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

Steven Heiskary,

Environmental Research Scientist

Minnesota Pollution Control Agency

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

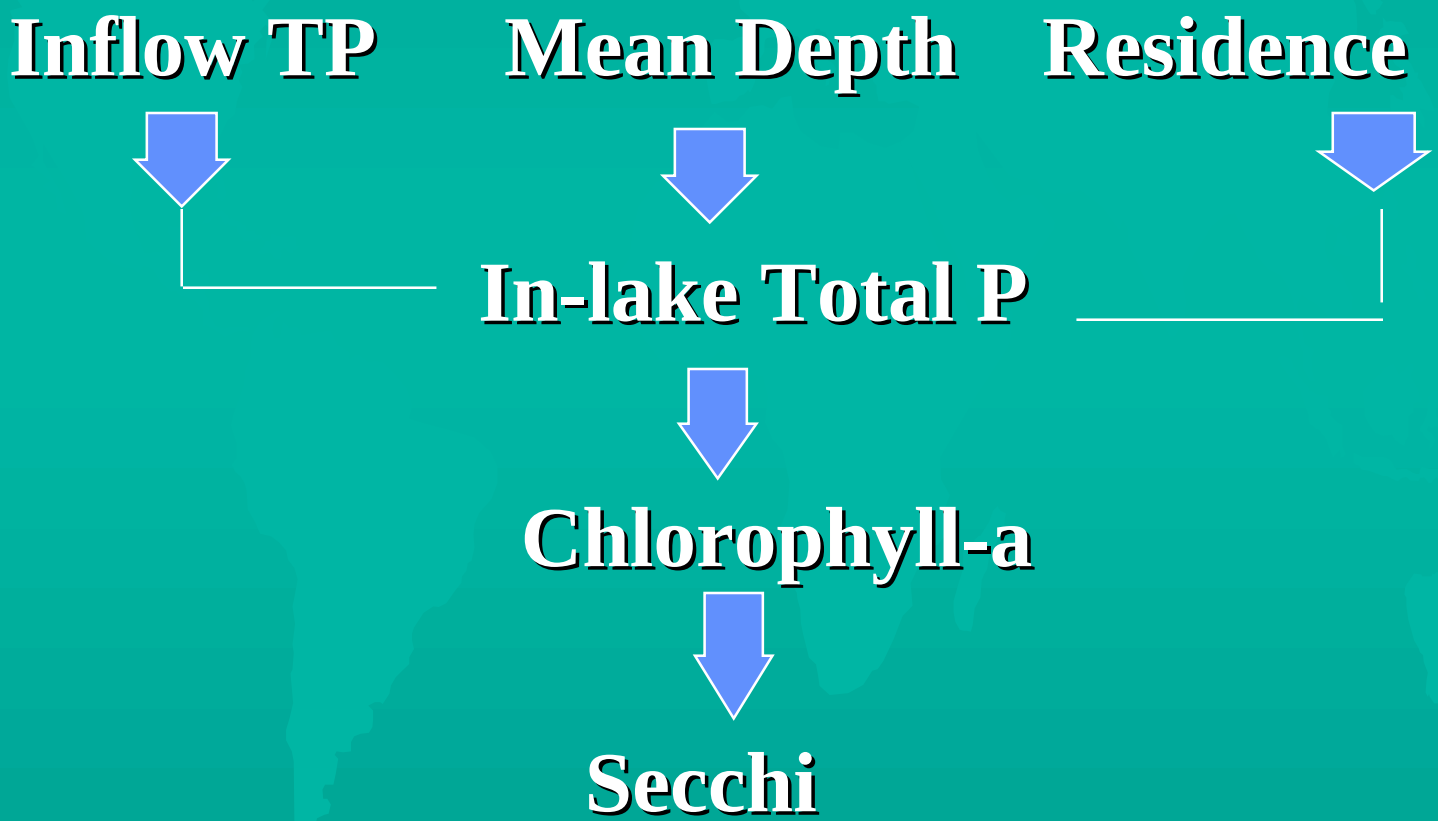
- Loading and using MINLEAP
- Case Studies;

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;

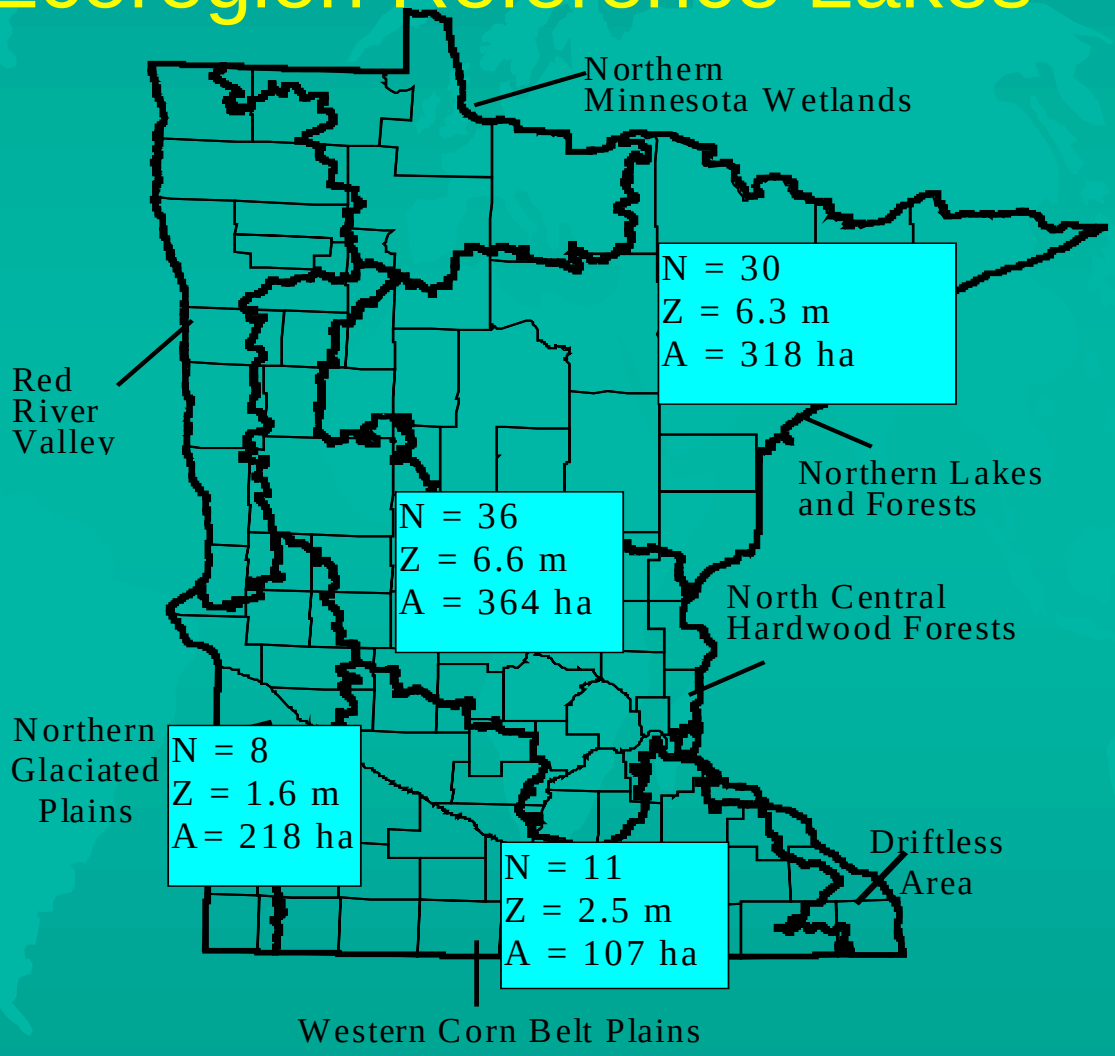
Typical Empirical Model Network



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 sedmentation model used;
- TP, Chl-a, and Secchi models based on MN reference lakes;

Ecoregion Reference Lakes



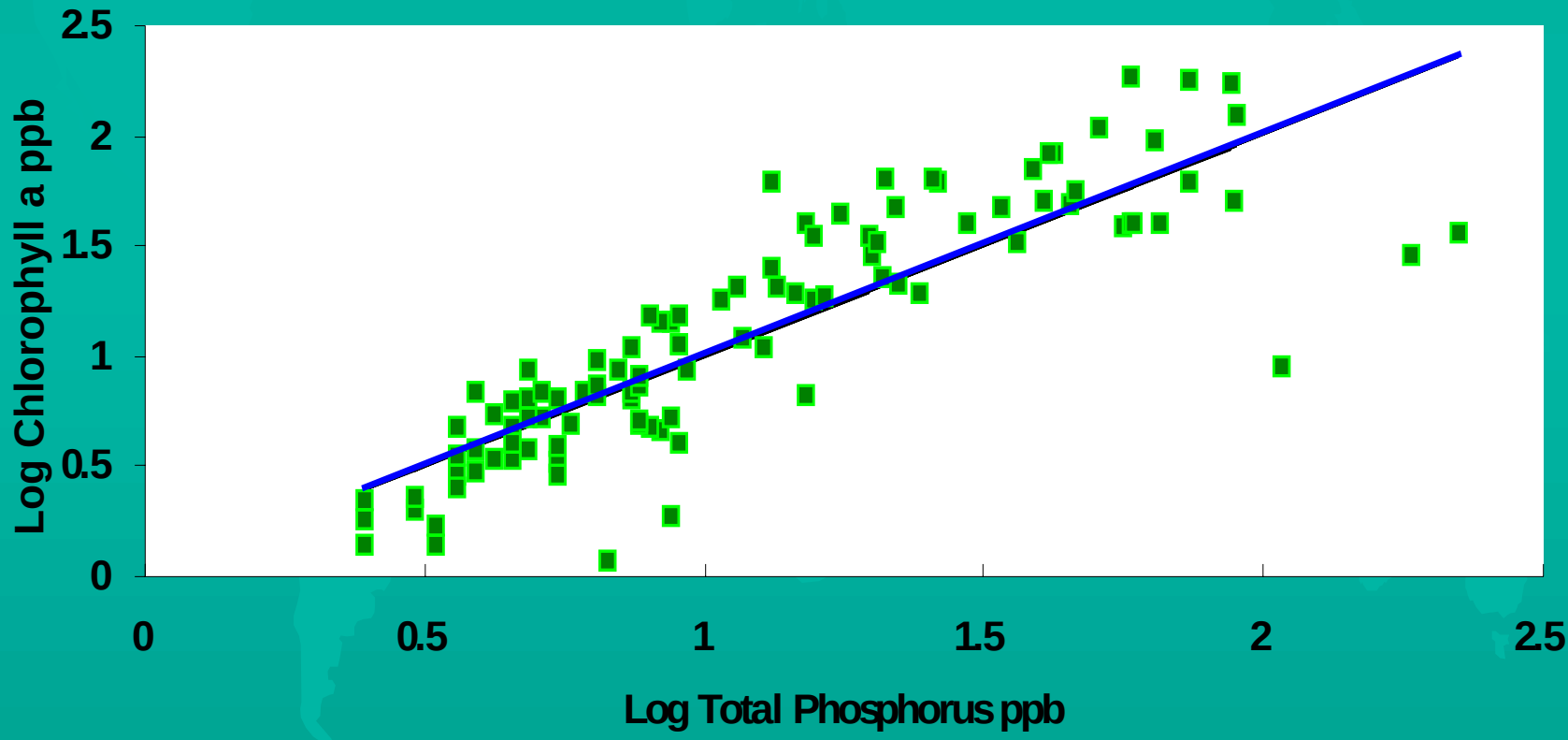
Distribution of Phosphorus by Lake Mixing Status and Ecoregion

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 %	**37**	53	57	**104**	263	344	--	--	284
75 %	**29**	35	39	**58**	100	161	**101**	195	211
50 %	**20**	26	29	**39**	62	89	**69**	135	141
25 %	**13**	19	19	**25**	38	50	**39**	58	97
10 %	**9**	13	12	**19**	21	32	**25**	--	69
# of obs.	257	87	199	152	71	145	4	3	38

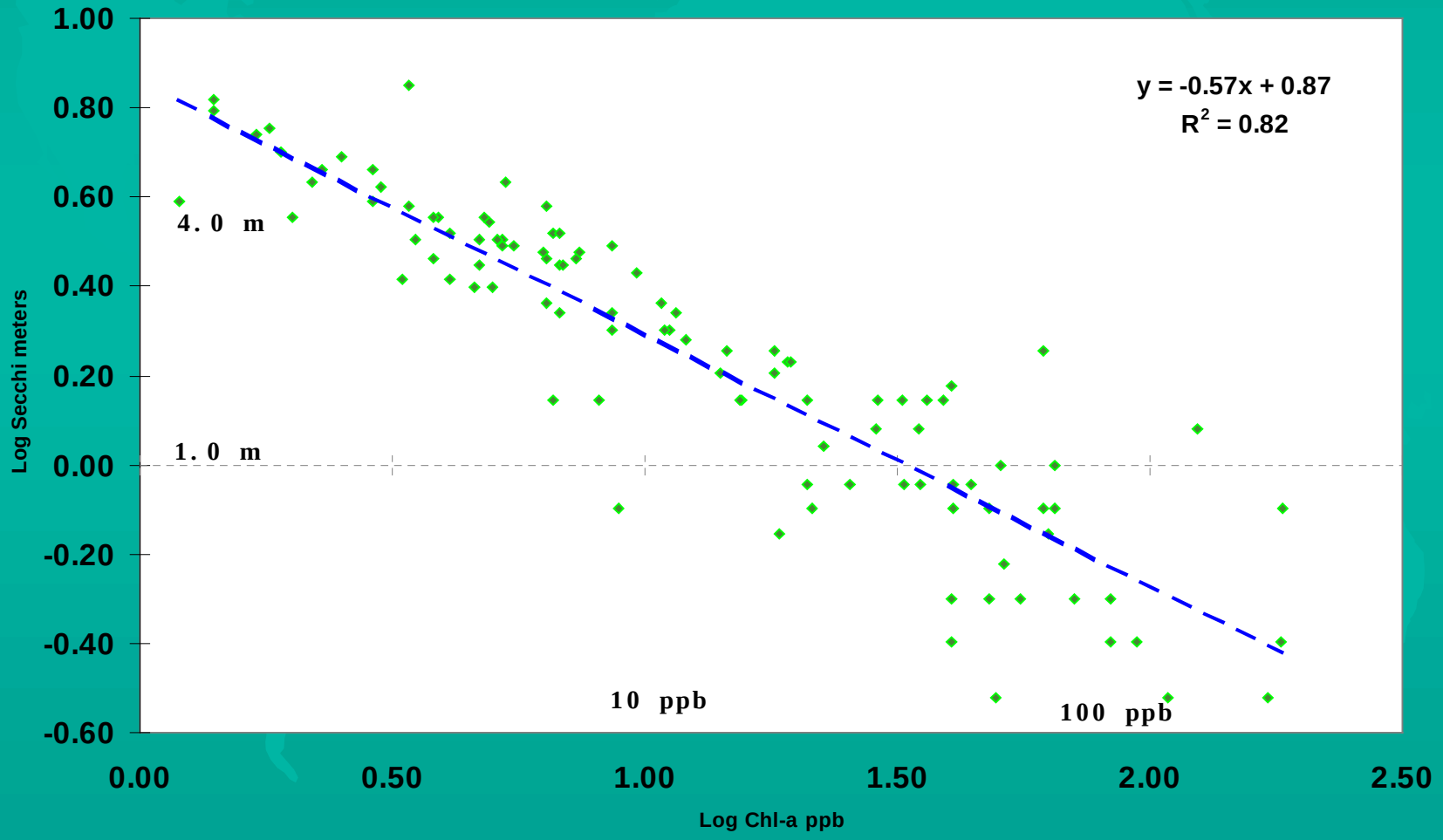
TP and Chl-a

ECOREGION REFERENCE LAKES
Mean summer concentrations



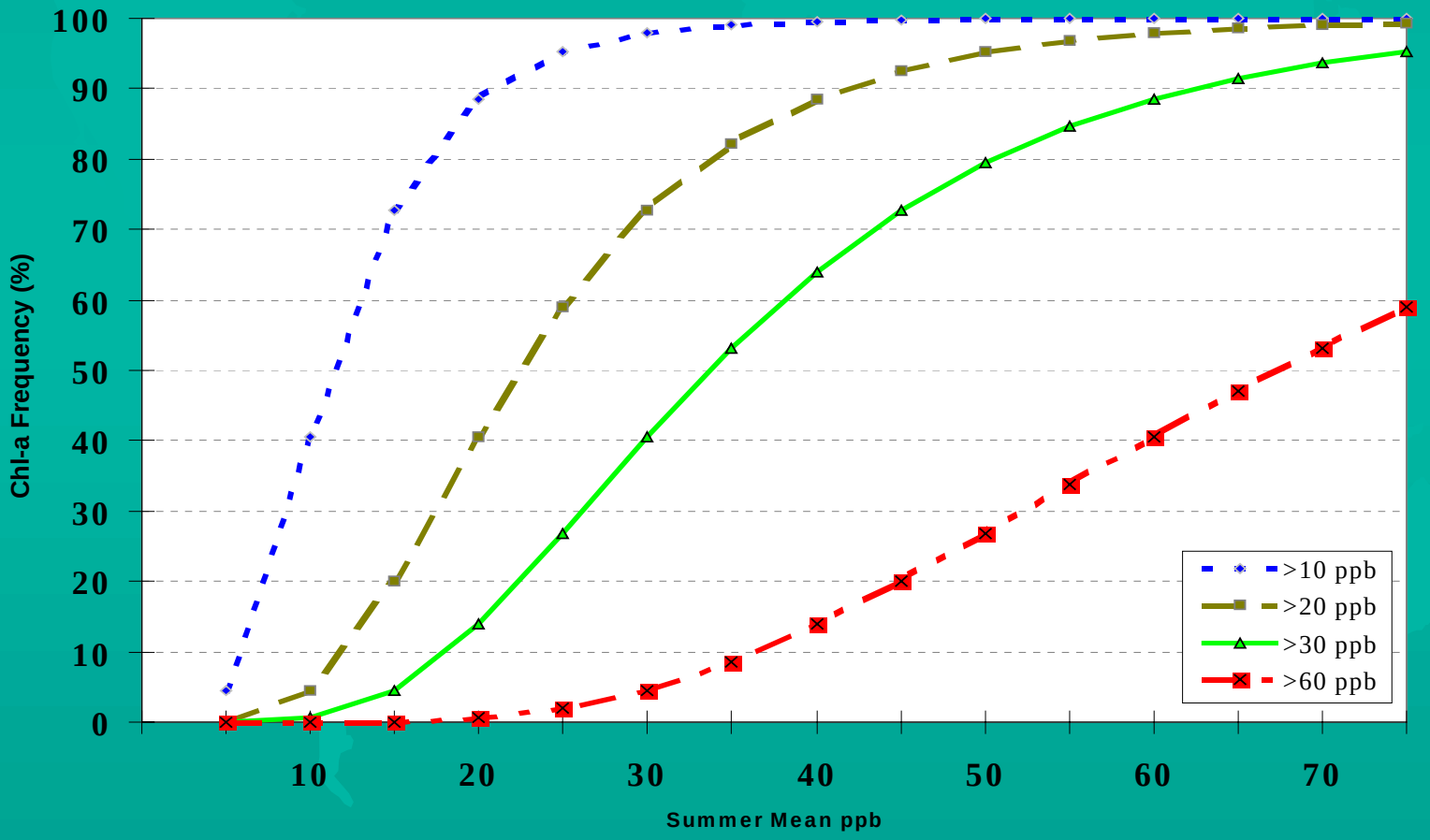
Chlorophyll-a and Secchi

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
Northern Lakes and Forests	drinking water supply cold water fishery primary contact recreation and aethetics	**< 15 µg/L** **< 15 µg/L** **< 30 µg/L**
North Central Hardwood Forests	drinking water supply primary contact recreation and aesthetics	**< 30 µg/L** **< 40 µg/L**
Western Corn Belt Plains	drinking water supply primary contact recreation (full support) (partial support)	**< 40 µg/L** **< 40 µg/L** **< 90 µg/L**
Northern Glaciated Plains	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 = 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 (chla and Secchi);
- One basis for goal setting;

Goal Setting

1995 mean	Long-term	MIN-LEAP	Vighi -	BATHTUB
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

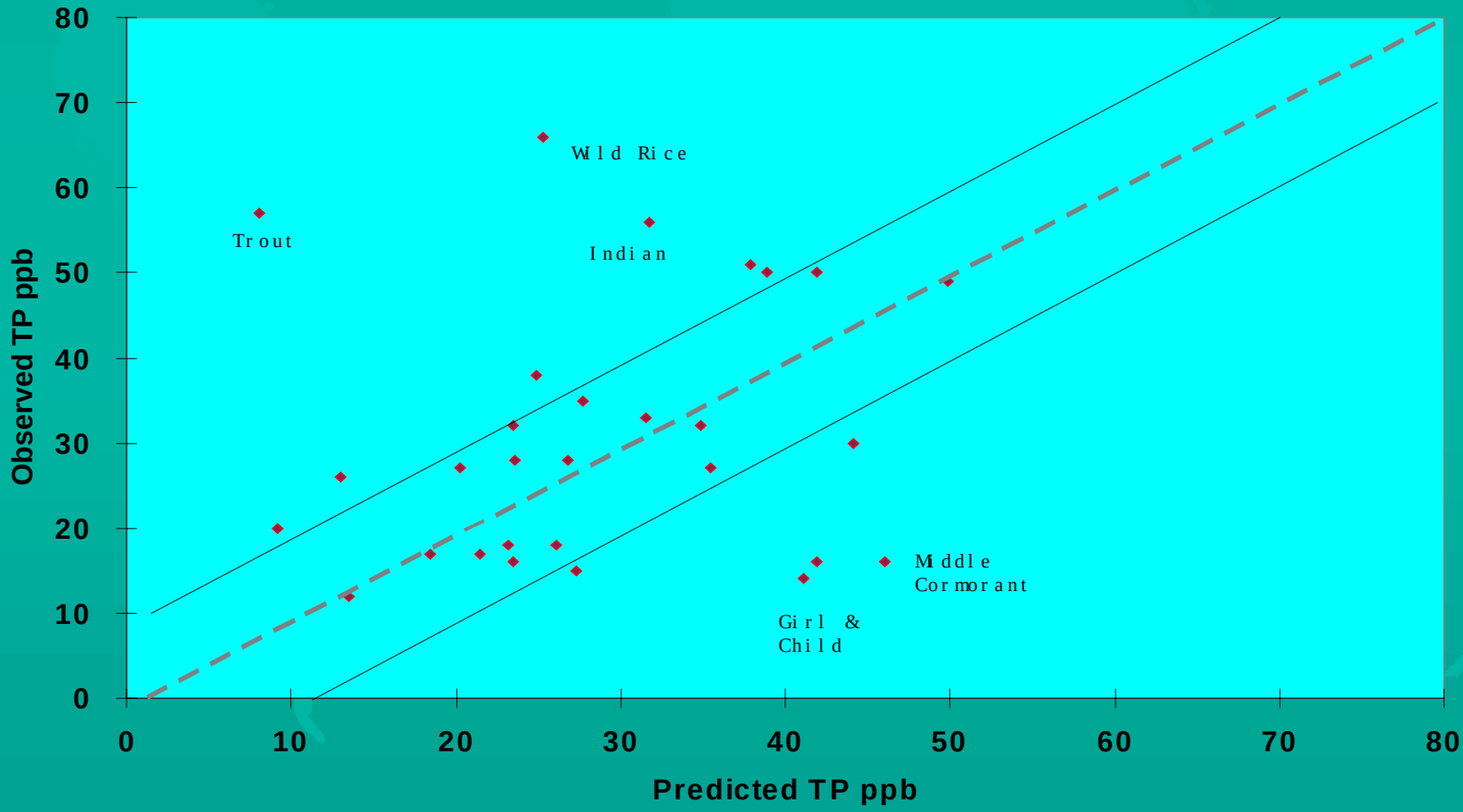
- **Dimictic - NLF, NCHF;**
- **No large upstream lakes;**
- **Watershed char. similar to norm for ecoregion;**

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;