

**Relating Water Quality to
Catchment Characteristics in the
Tahoe Basin:
A TMDL Progress Report**



Acknowledgements

- SWRCB Staff

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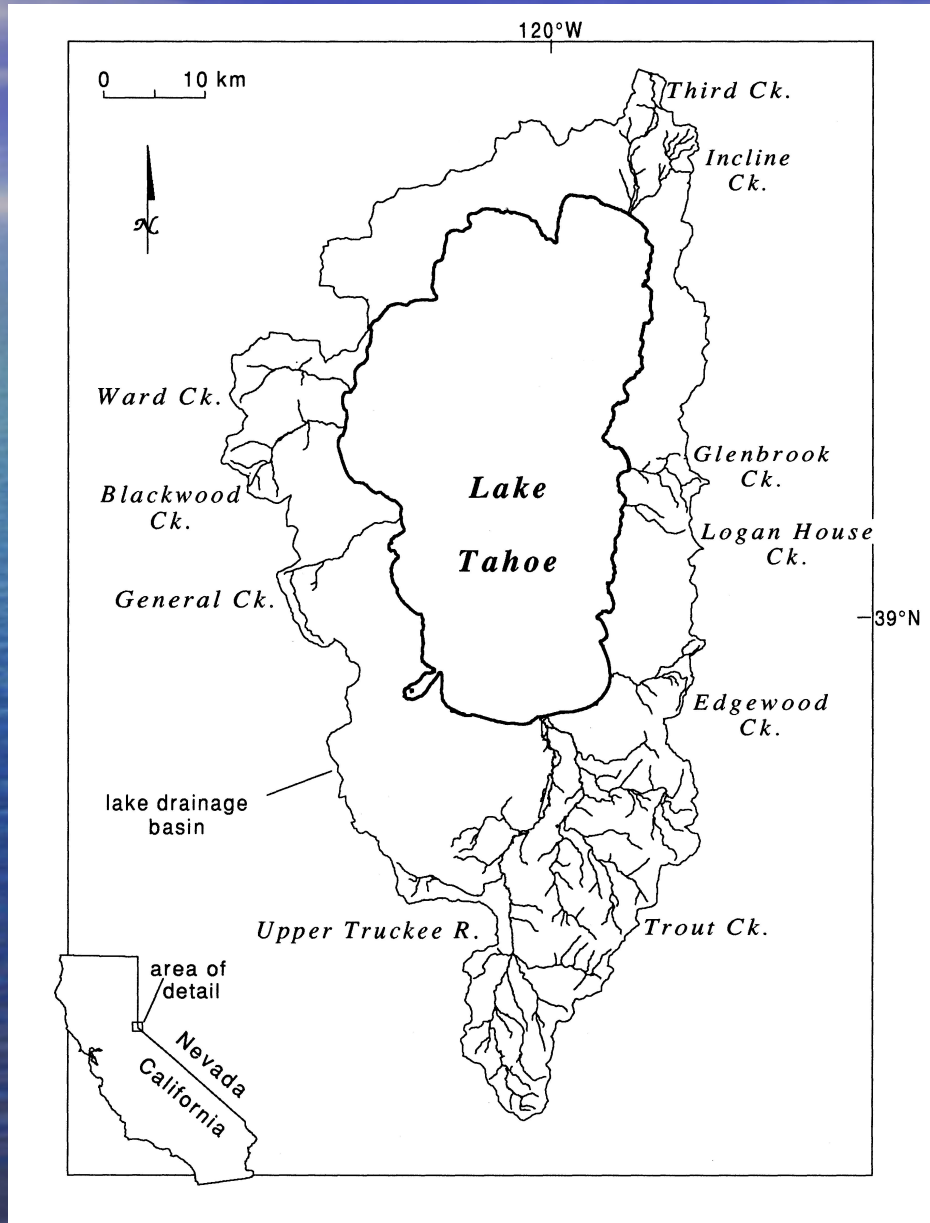
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John Tracy

Objectives

- To develop quantitative relationships between water quality and catchment attributes
 - Help target problem areas for action
 - Provide a quantitative basis for estimating total basin loads
 - Help develop methods for monitoring
- Provide input and a reality check for the TMDL water quality model



The LTIMP Watersheds



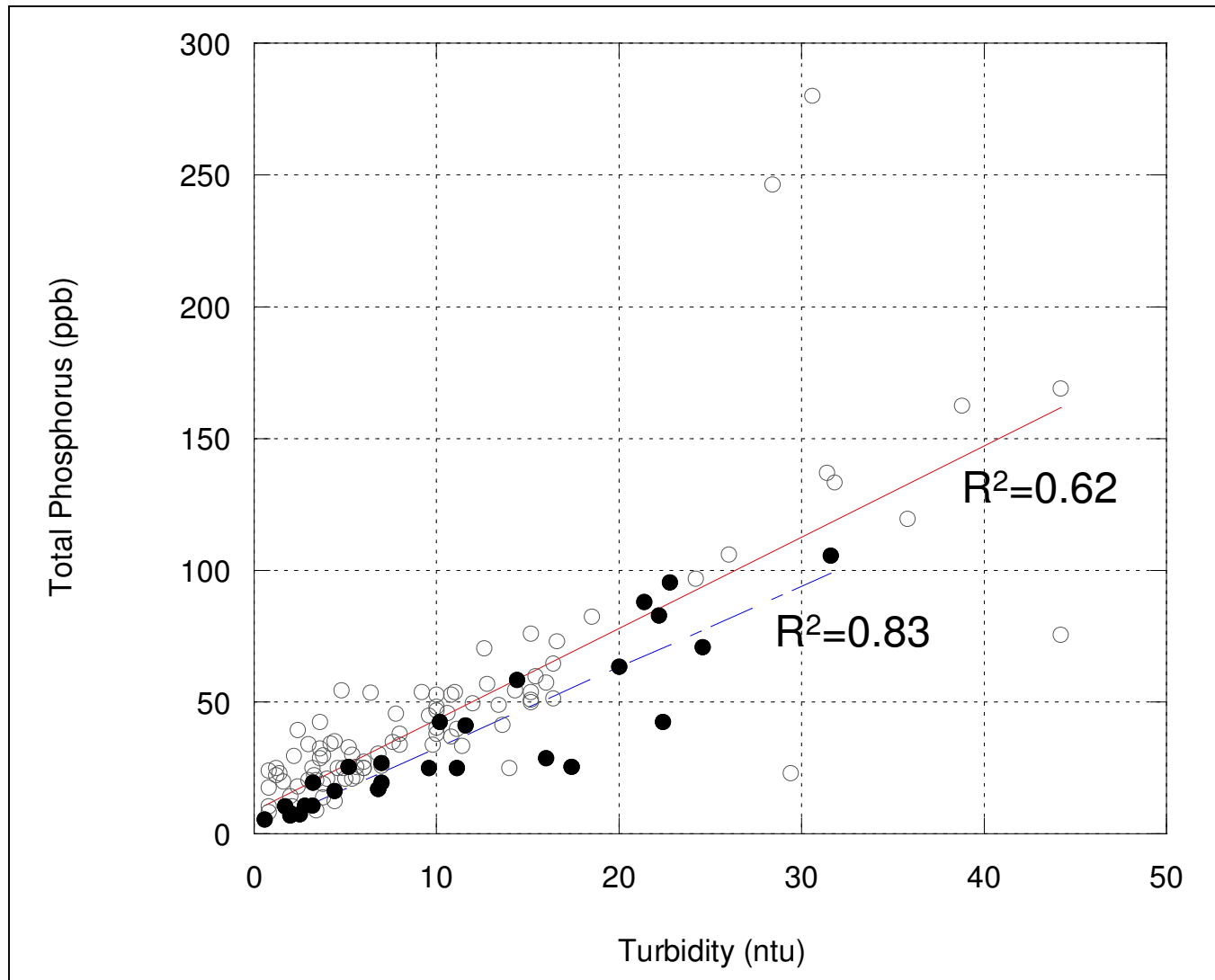
Dependent Variables--Derived from LTIMP Data

- Discharge-weighted mean concentration at 20 stations, 1993-2000
 - At a station:
$$(\sum Q_i C_i) / \sum Q_i$$
 - Between stations:
$$\sum (Q_{i2} * C_{i2} - Q_{i1} * C_{i1}) / \sum (Q_{i2} - Q_{i1})$$
- Total and Ave. Ann. Load, for 20 stations, 1990-2001
 - Period-weighted sample method, for dissolved constituents
 - Regression method for suspended sediment
 - Regression for TP and TKN if $R^2 > 0.6$; otherwise PWS method



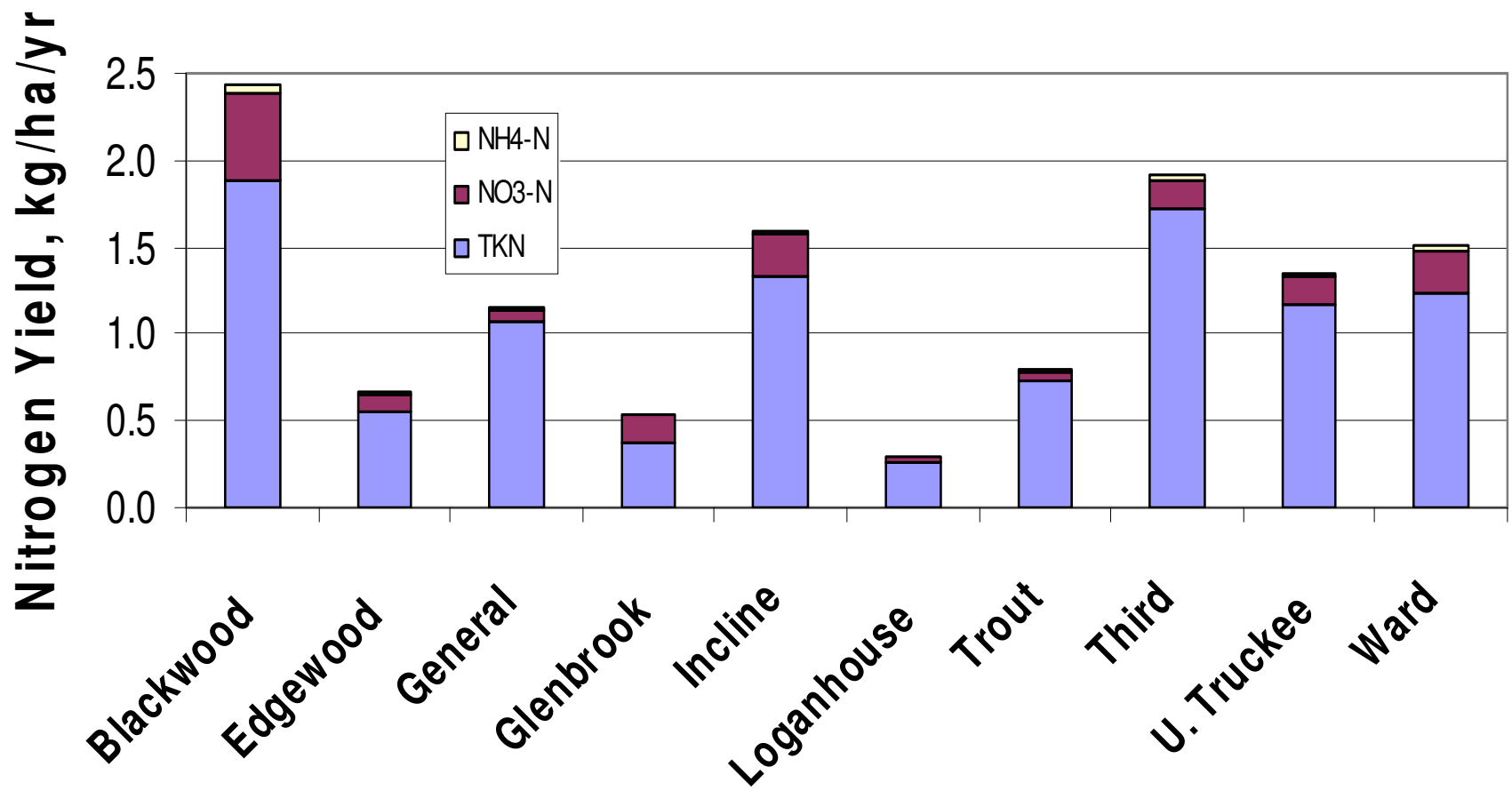
Forestry Suppliers, Inc.
1-800-647-5368
#49352 Field Book

Model: OBS-3
Max. Depth: 500m
D&A Instrument Company
Made in the USA
S/N: 1729

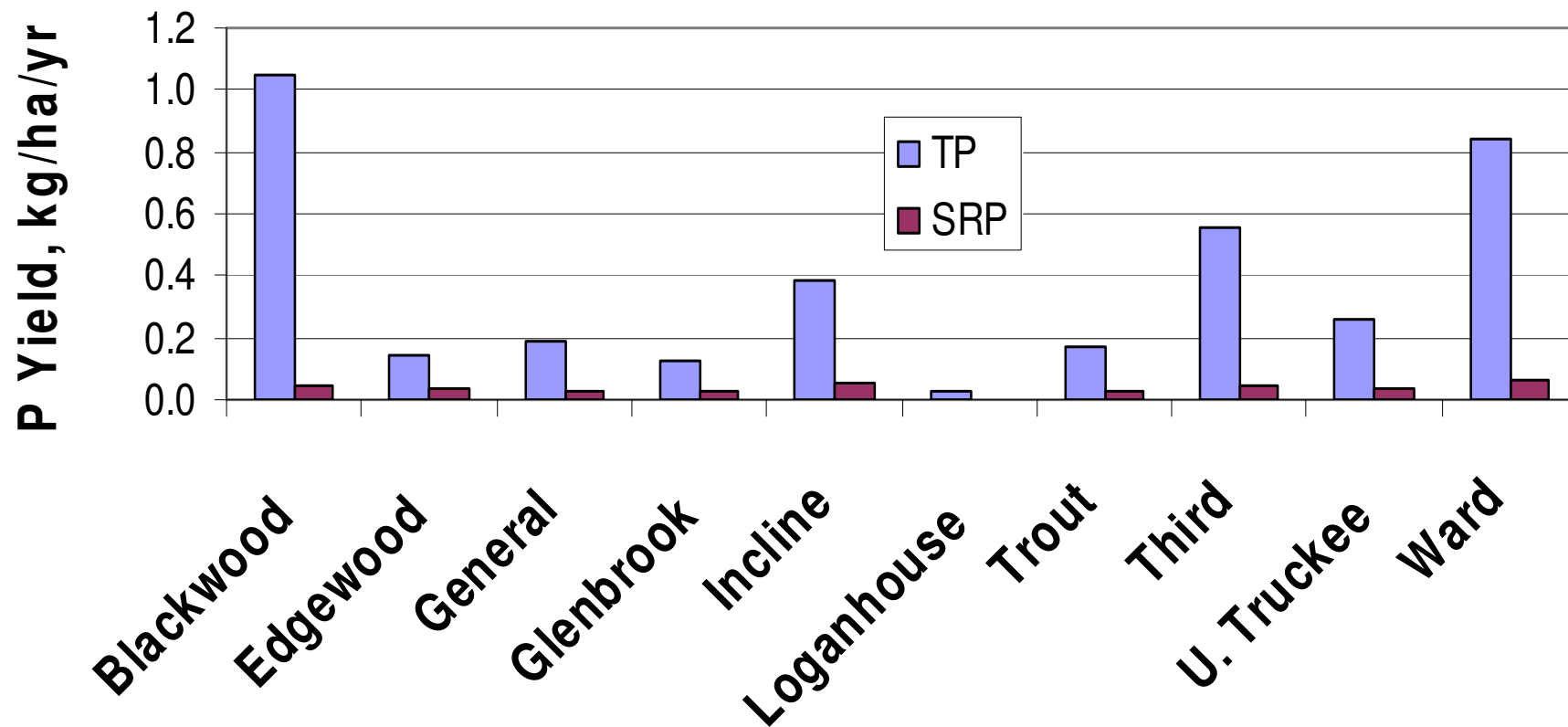


Relationships between turbidity and TP, 1999-2001 snowmelt periods. Open circles for Ward Cr.; filled circles for Blackwood Cr. (Stubblefield et al. 2004)

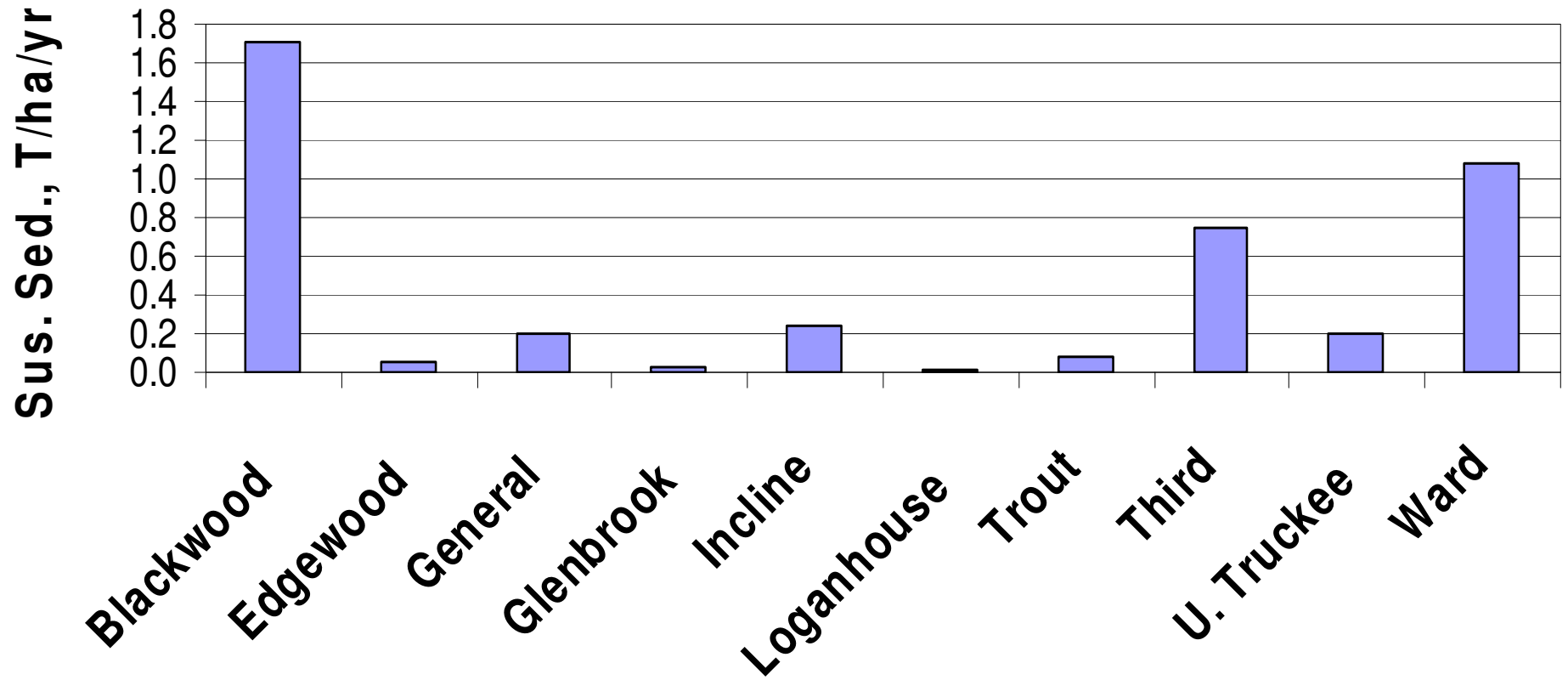
Average Annual Nitrogen Yield by Watershed, 1990-2001



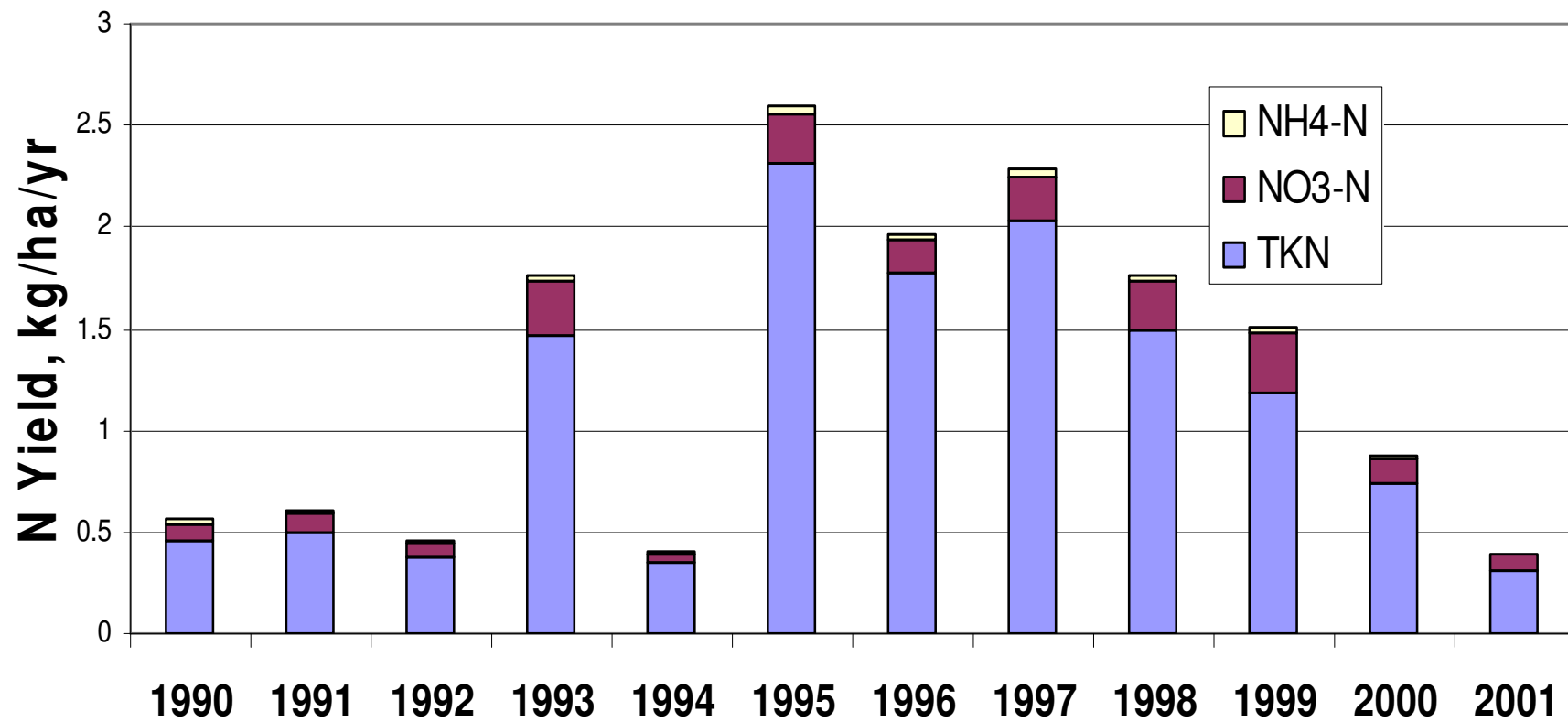
Average Annual Phosphorus Yield, 1990-2001



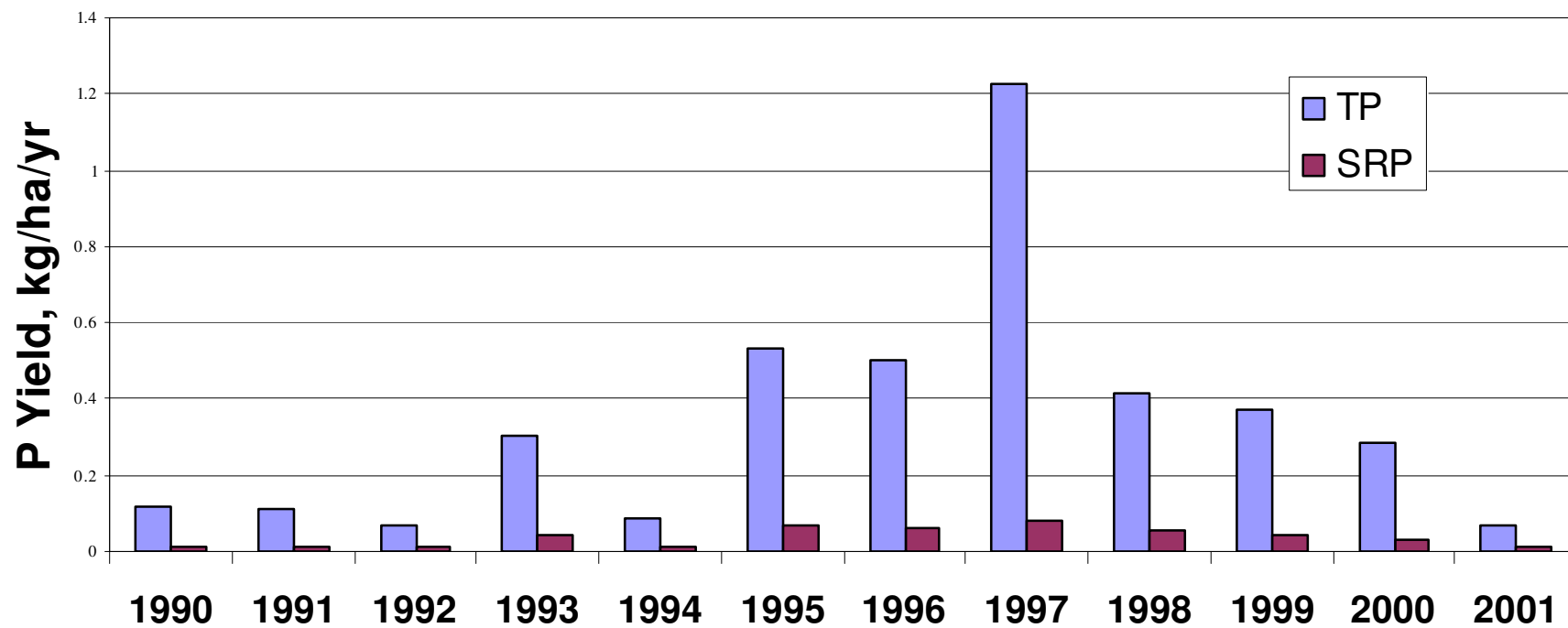
Mean Annual Suspended Sediment Yield, 1990-2001



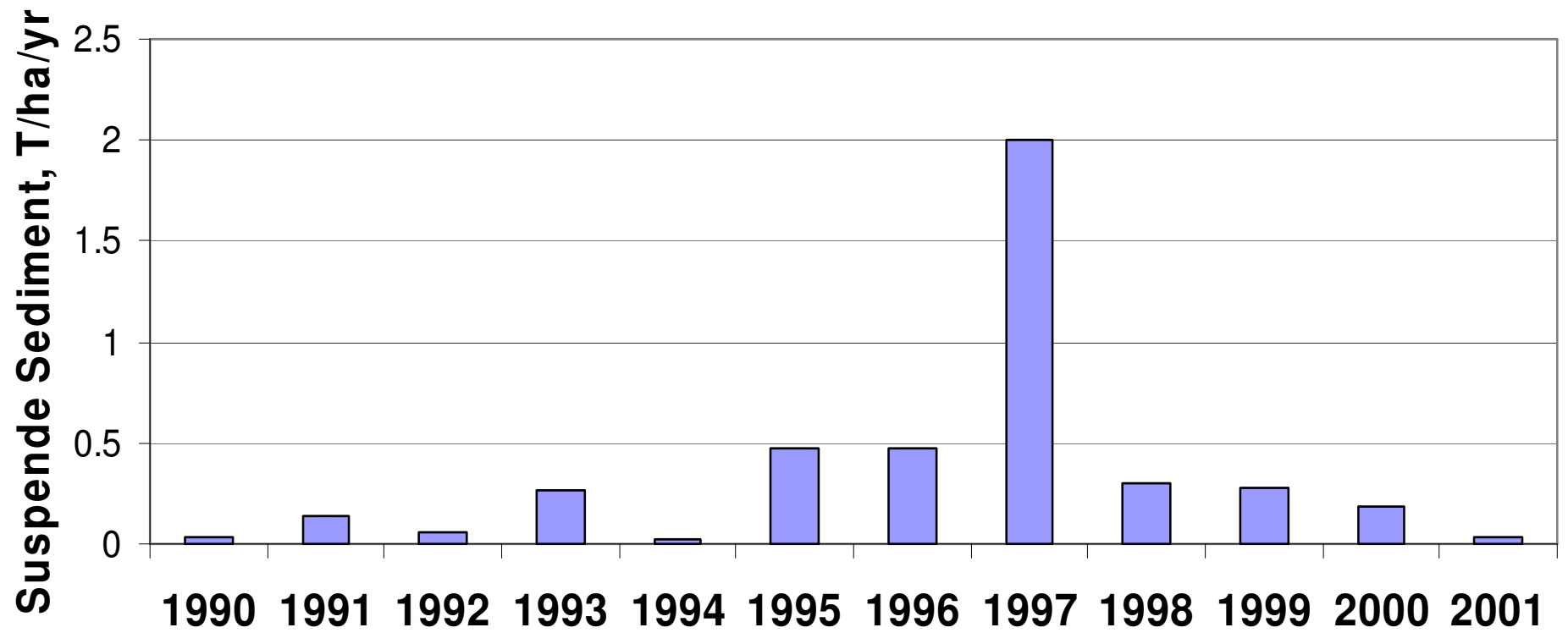
Nitrogen Yield from LTIMP Watersheds



Phosphorus Yield from LTIMP Watersheds



Suspended Sediment Yield from LTIMP Watersheds



Independent Variables—from GIS

- Hydrology
 - Mean ann. Precip. (cm)
 - River density (km/km²)
 - Alluvial & Riparian Rivers (pct.)
- Geology/soils/geomorph
 - Volcanic soils (pct.)
 - Granitic Soils (pct)
 - Area-wtd. Site Class
 - Unwtd. Ave. slope
 - Flowpath-wtd. Slope
- Land Use
 - Low-intensity residential (pct.)
 - Commercial/indust. (pct)
 - Hazard class by land use (pct)
 - Unimp. Dirt roads (km/km²)
 - Residential roads (km/km²)
 - State/Fed. Highways (km/km²)
 - Impervious surface (pct.) from IKONOS data, by land use category
 - Precip. X Dirt Roads interaction

Results of Multiple Regressions of Q-wtd. Mean Concentration vs. Watershed Characteristics, for 19 catchments, 1993-2000

	REGRESSION COEFFICIENTS			
	NH4-N	TKN	NO3-N	SRP
Multiple R ² =	0.67	0.64	0.85	0.65
Area, sq km	-	-		-
Mean Ann. Precip, cm	-	-		-
River density, Km/sq km	-	+	+	
Riparian rivers, percent	+			
Alluvial rivers, percent	+		-	
Percent volcanic soils	-		+	
Percent granitic soils		-		
Average slope, percent	+		+	
Area-wtd. Soil index		-		
ln(Area-wtd soil index)	-	+	+	-
Low-intensity residential, percent of area	+			+
Comm./Indust./Trans. Pct area	+		+	+

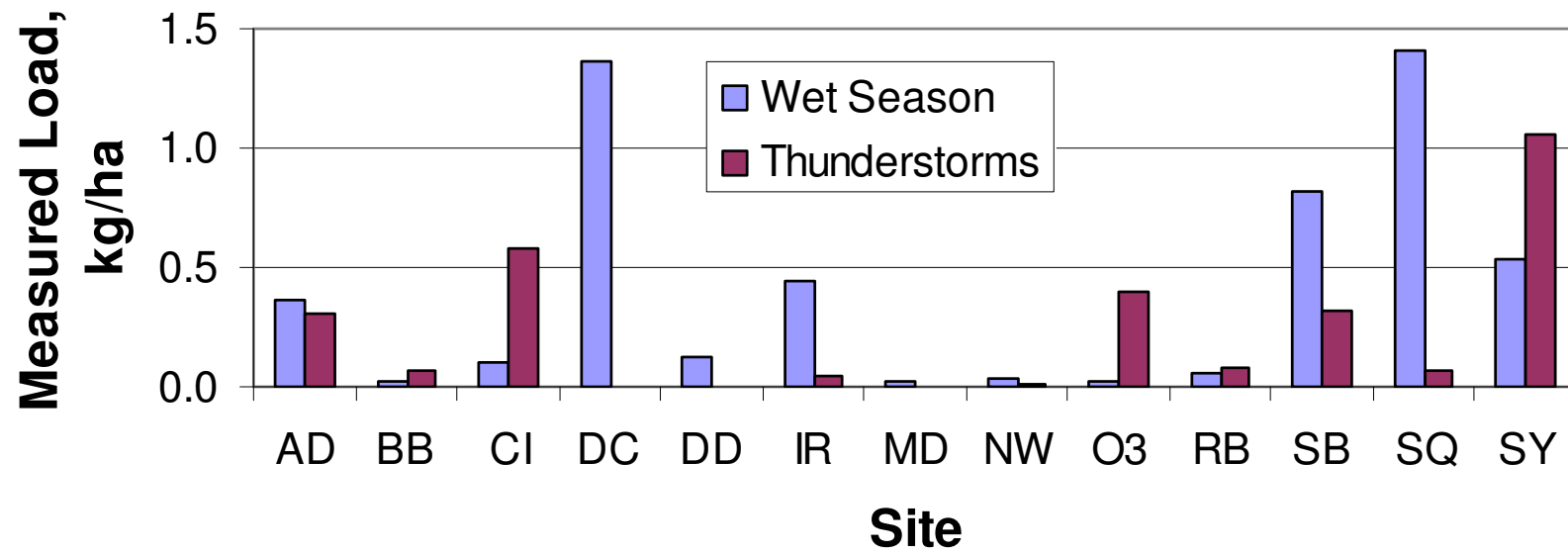
Regression of Constituent Loads (kg/ha/yr) vs. Watershed Characteristics

	WATER QUALITY CONSTITUENT					
	NH ₄ -N	NO ₃ -N	TKN	SRP	TP	SS
Basis	MR	PCA/MR	MR	MR	PCA/MR	PCA/MR
R²	0.70	0.61	0.88	0.60	0.65	0.40
Area				-	+	+
Mean Ann. Precip.	+	+			-	+
River Density					+	+
Riparian Rivers	+	+			-	+
Alluvial Rivers		+		+	-	-
Pct. Volcanic		-			-	-
Pct. Granitic		+	-		-	-
Wtd. Slope					+	+
Soil Index		-	-	-	-	-
Turf					-	-
Pct. Imp., C/I	+					
Pct. Imp., non-Hiwy		+	+	+	+	+
Pct. Imp., Hiway		+				
Dirt Roads		-			+	
Dirt Roads X Precip			+		+	

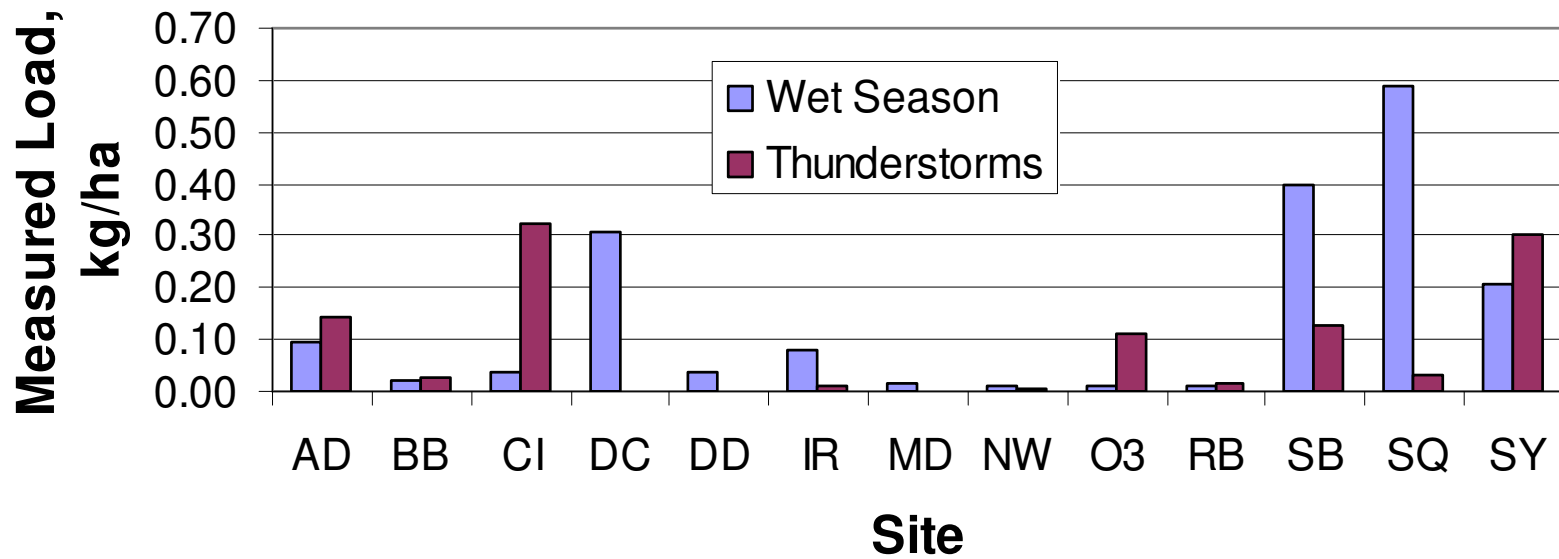
**WHEN CANDIDATE
EXPLANATORY
VARIABLES
ARE CORRELATED,
THERE IS MORE THAN
ONE SOLUTION**

**CORRELATION
DOES NOT
PROVE
CAUSATION**

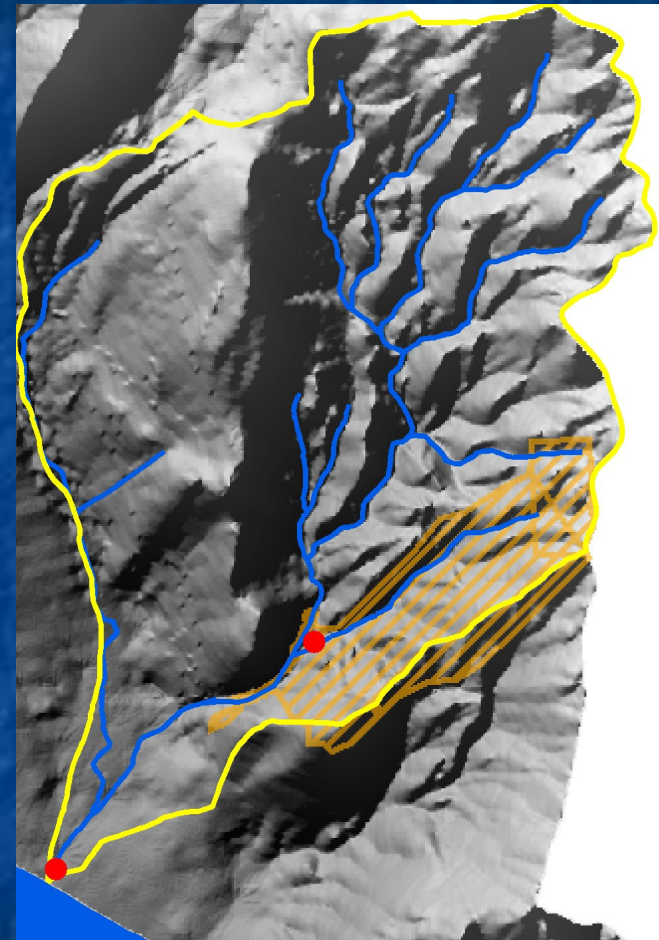
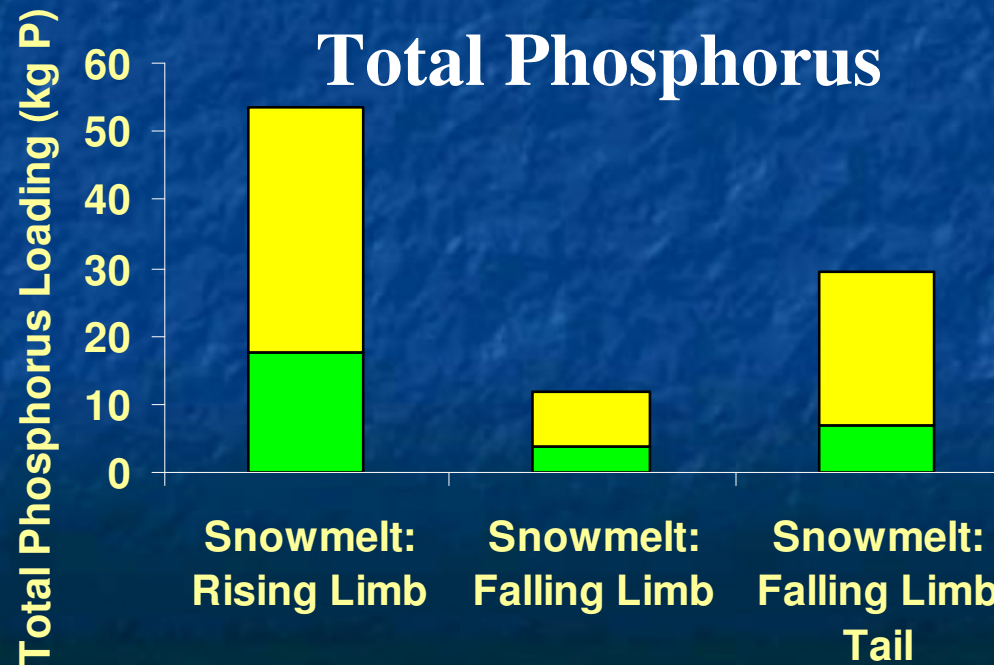
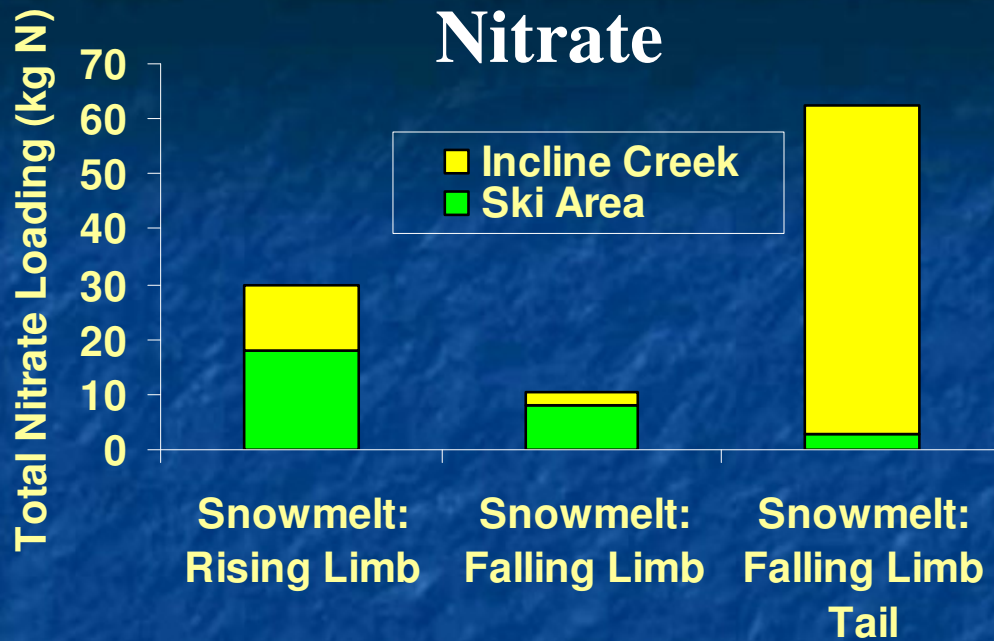
Total KjedahI N Loads, SWM Sites, 2003 WY



Total P Loads, SWM Sites, 2003 WY



Incline Creek Watershed: Contribution of Ski Creek



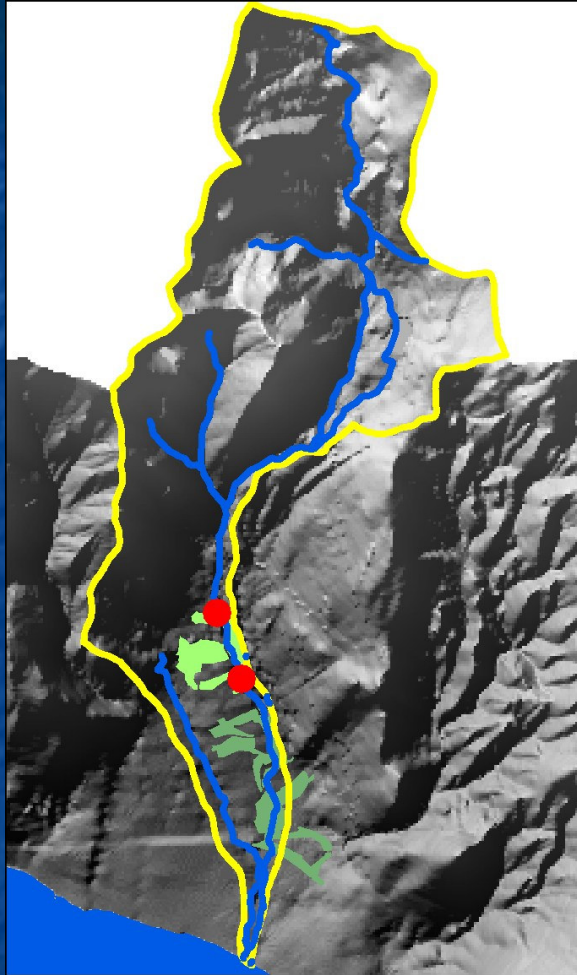
2004 Snowmelt Season

Rising Limb: 4/22-5/6

Falling Limb: 5/7-5/19

Falling Limb Tail: 5/20-6/14

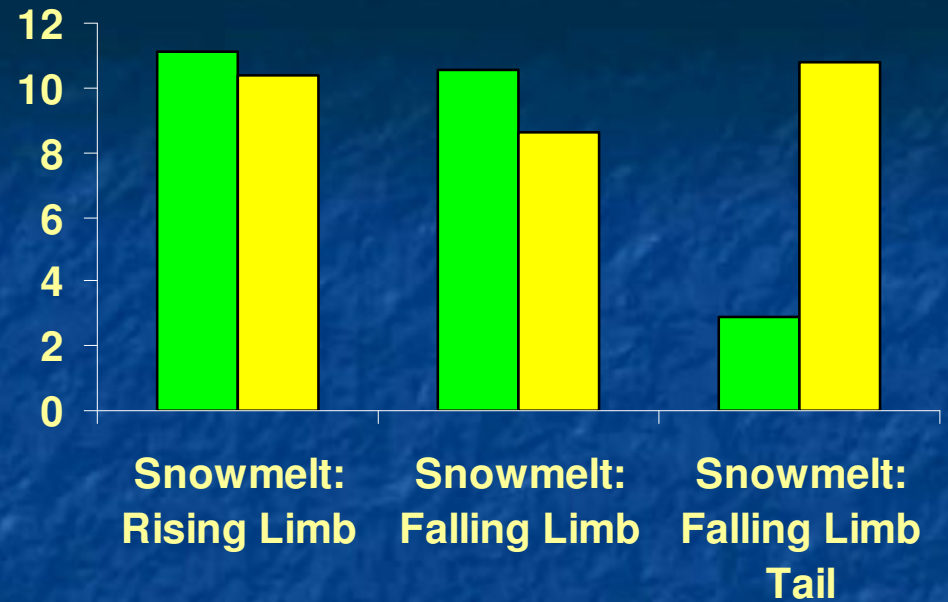
Third Creek Watershed: Above and Below Golf Course



2004 Snowmelt Season	
Rising Limb:	4/22-5/6
Falling Limb:	5/7-5/19
Falling Limb Tail:	5/20-6/14

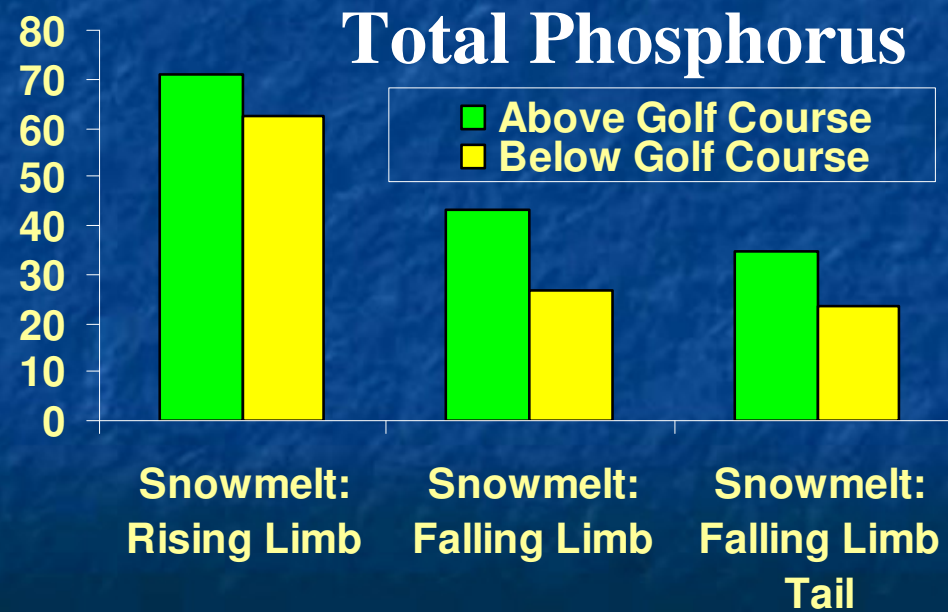
Total Nitrate Loading (kg N)

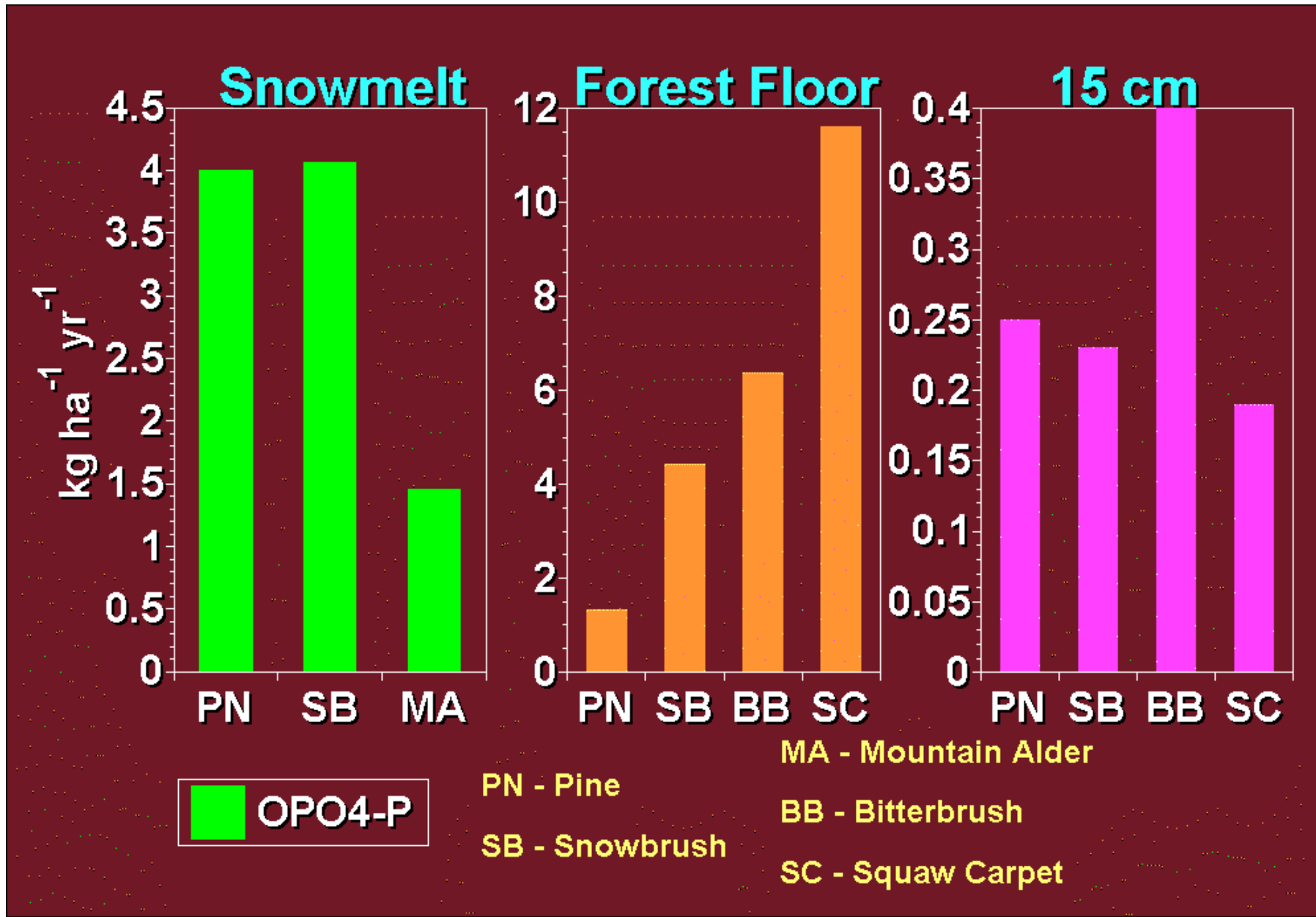
Nitrate



Total Phosphorous Loading (kg P)

Total Phosphorus

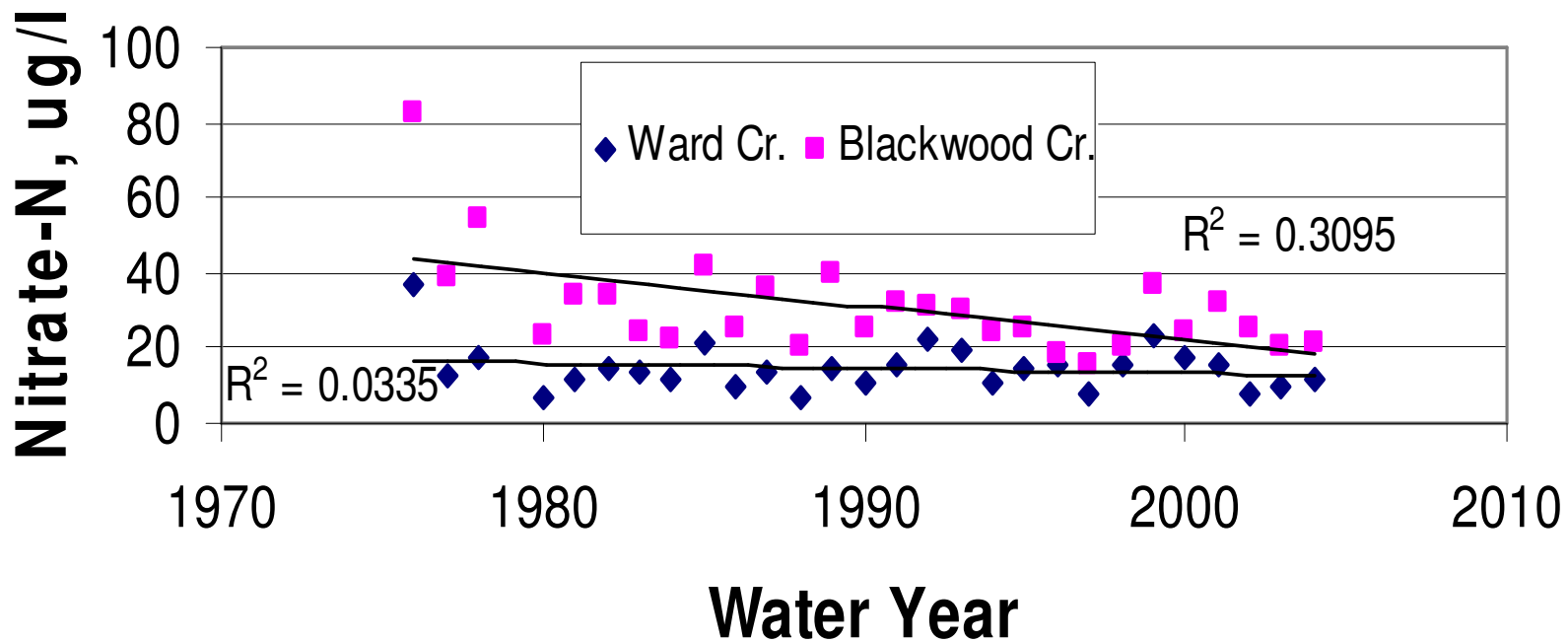




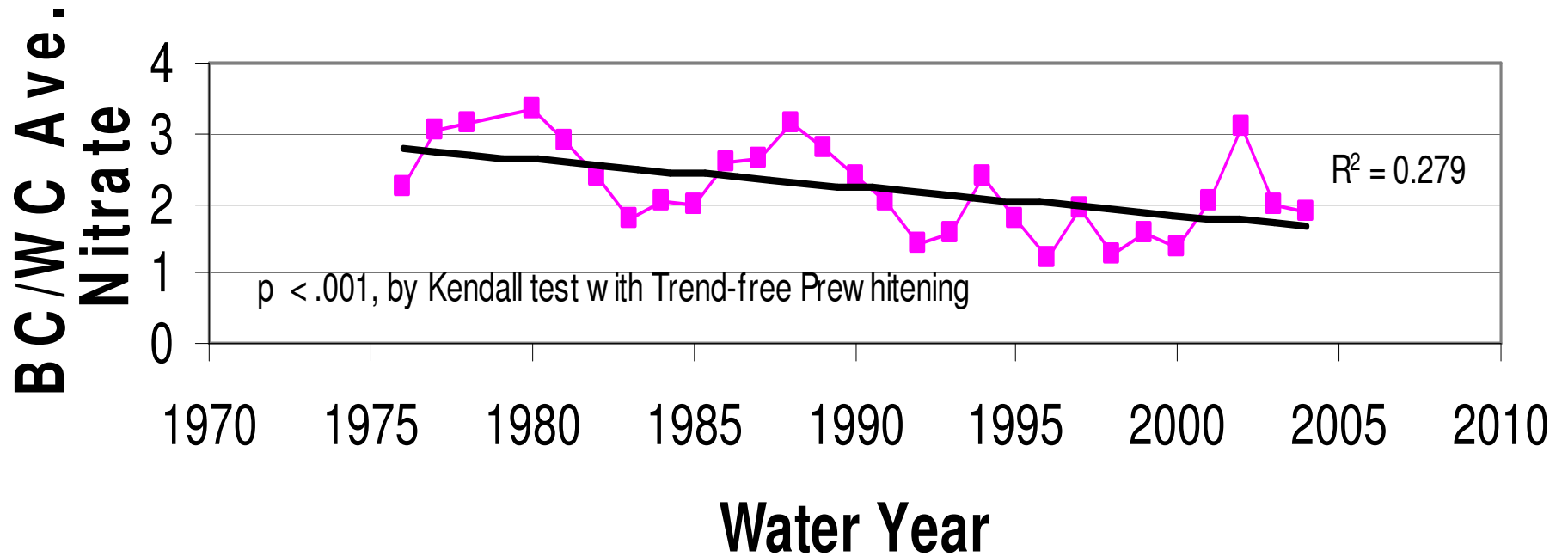




Ave. Ann. NO3-N Conc (unwtd.)

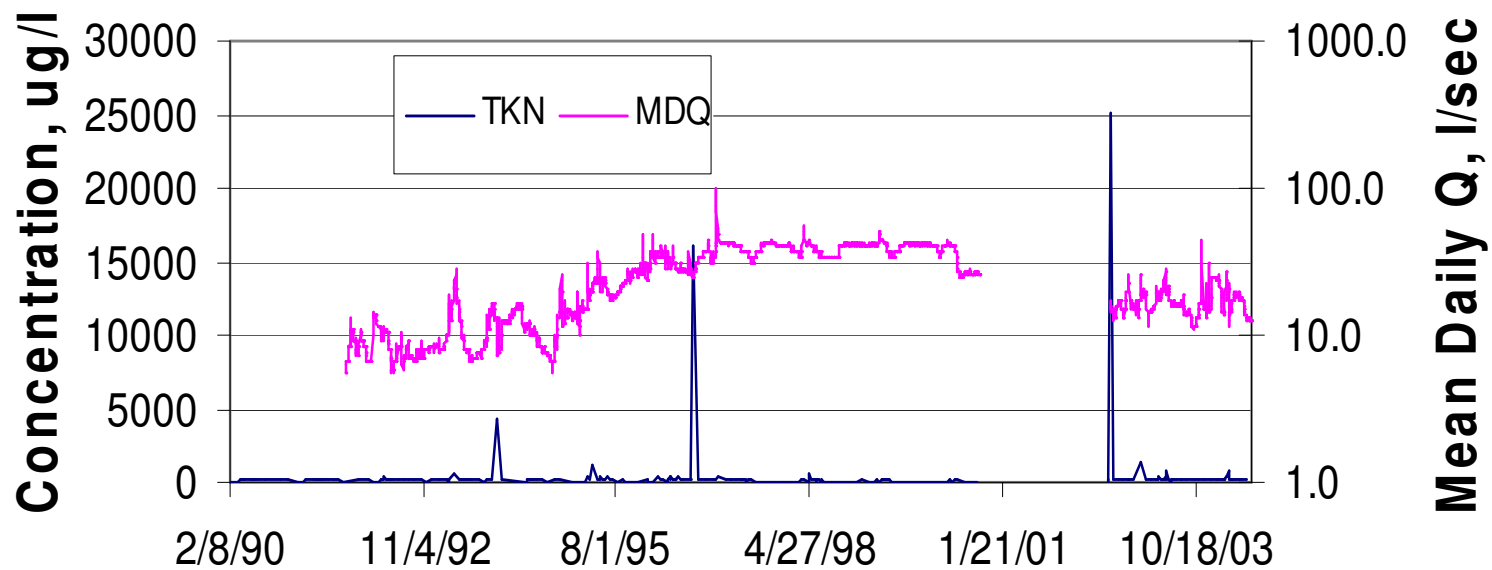


Ratio of Ann. Ave. NO3-N Conc., Blackwood:Ward Same-day Samples

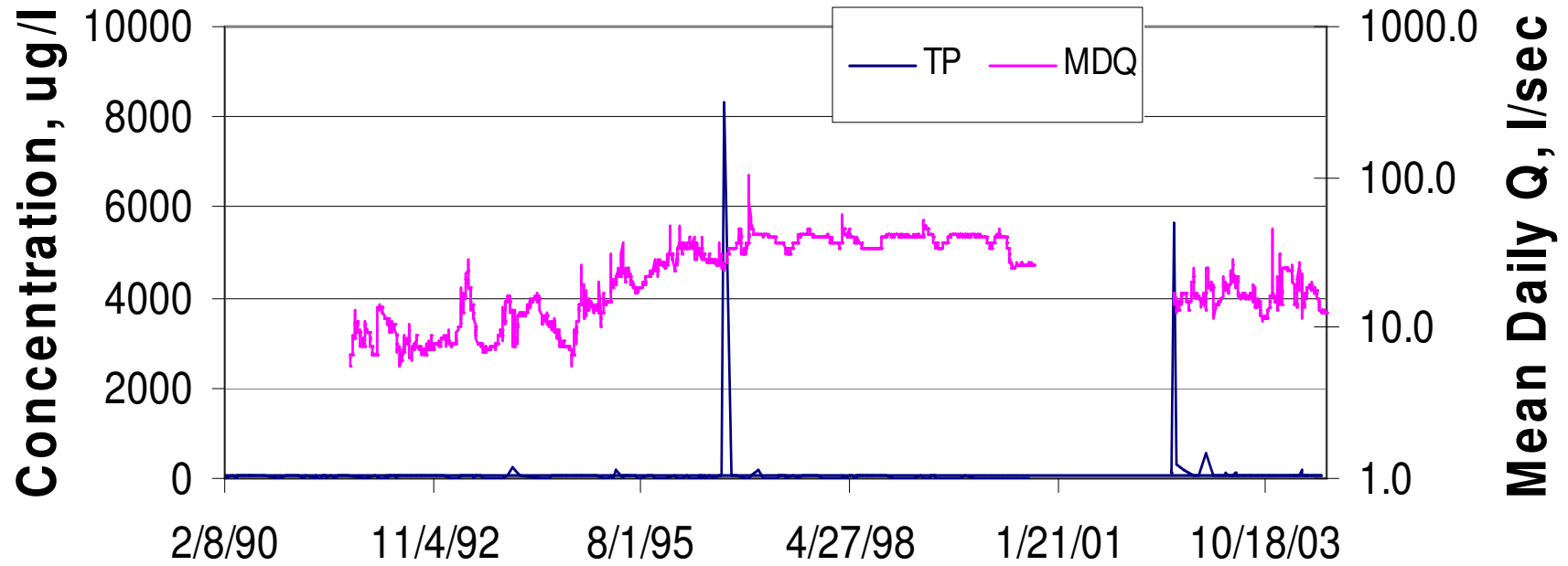




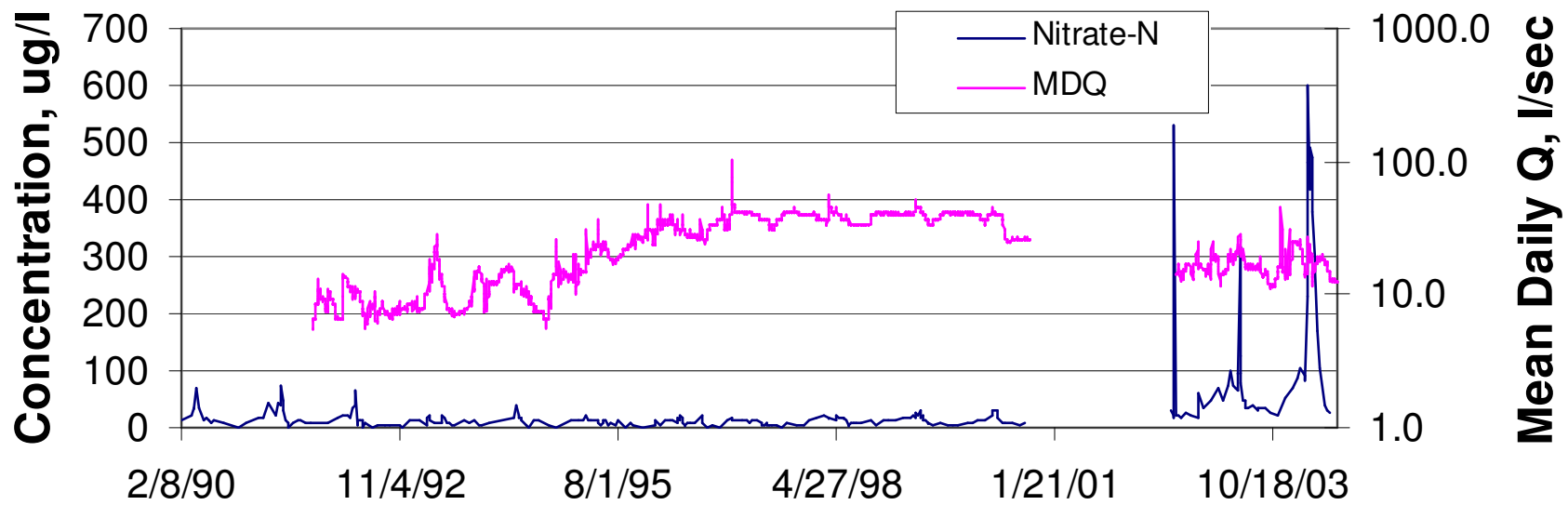
TKN, Eagle Rock Cr.



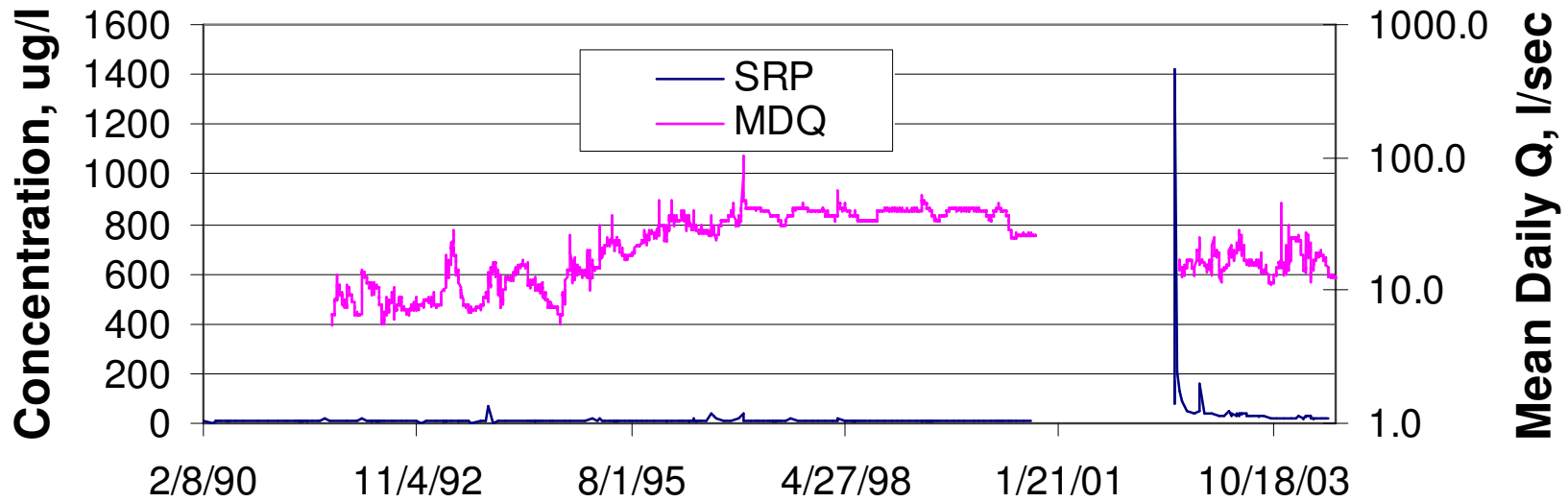
Total Phosphorus, Eagle Rock Cr.



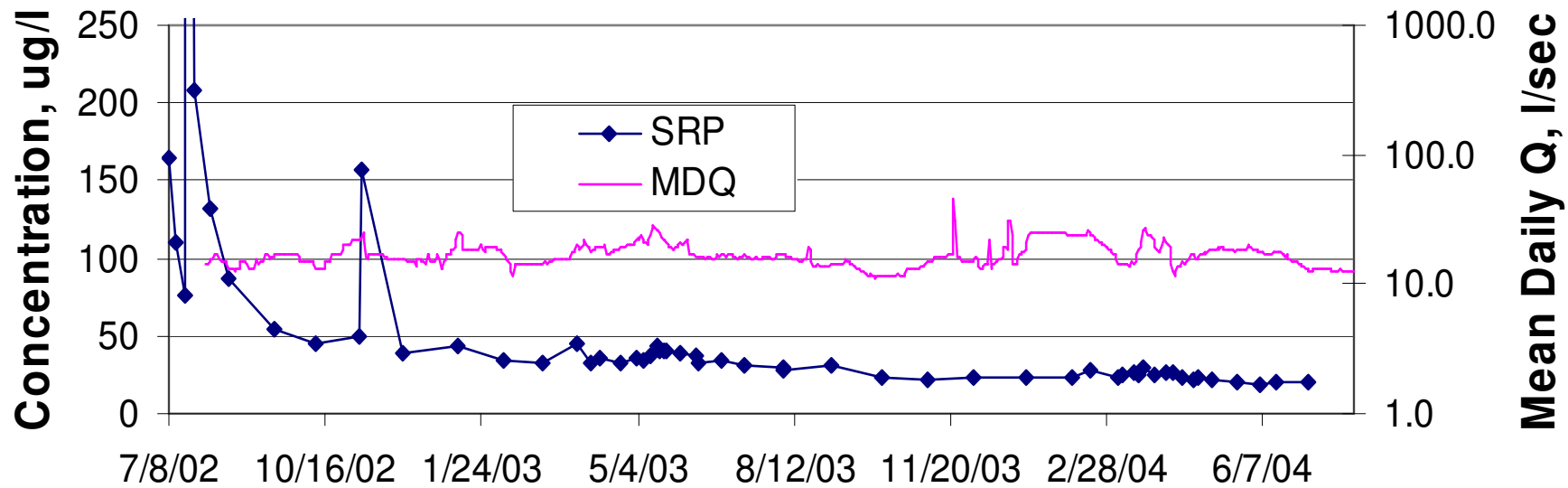
Nitrate-N, Eagle Rock Cr.



Soluble Reactive Phosphorus, Eagle Rock Cr.



Soluble Reactive Phosphorus, Eagle Rock Cr.



Conclusions

- Hydrology, geology, vegetation and land use can explain 60 to 88 percent of the inter-watershed variation in nutrient yields, and 40 percent of the SS yields in the Tahoe basin.
- Poor land use and forest fires can increase yields of N and P, but watersheds recover over annual to decadal time scales
- Runoff from urbanized areas has much higher concentrations of N and P than runoff from undeveloped areas.

Conclusions (cont.)

- More work is needed to compare total loads from urbanized and undeveloped areas.
- More work is needed to compare the uncertainty of modified rating curve method with regressions using continuous turbidity measurements.