Stream Team Data Analysis: Fall 2011-Spring 2015

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Problem Statement and Results Summary

Since Fall 2011, the UCA Stream Team has been monitoring the UCA campus section of Stonedam Creek. Thus far, this activity has yielded enough data to track the progress of the following analytes:

- *Specific conductivity.* Conductivity, measured in µS/cm, is the ability of a water sample to conduct an electrical charge. This is used as an indicator of the quantity of positively and negatively charged ions present in a water sample. These ions typically include chloride, nitrate, phosphate, sulfate, sodium, magnesium, calcium, and aluminum. Conductivity is affected by water temperature: a measurement of specific conductivity takes water temperature into account.
- *NO_3 (nitrates) and PO_4 (orthophosphates).* These nutrients stimulate algae growth, which can lead to hypoxic (low dissolved oxygen) conditions. Stream hypoxia leads to the elimination of organisms sensitive to dissolved oxygen concentrations.
- *Dissolved oxygen.* A requirement for most aquatic life. However, some organisms are more tolerant to low dissolved oxygen concentrations, while others are more sensitive to its absence.
- *Index Values.* Biological Index Values (BIV) are used as indicators of stream water quality and aquatic biodiversity. BIV take account of the number of organisms found in a section of stream, rank these organisms based on their sensitivity to dissolved oxygen levels, and then combine these two variables into an Index Value. A higher BIV indicates a higher number of sensitive organisms (better water quality), while a lower BIV indicates a lower number of sensitive organisms (worse water quality).

It is known that dredging and mowing ended in Spring 2012, and this study compares these metrics before and after dredging/mowing ended. The results indicate a significant improvement over time for specific conductivity and dissolved oxygen, a possible improvement for nitrates and Index Values, and no significant improvement for orthophosphates. The Stream Team will continue to seasonally monitor the stream and incorporate more data as it becomes available.

Methodology

Line graphs. The line graphs depict mean (± SE) specific conductivity, NO_3, PO_4, dissolved oxygen, and Index Values over time. Single Factor Analysis of Variance (ANOVA) was used to initially detect significant differences between seasons, and post-hoc T-tests were used to compare individual seasons to one another. As needed, data points are assigned letters to show where significant differences exist.

Charts. Since it was agreed that dredging and mowing ceased in Spring 2012, the charts compare the aggregate means of all recorded data before Fall 2012 with the aggregate means of all recorded data after Fall 2012. This approach assumes that any change caused by the absence of dredging/mowing would be detected as a significant increase or decrease in the post-Fall 2012 aggregates. T-tests are used to detect significant differences between aggregates.

A potential confounding factor for this approach is the relative amounts of precipitation in the time periods recently preceding each Stream Team date. For example, a higher amount of rain in a given period could lead to a greater influx of nutrients, leading to higher NO_3 and PO_4 concentrations. This, in turn, could inhibit our ability to detect significant differences between time periods. To investigate this confounding factor, monthly precipitation data for Conway, AR from the National Oceanic and Atmospheric Administration (NOAA) for the years 2011-2014 were analyzed, focusing specifically on the two months immediately preceding each sampling date (Table 1). No 2015 data are yet available from the NOAA. No significant differences were found in either total precipitation or aggregate mean precipitation between Fall 2011-Fall 2012 and Spring 2013-Spring 2014. This suggests that precipitation can be eliminated as a confounding factor.

Table 1. NOAA precipitation data by season and year for the two months preceding each sampling date (NOAA, 2011-2014).

Season/Year	Sampling Date	Preceding Months Data Used	Date of Greatest Observed Precipitation	Total Precipitation in Months (in.)
Fall 2011	November 5	September	9-19	1.54
		October	10-13	2.74
Spring 2012	April 22	March	3-21	8.77
		April	4-16	1.95
Fall 2012	October 19	September	9-08	5.66
		October	10-14	3.04
				2011-2012 Total: 23.70
Spring 2013	April 22	March	3-11	3.38
		April	4-19	4.63
Fall 2013	November 1	September	9-21	1.37
		October	10-31	4.21
Spring 2014	April 22	March	3-03	4.20
		April	4-14	5.24
				2013-2014 Total: 23.13

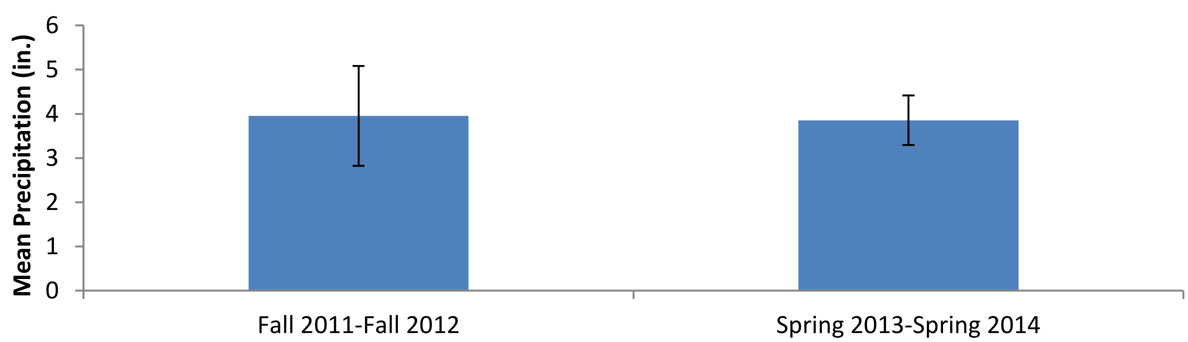

Figure 1. Aggregate mean (± SE) precipitation for the two months preceding each Stream Team date. As in Table 1, the aggregates are segregated between Fall 2011-Fall 2012 and Spring 2013-Spring 2014 dates to give a comparison of rainfall between the two periods. No significant difference was detected between aggregates ($p = 0.942057$).

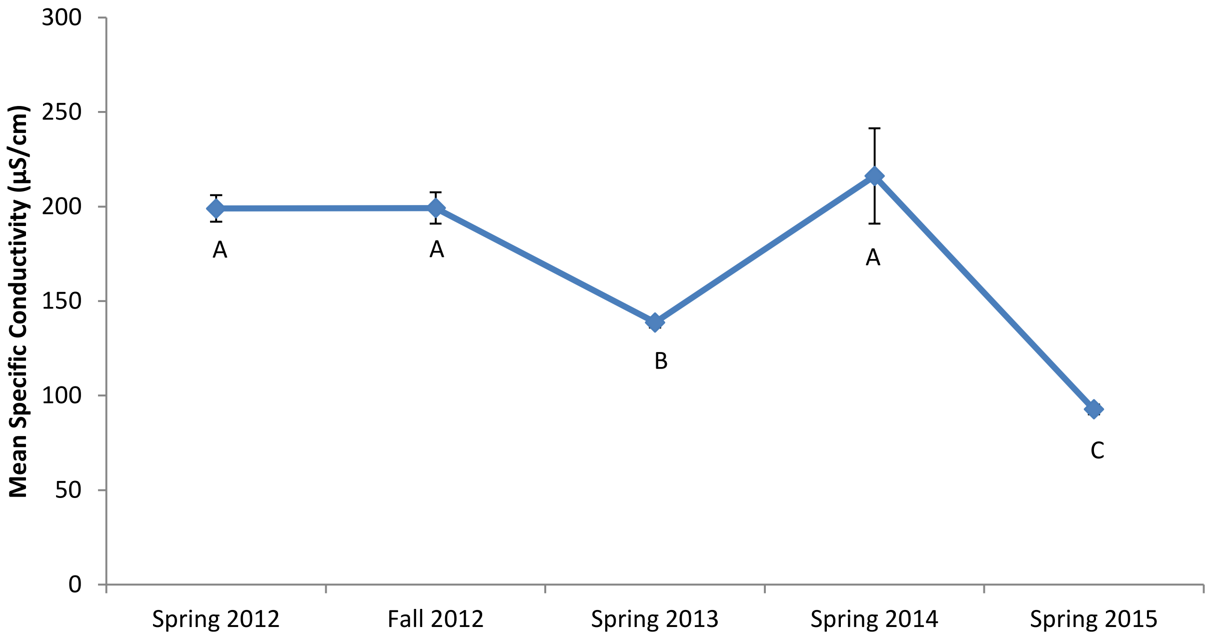

Figure 2a. Mean (± SE) specific conductivity (SC) for Stream Team data collected over five seasons. ANOVA indicated a significant difference between seasons ($p = 0.000115$). SC measurements for both Spring 2013 (B) and Spring 2015 (C) were significantly lower than Fall 2012 ($p = 0.003309$, $p = 2.38E-06$), and the SC measurement for Spring 2015 was significantly lower than Spring 2013 ($p = 1.19E-05$).

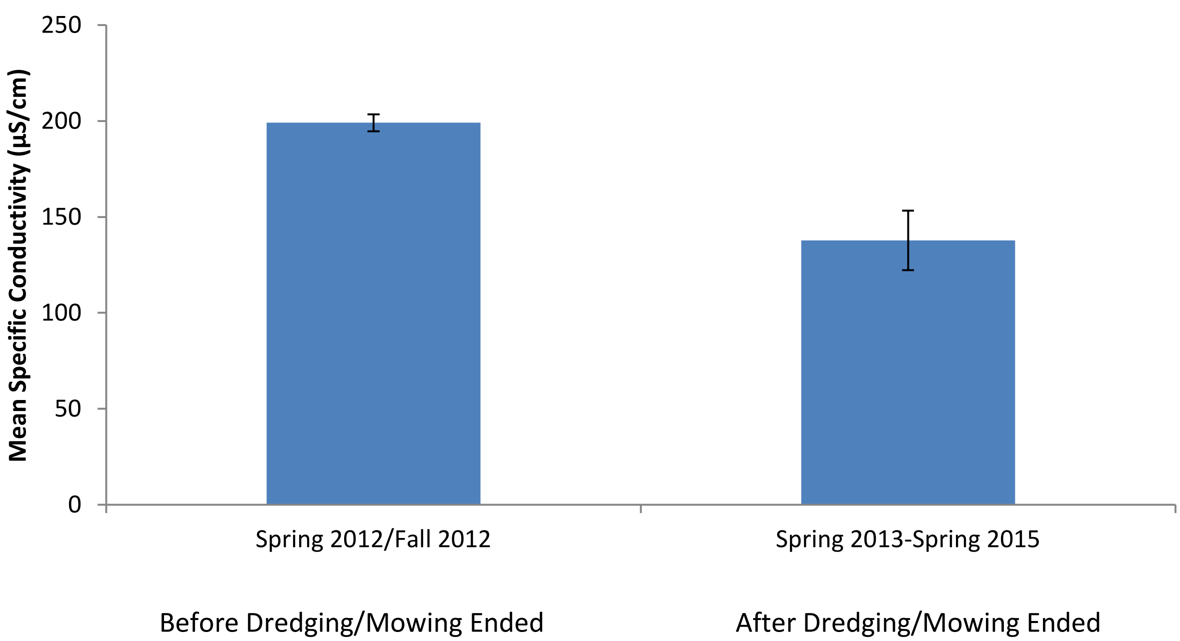

Figure 2b. Aggregate mean (± SE) conductivity for Stream Team data collected over five seasons. The Spring 2013-Spring 2015 aggregate was found to be significantly lower than the Spring 2012/Fall 2012 aggregate ($p = 0.002002$).

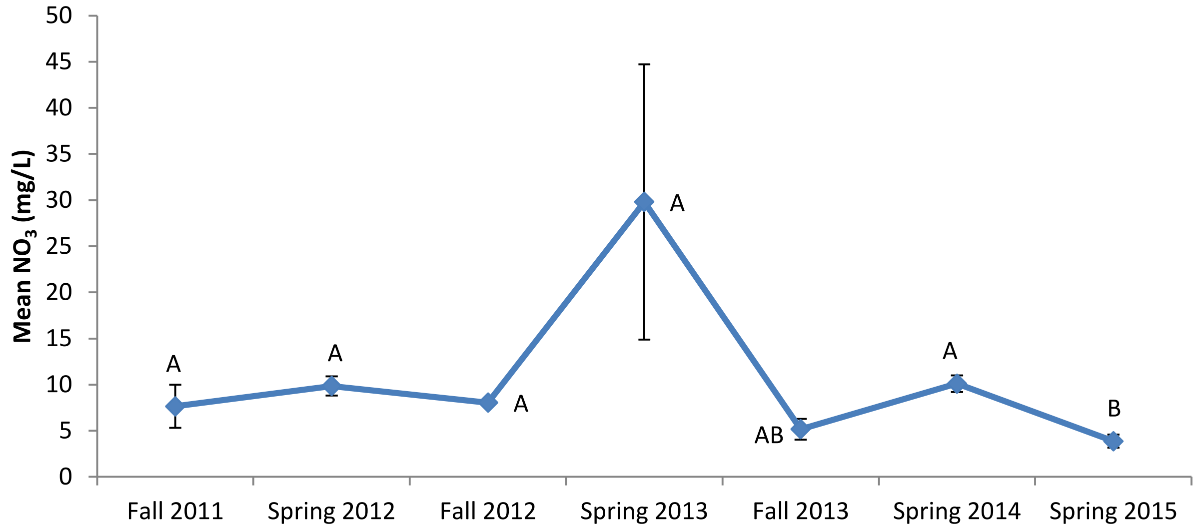

Figure 3a. Mean (± SE) nitrates for Stream Team data collected over seven seasons, including Spring 2013 data.

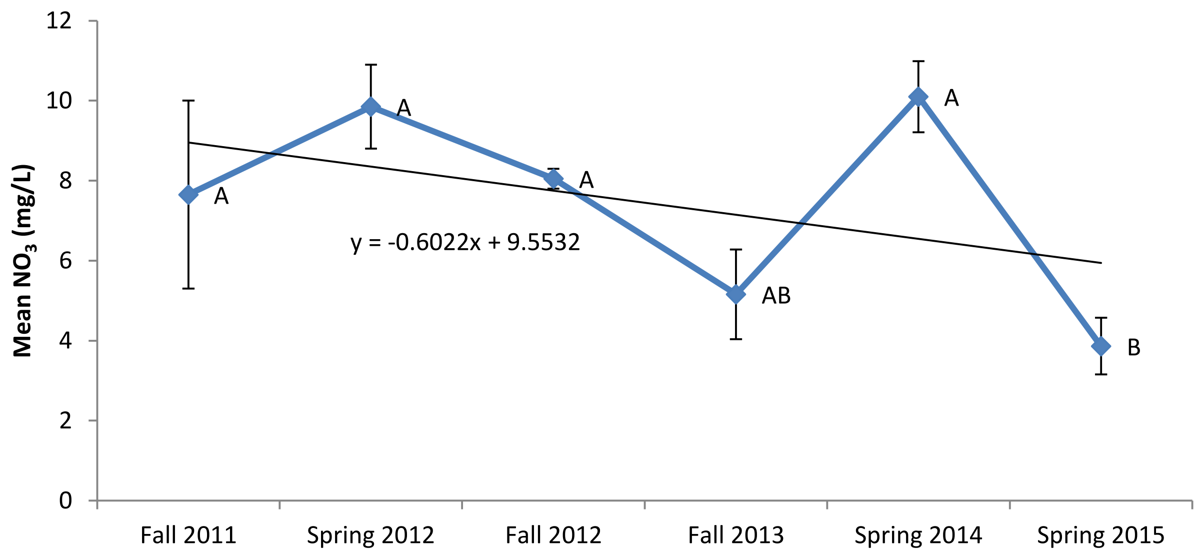

Figure 3b. Mean (± SE) nitrates for Stream Team data collected over six seasons, excluding Spring 2013 data. Spring 2013 is treated as an outlier in Figure 3b, attributed at the time of sampling to recent fertilizer use. This data point was not used in the ANOVA test, which still indicated a significant difference between seasons ($p = 0.016316$). The mean NO_3 concentrations for Fall 2013 (AB) and Spring 2015 (B) were both significantly lower than Fall 2012 (A)($p = 0.030787$, $p = 0.022632$), but Spring 2015 (B) was not significantly lower than Fall 2013 (AB)($p = 0.371568$).

However, it must also be noted that no significant difference was detected between Fall 2011 and Fall 2013 ($p = 0.383724$). Although Spring 2015 concentrations tended to be lower than Fall 2011, the T-test p-value was slightly above the $\alpha = 0.05$ level ($p = 0.062435$). The reason that significant differences existed between Fall 2012 and Fall 2013/Spring 2015, but not as clearly between Fall 2011 and Fall 2013/Spring 2015, is the greater range between high and low measurements in Fall 2011 (demonstrated by Fall 2011's error bars). So, although it appears that nitrate concentrations have decreased, more data will be needed to determine whether or not nitrate concentrations have shifted to a lower range.

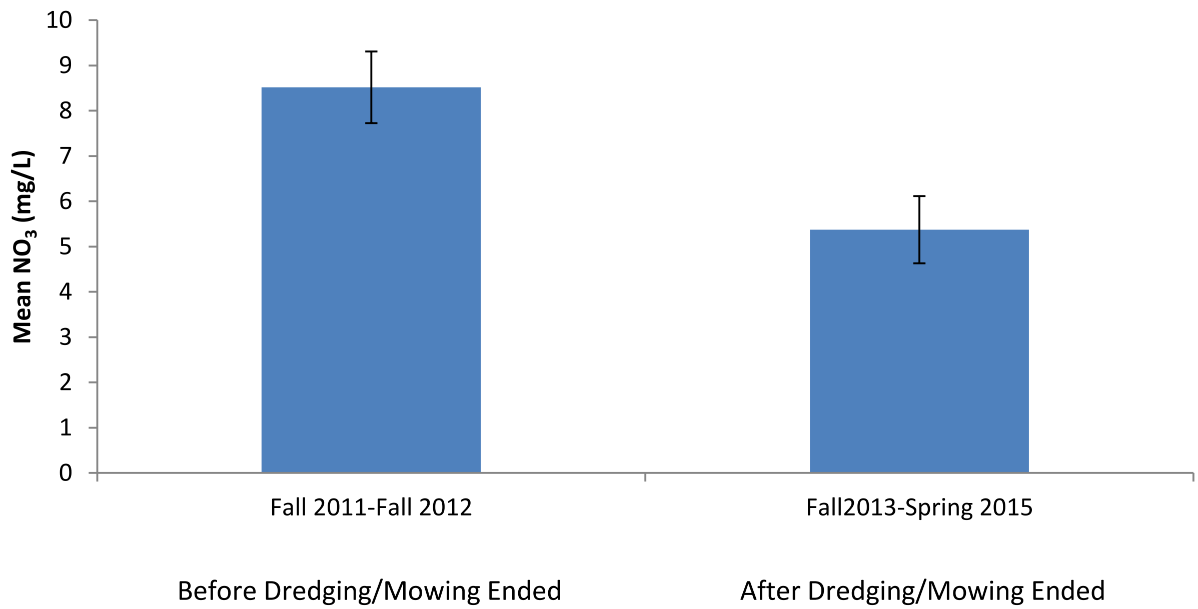

Figure 3c. Aggregate mean (± SE) nitrates for Stream Team data collected over six seasons (without including Spring 2013 data). The Fall 2013-Spring 2015 aggregate was found to be significantly lower than the Fall-2011-Fall 2012 aggregate ($p = 0.041917$).

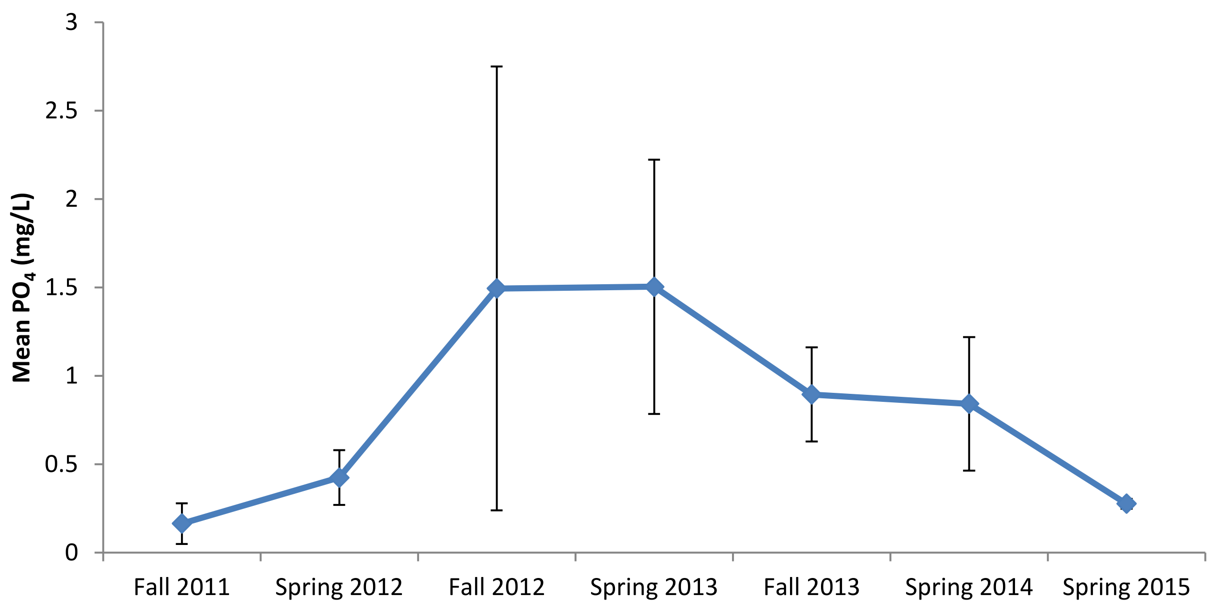

Figure 4a. Mean (± SE) orthophosphates for Stream Team data collected over seven seasons. ANOVA indicated no significant difference between seasons ($p = 0.219282$).

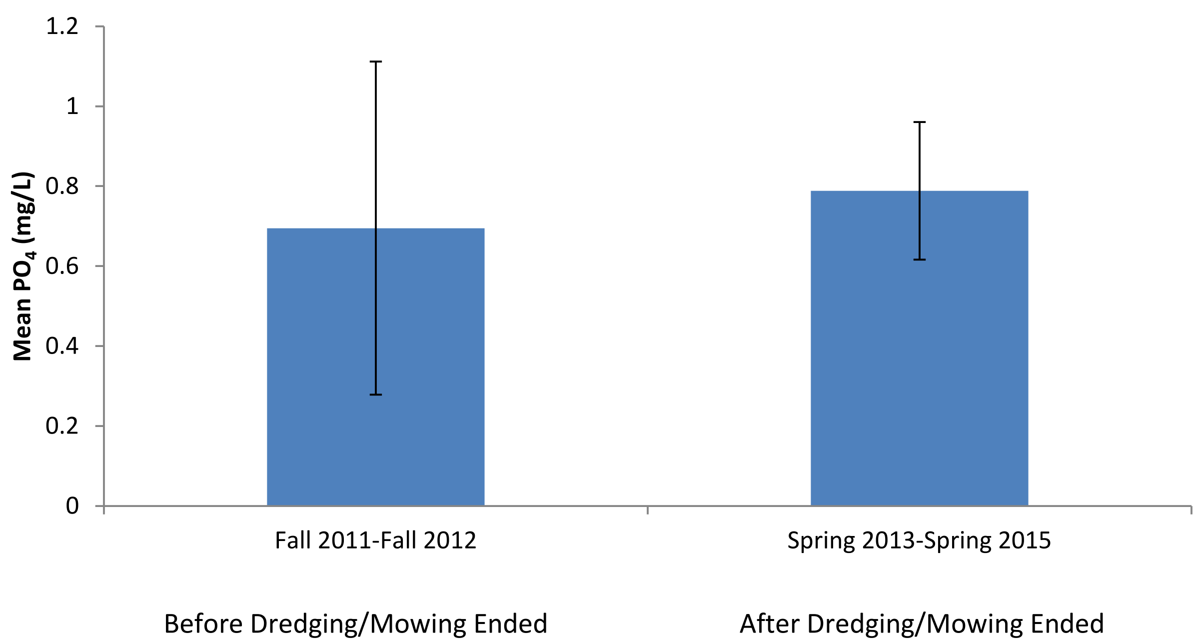

Figure 4b. Aggregate mean (± SE) orthophosphates for Stream Team data collected over seven seasons. No significant difference was found between aggregates ($p = 0.818755$).

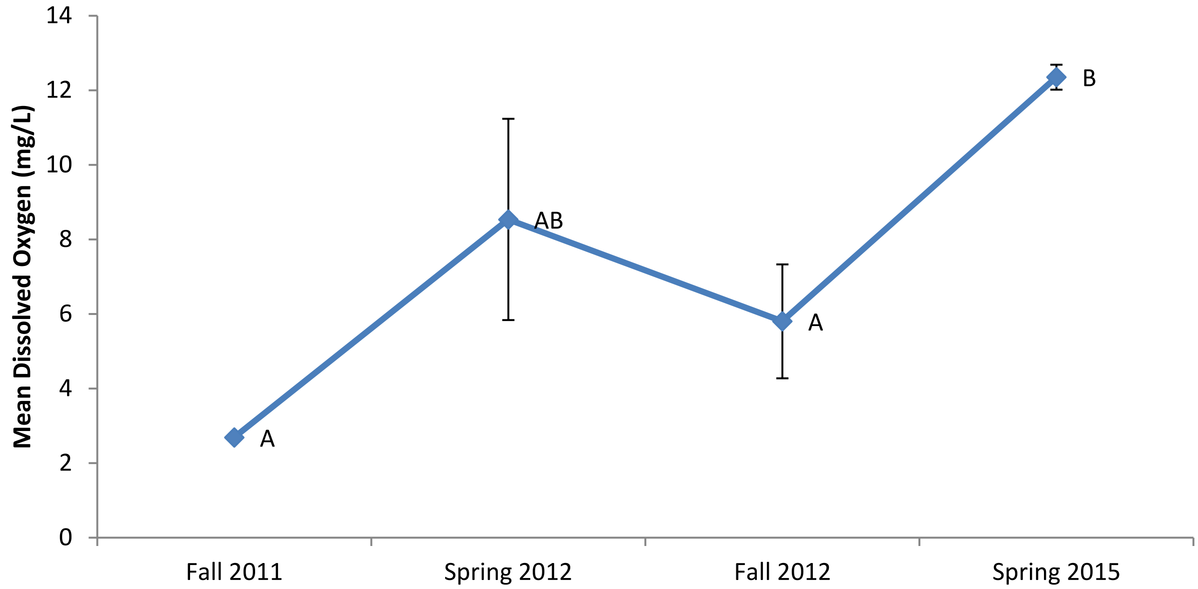

Figure 5a. Mean (± SE) dissolved oxygen for Stream Team data collected over four seasons. ANOVA indicated a significant difference between seasons (p = 1.38E-05). Spring 2015 (B) dissolved oxygen concentrations were significantly higher than both Fall 2012 (A)(p = 1.13E-05) and Fall 2011 (A)(p = 3.71E-07), but were not significantly higher than Spring 2012 (AB)(p = 0.393982). Spring 2012 (AB) concentrations were not significantly higher than either Fall 2011 (A)(p = 0.275636) or Fall 2012 (A)(p = 0.30364). More data will be needed to determine whether or not concentrations have shifted to a higher range.

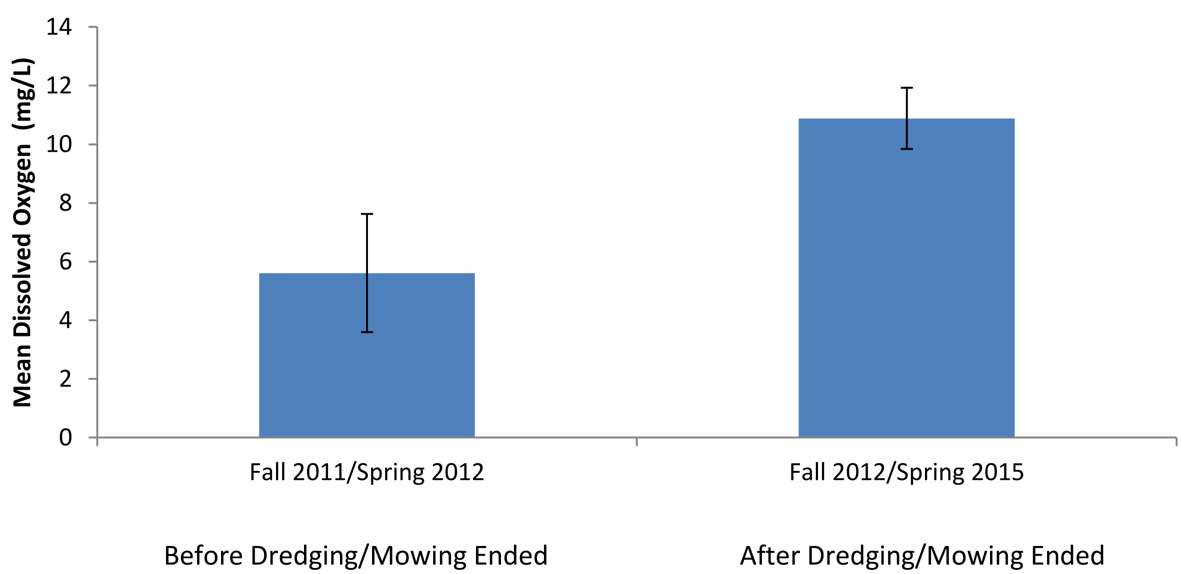

Figure 5b. Aggregate mean (± SE) dissolved oxygen for Stream Team data collected over four seasons. The Fall 2012/Spring 2015 aggregate was significantly higher than the Fall 2011/Spring 2012 aggregate (p = 0.026008).

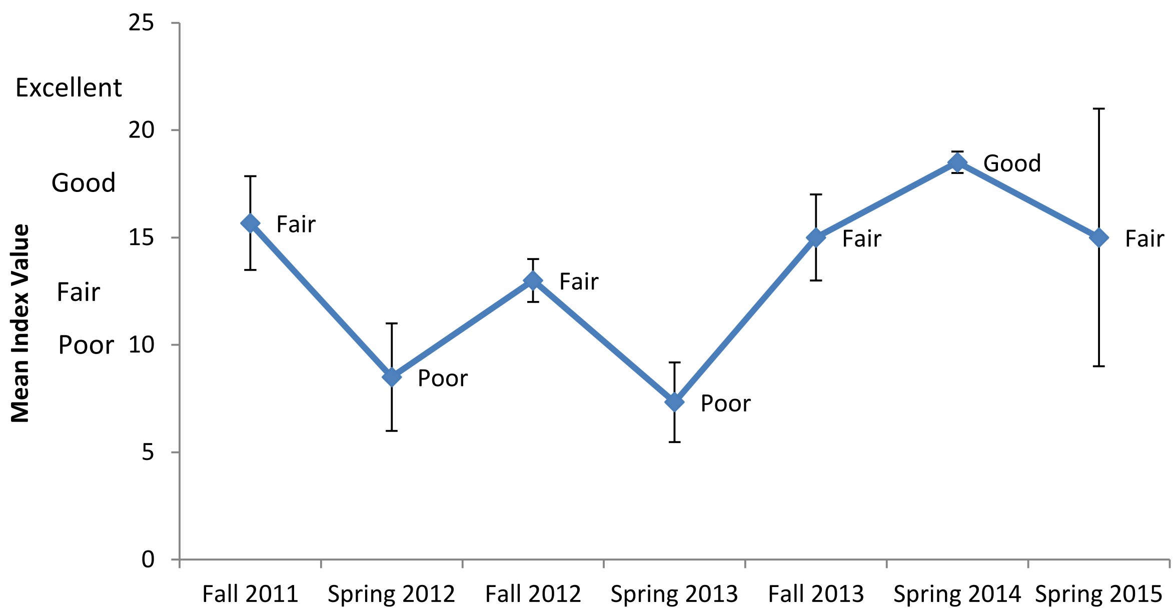

Figure 6a. Mean (± SE) Index Values for Stream Team data collected over seven seasons. A high Index Value indicates a higher number of dissolved oxygen-sensitive taxa, while a lower Index Value indicates a lower number of dissolved oxygen-sensitive taxa. ANOVA indicated no significant difference between seasons (p = 0.110792). However, it is notable that Spring 2014 was the first Spring in which a 'Good' score was achieved. More data will be needed to determine whether or not scores have shifted to a higher range.

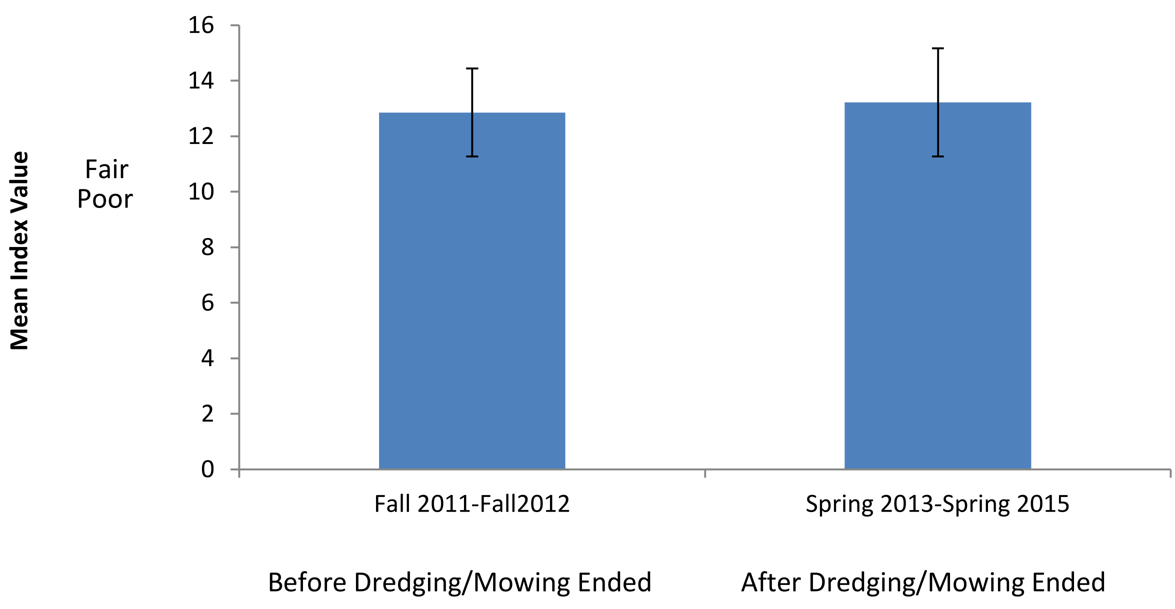

Figure 6b. Aggregate mean (± SE) Index Values for Stream Team data collected over seven seasons. A high Index Value indicates a higher number of sensitive taxa, while a lower Index Value indicates a lower number of sensitive taxa. The aggregate means of both periods indicate a mean score of 'Fair'. No significant difference was found between aggregates (p = 0.891165).

Conclusion

Significant improvement has been achieved for levels of specific conductivity and dissolved oxygen, while nitrate concentrations and Index Values may also be improving. The Stream Team will continue to seasonally monitor the stream and gather data.

Works Cited

National Oceanic and Atmospheric Administration. (2011-2014). *Annual Climatological Summary.* Asheville: National Centers for Environmental Information. Retrieved from http://www.ncdc.noaa.gov/cdo-web/datasets/ANNUAL/stations/COOP:031596/detail