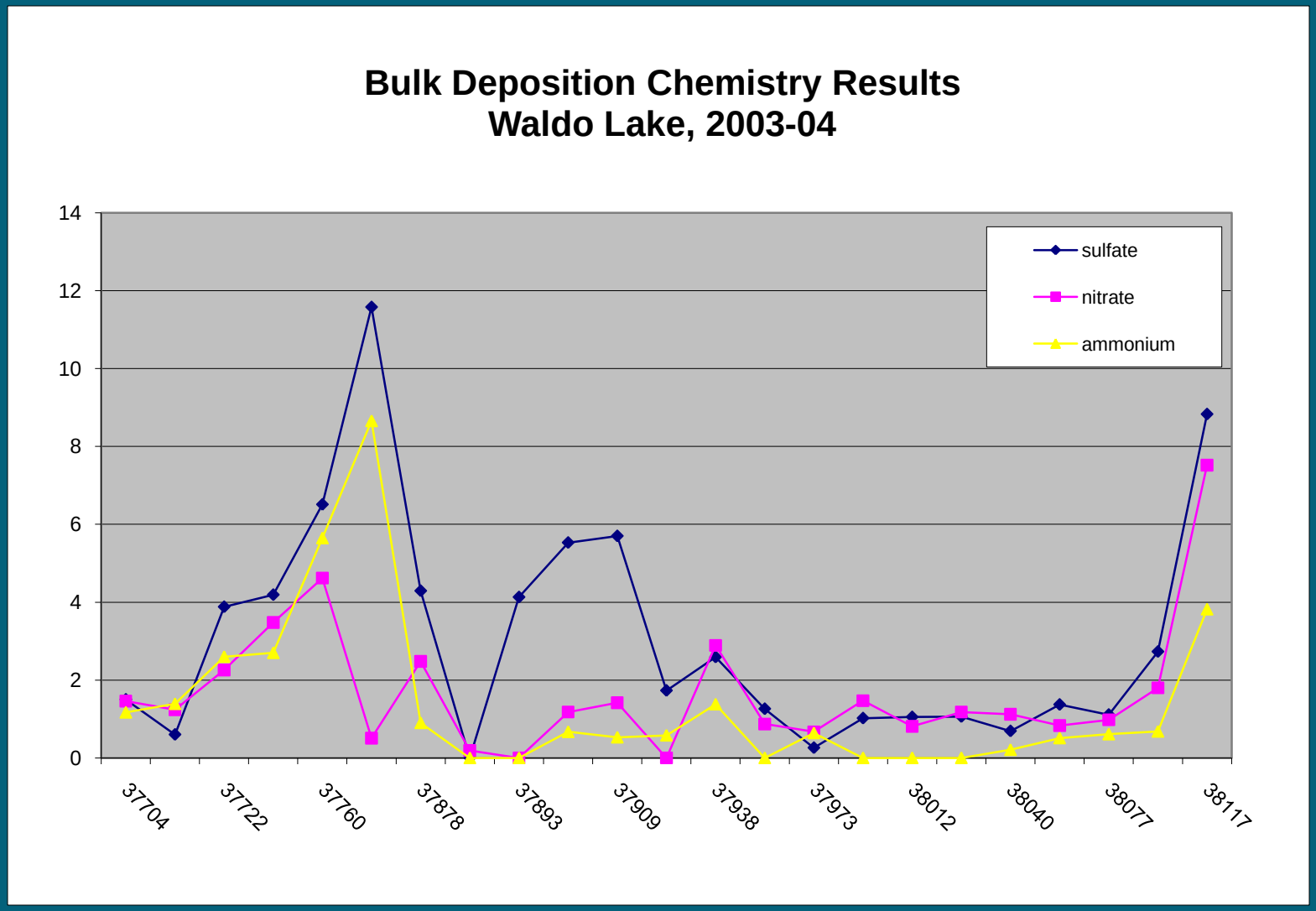

Sonar Transects - August 1990 with representative plant signatures

Jones 2000

# Snowpack- and Bulk-Deposition Chemistry
# Waldo Lake sites, 2003-2004



Collection began 3/12/03 with full-snowpack sampling at 3 sites near Waldo Lake.




Ammonium, nitrate, and sulfate concentrations in precipitation over an 18 month period beginning March 23, 2003

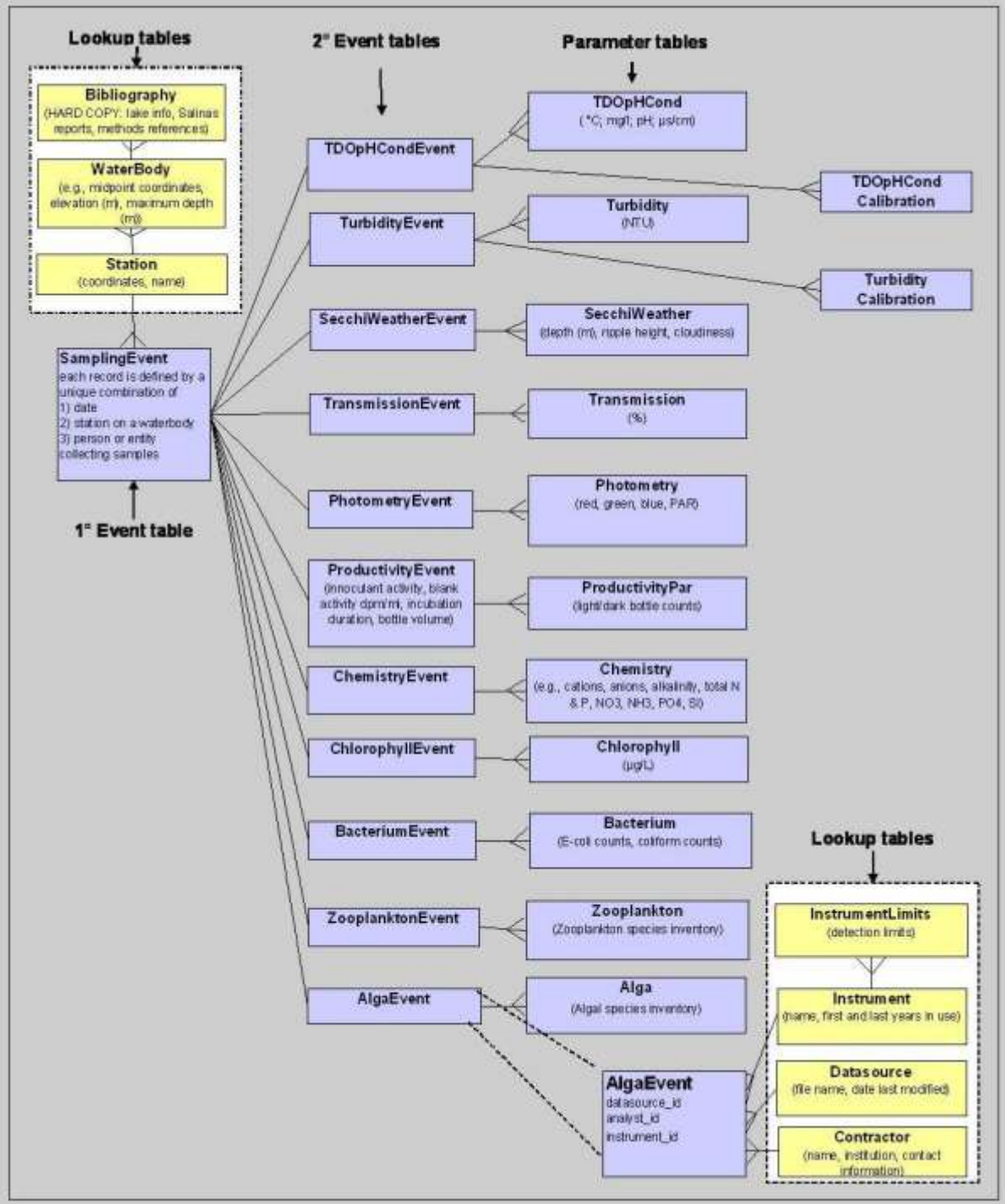
# Relational Database for Limnological Data

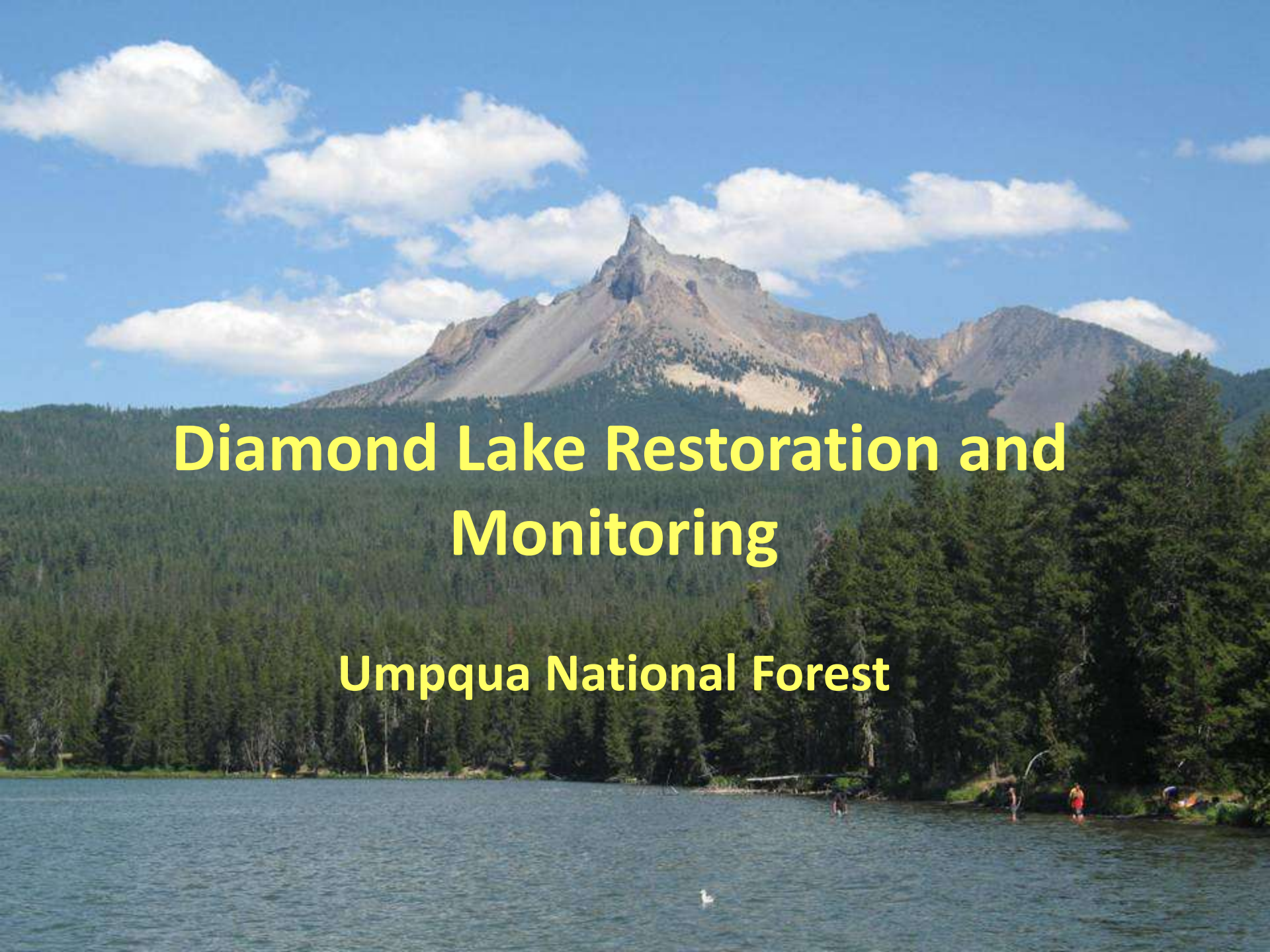
Created in Microsoft Access in partnership with Oregon State University

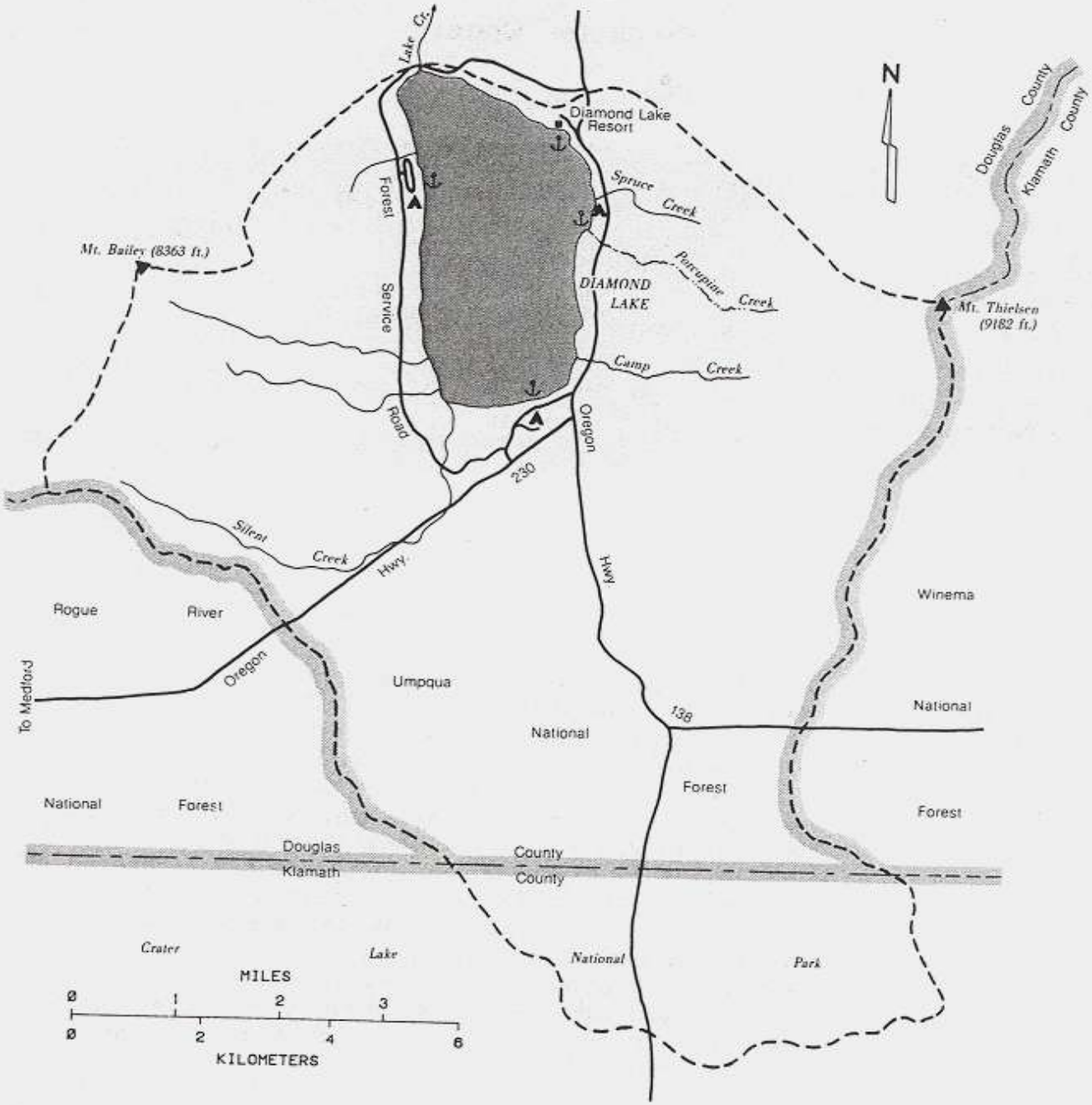
A central organizing lookup table (Sampling Event) is used to define each unique combination of water body, date, station, and sampler

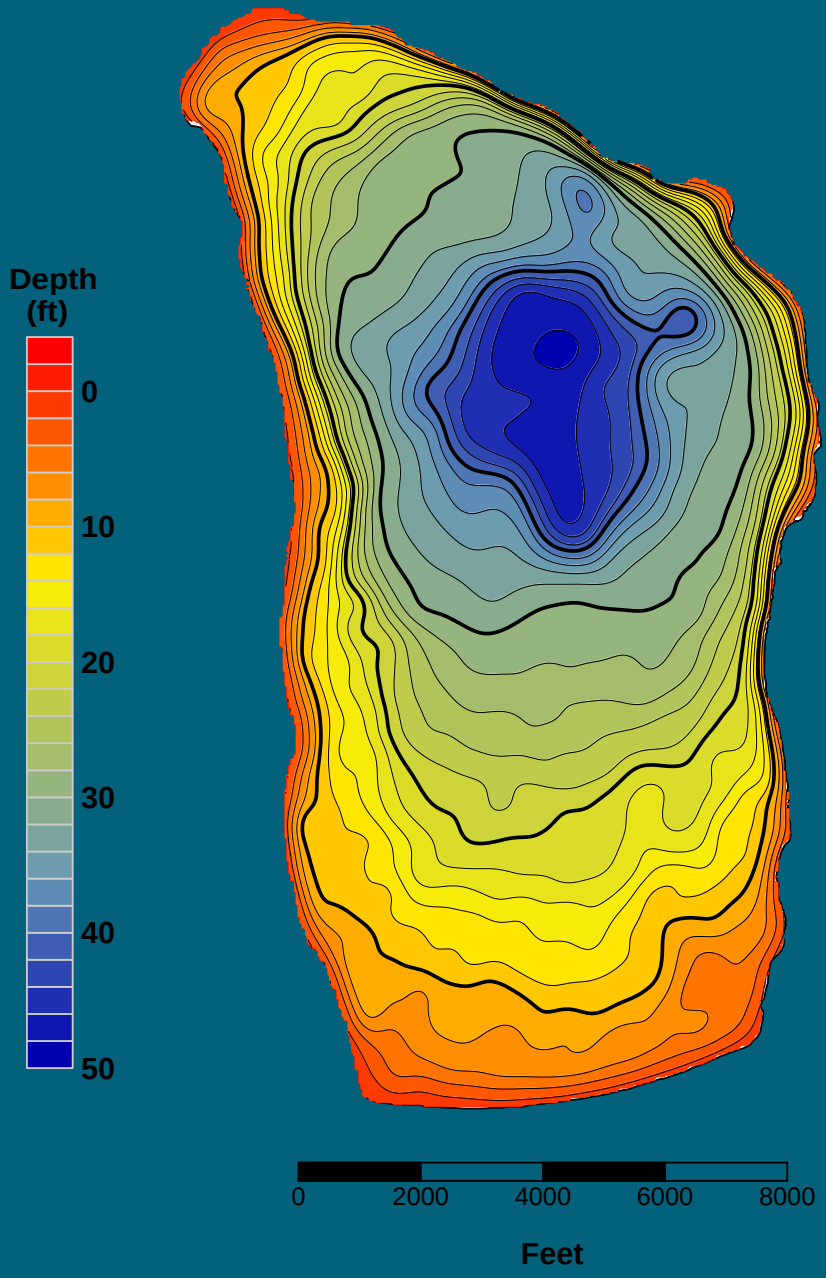
Each Parameter table containing physical, chemical, and biological data has an associated Event table.

Currently populated with data on 16 lakes




Diamond Lake Restoration and Monitoring
Umpqua National Forest


DRAINAGE BASIN
Basin Boundary
Lake Ck.
Diamond Lake Resort
Forest Service Road
Spruce Creek
Porcupine Creek
DIAMOND LAKE
Camp Creek
Mt. Bailey (8363 ft.)
Mt. Thielsen (9182 ft.)
Douglas County
Klamath County
N
Oregon 230 Hwy
Oregon 138 Hwy
Silent Creek
Rogue River National Forest
Umpqua National Forest
Winema National Forest
To Medford
Douglas County
Klamath County
Crater Lake National Park
MILES
0 1 2 3
0 2 4 6
KILOMETERS




| Attribute | |
|---|---|
| Elevation (m) | 1580 |
| Lake Area (ha) | 1226 |
| Max. Depth (m) | 14.8 |
| Mean Depth (m) | 6.9 |
| Residence Time (yr) | 1.6 |

JC Headwaters, Inc. 2002

# Recent Management History of Diamond Lake

- In 1992, tui chub were discovered in Diamond Lake and their population expanded exponentially over the next several years
- The situation closely paralleled the situation seen in the early 1950's including a decline in the trout fishery
- Health advisories for the lake were issued due to blooms of potentially toxic cyanobacteria for portions of years 2001 – 2003, 2004, and 2006
- The entire lake was treated with rotenone in September 2006 to eliminate all fish

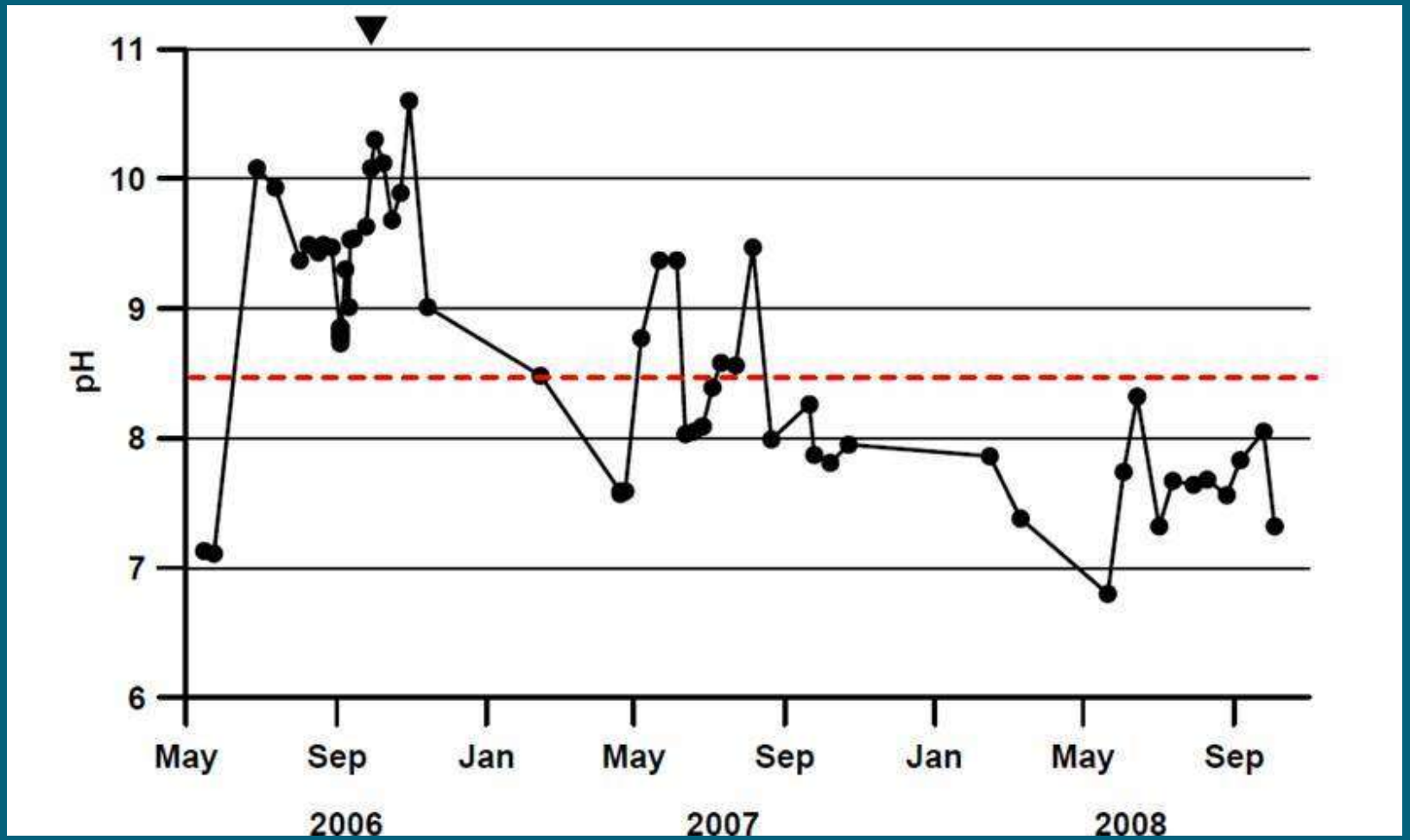
# Phases of Diamond Lake Restoration Project

- Lake drawdown (fall-winter 2005-06)
- Flow through (summer 2006)
- Rotenone treatment (September 14, 2006)
- Lake refill (fall-winter 2006-07)
- Fish stocking (beginning spring 2007)
- Public education efforts continuous in the future

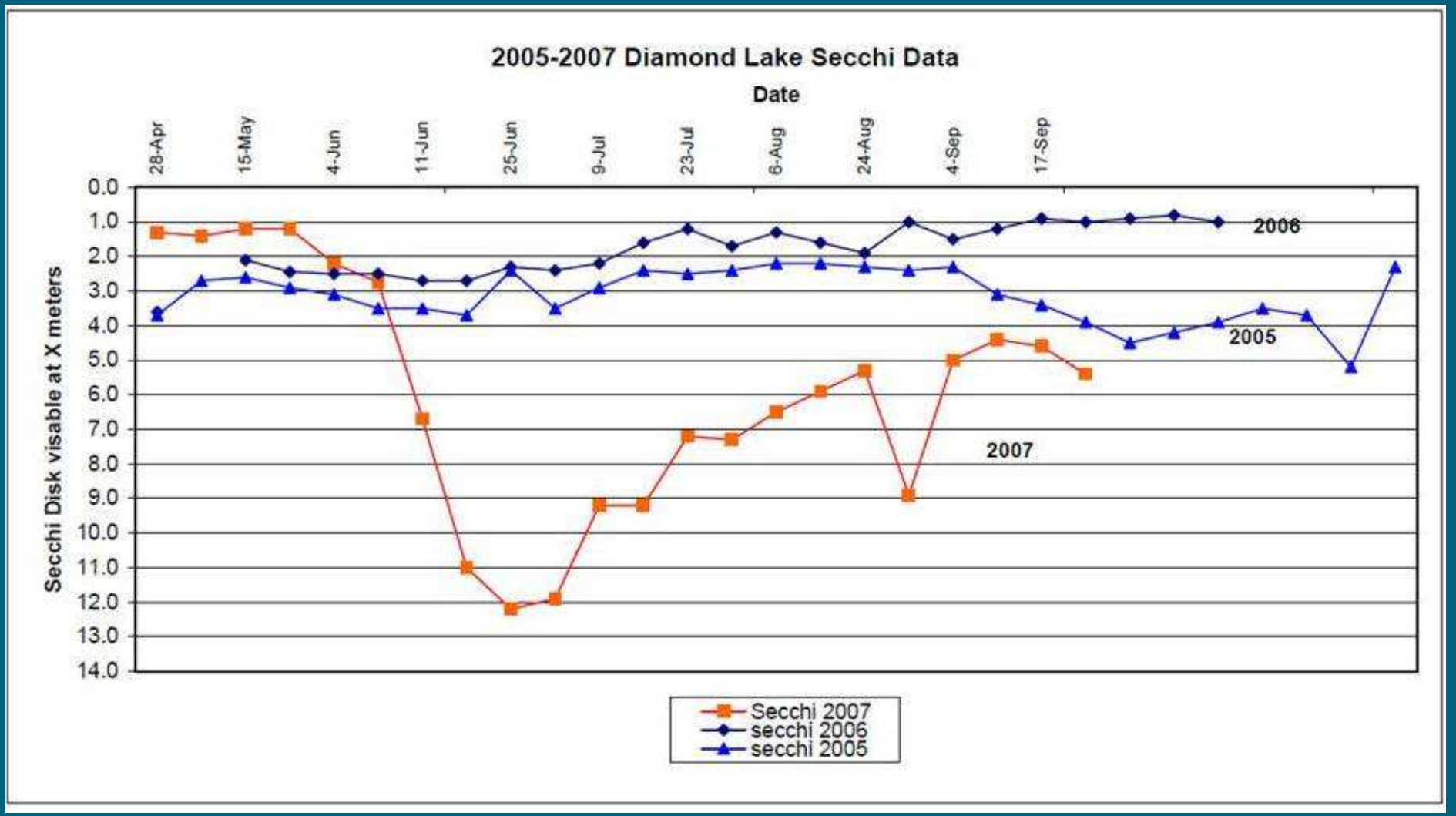

Rotenone treatment,
September 14, 2006

North Shore of
Diamond Lake,
September 15, 2006

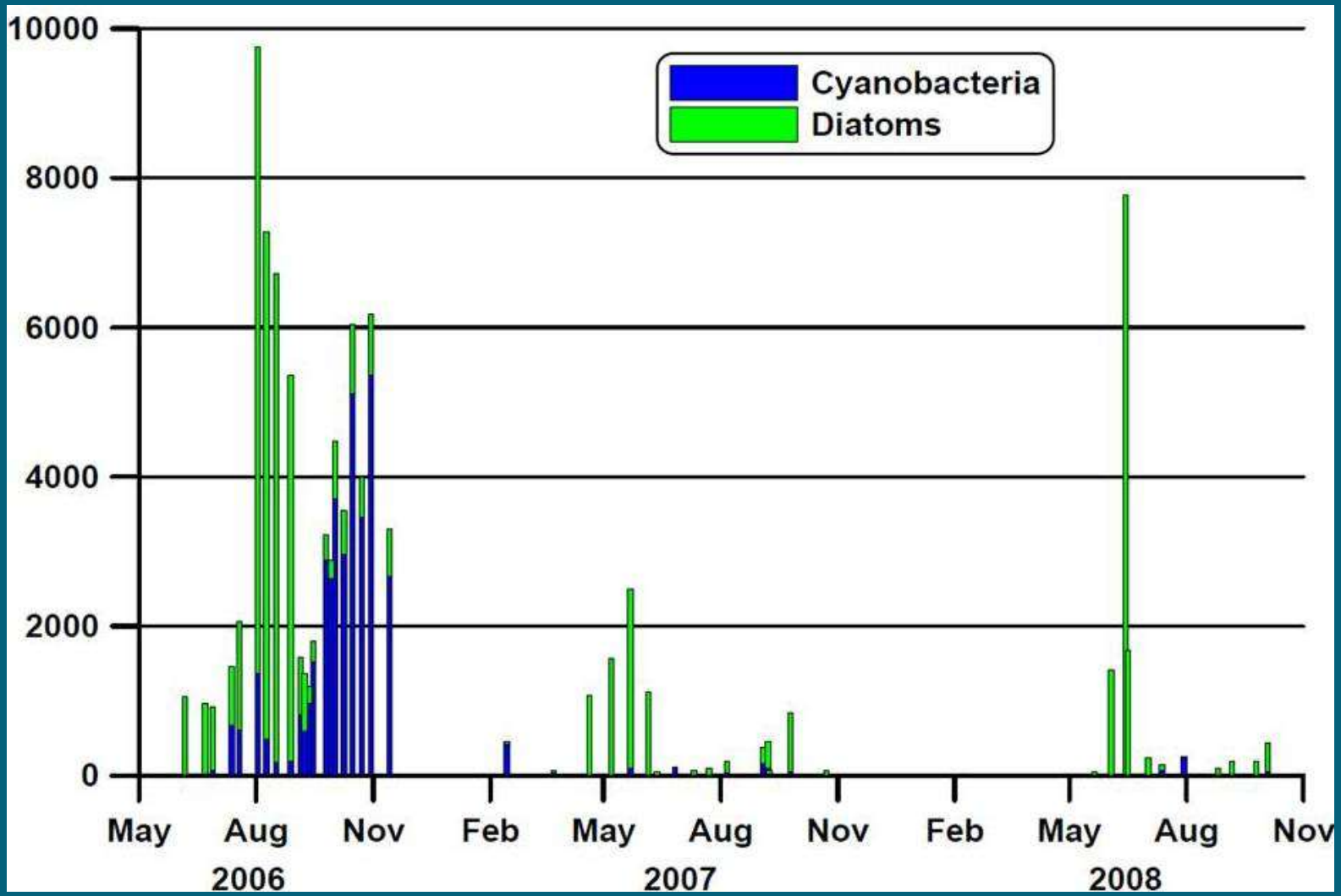
# Field pH at a depth of 1 meter in Diamond Lake measured from May 2006 to October 2008[1]




[1] Report for ODFW by Joe Eilers, MaxDepth Aquatics, Inc. 2009

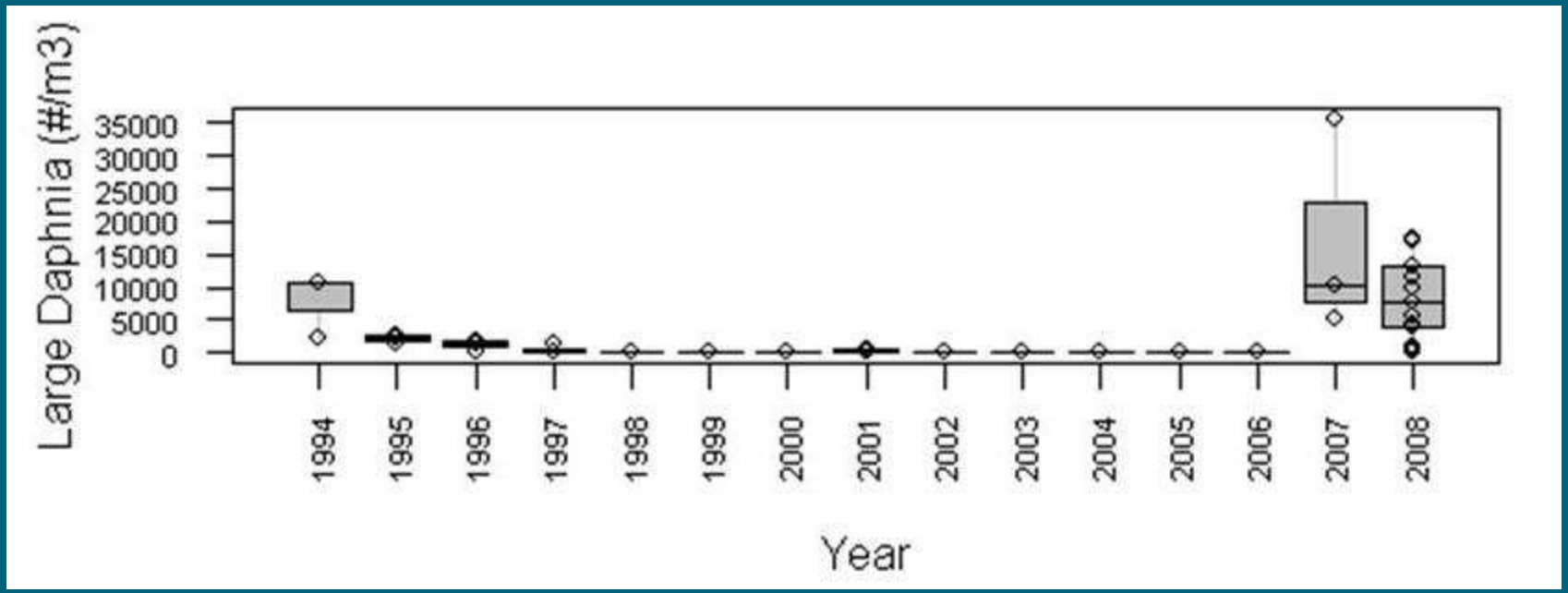

2005-2007 Diamond Lake Secchi Data
Date
28-Apr
15-May
4-Jun
11-Jun
25-Jun
9-Jul
23-Jul
6-Aug
24-Aug
4-Sep
17-Sep
Secchi Disk visable at X meters
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
2006
2005
2007
Secchi 2007
secchi 2006
secchi 2005

# Dominant phytoplankton groups, cyanobacteria and diatoms, in Diamond Lake from 2006-2008 [1]




[1] Report for ODFW by Joe Eilers, MaxDepth Aquatics, Inc. 2009

# Density of "large" *Daphnia* species (*D. pulicaria and D. rosea*) in Diamond Lake[1]




[1] Report by Center for Lakes and Reservoirs, Portland State University, 2009

# Diamond Lake Condition Metrics

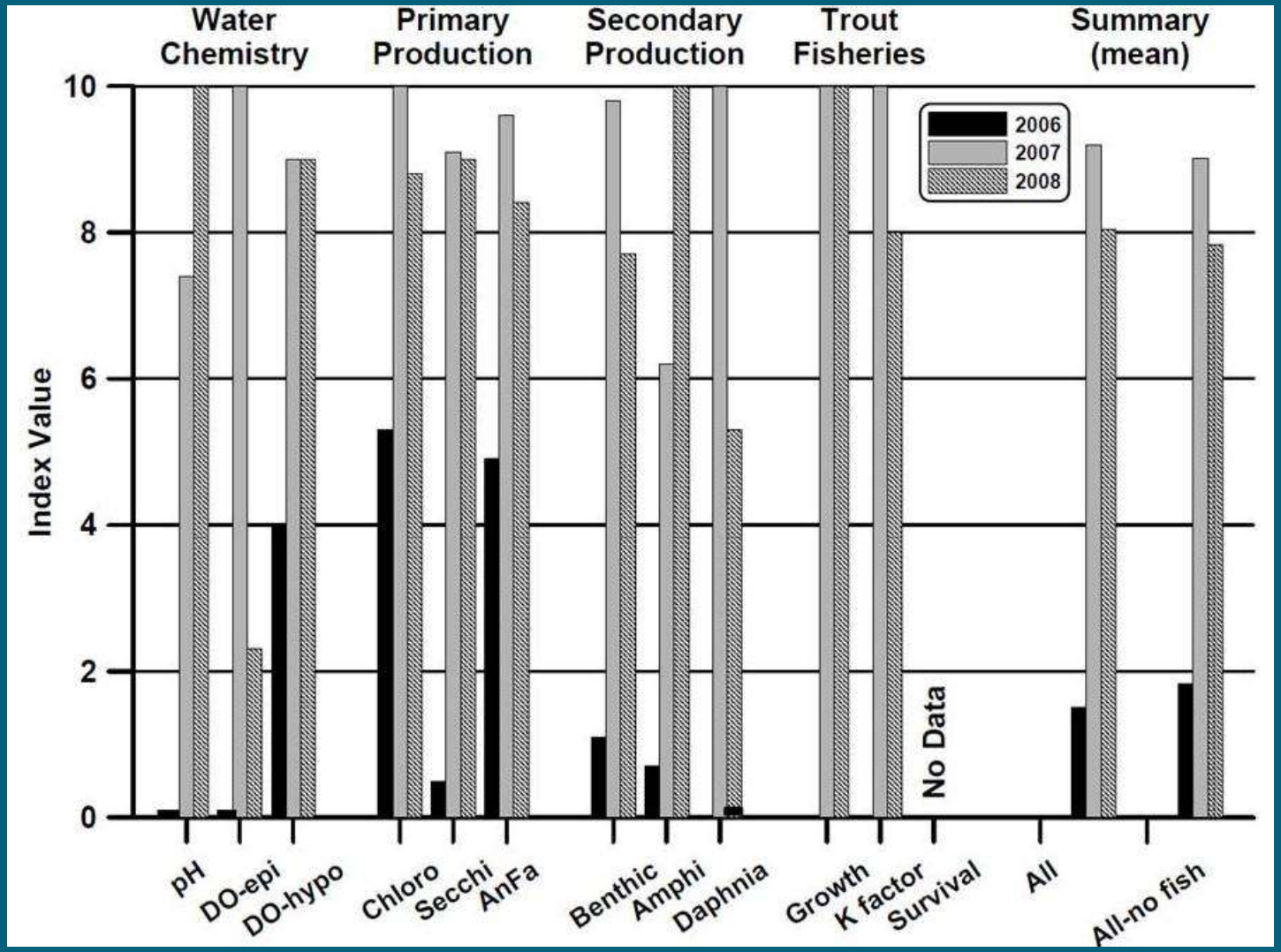
| Metric | Measurement | Range |
|---|---|---|
| pH | pH scale | 8 – 9.5 |
| Epi DO | Epilimnetic DO saturation | 83 - 103 |
| Hypo DO | Depth (m) where DO<1 mg/L | 14 - 6 |
| Chlorophyll | Epilimnetic concentration (µg/L) | 2 - 22 |
| Secchi Disk | Median transparency(m) | 8 - 1 |
| *Anabaena* median | Density (cells/mL) | 0 – 200,000 |
| *Anabaena* max | Density (cells/mL) | 100 – 1,000,000 |
| Benthic Biomass | Avg. benthic biomass (lbs/ac) | 250 - 5 |
| Amphipods | % individuals in sample | 30 - 0 |
| Large *Daphnia* | #/$m^{3,}$ median sum of *D. pulicaria* + *D. rosea* | 15000 - 0 |
| Trout Growth | Increase in fork length of stocked fingerlings | 6.5 – 1.5 |
| K-factor | Trout condition factor | 1.7 - 0.9 |
| Trout survival | % of stocked trout surviving over 1 year | 80 - 0 |

# Lake condition index values for Diamond Lake [1]

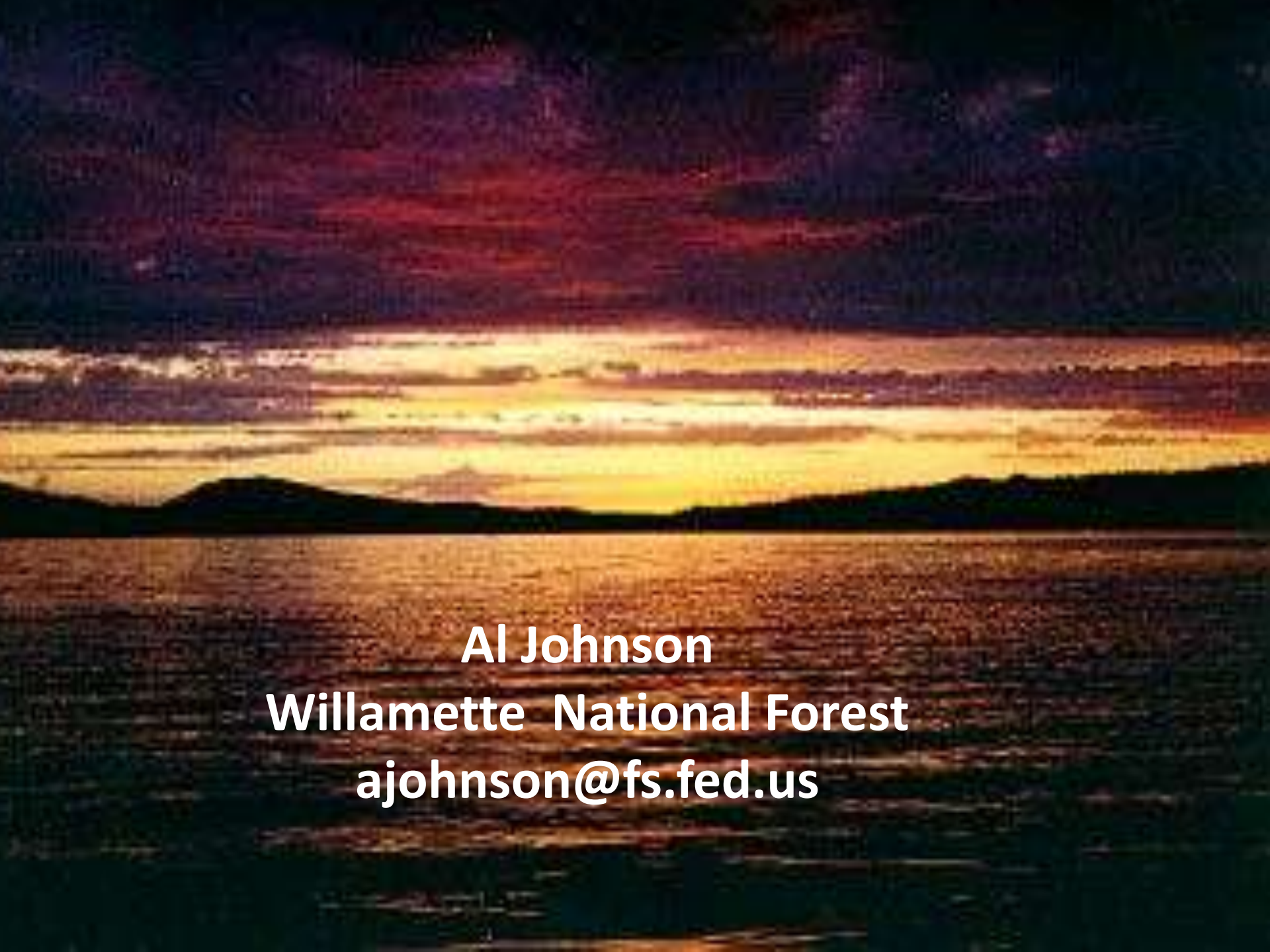
| Index | pH | Epi DO (%) | Hypo DO (m) | Chloro -phyll (µg/L) | Secchi Disk (m) | *Anabaena* (median cells/mL) | *Anabaena* (maximum cells/mL) | Benthic Biomass (lbs/ac) | Amphi -pods (%) | Large *Daphnia* (#/m3) | Trout Growth (in) | K-factor | Trout survival (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 8 | 83 | 14 | 2 | 8 | 0 | 100 | 250 | 30 | 15000 | 6.5 | 1.7 | 80 |
| 9 | 8.1 | 85 | 13 | 4 | 7 | 10 | 1000 | 200 | 25 | 12000 | 6 | 1.65 | 70 |
| 8 | 8.2 | 87 | 12 | 6 | 6.5 | 50 | 2000 | 175 | 20 | 10000 | 5.5 | 1.6 | 60 |
| 7 | 8.3 | 89 | 11 | 8 | 6 | 100 | 3000 | 150 | 15 | 8000 | 5 | 1.5 | 50 |
| 6 | 8.4 | 91 | 10 | 10 | 5.5 | 300 | 4000 | 125 | 10 | 6000 | 4.5 | 1.4 | 40 |
| 5 | 8.5 | 93 | 9 | 12 | 5 | 500 | 5000 | 100 | 8 | 4000 | 4 | 1.3 | 30 |
| 4 | 8.7 | 95 | 8 | 14 | 4.5 | 1000 | 10000 | 75 | 6 | 2000 | 3.5 | 1.2 | 20 |
| 3 | 8.9 | 97 | 7.5 | 16 | 4 | 5000 | 50000 | 50 | 4 | 1000 | 3 | 1.1 | 15 |
| 2 | 9.1 | 99 | 7 | 18 | 3 | 50000 | 100000 | 25 | 2 | 100 | 2.5 | 1 | 10 |
| 1 | 9.3 | 101 | 6.5 | 20 | 2 | 100000 | 500000 | 10 | 1 | 10 | 2 | 0.95 | 5 |
| 0 | 9.5 | 103 | 6 | 22 | 1 | 200000 | 1000000 | 5 | 0 | 0 | 1.5 | 0.9 | 0 |

[1] Report for ODFW by Joe Eilers, MaxDepth Aquatics, Inc. 2009

# Lake Condition Index for Diamond Lake from 2006-2008 [1]




[1] Report for ODFW by Joe Eilers, MaxDepth Aquatics, Inc. 2009



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