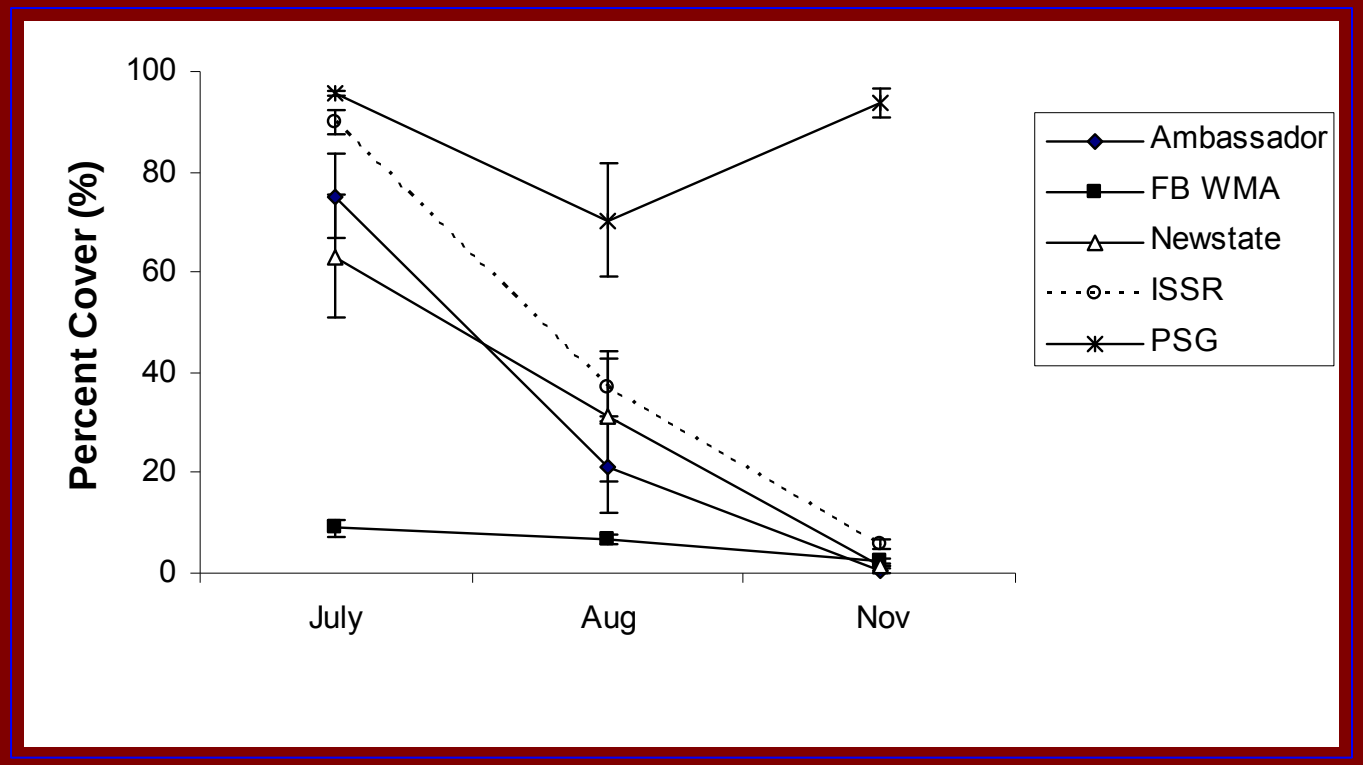
Refining Condition Assessment Metrics for Impounded Wetlands of Great Salt Lake, Utah

Prepared by Heidi M. Hoven [1]

for Utah DEQ, Division of Water Quality

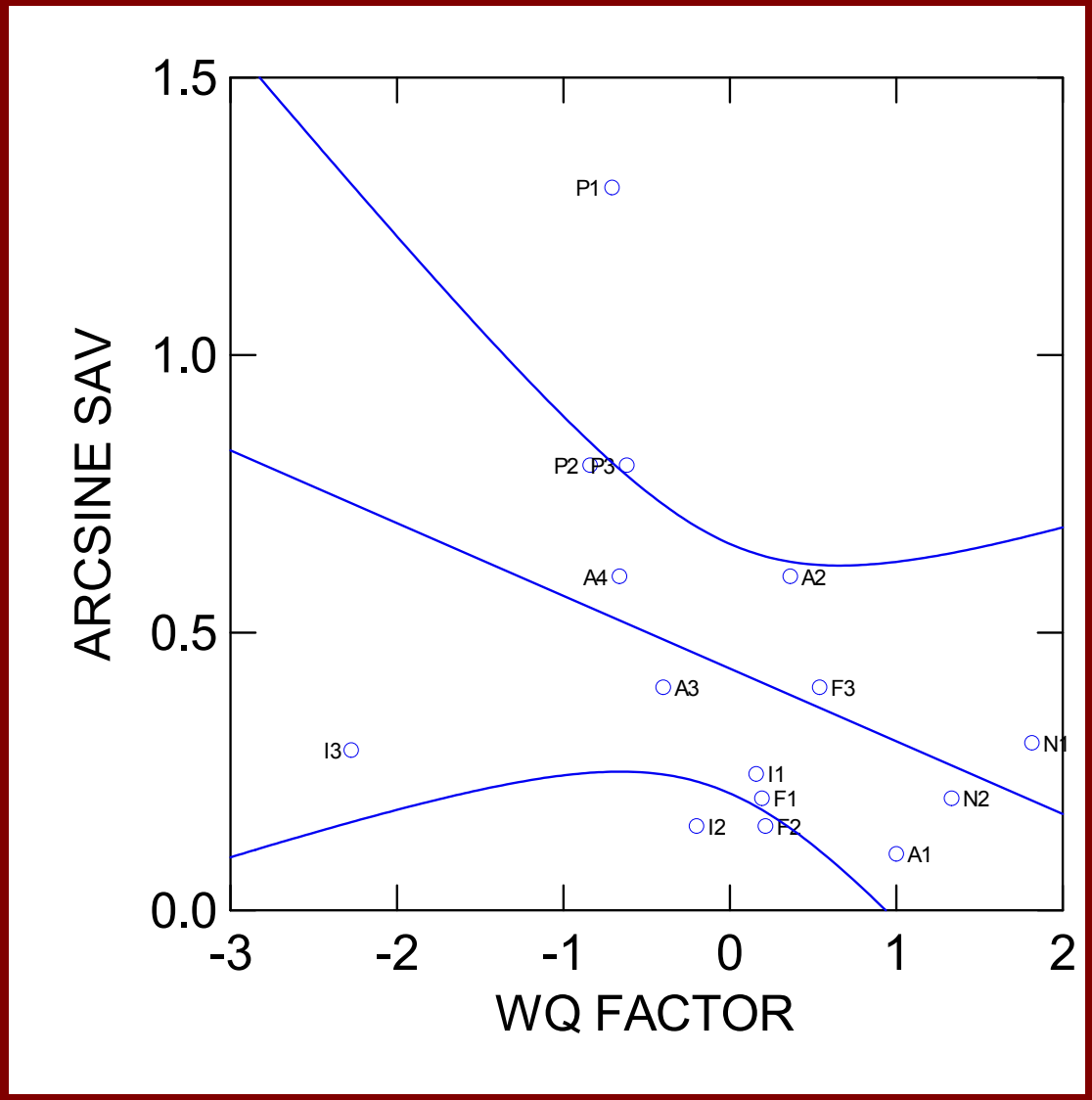
[1] The Institute for Watershed Sciences

% Cover SAV - 1st "Ponds", 2005



$F_{(df\ 4,\ 8)} = 75.5,\ 13.5;\ P \leq 0.0001$, Hoven and Miller 2009)

SAV % Cover – "All Ponds" vs WQ Factor, 2005



Increasing TDS, EC ⟷ Increasing Nutrients, DO

(P = 0.026, Hoven and Miller 2009)

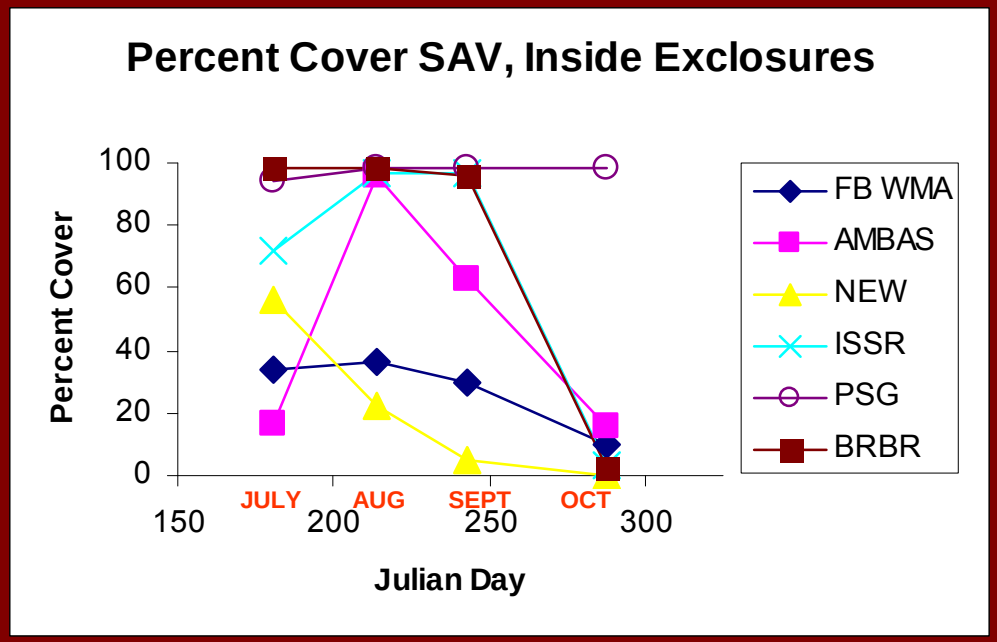
C:N:P of Summer and Fall SAV Leaf Tissue for Reference and Target Sites, 2005; n = 3 for all sites

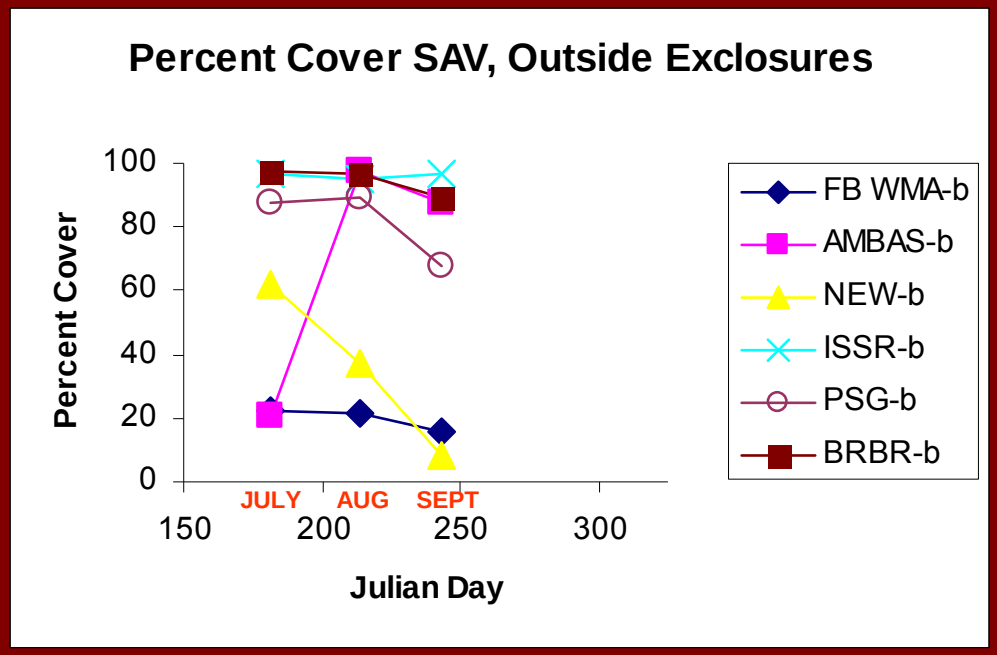
SITE	JULY	NOVEMBER
AMB T1	61:6:1	-
AMB T2	111:10:1	97:9:1
AMB T3	89:8:1	-
AMB T4*	87:8:1	67:7:1
FB T1	75:5:1	176:19:1
FB T2	55:4:1	-
FB T3	79:5:1	58:6:1
ISSR T1	86:7:1	-
ISSR T2*	100:8:1	-
ISSR T3*	73:8:1	-
NEW T1	72:8:1	-
NEW T2	90:9:1	-
NEW T3	76:8:1	-
PSG T1	166:11:1	188:14:1
PSG T2	202:14:1	220:16:1^
PSG T3	205:14:1	161:12:1

2008 Sample Design

- H_0: SAV % cover does not vary among target and reference ponds seasonally
- H_0: Carp grazing does not affect SAV % cover significantly
- H_0: SAV leaf CNP does not vary among target and reference ponds seasonally
- H_0: SAV are not light limited at target or reference ponds seasonally
- (Other H_0: Biomass, Pn, SAV Fv/Fm)

% Cover SAV 08

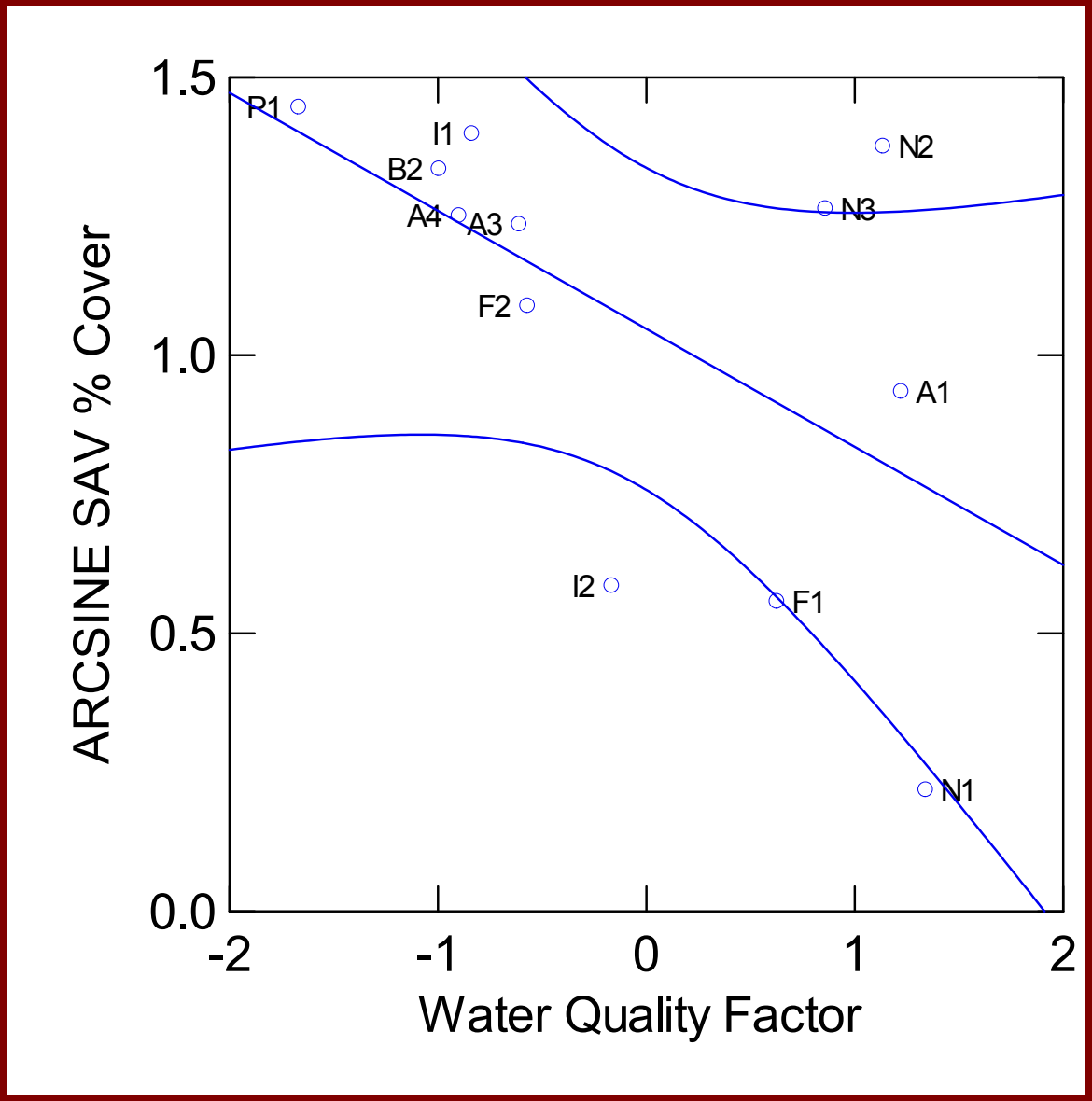




Inside: $F_{(df\ 5)} = 105.8$, $P \leq 0.0001$

Outside: $F_{(df\ 5)} = 17.65$, $P \leq 0.0001$

SAV % Cover – "All Ponds" vs. WQ Factor, September 2008

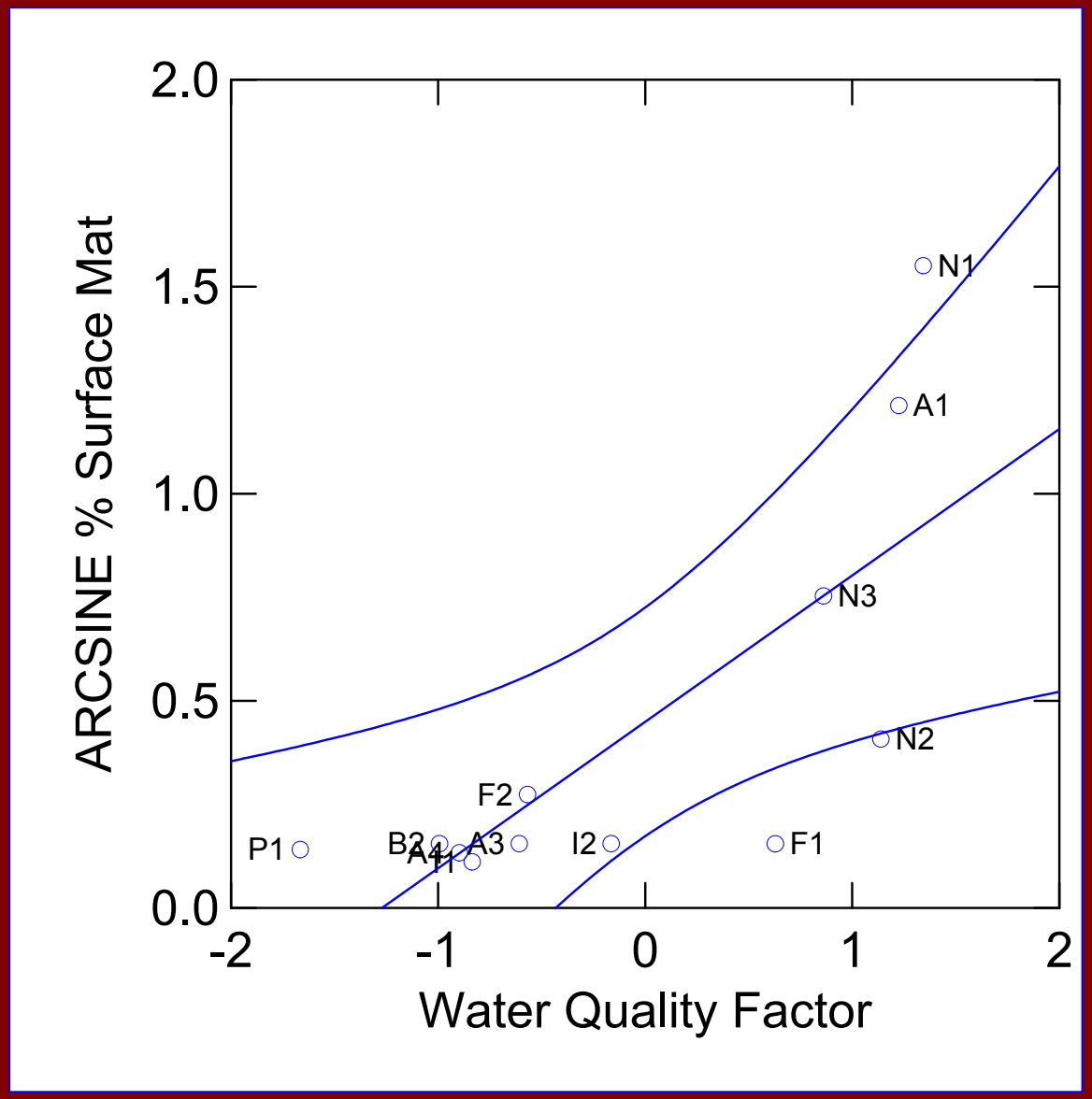


Increasing TDS, pH

Increasing Dis P, Tot P, NO2 + NO3, NH4

$F_{(df\ 1)} = 4.304$, $P = 0.065$
$r^2 = 0.301$

% Surface Mat – "All Ponds" vs. WQ Factor, September, 2008

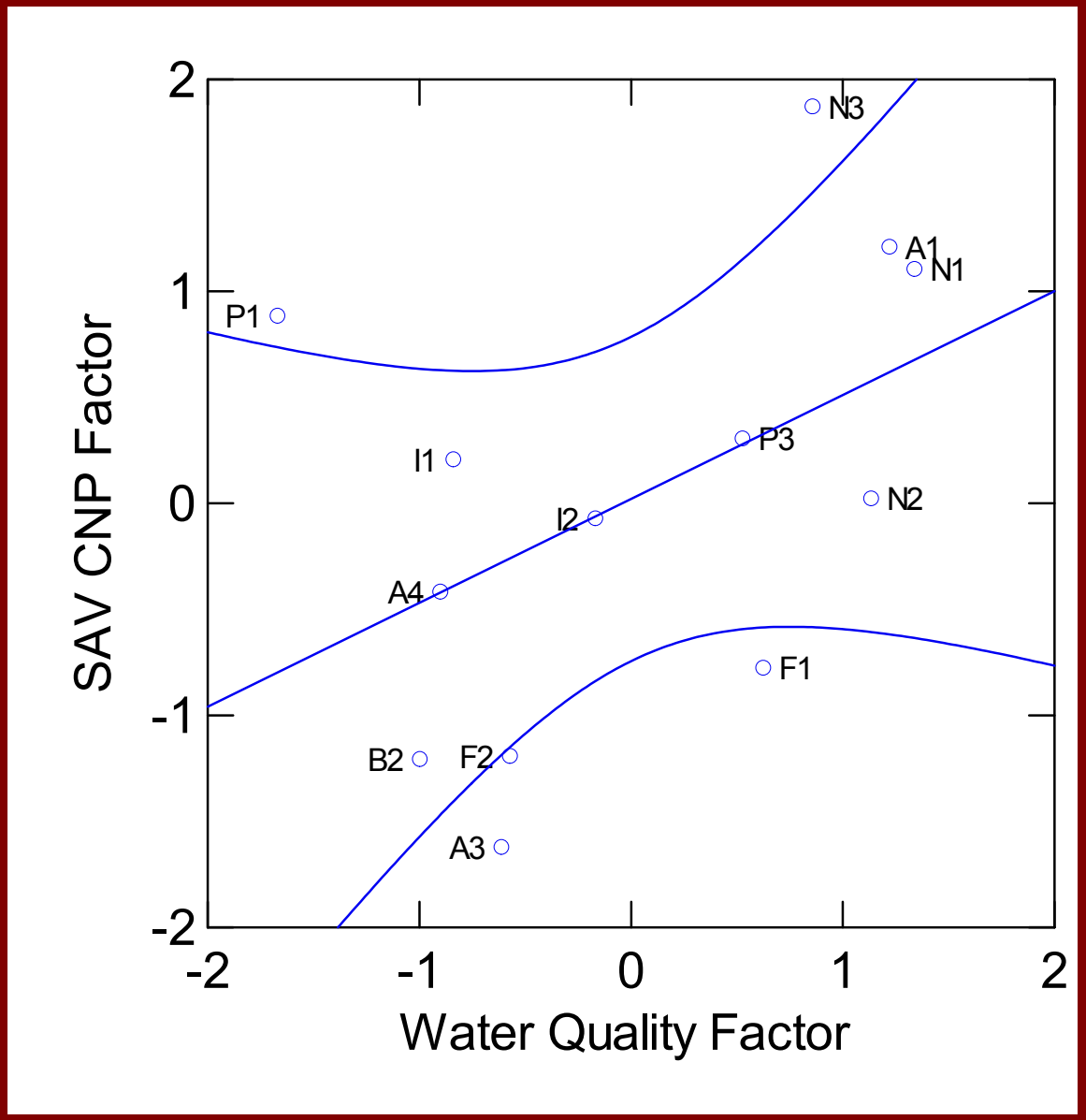


$F\ (_{df\ 1}) = 13.133,\ P = 0.005$
$r^2 = 0.568$

Increasing TDS, pH

Increasing Dis P, Tot P, NO2 + NO3, NH4

CNP SEPT-08

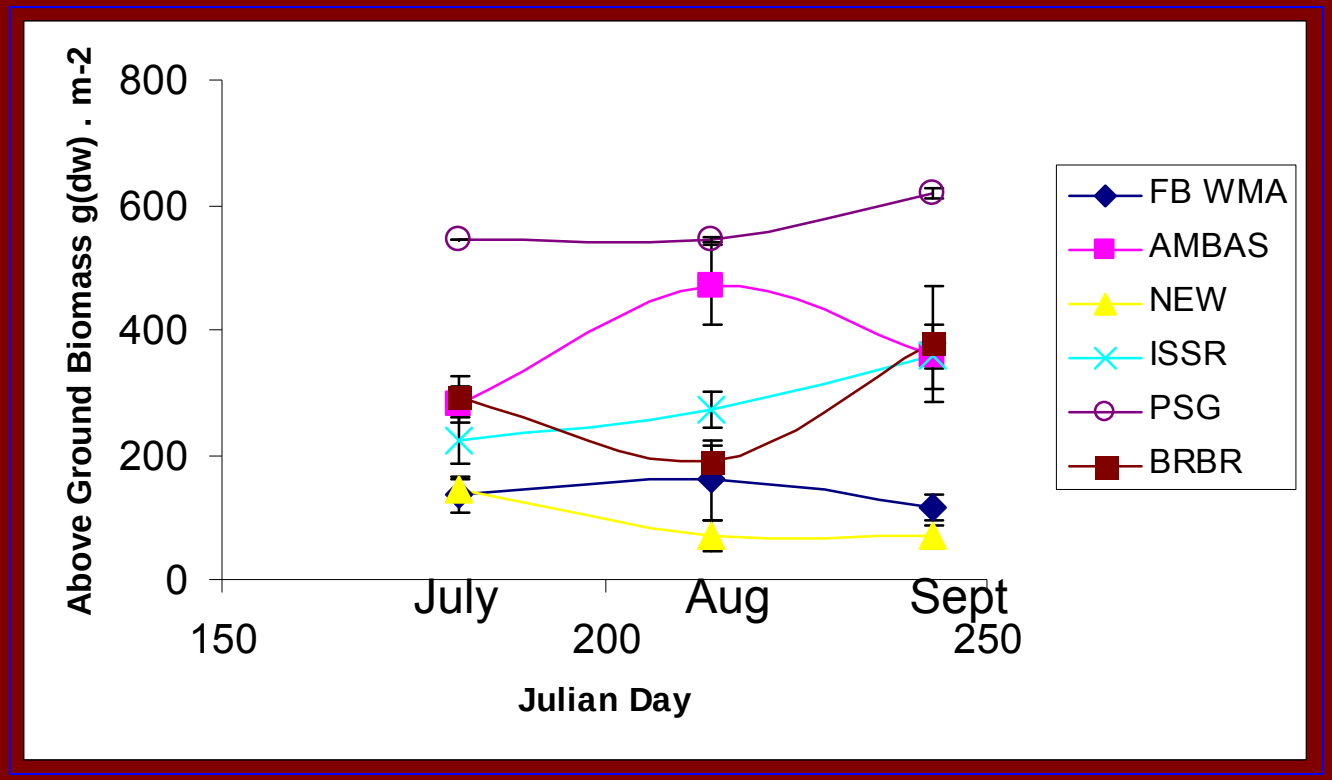


Increasing TDS, pH

Increasing Dis P, Tot P, NO2 + NO3, NH4

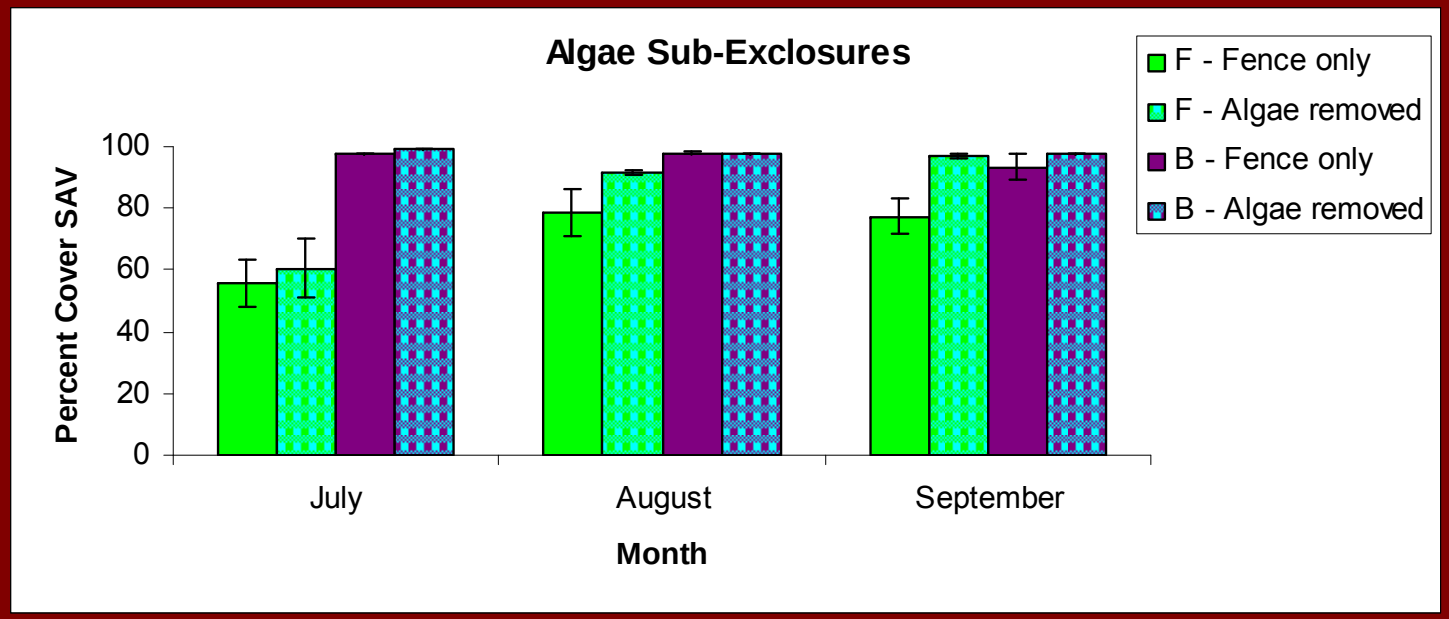
$F_{(df\ 1)} = 3.017$, $P = 0.110$
$r^2 = 0.215$

SAV Biomass-08



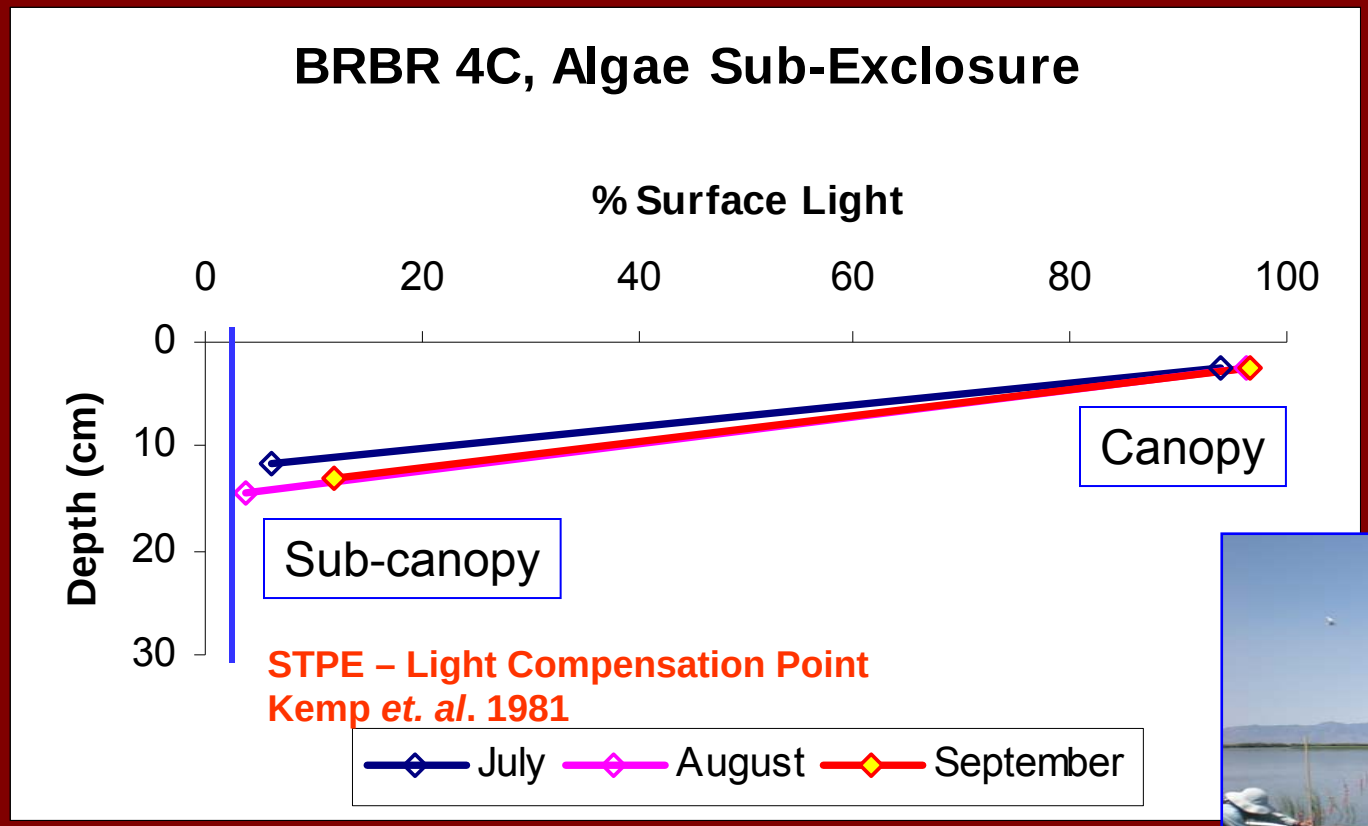
F (df 5) = 28.292, P ≤ 0.0001

Light Limitation from Floating Vegetation

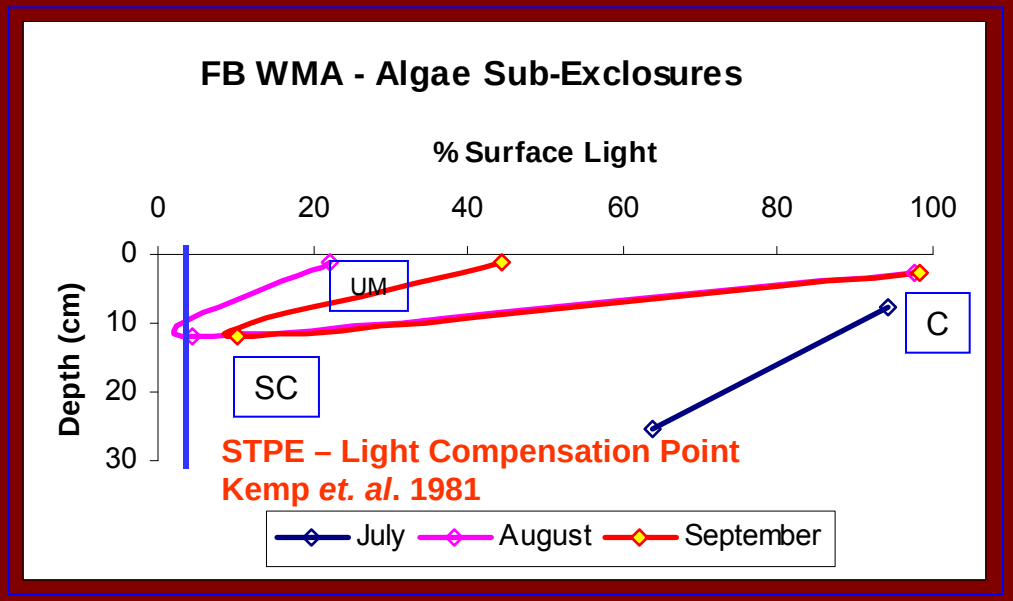


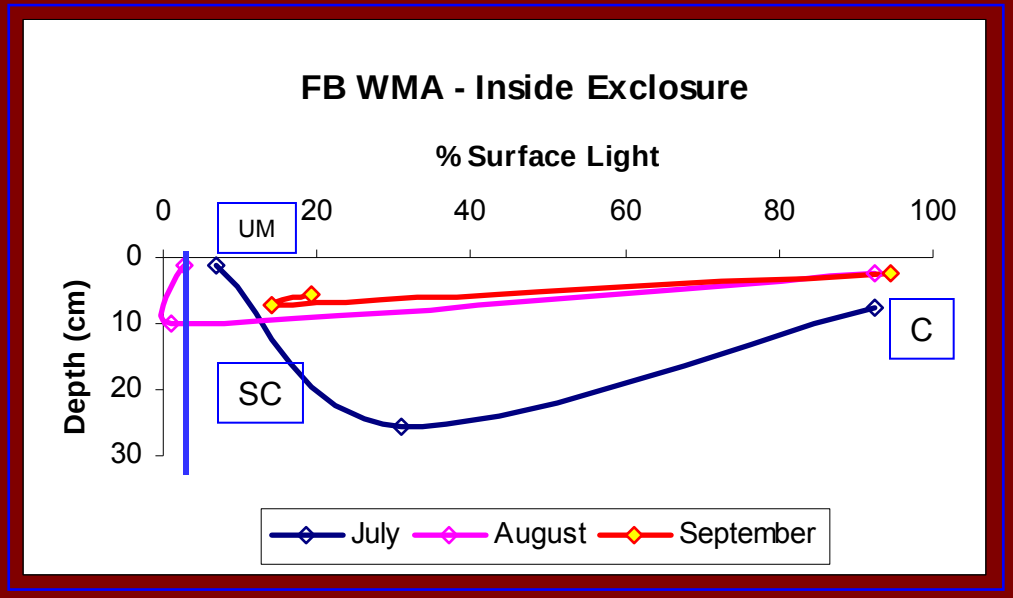
$F_{(df\ 1)} = 20.058$, $P = 0.004$

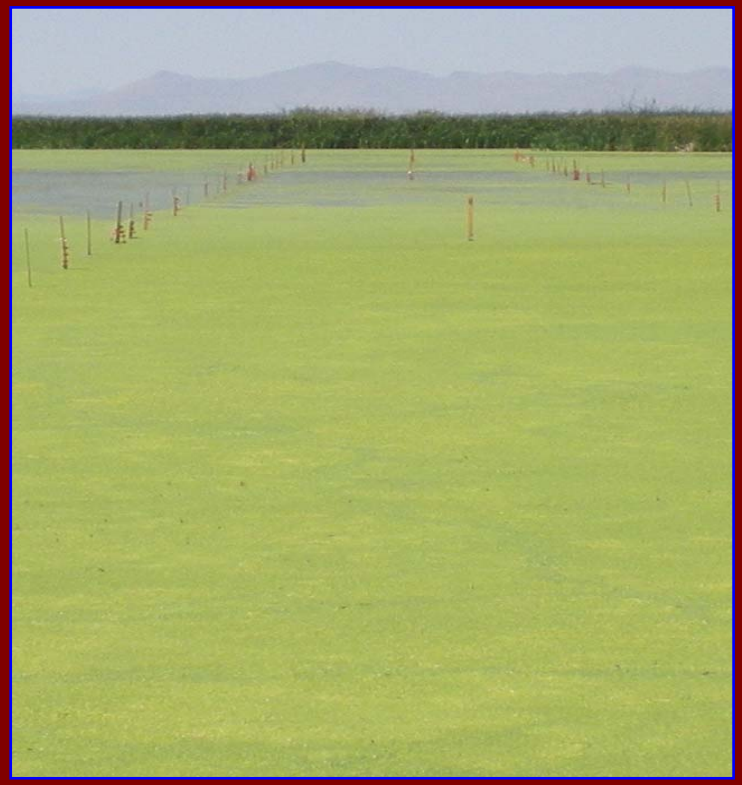
Light Attenuation



Light Attenuation





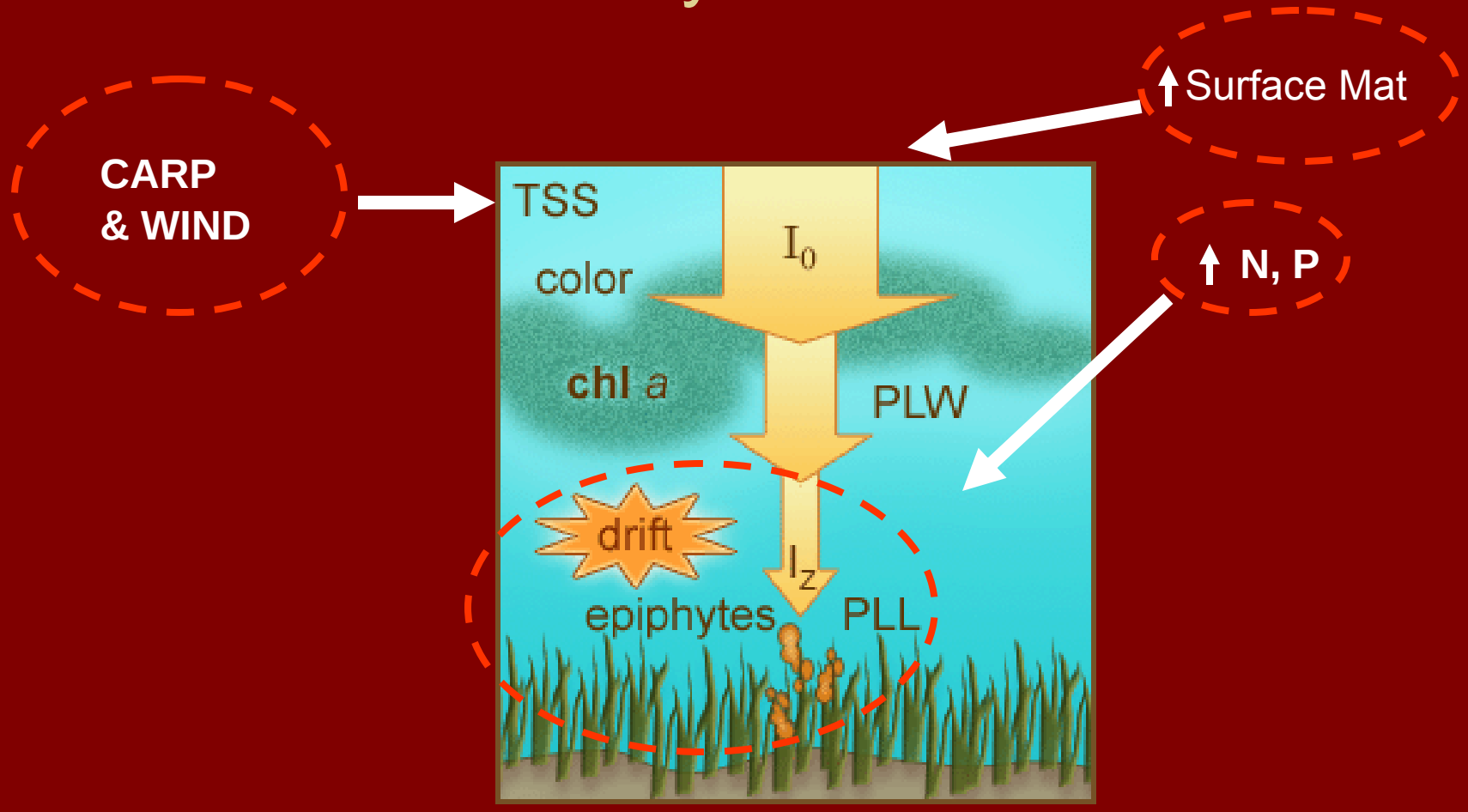


Epiphyte / Algal Load

SITE	July	Aug	Sep	Oct
A1				
A2				
A3				
A4				
B1				
B2				
F1				
F2				
F4				
I1				
I2				
N1				
N2				
N3				
N4				
P1				
P2				
P3				
# Abundant:	4	5	7	4

ABUNDANT
COMMON
RARE
NOT SAMPLED

What are the Tipping Points for SAV Productivity and Condition?



Potential Surface Mat Metrics

<u>Maximum Algae Mat Cover (MAXALGAE)</u>

The maximum yearly percent cover of a surface mat predominantly composed of algae.

Predicted to increase with increasing human-caused disturbance.

<u>Maximum Duckweed Mat Cover (MAXDW)</u>

The maximum yearly percent cover of a surface mat predominantly composed of algae.

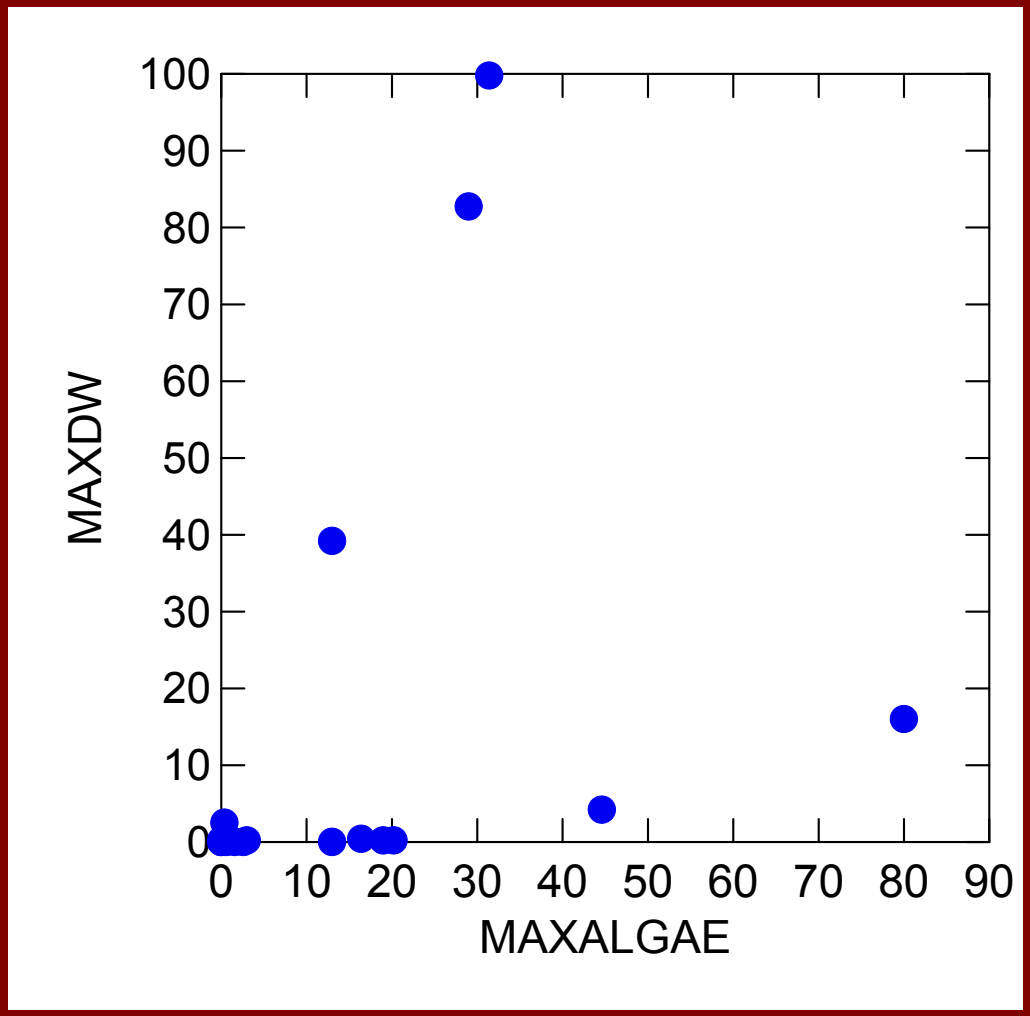
Predicted to increase with increasing human-caused disturbance.

<u>Maximum Surface Mat Cover (MAXMAT)</u>

The maximum yearly percent cover of any surface mat, either algae or duckweed.

Predicted to increase with increasing human-caused disturbance.

Surface Mat Metrics



1. It looks like algae and duckweed provide different information, especially at extremes.

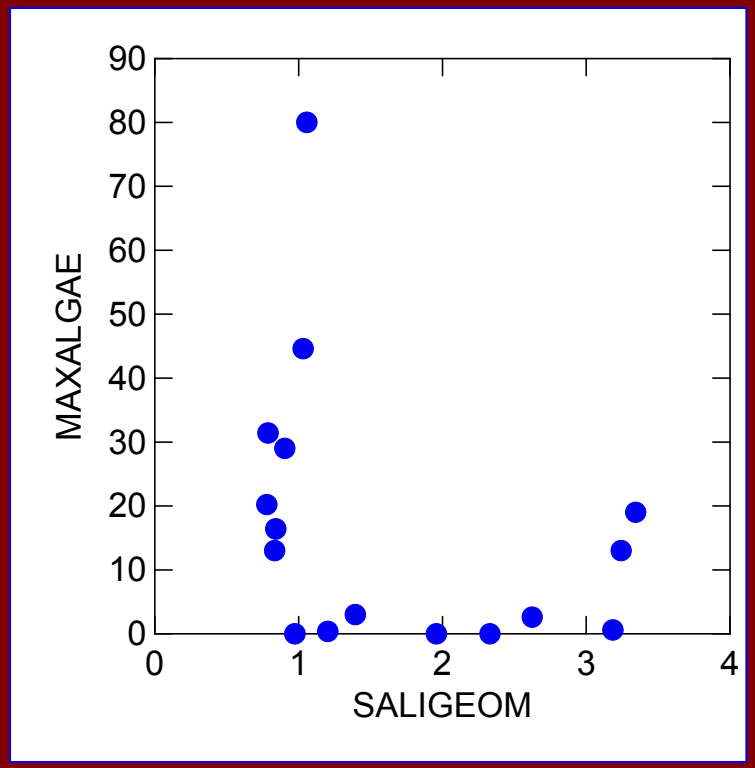
2. What do each mean in the context of our standards?

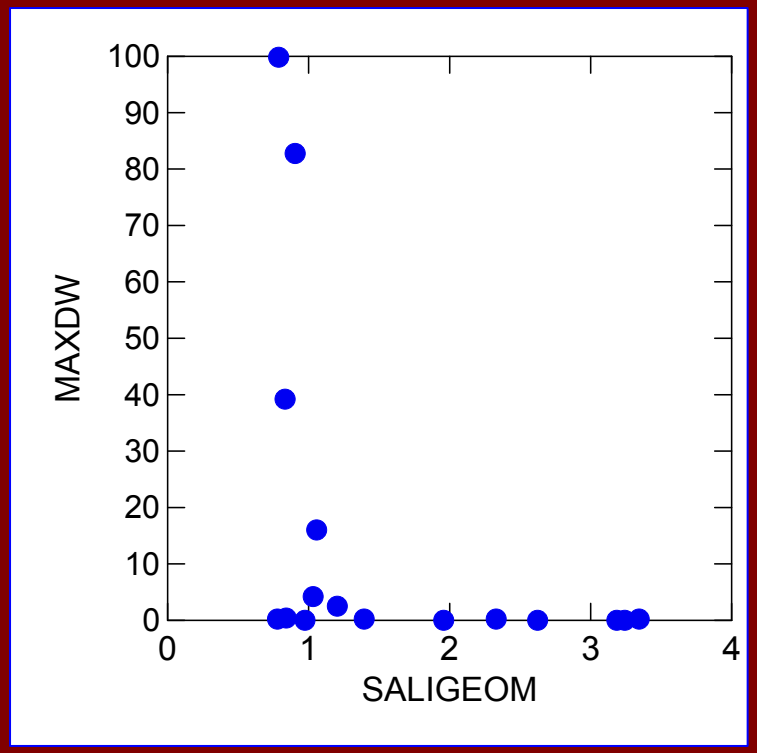
<u>Key Considerations</u>

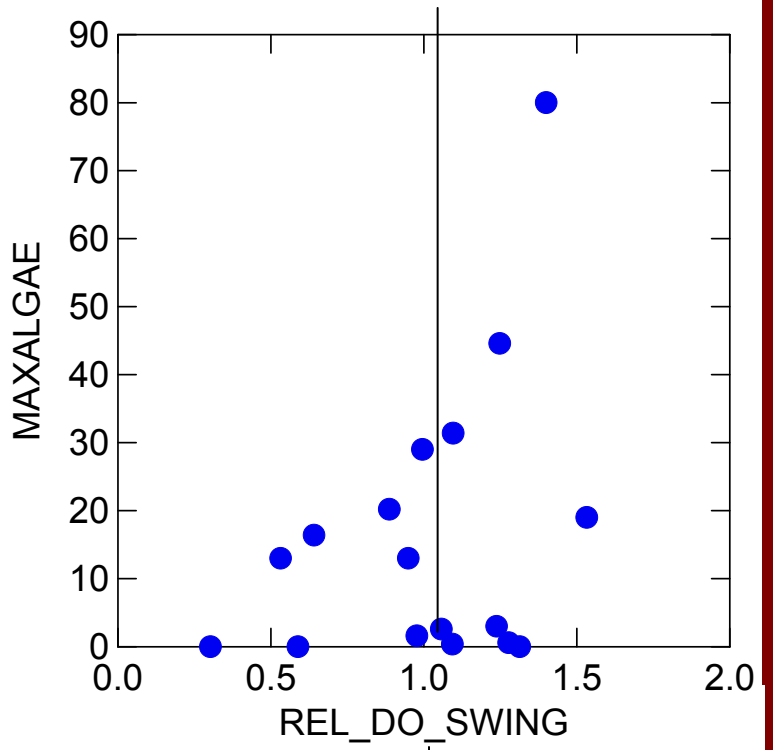
- Ecological explanations
- Tie to Use
- Future use to diagnose likely stressors
- Future use to evaluate the efficacy of remediation efforts

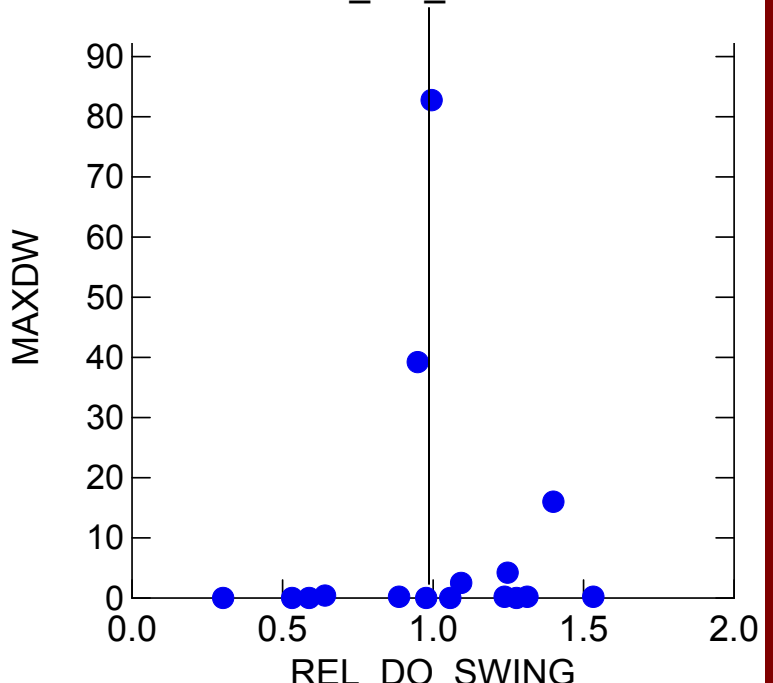
Surface Mat Metrics: Relation to Possible Covariates

Neither duckweed nor algae mat metrics show a response to salinity.





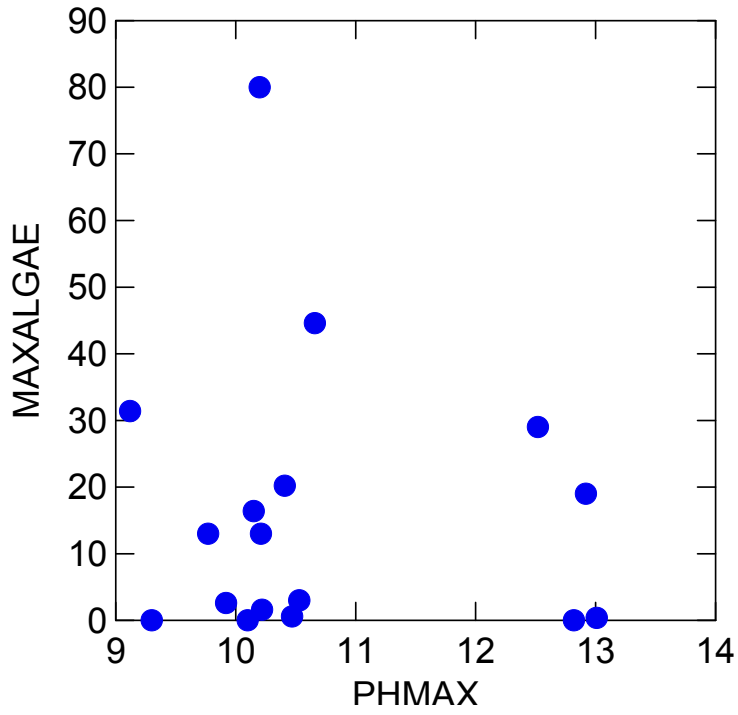


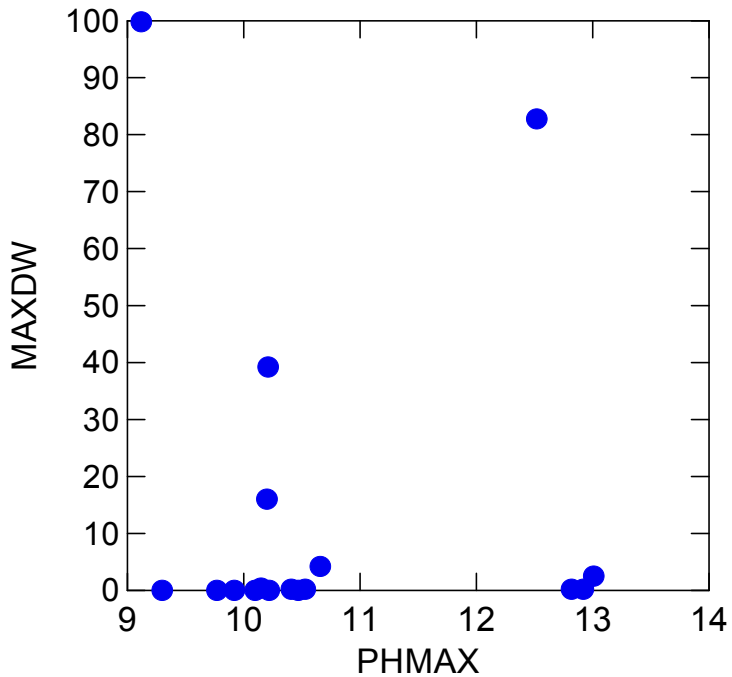


Surface Mat Metrics: Relations to Stressors

MAXALGAE does not show any relationship at low to moderate cover, but once the mat gets very large, all of the swing values are >1 (above average).

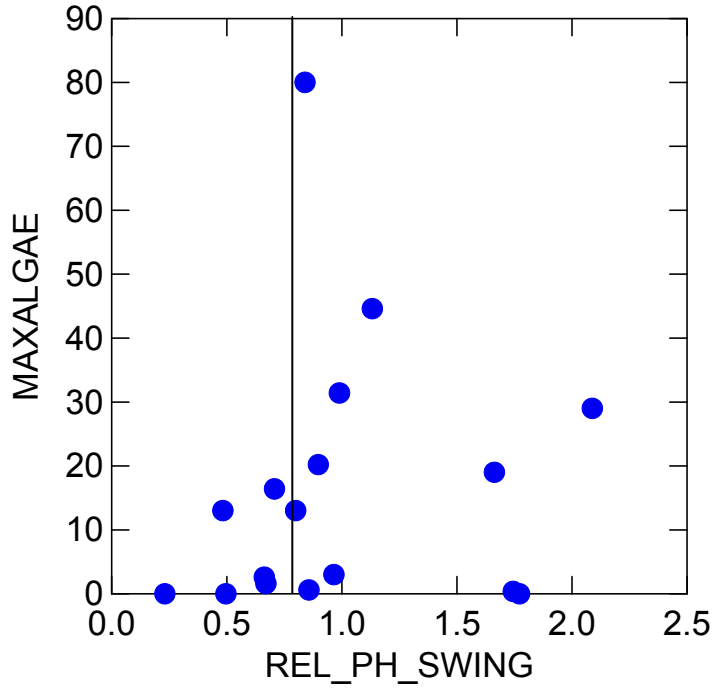
There is no relationship for the duckweed mat metric.

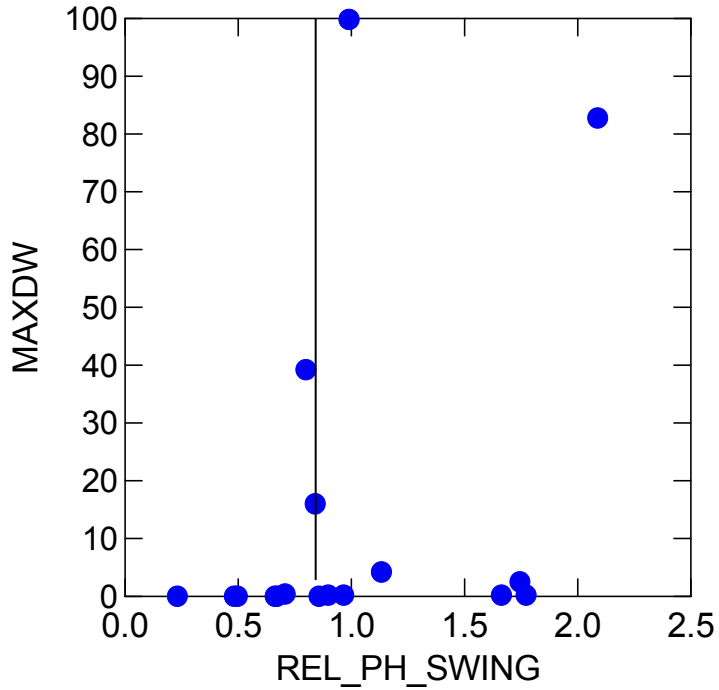




Mat Metrics (Maximum algae cover on top pane and maximum Duckweed cover on the bottom pane) as a function of the maximum pH value measured at each site.

No relationships evident.

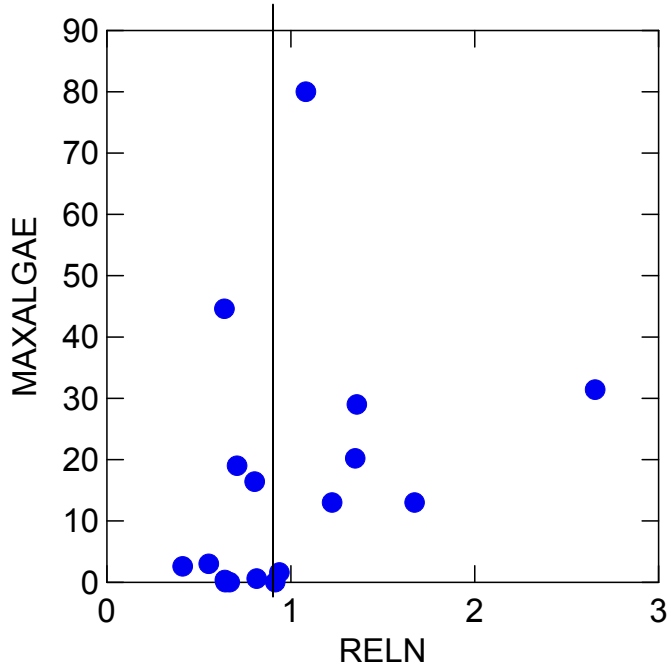


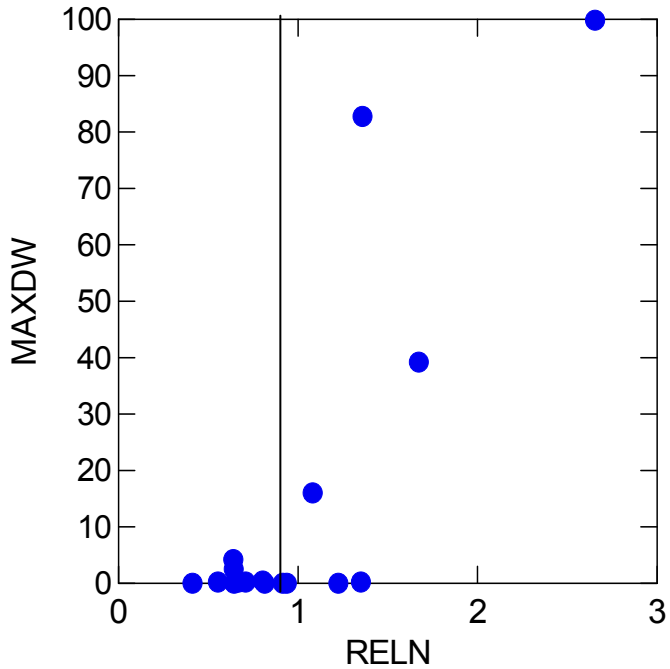


Mat Metrics (Maximum algae cover on top pane and maximum Duckweed cover on the bottom pane) as a function of the difference between the maximum pH and the minimum pH measured at each site.

The response for the algae mat is in the direction predicted. However, note that there are a couple of sites relatively high pH swings that do not have extensive algae mats.

Duckweed responds predictably, but the trend is also very weak.

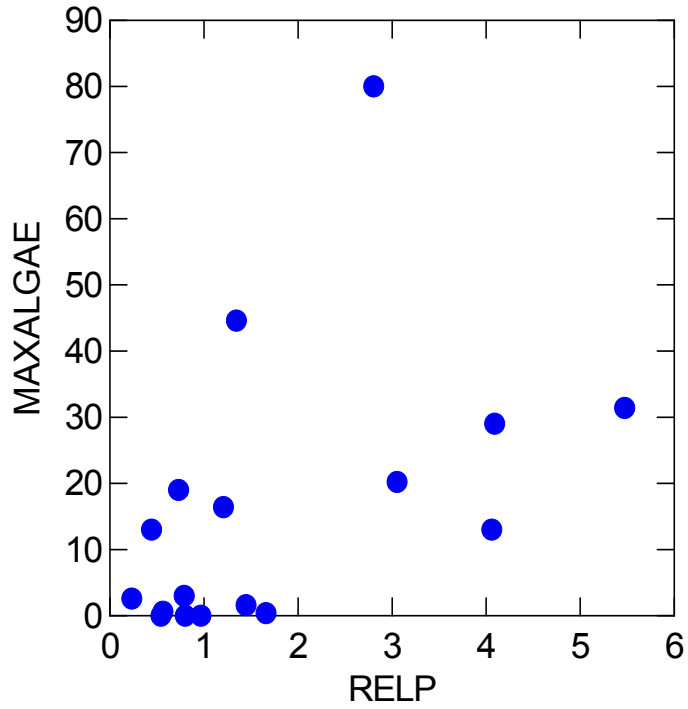


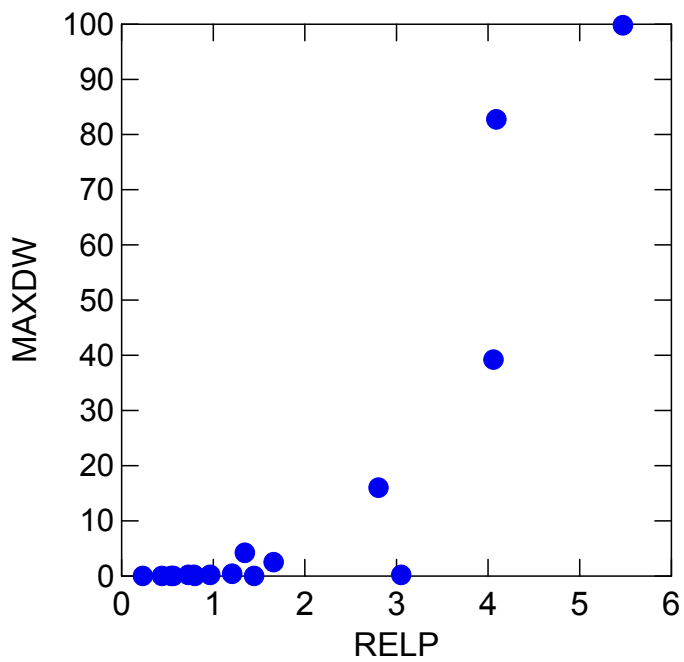


Mat Metrics (Maximum algae cover on top pane and maximum Duckweed cover on the bottom pane) as a function of the average, relative amount of nitrogen measured at each site.

Although the response is not strong, the algae mat score responds to nitrogen as predicted. Note also that all of the sites with small algae mats has relatively low nitrogen concentrations.

The duckweed mat (especially at the upper extremes) may show some response to higher levels of relative nitrogen.

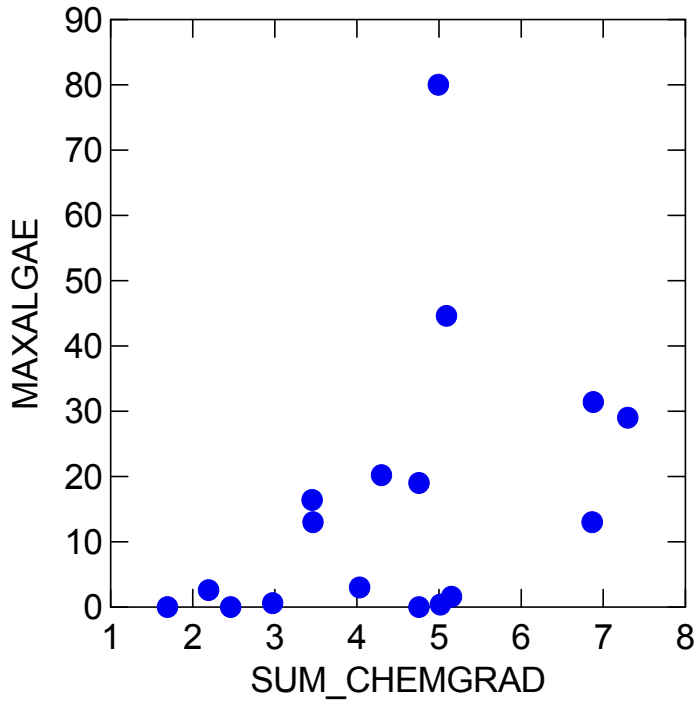


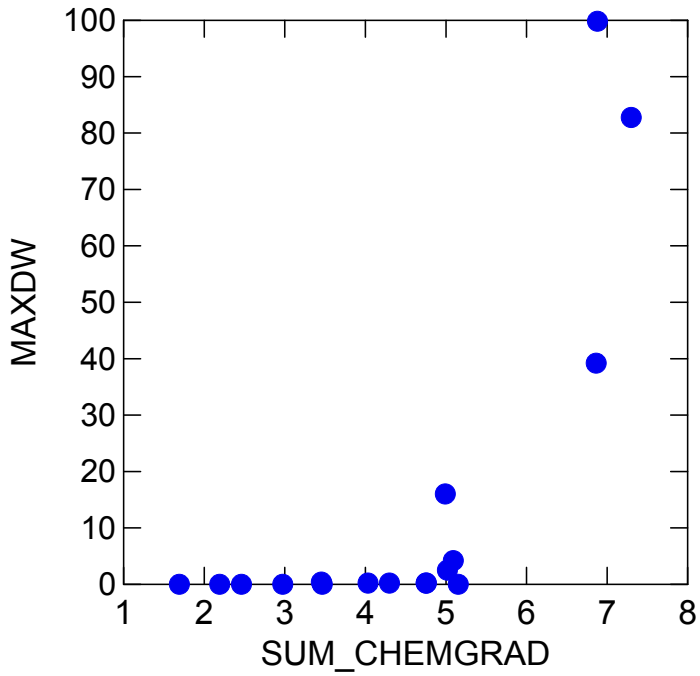


Mat Metrics (Maximum algae cover on top pane and maximum Duckweed cover on the bottom pane) as a function of the average, relative amount of phosphorous measured at each site.

Phosphorous does not show any relationship with the algal mat matrix.

However, there is a nice trend for the duckweed metric.





Mat Metrics (Maximum algae cover on top pane and maximum Duckweed cover on the bottom pane) as a function of the overall chemistry gradient.

High chemistry values indicate increasing levels of water quality indicators.

The algal mat metric responds predictably to the overall chemistry gradient, but other factors that water chemistry are obviously important in determining this variable.

The response for the duckweed metric is pretty good.

SAV Potential Metrics

Maximum (pre-collapse) SAV Cover (J_A_MAX_SAV)

Calculated as the maximum percent cover (averaged across plots) obtained in either July or August.

Predicted Response: Decrease with increasing human-caused stress.

Fall SAV Cover (Sept_SAV)

Provides a measure of the amount of food available to ducks during fall migration.

Predicted Response: Decrease with increasing human-caused stress.

Magnitude of SAV Collapse (SAV_TANK)

Calculated as the difference between the maximum SAV percent cover in July/August and the percent SAV cover obtained in September.

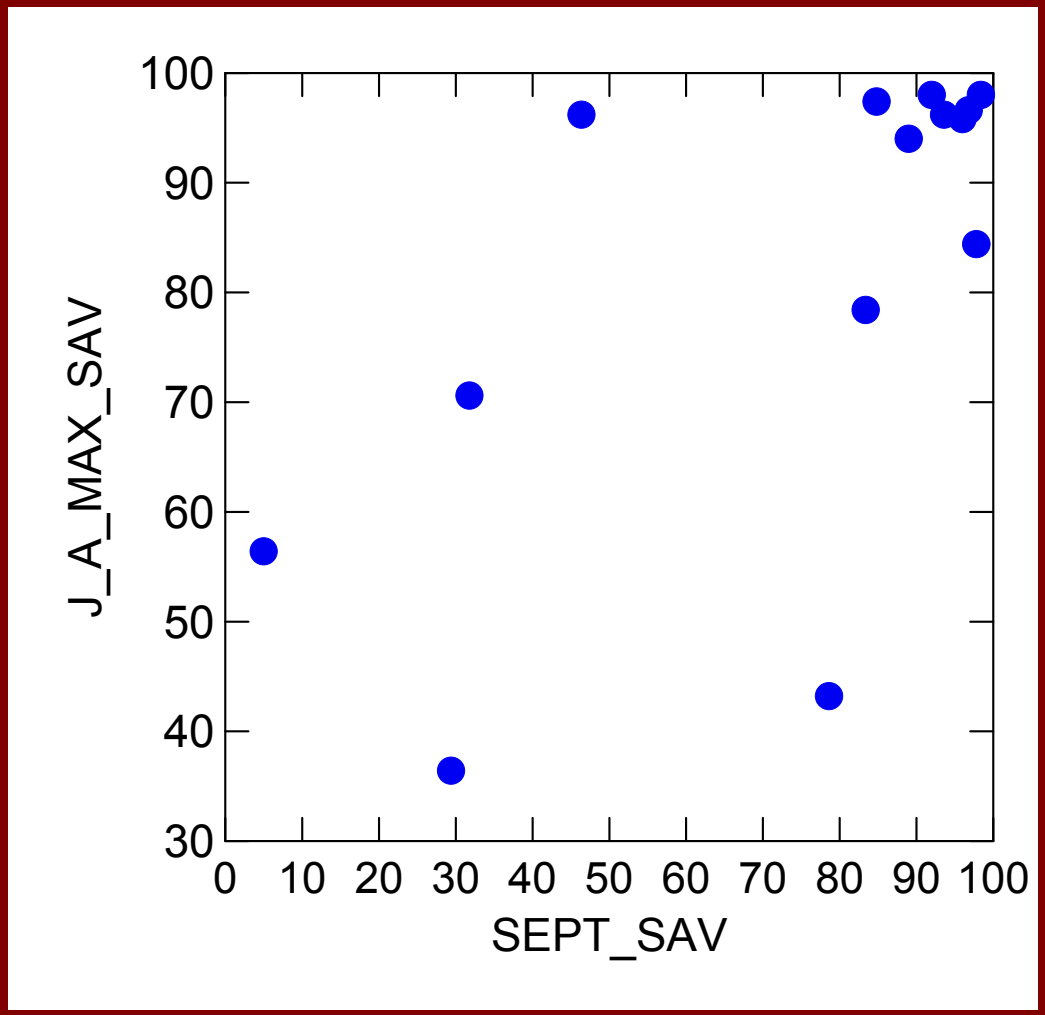
Predicted Response: Increase with increasing human-caused stress.

Percent Loss of SAV (PCT_SAV_TANK)

Because the magnitude of SAV loss might be dependent on initial conditions, this metric quantifies the percent change in SAV cover ((July/Aug SAV – September SAV)/July/Aug SAV * 100).

Predicted Response: Increase with increasing human-caused stress.

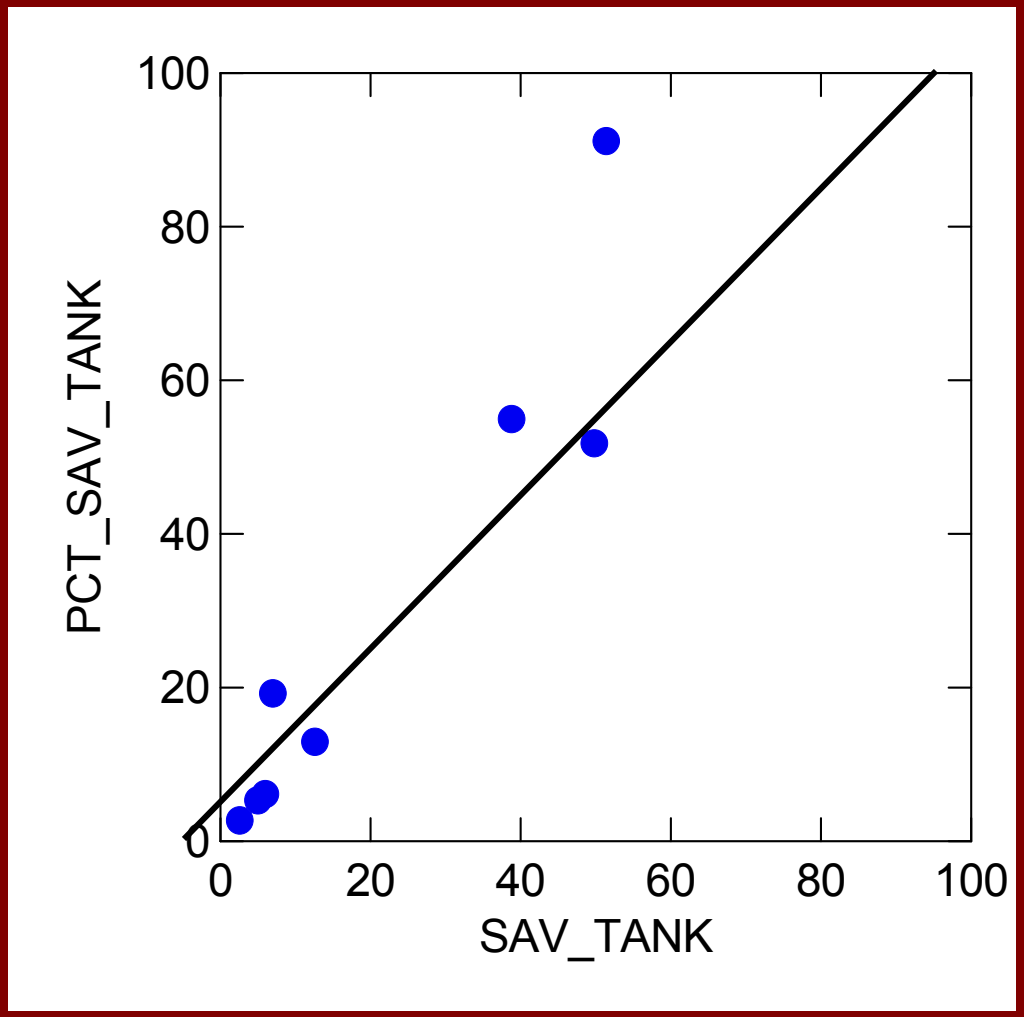
Comparisons of Measures of SAV Quantity



Both measures of the overall quantity of SAV seem to be indicating something different.

Plus they both mean something different with regard to aquatic life uses.

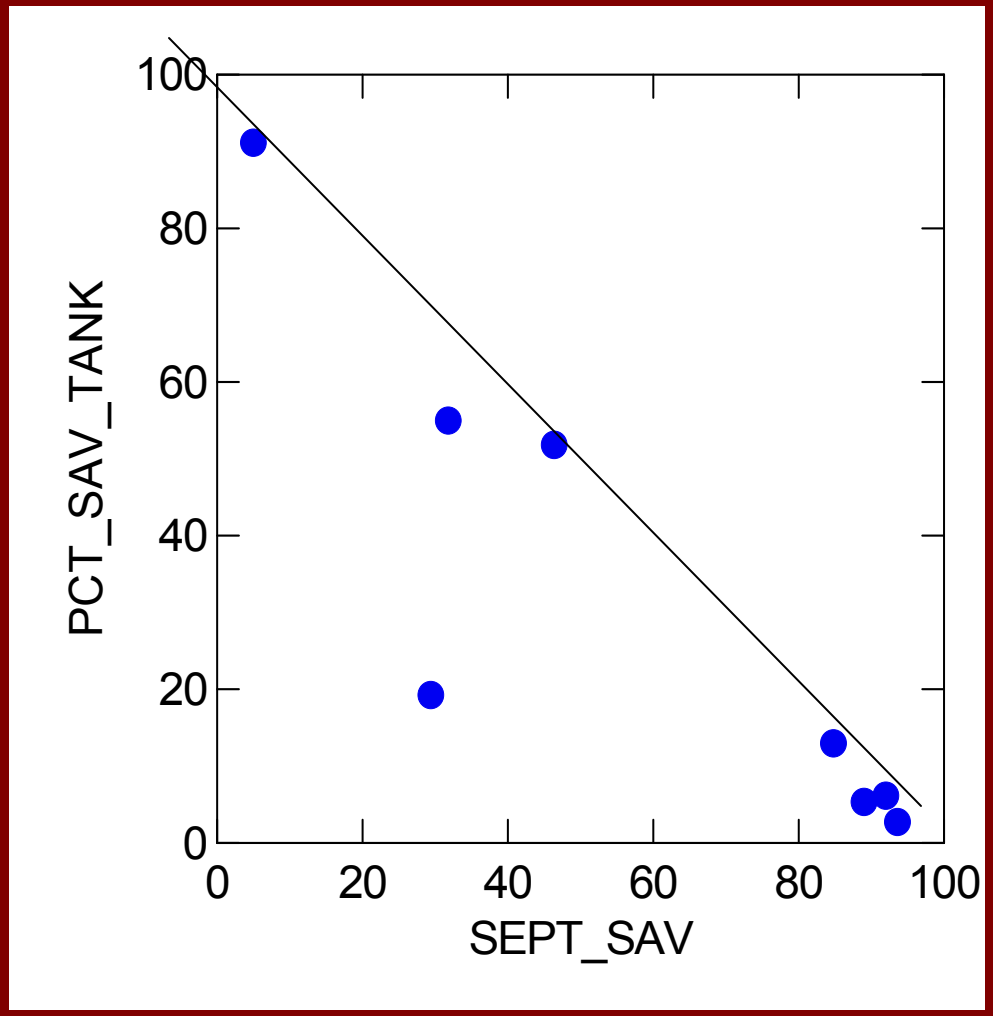
Measures of SAV Collapse



Note that as might be expected both are strongly correlated.

Measures of percent change go over a larger range and may be a better indicator.

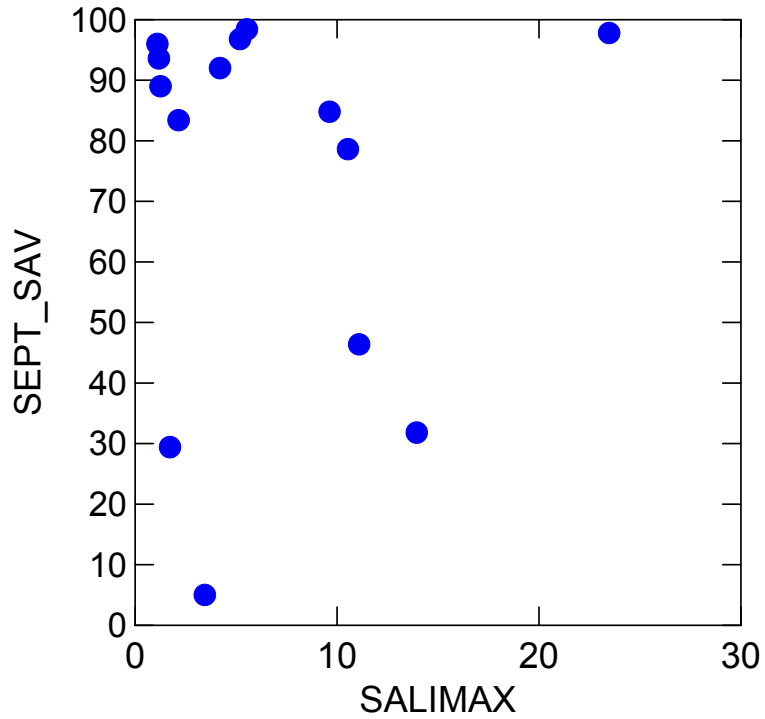
Percent SAV Change as a Function of SAV Maximum SAV Cover

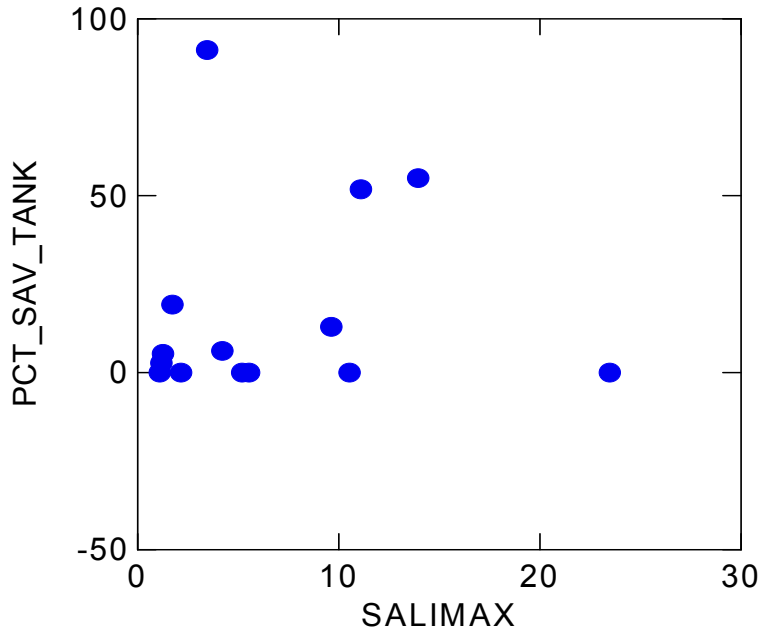


This plot is very interesting..

First, it implies that the amount of food available to ducks in the fall is very much influenced by SAV collapse.

Second, while we may want to measure both variables to understand conditions, this graph implies that a single fall screening of SAV cover my be a good first pass estimate of condition.





Are these SAV metrics affected by salinity?

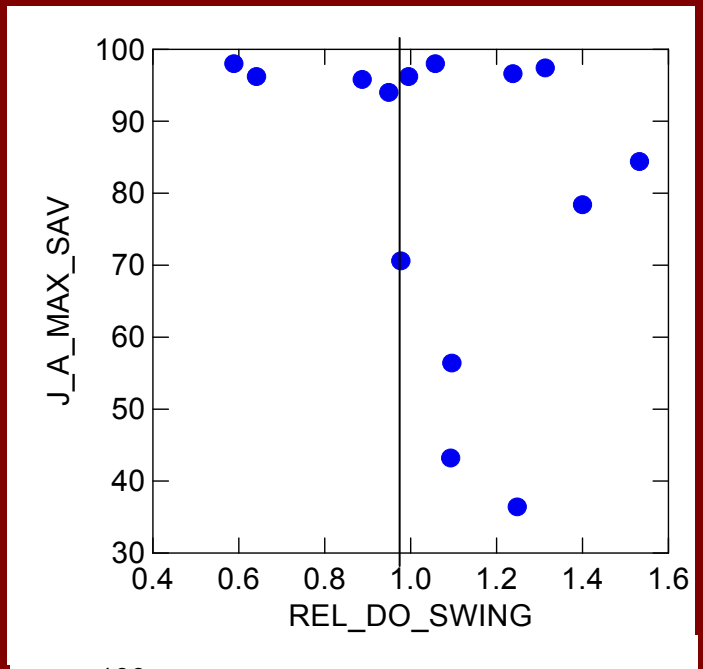
Overall conclusions on the salinity…

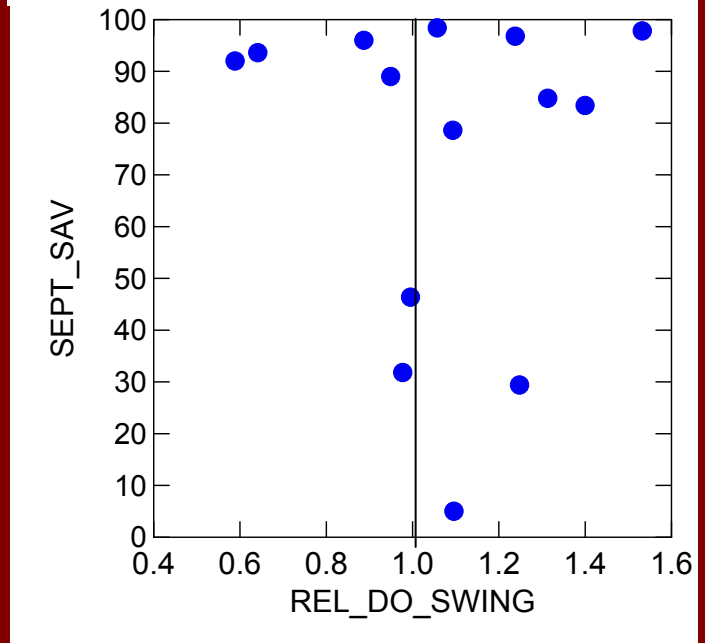
While it is certainly worth looking at salinity values as a potentially weighting factor when interpreting the data, salinity does not seem to be a strong covariate for these metrics at these sites.

In every case, the metrics had both low and high values across the salinity gradient.

How Do the SAV Metrics Respond to Stressor Gradients?

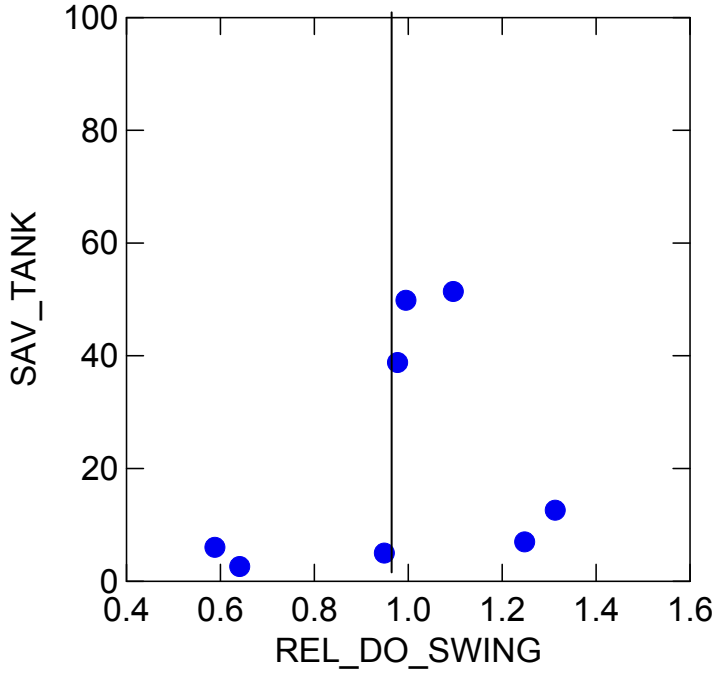
Difference in Maximum and Minimum DO Values

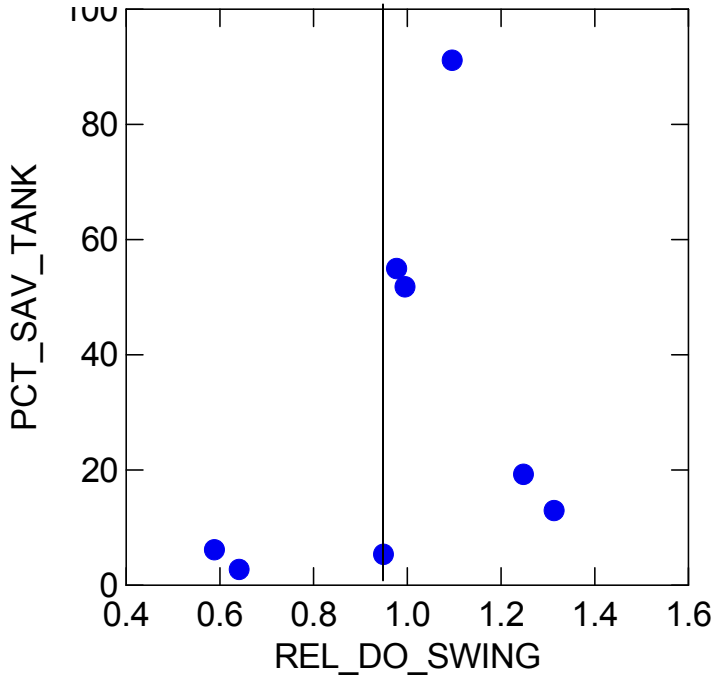




The response variables are the two measures of SAV quantity.

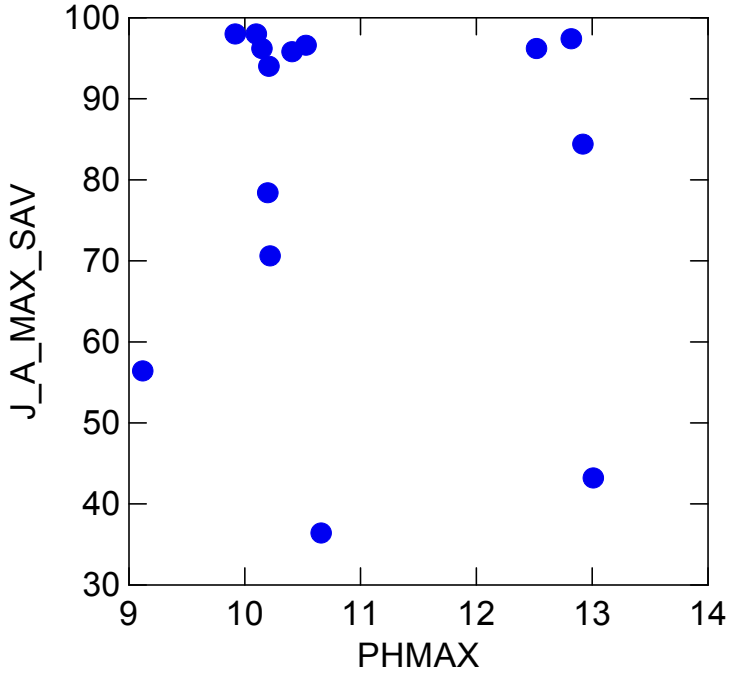
Note that the sites with the lowest cover of July/August SAV (<60%) actually had higher than average differences.

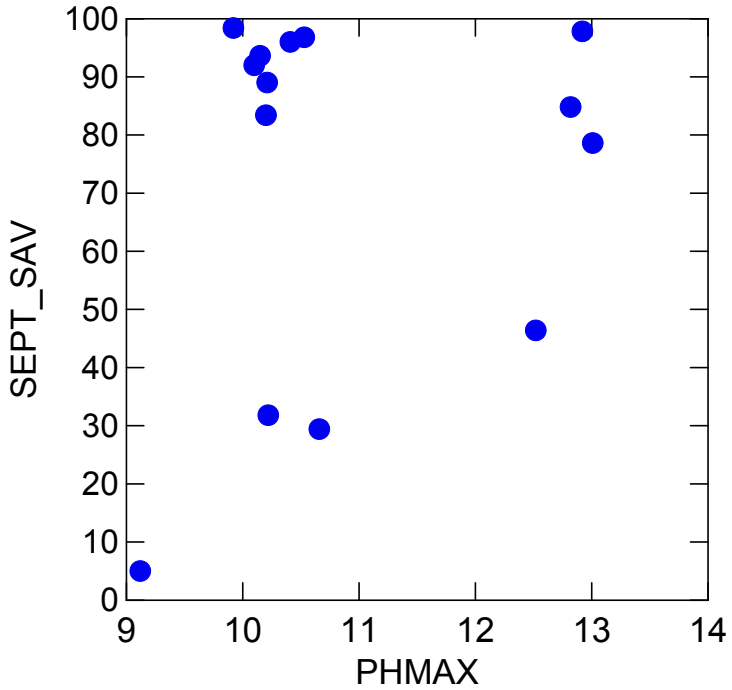




The tendency for SAV to tank seems unrelated to the relative difference between the maximum and minimum DO values.

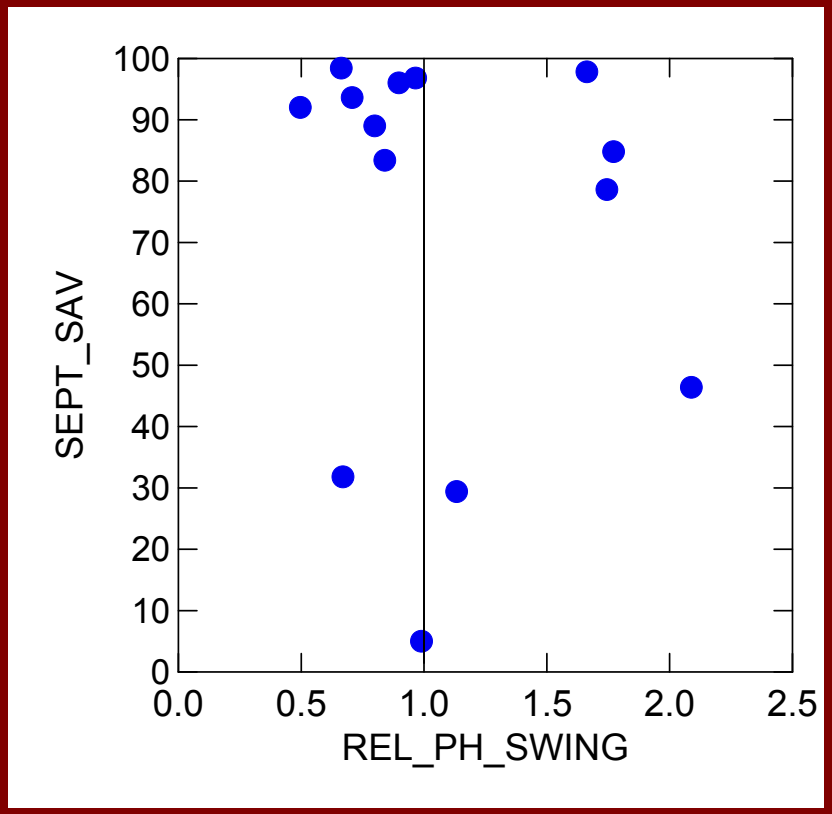
No strong relationships evident.





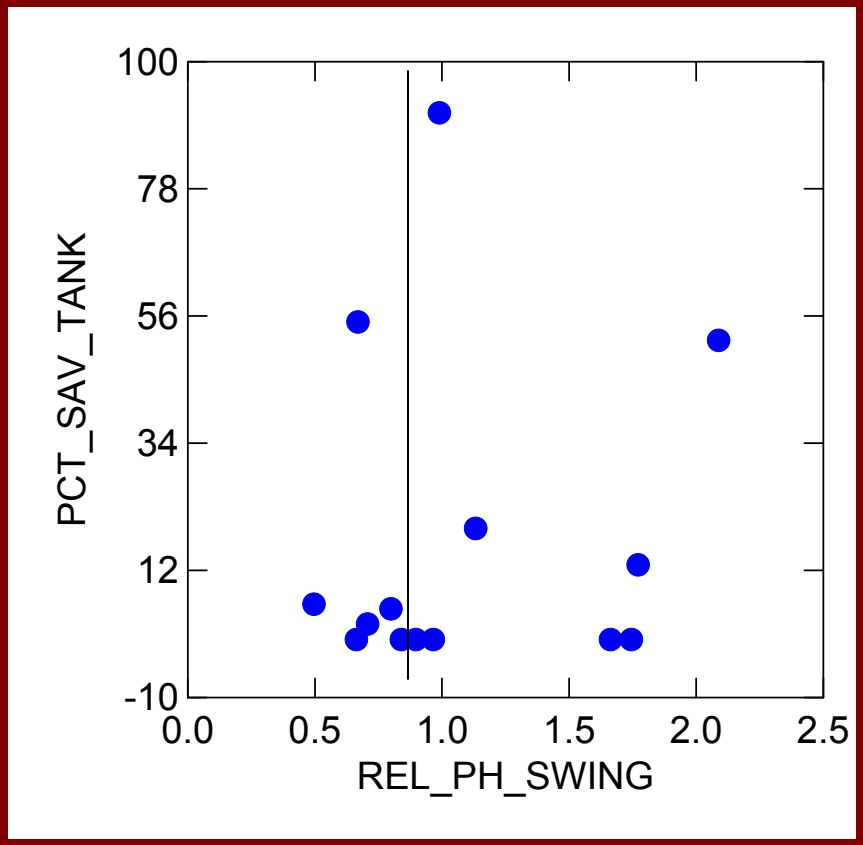
Y= SAV abundance values
X= maximum pH value

No relationships evident.



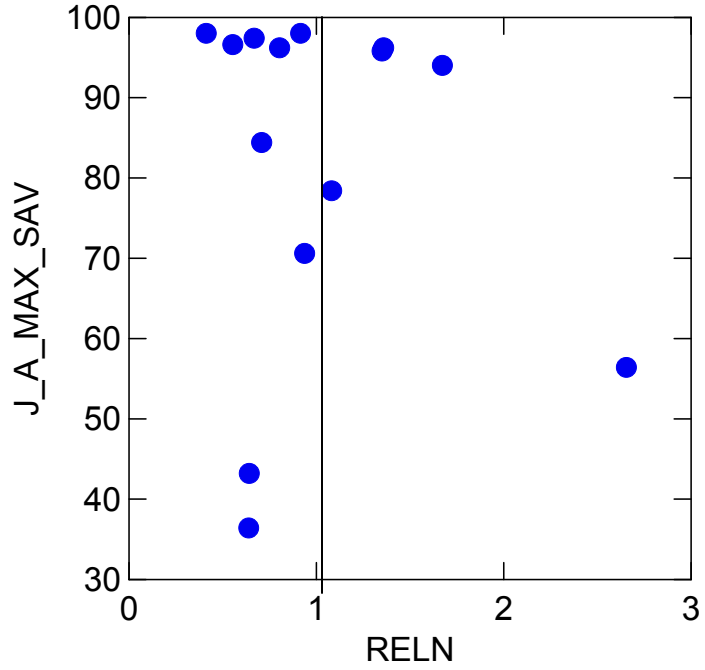
SAV Abundance metrics as a function of the relative difference between maximum and minimum pH values.

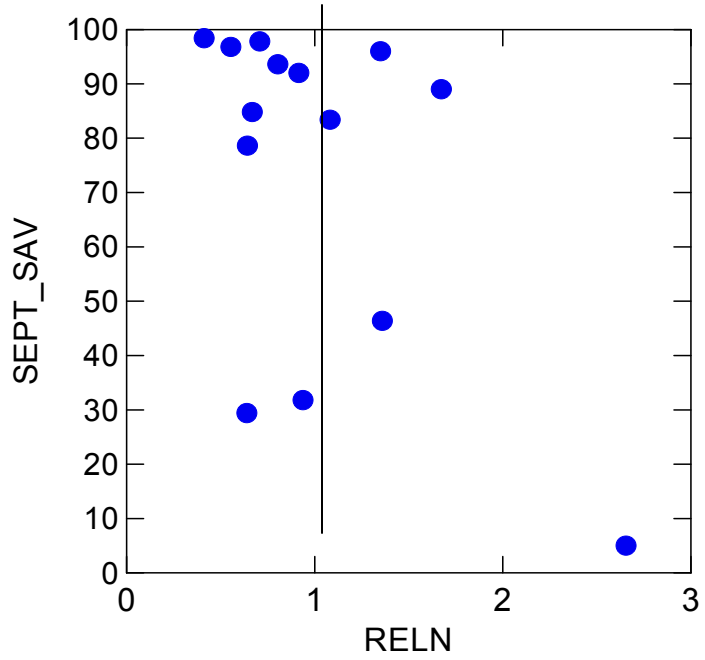
No relationships evident.



Percent change in SAV as a function of difference between maximum and minimum pH scores.

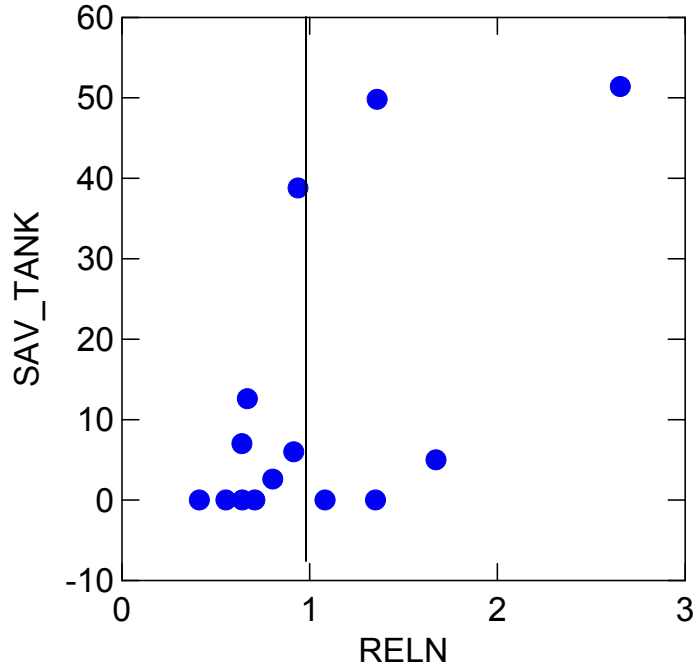
No relationships evident.

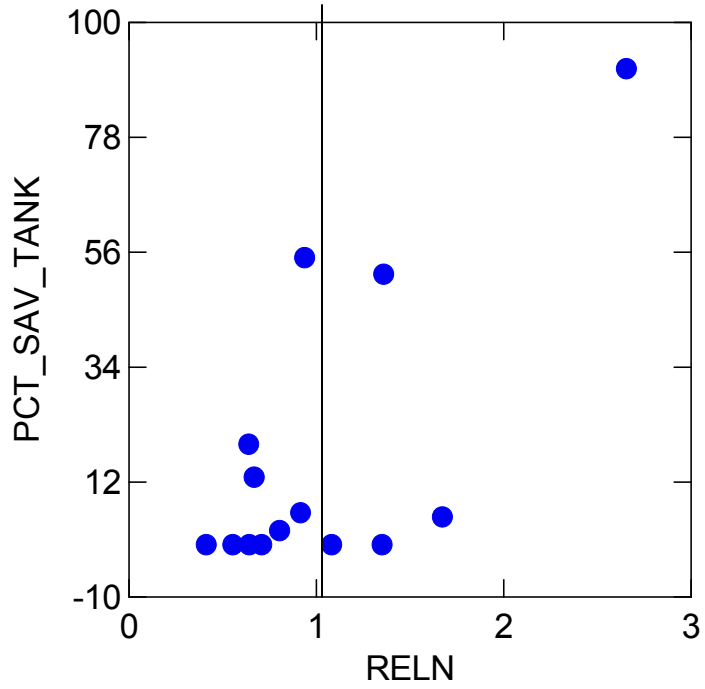




SAV collapse values as a function of relative nitrogen.

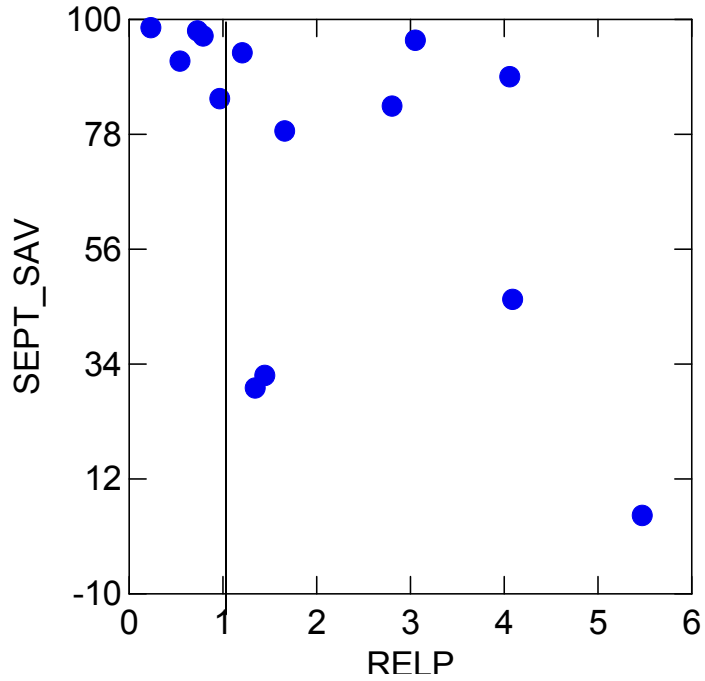
No relationships evident.

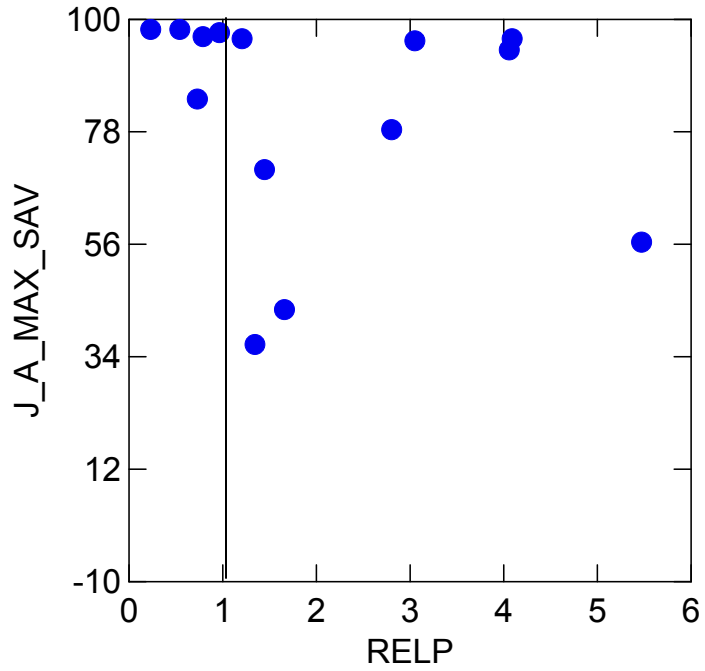




SAV collapse values as a function of relative nitrogen,

No strong relationships evident.



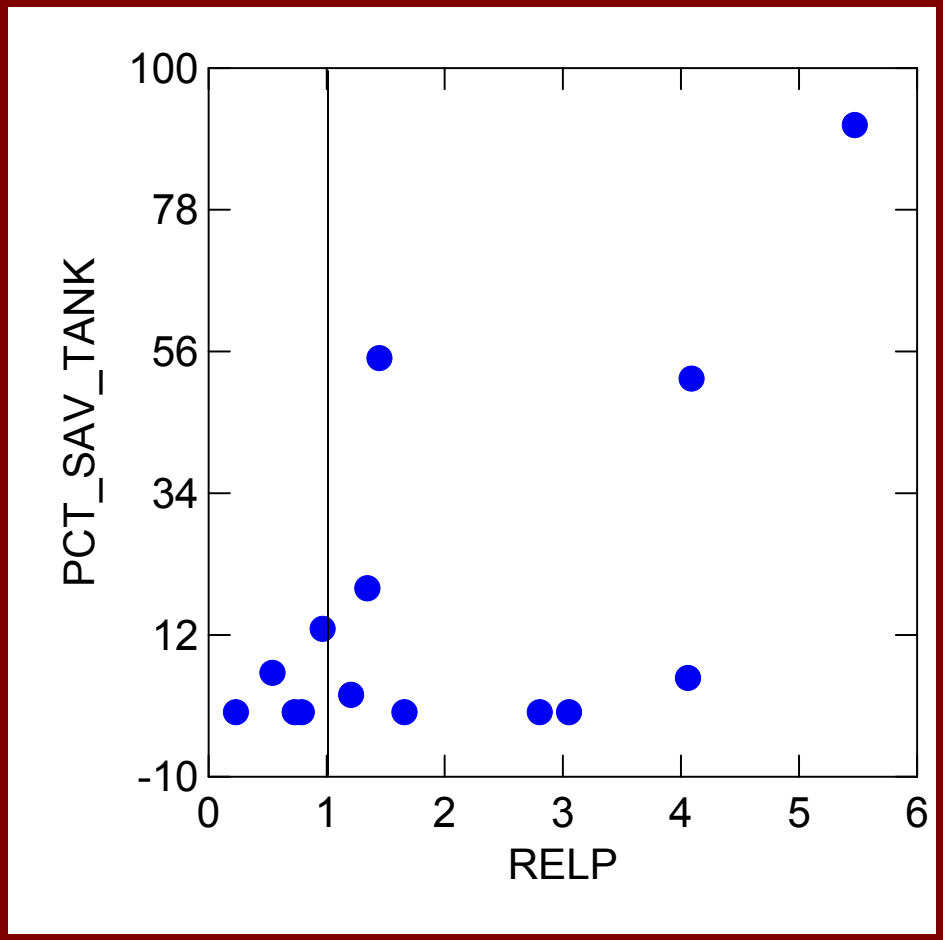


Measures of SAV cover as a function of relative Phosphorous.

Direction of change was as predicted.

Note that all of the sites with lower SAV cover were at sites with relatively high phosphorous, but not all sites with high phosphorous had lower SAV cover.

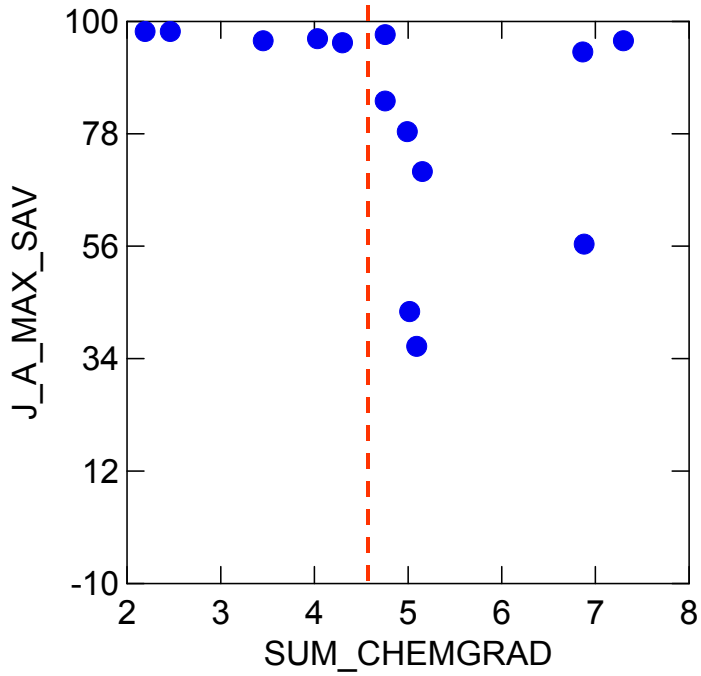
P may be some of the story, but is not the entire story. This is promising with regard to management options, because it means that it may be possible to improve this measure of condition in less expensive ways than P reductions.

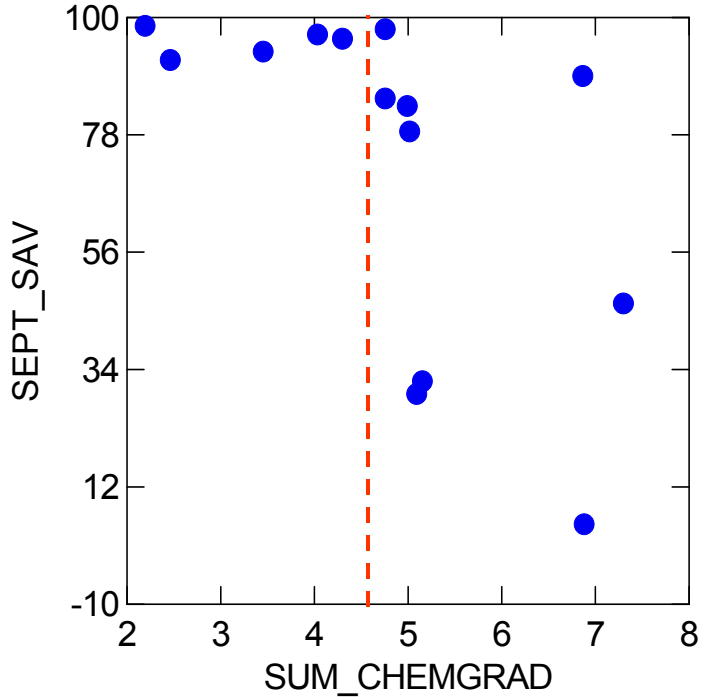


Percent change SAV as a function of relative phosphorous.

Direction of change is as predicted.

Same general relationship as previous graph.



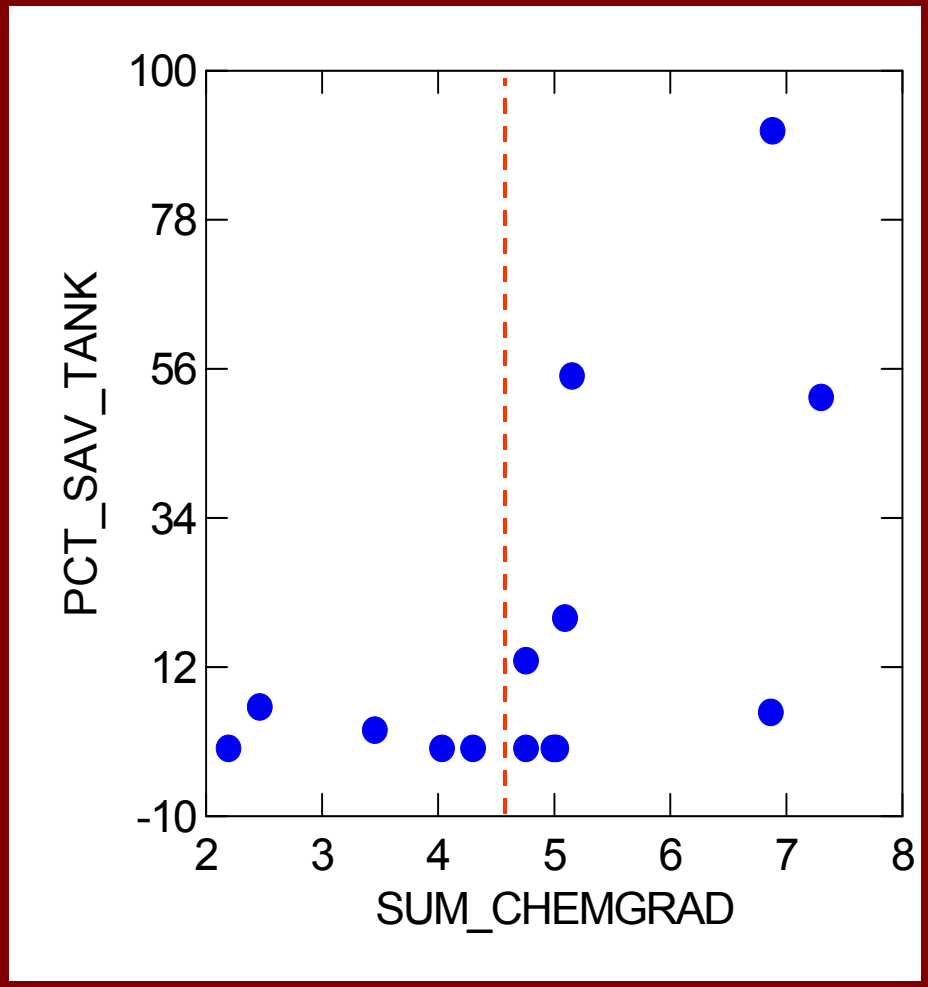


SAV abundance metrics as a function of the overall chemistry gradient.

All of the sites with lower SAV cover in either July/August or in September had high water chemistry scores.

A couple of sites with very poor chemistry scores maintained high SAV cover in summer, but one of these site severely tanked in September.

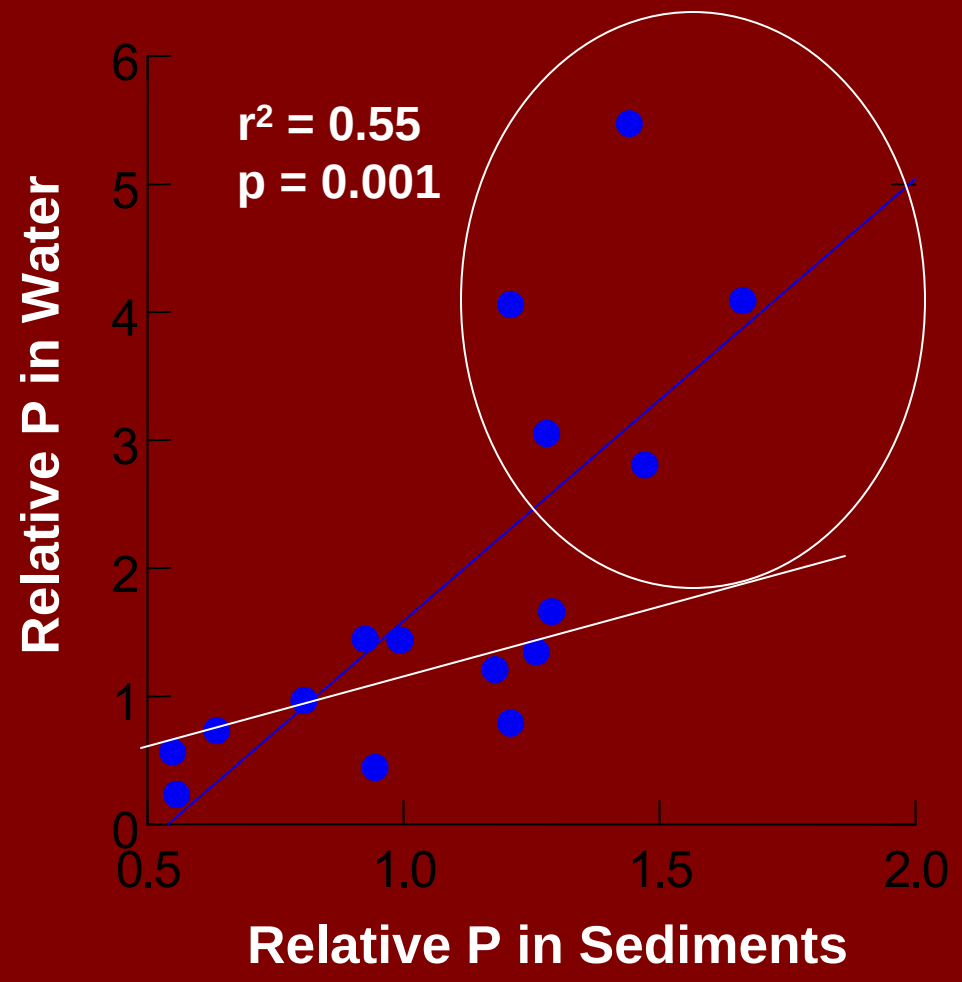
Conversely, all of the sites with a chemistry score <4.5 maintained high abundance in both seasons.



Direction is as predicted for Percent change SAV.

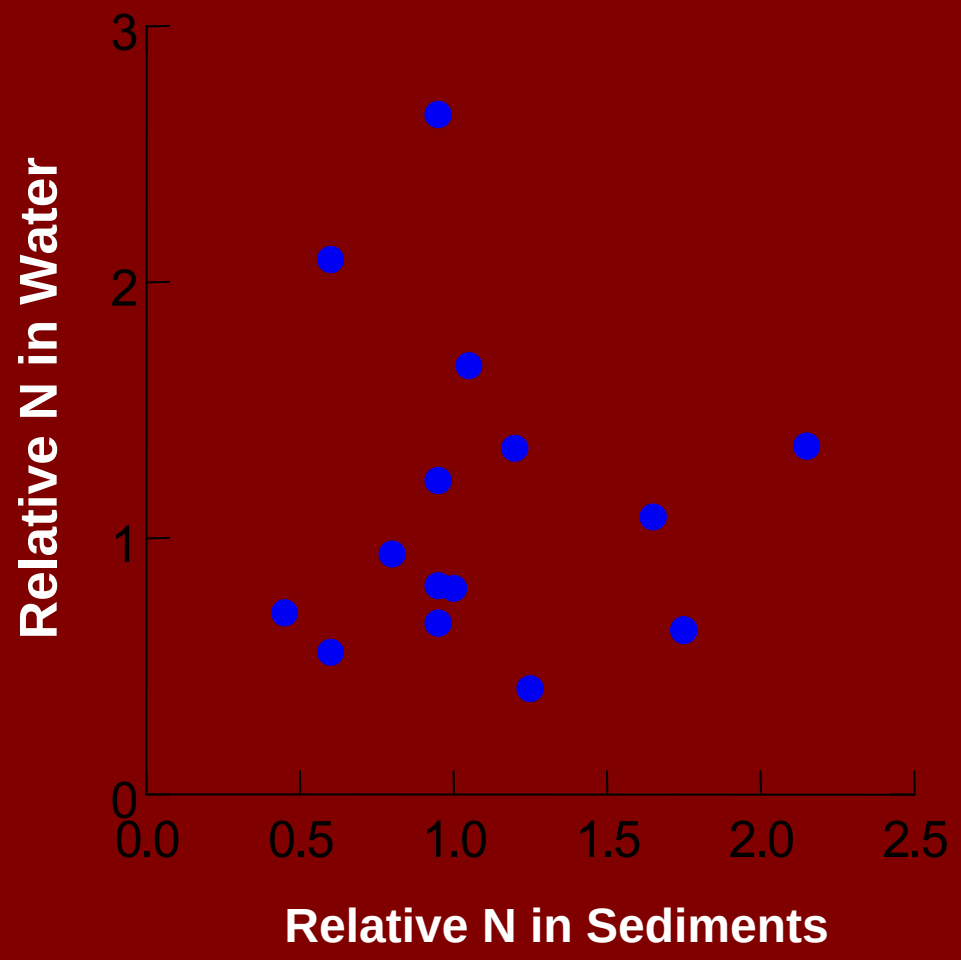
It would be interesting to look further into the site with poor chemistry that maintained high cover.

Work in Progress…



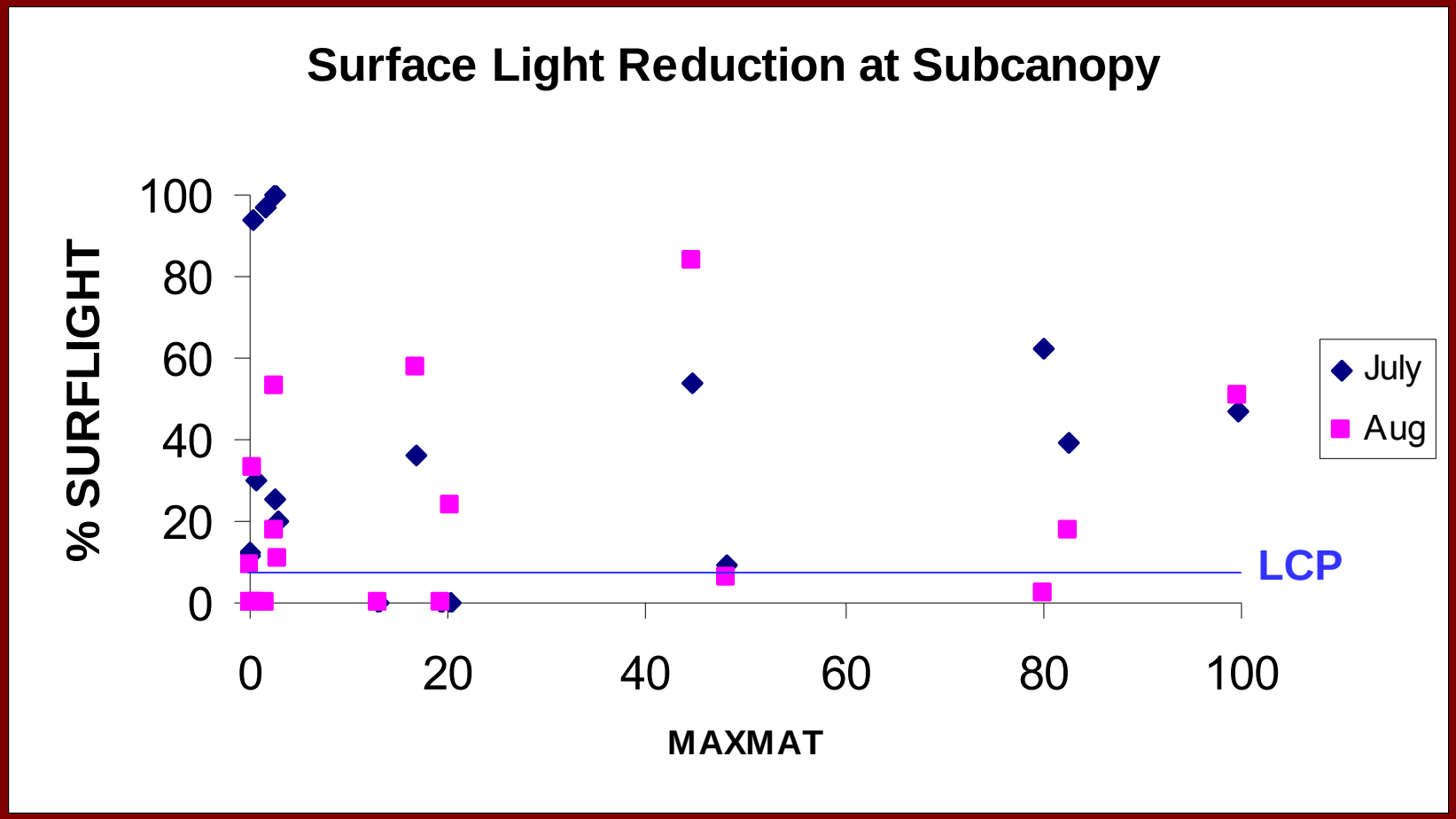
It is interesting that at the sites with very high P, levels are higher in water than in sediments.

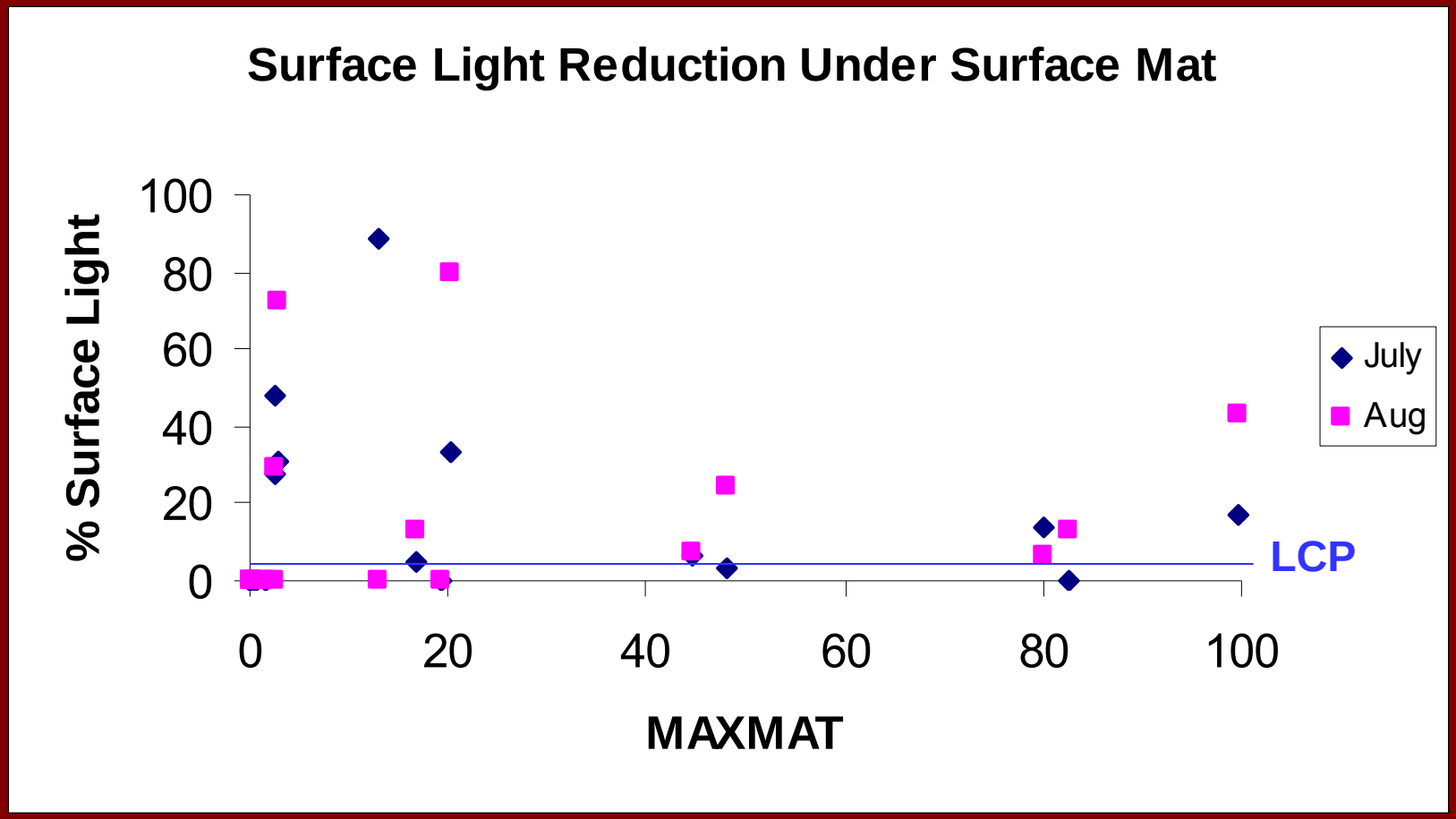
However, once again there are two clear groups of sites. At lower levels of P in both water and sediments they appear to roughly be in equilibrium. Yet at those sites with highest P concentrations the values are much higher in water than in sediments.



No relationships evident.

Work in Progress…




Surface Light Reduction Under Surface Mat
% Surface Light
100
80
60
40
20
0
0
20
40
60
80
100
MAXMAT
July
Aug
LCP

SAV SHADING MATRIX

		Surface Mat		
		H	M	L
Epi/Biofilm	H	H	M-H	M
Epi/Biofilm	M	M-H	M	L-M
Epi/Biofilm	L	M-H	L	L

Overall Summary

Based on these data, the following metrics look to be good candidates:

1) Max algae mat
2) Max duckweed mat
3) July/August SAV Cover
4) September SAV Cover
5) Percent Change in SAV
6) SAV Light Compensation Point
7) Shading Matrix

These can be combined with whatever else we come up with as multiple lines of evidence of the relative condition of wetlands.

Other Potential Lines of Evidence:

- SAV leaf nutrients
- SAV fv/fm
- SAV Pn