

# Simplified Lake Eutrophication Modeling: Using the Ecoregion- based model MINLEAP

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# MINLEAP - Development and Acknowledgements

- ◆ “Minnesota Lake Eutrophication Analysis Procedure”
- ◆ Developed by Bruce Wilson and Dr. William Walker Jr. (1989), published in Lake and Reserv. Manage. 5(2): 11-22 “Development of Lake Assessment Methods Based on Aquatic Ecoregion Concept”
- ◆ BASIC originally (Wilson), recent Windows version - (Wade Gillingham, MPCA)

# Overview

## Session I

- ◆ General modeling concepts;
- ◆ Ecoregion framework and MINLEAP;
- ◆ MINLEAP background and subroutines;
- ◆ Application of MINLEAP

## Session II

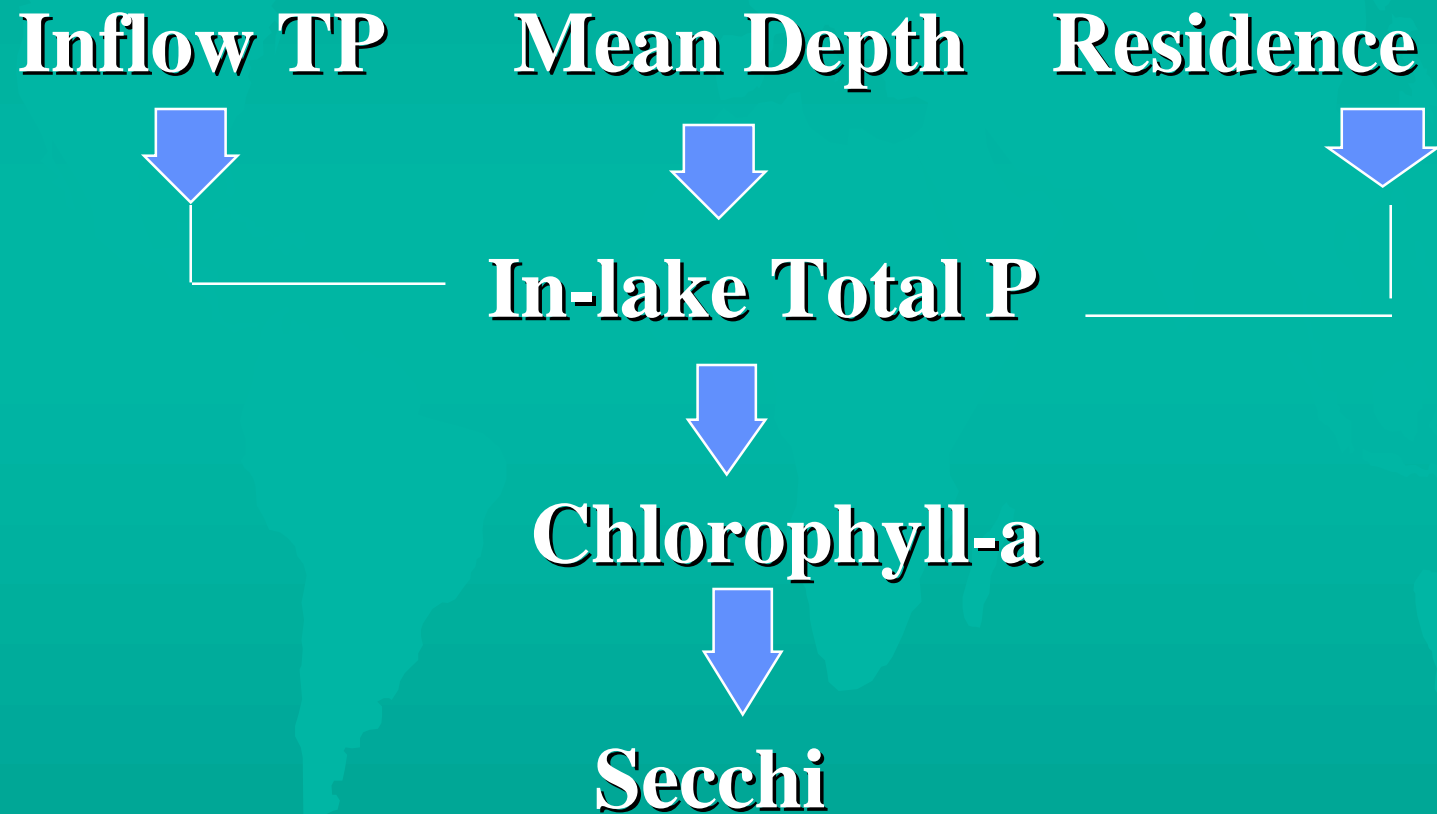
- ◆ Loading and using MINLEAP
- ◆ Case Studies;

# Lake Eutrophication Modeling

(Drawn from Wilson, 1990)

- ◆ Predictive techniques to assess common lake problems;
- ◆ Foundation is reasonable estimation of water and nutrient budgets or loading;
- ◆ Lakes often exhibit similarities in response to nutrient loading;
- ◆ Most techniques based on cross-sectional studies -- e.g., ecoregion reference lakes;

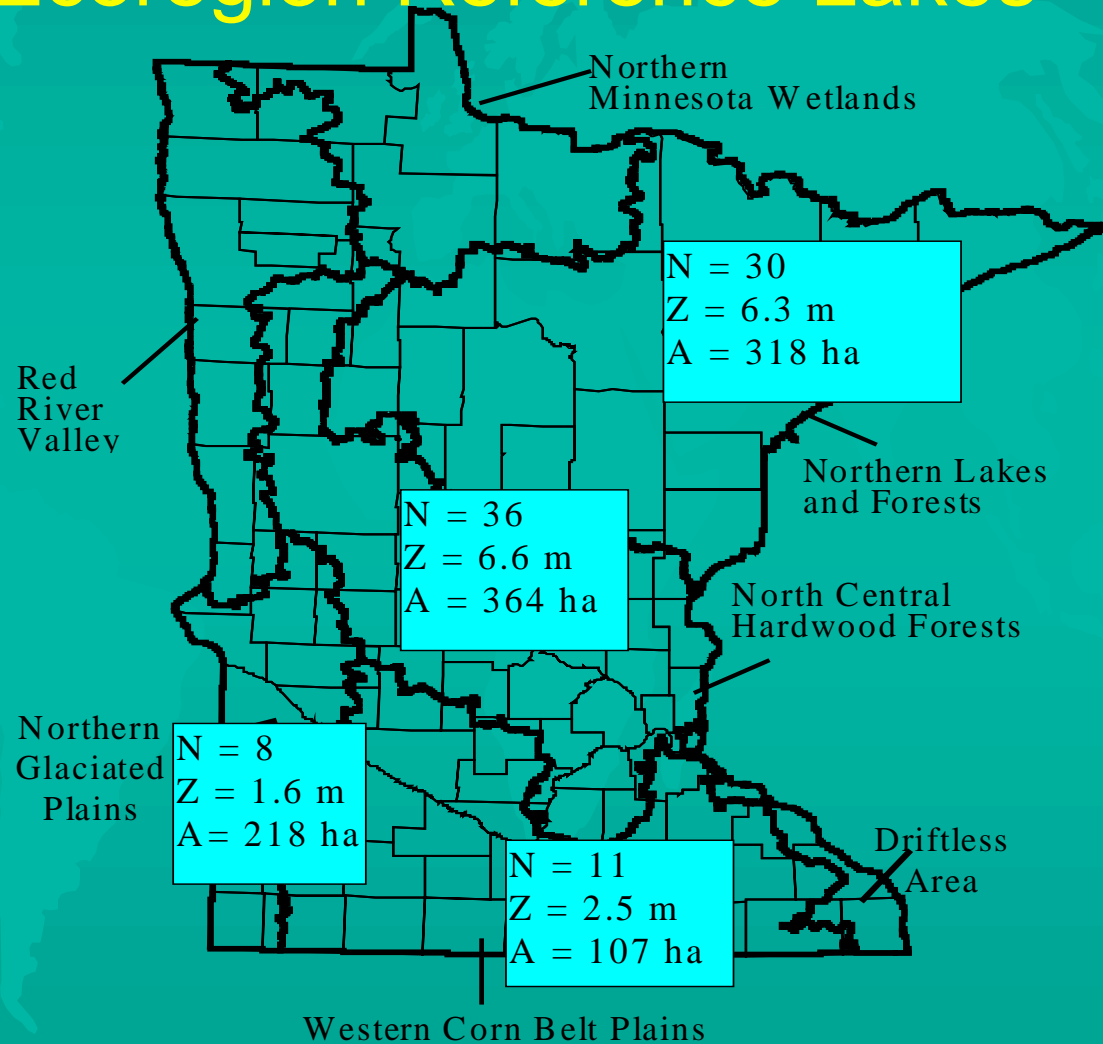
# Typical Empirical Model Network



# MINLEAP Development

- ◆ Based on ecoregion framework -- considers regional patterns in geomorphology, soils, landuse, and climatic characteristics;
- ◆ Uses average precip., evap., and runoff
- ◆ Canfield and Bachmann (1981) is the P sedimentation model used;
- ◆ TP, Chl-a, and Secchi models based on MN reference lakes;

# Ecoregion Reference Lakes



# Distribution of Phosphorus by Lake Mixing Status and Ecoregion

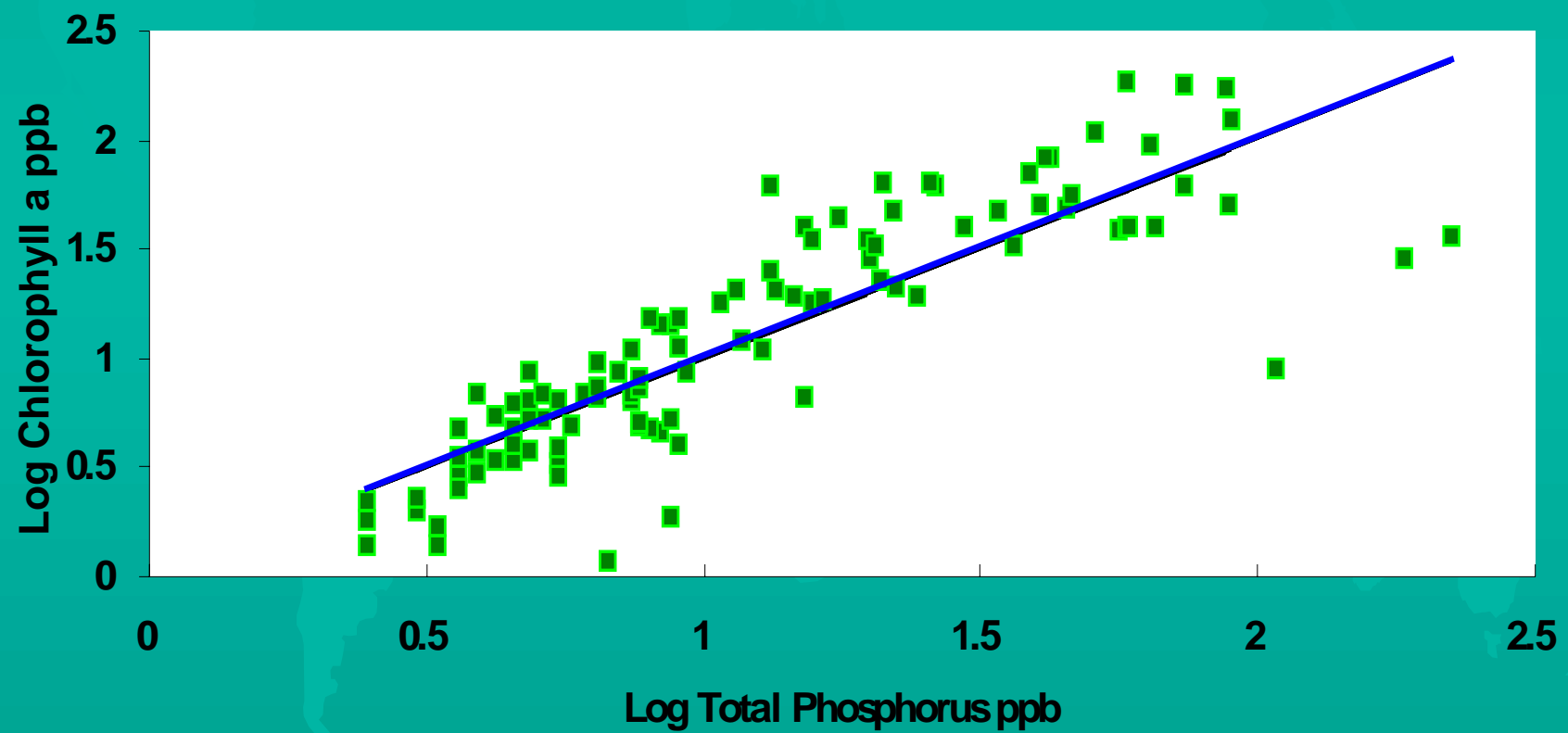
**D** = Dimictic, **I** = Intermittent, **P** = Polymictic

	NLF			NCHF			WCBP		
Mixing Status:	D	I	P	D	I	P	D	I	P
Percentile value for [TP]									
90 %	<b>37</b>	53	57	<b>104</b>	263	344	--	--	284
75 %	<b>29</b>	35	39	<b>58</b>	100	161	<b>101</b>	195	211
50 %	<b>20</b>	26	29	<b>39</b>	62	89	<b>69</b>	135	141
25 %	<b>13</b>	19	19	<b>25</b>	38	50	<b>39</b>	58	97
10 %	<b>9</b>	13	12	<b>19</b>	21	32	<b>25</b>	--	69
# of obs.	257	87	199	152	71	145	4	3	38



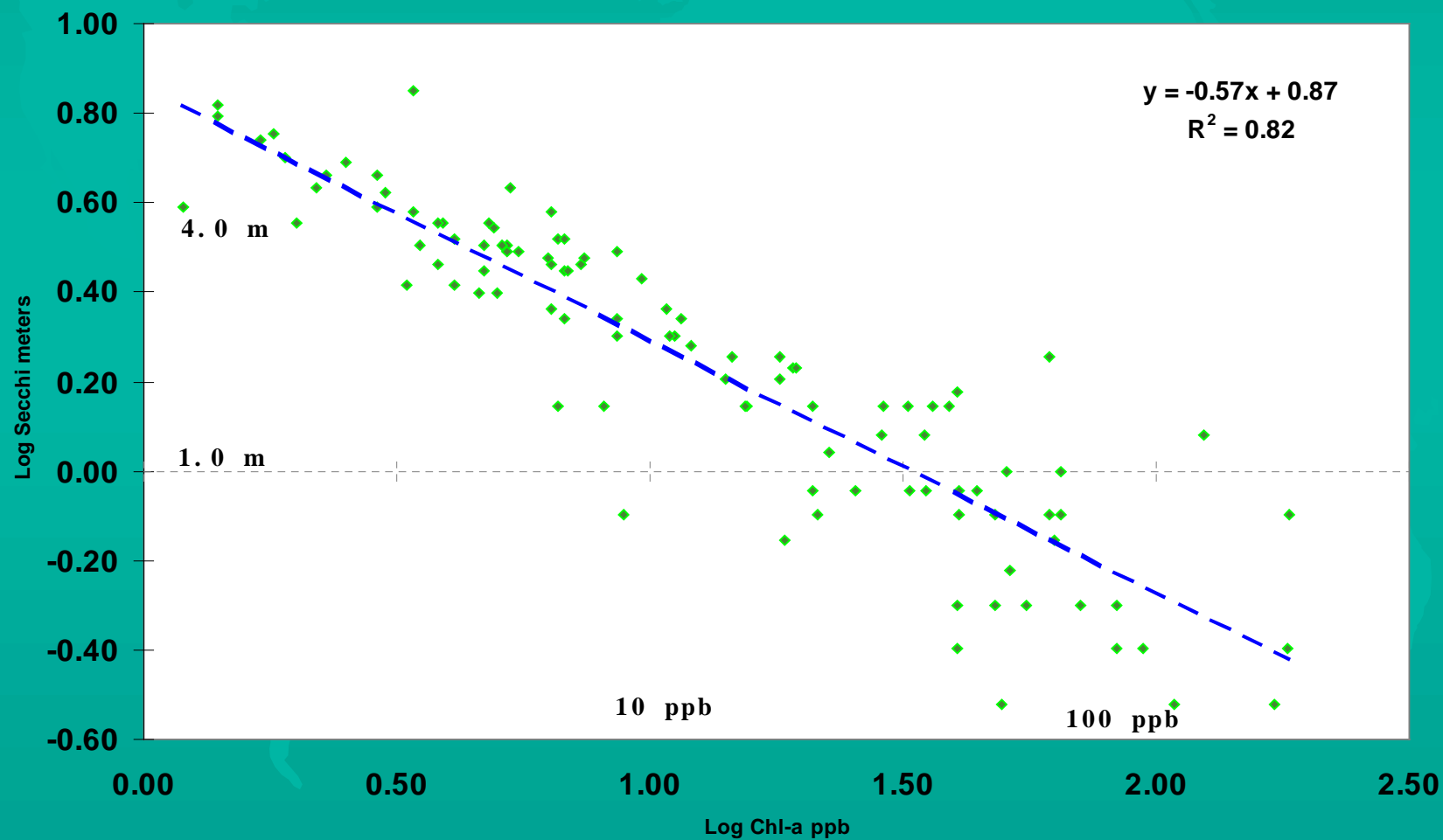
# TP and Chl-a

ECOREGION REFERENCE LAKES  
Mean summer concentrations



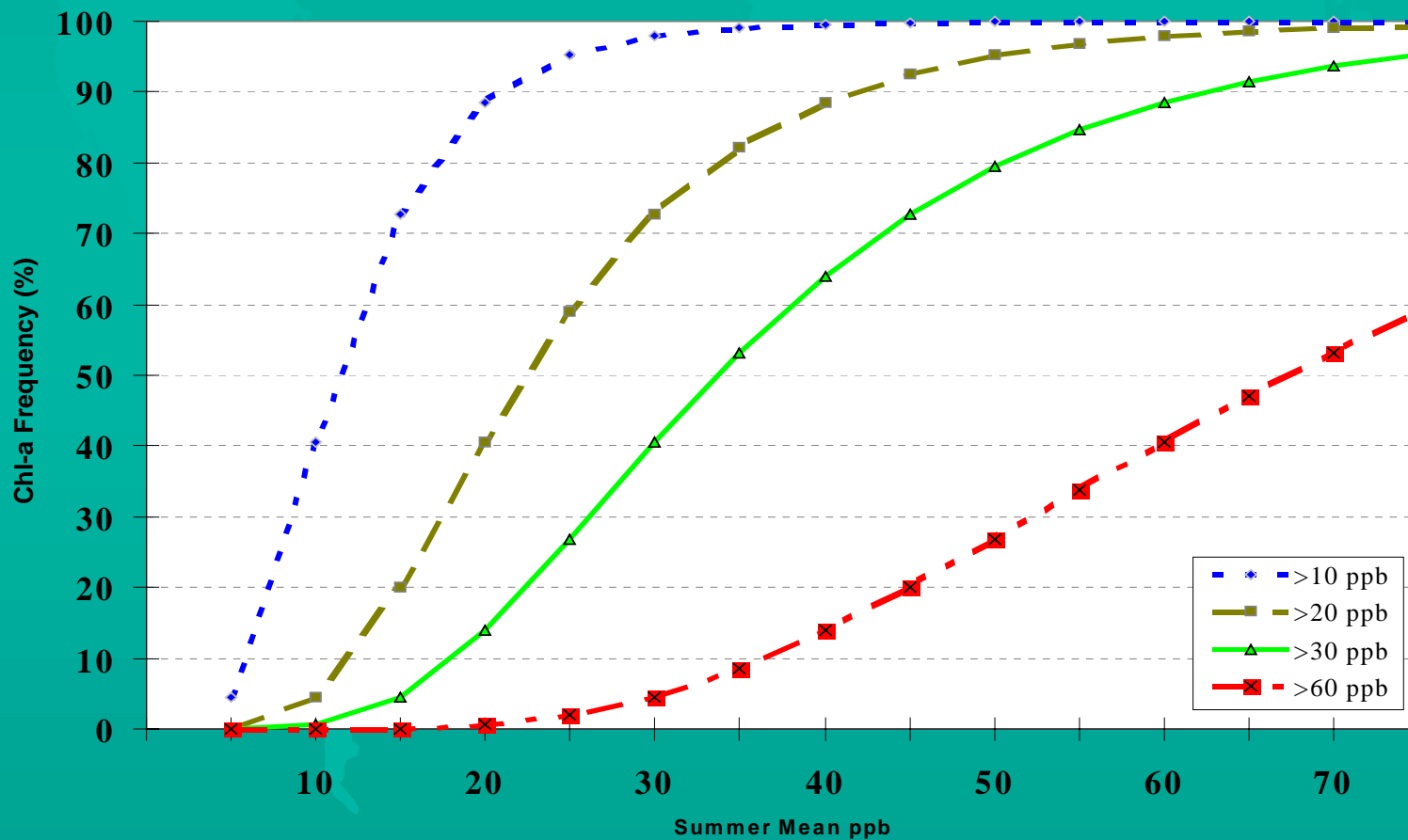
# Chlorophyll-a and Secchi

Summer-mean Secchi vs. Chlorophyll-a (log-log).  
Based on ecoregion reference lakes.



# Algal Bloom Frequency

Chlorophyll-a Bloom Frequency as a Function of Summer Mean. Based on a single season of data (Walker, 1985).



# MN Lake P Criteria

Heiskary and Wilson, 1988

Ecoregion	Most Sensitive Use	P Criteria
<b>Northern Lakes and Forests</b>	drinking water supply cold water fishery primary contact recreation and aesthetics	< 15 µg/L < 15 µg/L < 30 µg/L
<b>North Central Hardwood Forests</b>	drinking water supply primary contact recreation and aesthetics	< 30 µg/L < 40 µg/L
<b>Western Corn Belt Plains</b>	drinking water supply primary contact recreation (full support) (partial support)	< 40 µg/L < 40 µg/L < 90 µg/L
<b>Northern Glaciated Plains</b>	primary contact recreation and aesthetics (partial support)	< 90 µg/L

# Model Statistics

- ◆ Error: Difference between observed and predicted mean value (e.g. standard error);
- ◆ Variability: Considers spatial and temporal fluctuations in concentration about mean;
- ◆ T-test: If absolute value is  $< 2$  the obs. mean is not significantly different than predicted (95 % confidence). Useful for identifying problem lakes.

# Vighi and Chiaudani

## “Background P”

- ◆ Based on MEI -- ratio between TDS and Z, used to estimate fishery yields;
- ◆ Regression based on 53 lakes with negligible anthropogenic P loading;
- ◆  $MEI = \text{alk (meq/L)} / Z$ ;
- ◆ Lakes within the predicted [P] +/- C.I. approach background P;
- ◆ May not work well on ‘naturally eutrophic’

# Applications

- ◆ How is lake doing given its ecoregion and morphometric considerations;
- ◆ Estimates water and nutrient budget;
- ◆ Assesses inter-relationship of TP, Chl-a, and Secchi -- compared to reference;
- ◆ Estimates background P (chl-a and Secchi);
- ◆ One basis for goal setting;

# Goal Setting

1995 mean	Long- term	MIN- LEAP	Vighi -	BATH TUB
24 ± 3	40 ± 4	31	25	26

**Lake Minnewaska Summer-Mean P (ppb)**

- recent summer-mean TP comparable to predicted - at or near “background TP”
- Goal - TP < 30 µg/L (criteria for NCHF ecoregion < 40 µg/L)
- Below 30 µg/L nuisance blooms <5% of summer; 40 µg/L TP - blooms ~ 30 %



# Model Performance

## *Good*

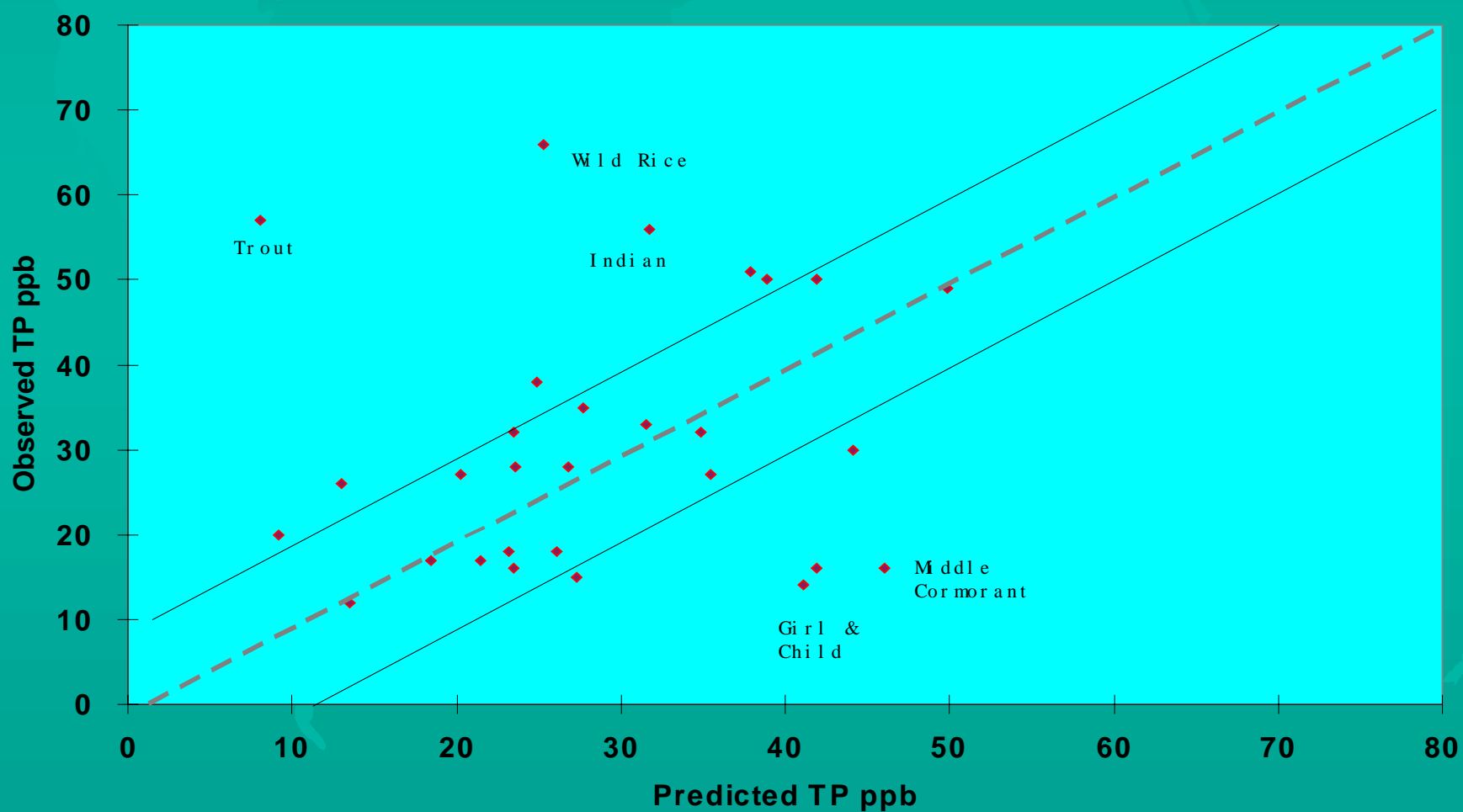
- ◆ Dimictic - NLF, NCHF;
- ◆ No large upstream lakes;
- ◆ Watershed char. similar to norm for ecoregion;

## *Poor*

- ◆ Polymictic WCBP, NGP
- ◆ high internal recycle, high turbidity;
- ◆ Seepage lakes
- ◆ Chains of lakes -- upstream sedimentation;

# MINLEAP Predicted vs Observed

Confidence interval = mean std. error of observed data.



# Conclusions and Recommendations

- ◆ Simple model - first cut analysis;
- ◆ Rough estimate of nutrient and water budgets;
- ◆ Tool to flag lakes that may deserve additional study -- relative to others in ecoregion;
- ◆ Basis for communicating lake response and estimating response to change in load;
- ◆ One basis for goal setting -- along with Vighi, P criteria, observed data, and related;