Implementation of Intensive Water Quality Monitoring and Evaluation to Support the Lake O' the Pines National Water Quality Initiative (NWQI) – Phase I Final Report

Texas Water Resources Institute TR-505
August 2017

Texas Water Resources Institute
make every drop count

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Texas State Soil and Water Conservation Board Project #12-12

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August 2017

Funding for this project was provided through a Clean Water Act §319(h) Nonpoint Source Grant from the Texas State Soil and Water Conservation Board and the U.S. Environmental Protection Agency

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Introduction

Lake O' the Pines (Segment 0403) is listed on Texas' 303(d) list as impaired due to low levels of dissolved oxygen (DO). In 2006, it was determined that nutrient loading from the watershed, namely phosphorous, was responsible for the DO impairment. Data collected from Ferrell's Bridge Dam shows a steady decline in DO since data collection began in 1973 (Figure1). The Texas Commission on Environmental Quality (TCEQ) addressed this issue in the development of *One Total Maximum Daily Load for Dissolved Oxygen in Lake O' The Pines* (TCEQ 2006). Sources of phosphorous were determined to come from both point and non-point sources within the watershed.

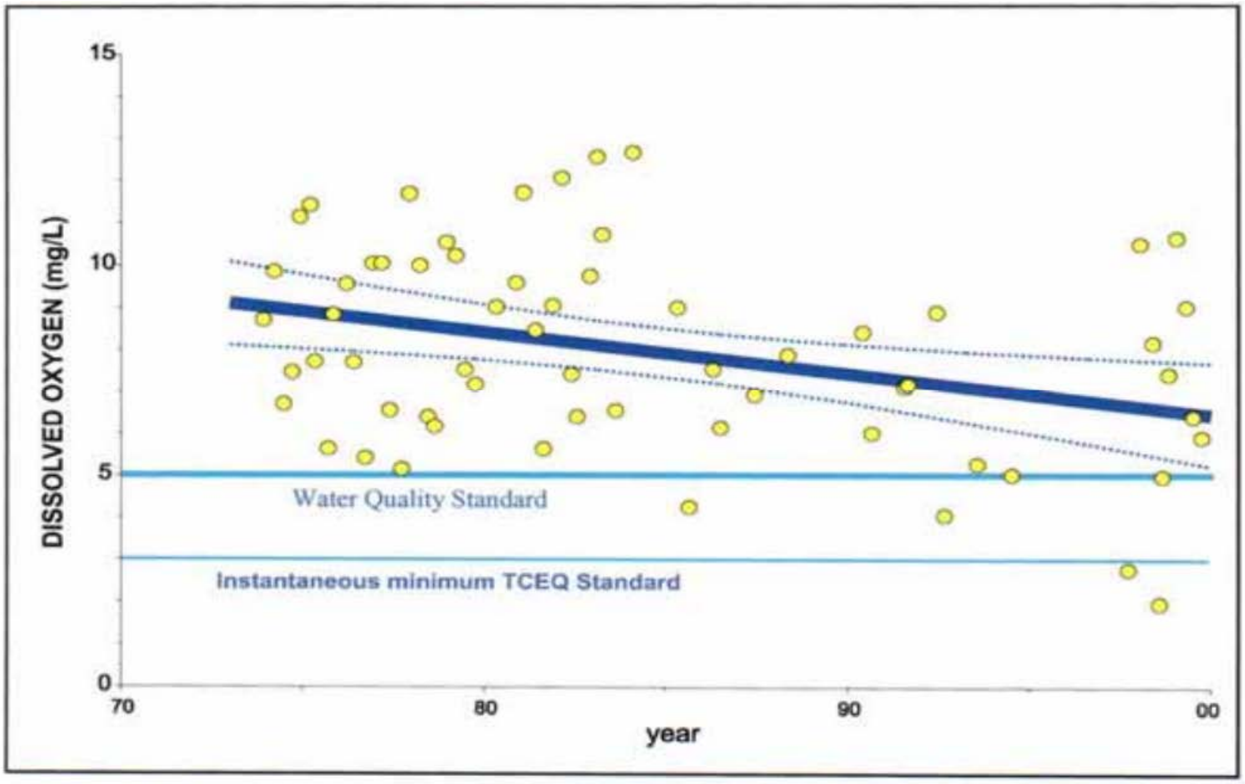


Figure 1. Dissolved Oxygen concentrations in Lake 'O the Pines at Ferrells Bridge Dam from 1973 to 2000. Graph from TCEQ

To address pollutant loading sources, both point and nonpoint source management measures were identified in the Implementation Plan for *One TMDL for Dissolved Oxygen in Lake O' the Pines*. These included the development of a group wastewater permit to address point sources and the implementation of best management practices (BMP) to address agricultural related nonpoint sources. The TMDL I-Plan specifically identified the need for BMP evaluations to be conducted (Management Measure AG 3). An effort led by NETMWD began in 2004 and aimed to evaluate the effectiveness of several BMPs; however, the project period encompasses sporadic weather conditions and was hampered by equipment malfunctions that contributed to mostly inconclusive results. BMP implementation has been underway for a number of years while the implementation of a group permit was only effectively carried out in June 2013. To date, DO levels in the lake have not improved sufficiently to restore water quality.

As a result, natural resource management professionals in Texas recommended the Lake O' the Pines watershed for implementation of the National Water Quality Initiative (NWQI) Program in 2013. Through the NWQI program, the Natural Resources Conservation Service (NRCS) offered financial and technical assistance to farmers, ranchers and forest landowners interested in improving water quality and aquatic habitats in priority watersheds with impaired streams. The NRCS offered assistance implementing conservation and management practices through a systems approach to control and trap nutrient, sediment and manure runoff from their operations. Qualified producers could receive assistance for installing conservation practices such as cover crops, waste storage facility, pasture planting and tree planting, among others.

Site-specific conditions where practices are implemented can have considerable influence on off-site water quality. To determine water quality impacts from implemented practices, a robust water quality monitoring regime that can describe field, farm and sub-watershed level pollutant reductions was implemented. The monitoring regime implemented was designed to provide data at multiple scales to illustrate the level of water quality improvements realized through implementation of the NWQI program to address nutrient, pathogen and sediment resource concerns. This program allows NRCS to work with farmers, ranchers and forest owners to install conservation practices on their lands.

The original intent of this project was to collect several years of pretreatment and several years of post-treatment data using a paired watershed monitoring design. However; due to program timelines, no pretreatment data was able to be collected on any monitoring scale. This forced the monitoring design to shift to a multiple watershed approach (NRCS 2003). This approach allows for direct comparisons of multiple treatment types on similar scales. Data collected through this project illustrates and will ultimately be used to educate producers on the water quality impacts of implemented conservation practices.

Site Description and Methods

This monitoring program's goal is to assess water quality improvements resulting from conservation practice implementation in the Lake O' the Pines watershed. Monitoring methods used include edge-of-field, edge-of-farm and instream sampling. Edge-of-field and edge-of-farm monitoring was implemented to quantify non-point source pollutant loading differences resulting from implemented conservation practices. Instream monitoring established an overall pollutant load from monitored watersheds. In total, four edge-of-field, four edge-of-farm and two instream monitoring stations were established (Table 1, Figure 2). One of each type site was designated as a control, and received no NWQI improvements. Three of the field sites and three farm sites each underwent some form of site improvement through the NWQI program.

Table 1. Study sites, location, land use, size, collection dates, and total number of sampling events.

Site	Type	County	Huc 12	Land Use	Acres	Data Collection Period	# Sampling Events
1A	Field	Titus	06	Cover crop, prescribed grazing, nutrient mgmt, waste application	1	Feb 2016-Aug 2017	16
2A	Field	Titus	05	Forest planting, prescribed grazing nutrent mgmt	2.18	Mar 2016-April 2017	5
3A	Field	Camp	07	Control: natural forest revegetation only	0.81	Mar 2016-June 2017	10
4A	Field	Camp	07	Forest planting, forest stand improvement	0.58	Mar 2016-June 2017	8
1B	Farm	Titus	06	Cover crop, prescribed grazing, nutrient mgmt, waste application	4.56	Feb 2016-July2017	16
2B	Farm	Titus	06	Cover crop, prescribed grazing, nutirient mgmt	9.34	Feb 2016-Aug 2017	12
3B	Farm	Titus	05	Cover crop, prescribed grazing, nutrient mgmt	4.63	Feb 2016-Aug 2017	20
4B	Farm	Camp	03	Control: continous grazing, periodic fertilizer application	2.92	Feb 2016-Aug2017	22
Boggy SH 11	Instream	Morris	06	N/A	N/A	Jan 2016-Aug 2017	35
Prairie FM 557	Instream	Camp	07	N/A	N/A	Jan 2016-Aug 2017	34

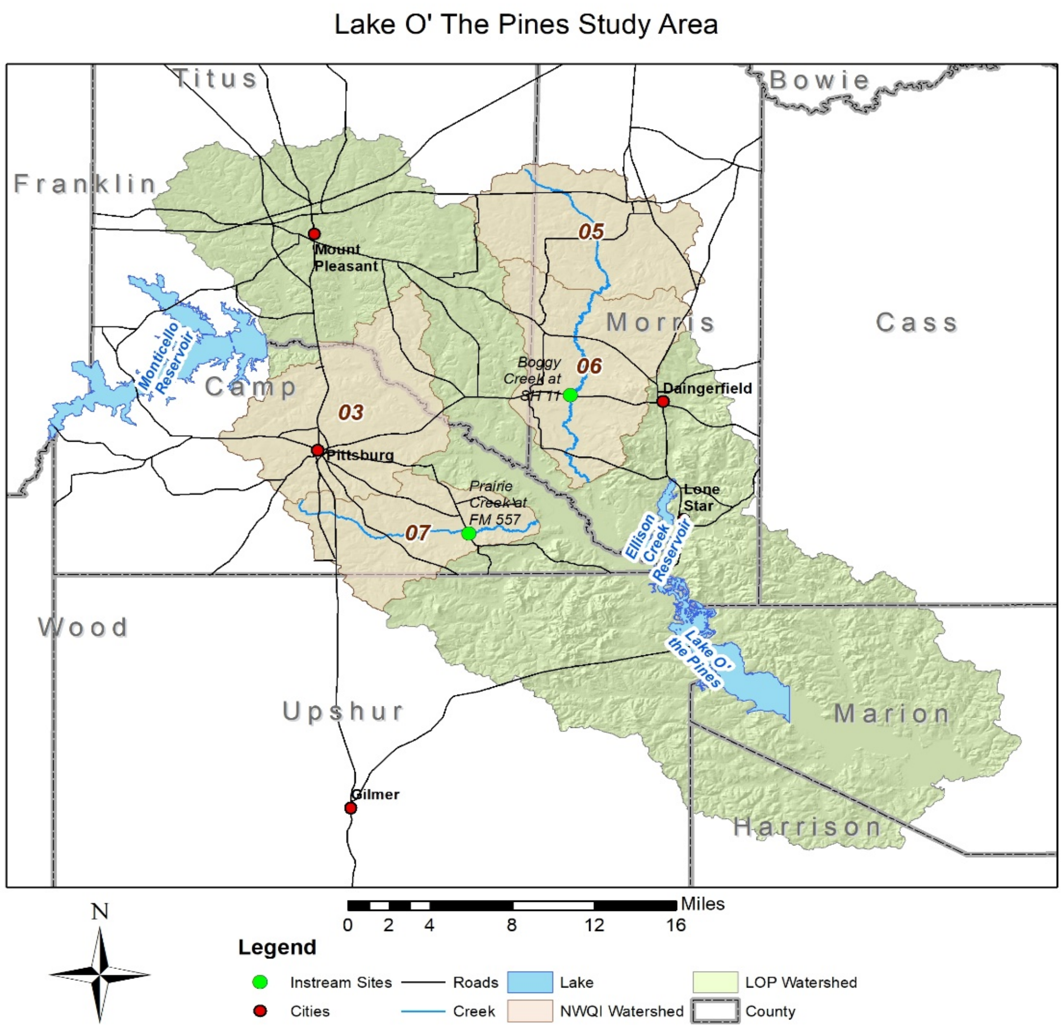


Figure 2. Lake O' The Pines study area. Field and farm sites are located in HUCs 03, 05, 06, and 07. Instream sites are located on Boggy and Prairie Creeks.

Figure 3. (clockwise from top left): Texas A&M Forest Service constructing earthen berm; completed earthen berm around farm-scale site; field scale plot with silvopasture and grazing management practices applied; field scale forest stand establishment plot (seedlings planted in furrows); farm scale control site (continuous grazing ~40 AUs); completed berm repairs following large rain event

Edge of Farm/Edge of Field Sites

Earthen berms were constructed to route overland flow downslope through 1- and 2-foot H-flumes on the field and farm sites, respectively (Figure 3). The H-flumes are equipped with bubbler flow meters to provide a stage-discharge relationship for flow rate measurement.

Teledyne ISCO® Avalanche refrigerated samplers were installed to automatically collect composite water quality samples and to measure and store flow rate at each site. An automated tipping bucket rain gauge connected to the Avalanche sampler measured precipitation on each property.

Runoff volume and flow-weighted water quality samples were collected at the each edge-of-field/farm sites as generated by natural storm events. Water level in the H-flume was recorded with an ISCO 730 bubbler flow meter. Samplers were programmed enable when water levels were ≥0.047' above zero. Once enabled, defined pre-programed flow intervals developed to collect each 1.32mm of runoff over the defined plot area dictated the sampling interval. When reached, the sampler rinsed the sampling tubing with ambient water prior to sample collecting 200 mL samples. Sampling continued at the defined interval until water level in the H-flume dropped below the 0.047' enable threshold. Samples were retrieved and delivered to the lab for analysis by field staff within 24hrs of sampler enabling.

Instream Sites

Instream, or subwatershed monitoring stations, were located on perennial streams in the Boggy Creek and Prairie Creek subwatersheds (Figure 4). At these locations, a Teledyne ISCO® 6712 sampler automatically collected water samples and recorded water levels. Samplers collected flow-weighted-composite samples at designated flow-paced intervals to allow baseflow and storm influenced flows to be captured. Stage discharge relationships developed for each site relate water depth to volumetric flow rates during flow conditions up to the bankfull level. This allowed water level data to be used for flow rate estimates. Several flood events occurred during the monitoring period; however, accurate flow rates were not recorded. Composite samples were retrieved on approximately 2 week intervals. *E. coli* loads at these sites were estimated using twice-monthly grab samples collected at the sampling locations when composite samples were retrieved. Instream field parameters including pH, specific conductance, dissolved oxygen and temperature were also collected during grab sampling events using a YSI EXO 1 hand-held instrument.

Monitoring in Boggy Creek (Figure 2) captured runoff and base flow from approximately 50,060 acres of the larger 63,276 acre watershed. A mixture of pasture and evergreen and deciduous forests make up the bulk of the watershed which also contains several small communities (Table 2). Pasture was the dominant land cover in this watershed. The Boggy Creek watershed received the highest level of NWQI implementation with 12 contracts covering 3,049 acres or 4.8% of the entire watershed. Of these, 9 contracts implemented practices including cover crops, pond construction, silvopasture, fencing, forest site preparation, forest stand improvement, tree planting, and prescribed grazing. These 9 contracts covered 2,746 acres which equals roughly 4.3% of the overall watershed area and 5.5% of the monitored area.

Monitoring in Prairie Creek (Figure 2) captured runoff and base flow from approximately 18,024 acres of the larger 24,467 acre watershed. The watershed consisted of a mixture of pasture and evergreen and deciduous forests (Table 2); however, forests made up a larger percentage of its area. A total of 7 NWQI contracts were implemented in this watershed on 844.5 acres or 3.4%

of the entire watershed. Of these, only 2 implemented forestry related practices including forest site preparation, forest planting, and forest stand improvement on 202.5 acres. This equates to roughly 1.1% of the monitored watershed area and 0.8% of the total area.

Table 2. Land cover quantities in monitored watersheds

Land Cover	Boggy Creek (HUCs 5 & 6)		Prairie Creek (HUC 7)	
	Acres	% of Total	Acres	% of Total
Barren Land	108.8	0.17%	66.3	0.27%
Cultivated Crops	966.1	1.53%	301.6	1.23%
Deciduous Forest	14,626.9	23.12%	8,017.5	32.77%
Developed, High Intensity	26.0	0.04%	14.2	0.06%
Developed, Low Intensity	3,151.3	4.98%	1,001.9	4.09%
Developed, Medium Intensity	149.7	0.24%	181.9	0.74%
Developed, Open Space	1,026.6	1.62%	527.3	2.16%
Emergent Herbaceuous Wetlands	386.3	0.61%	50.3	0.21%
Evergreen Forest	6,114.5	9.66%	2,954.1	12.07%
Hay/Pasture	24,315.5	38.43%	6,894.7	28.18%
Herbaceuous	2,258.4	3.57%	657.2	2.69%
Mixed Forest	96.1	0.15%	140.6	0.57%
Open Water	200.2	0.32%	181.9	0.74%
Shrub/Scrub	4,529.7	7.16%	2,293.6	9.37%
Woody Wetlands	5,320.8	8.41%	1,184.0	4.84%
TOTAL ACRES	**63,276.8**		**24,467.0**	

Sample Handling

Once samples were collected by the automated samplers, they were removed from the sampler and prepared in the field by pouring them from the large 20L sampler bottle into appropriate sample bottles provided by Ana-Lab Corporation located in Kilgore, Texas. Bottles were labeled with event information, filled, sealed, and transported on ice to Ana-Lab for analyses (Table 3). In the event that an insufficient sample volume was collected to fill all sample bottles a sample hierarchy was used. This hierarchy was: ortho-phosphate phosphorus (OP), nitrate-nitrite nitrogen (NNN), total Kjeldahl nitrogen (TKN), total phosphorus (TP), *E. coli,* and total suspended solids (TSS).

Laboratory Analysis

The Ana-Lab Corporation located in Kilgore, Texas received and processed all samples according to the approved quality assurance project plan (QAPP). Methods used included EPA and Standard Methods approaches including: ortho-phosphate phosphorus (EPA 365.3), nitrate-nitrite nitrogen (EPA 300.0), total Kjeldahl nitrogen (EPA 351.2), total phosphorus (SM 4500-P), and total suspended solids (SM 2540).

Data Analysis

The resulting data were tested for normality using a Kolmogorov-Smirnov test. Since none of the data had a normal distribution, the Mann-Whitney rank sum test was used to assess statistical differences in the median values between appropriate datasets. Comparisons made included natural forest revegetation vs. forest planting, continuous grazing vs. prescribed grazing, and a comparison of water quality in Boggy and Prairie Creeks. Differences in median constituent loadings were considered significant at the 0.05 level.

Figure 4. Boggy Creek (L) and Prairie Creek (R) sampling locations

Table 3. Sample storage, preservation, and handling requirements for parameters of concern

Parameter	Matrix	Container	Preservation	Minimum Sample Volume	Holding Time
Total Phosphorus	Water	Plastic or Glass Bottles	Acidify w/ H_2SO_4 to pH 2, 4°C, dark	150 mL	28 days
Nitrate/nitrite-Nitrogen	Water			150 mL	28 days
Total Kjeldahl Nitrogen	Water			200 mL	28 days
*E. coli**	Water	Sterile bottles or Sealable sterile plastic bags	<6°C, dark	100 mL	8 hr / 24 hr*
Ortho-Phosphate Phosphorus	Water	Plastic or Glass Bottles	4°C, dark	150 mL	28 days
Total Suspended Solids	Water			250 mL	7 days

**E. coli* samples should always be processed as soon as possible and within 8 hours. When transport conditions necessitate delays in delivery longer than 6 hours, the holding time may be extended for non-regulatory samples (edge-of-field/farm) but must be processed as soon as possible and within 24 hours. The holding time clock starts when the automatic sampler pulls the first sample.

Results/Discussion

The distribution of constituent concentrations and loads varied greatly between sampled events and sites. Most loads were comparatively low; however, several large loading events occurred due to large runoff volumes or large constituent concentrations. Loading variations occurred sporadically throughout the monitoring period and randomly varied by seasons across watersheds largely due to antecedent moisture conditions. Recorded 24-hour rain events that generated runoff ranged from 0.2” to 5.83”; however, most rain events produced no recordable runoff. Normal to wetter-than-normal conditions persisted throughout the monitoring period, but long dry periods between large rain events limited the number of runoff events generated.

Effects of Grazing Management

Nutrient, sediment, and *E. coli* loads were low compared to observed maximums and their range varied between 1 and 3 orders of magnitude. Comparing treated (prescribed grazing) and control (continuous grazing) loads revealed some differences in median loading rates. Significant differences in median values were identified for TSS and *E. coli* loads ($p \leq 0.02$). NNN exhibited diverging median values, but values were not different enough to be considered significant ($p=0.057$). Median values for TKN, OP, and TP were not significantly different ($p \geq 0.31$) (Figures 5 & 6). Median NNN, TKN, TSS, and *E. coli* values were higher under continuous grazing while OP and TP were slightly higher for prescribed grazing. Total loading from individual plots also exhibited marked differences. The control site (4B) generated larger loads than any other site for all parameters except ortho and total phosphorus (Table 4). Though still larger, ortho and total phosphorus loads were similar to treated sites 1A and 1B that received heavier grazing pressure and supplemental nutrient application.

Grazing management effects available grass cover and is known to influence offsite water quality by affecting runoff generation. Continuous grazing routinely results in limited ground cover and compacted soils. This can increase runoff and in many cases pollutant transport. In this case, continuously grazed land yielded ≥24% more runoff than land under prescribed grazing management; however, differences in soils and watershed slope were also contributors to observed differences. Conversely, prescribed grazing management results in less soil compaction from enhanced grass to growth and ground cover increases which ultimately leads to reduced runoff. Combined, these effects generally produce lower constituent loadings from properly managed properties. This was certainly the case for this demonstration project as prescribed grazing plots yielded less runoff and lower constituent loads.

The continuous grazing plot (4B) generated higher phosphorus loads than two plots with prescribed grazing (1A, 1B) (See Appendix A). These plots underwent considerable management with grass and cover crop plantings, intense grazing management, forage harvesting, and nutrient applications (commercial and poultry litter). Bulls were kept in one pasture and routinely disturbed soil within the plot area and feral hogs also contributed to soil disturbances. The combination of management applied and the timing of several significant rain events served to generate larger phosphorus losses from these nested plots.

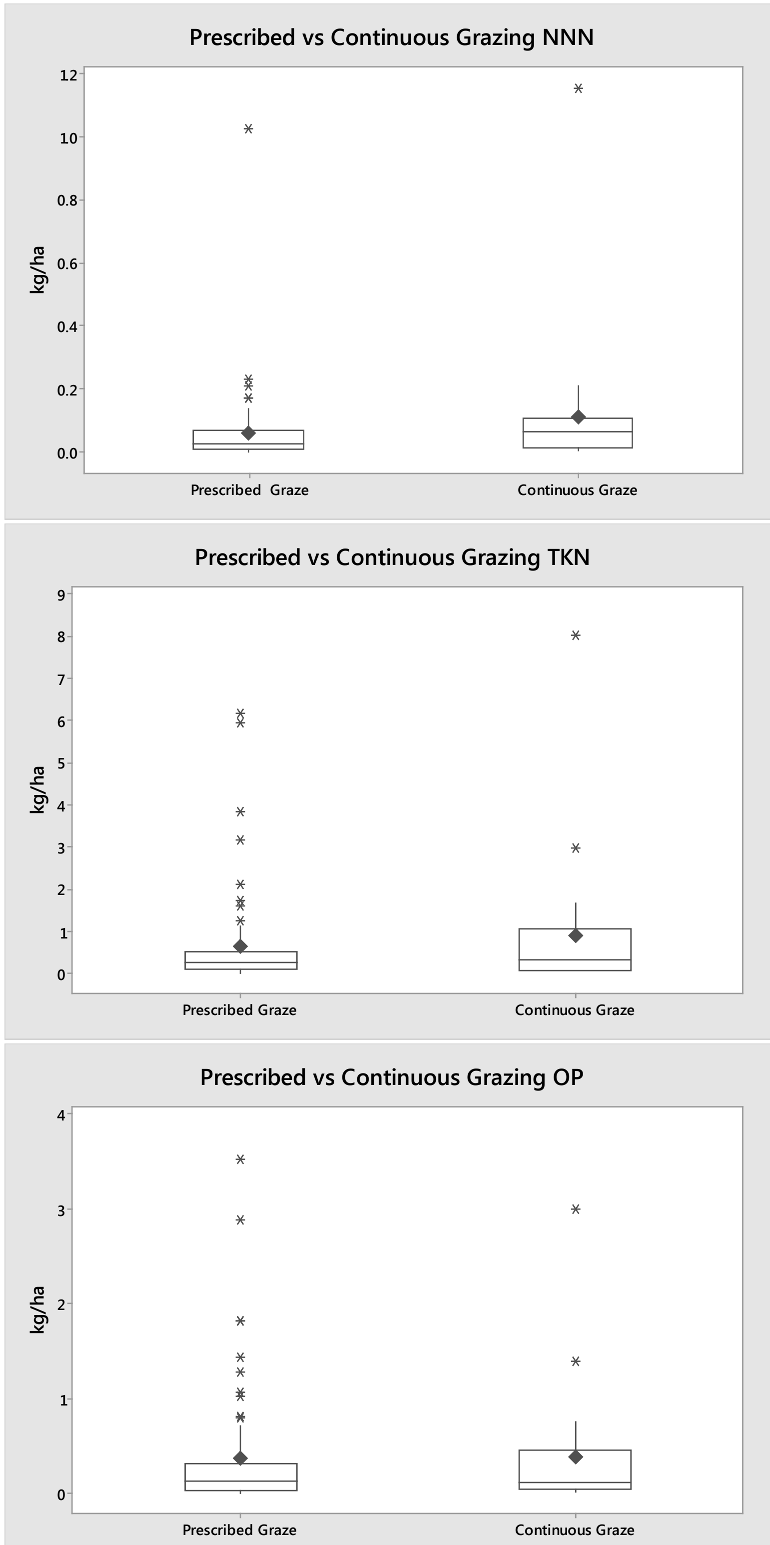


Figure 5. Nitrate-Nitrite Nitrogen, Total Kjeldahl Nitrogen and Ortho-Phosphorus loading box plots for prescribed grazing versus continuous grazing treatments

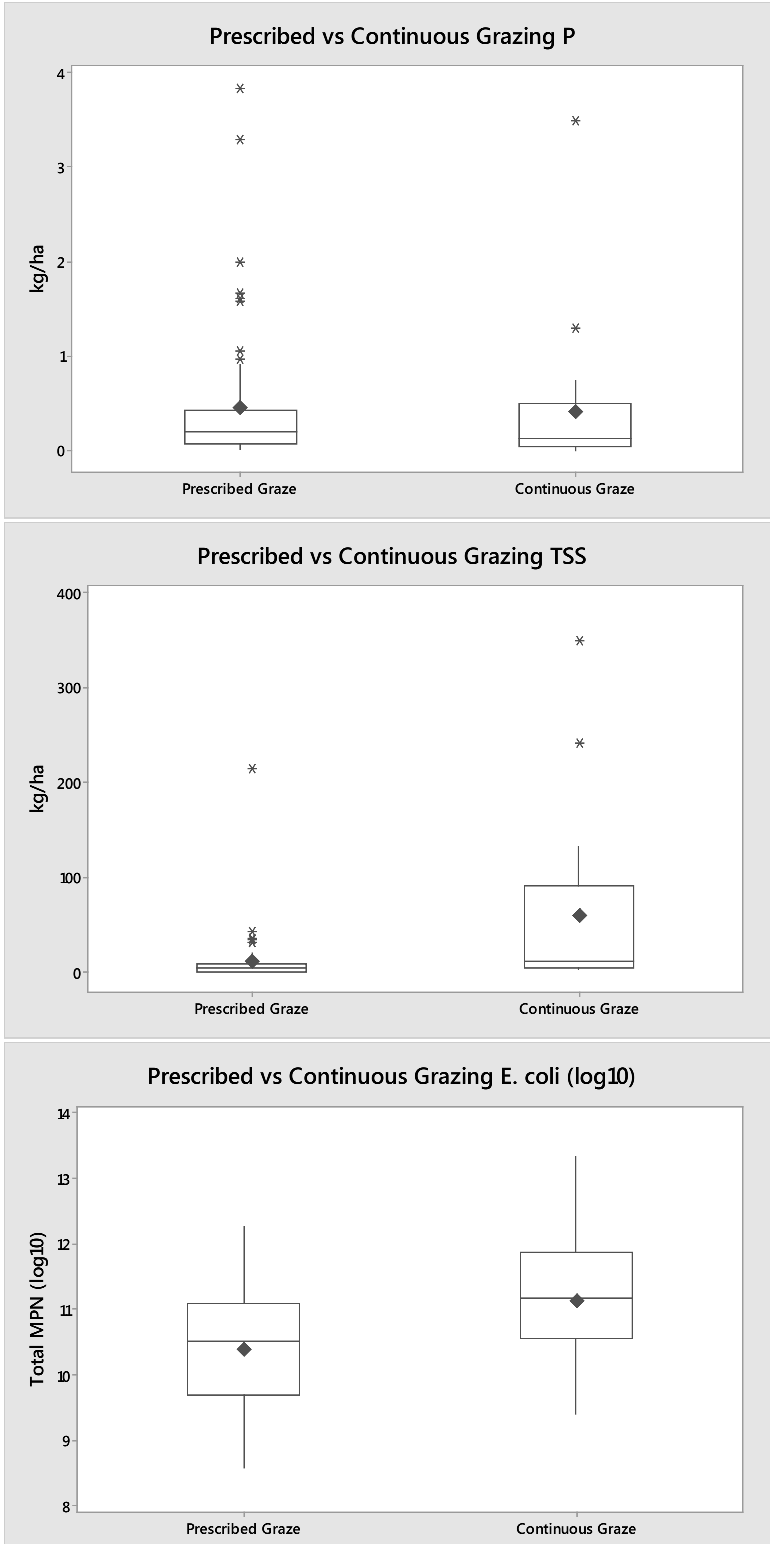


Figure 6. Total Phosphorus, Total Suspended Solids and *E. coli* loading box plots for prescribed grazing versus continuous grazing treatments

Table 4. Total constituent loads (January 5, 2016 – August 31, 2017)

Total Constituent Loads (January 5, 2016 - August 31, 2017)

	NNN	TKN	OP	P	TSS	E. coli
Grazed Sites	kg/ha					MPN
1A	1.69	18.62	11.62	12.88	132.85	1.84E+12
1B	0.92	13.20	8.02	8.45	141.56	2.92E+12
2A	0.20	1.63	1.27	1.37	244.28	7.09E+09
2B	0.64	2.80	1.57	1.64	20.49	1.93E+12
3B	0.55	4.50	2.88	3.15	43.72	2.24E+12
4B	2.43	19.96	8.13	9.03	1024.83	2.73E+13
Forested Sites	kg/ha					MPN
3A	1.52	7.52	0.11	0.61	184.51	2.77E+10
4A	1.66	4.76	0.12	0.43	167.29	2.82E+10
Instream Sites	kg					MPN
Prairie Creek	7,423	17,622	3,838	5,371	3,692,882	6.87E+14
Boggy Creek	21,898	61,483	12,074	16,407	3,046,690	1.77E+14

Effects of Forest Management

Constituent loads exhibited less variation than grazed pastures but still varied considerably during the monitoring period (Appendix A sites 3A and 4A). Observed median values were lower than maximums; however, several events did yield large constituent concentrations but were paired with small runoff volumes (Figures 7 & 8) resulting in a buffered load volume. Statistically, application of Mann-Whitney testing suggested no significant difference in median loading values for all constituents ($p \geq 0.29$) during the 10 monitored runoff events. Total load volumes over the course of monitoring exhibited some variability between sites with the treated site (4A) yielding lower constituent loads than the control site (3A). This is likely a function of difference in total runoff volume produced. The control site generated 79 mm more runoff than the treatment site.

Management of forest plots likely influenced observed results. Prior to treatment, the property was clear-cut and subsequently subjected to 'forest site preparation' by root plowing the land and stacking debris in windrows. In the treatment plot, pine plantation was established via machine planting. Competing vegetation was chemically treated to minimize competition with planted trees during the first growing season. This allowed planted trees to reach 4-5' height in two growing seasons. In the natural revegetation or control site, vegetation was allowed to regrow unaltered following root plowing and debris stacking. A mixture of densely spaced hardwood tree species have rapidly colonized this area and reach heights over 7' in two growing seasons. In both plots, stacked debris impedes runoff from moving offsite and causes increased water infiltration into the soil.

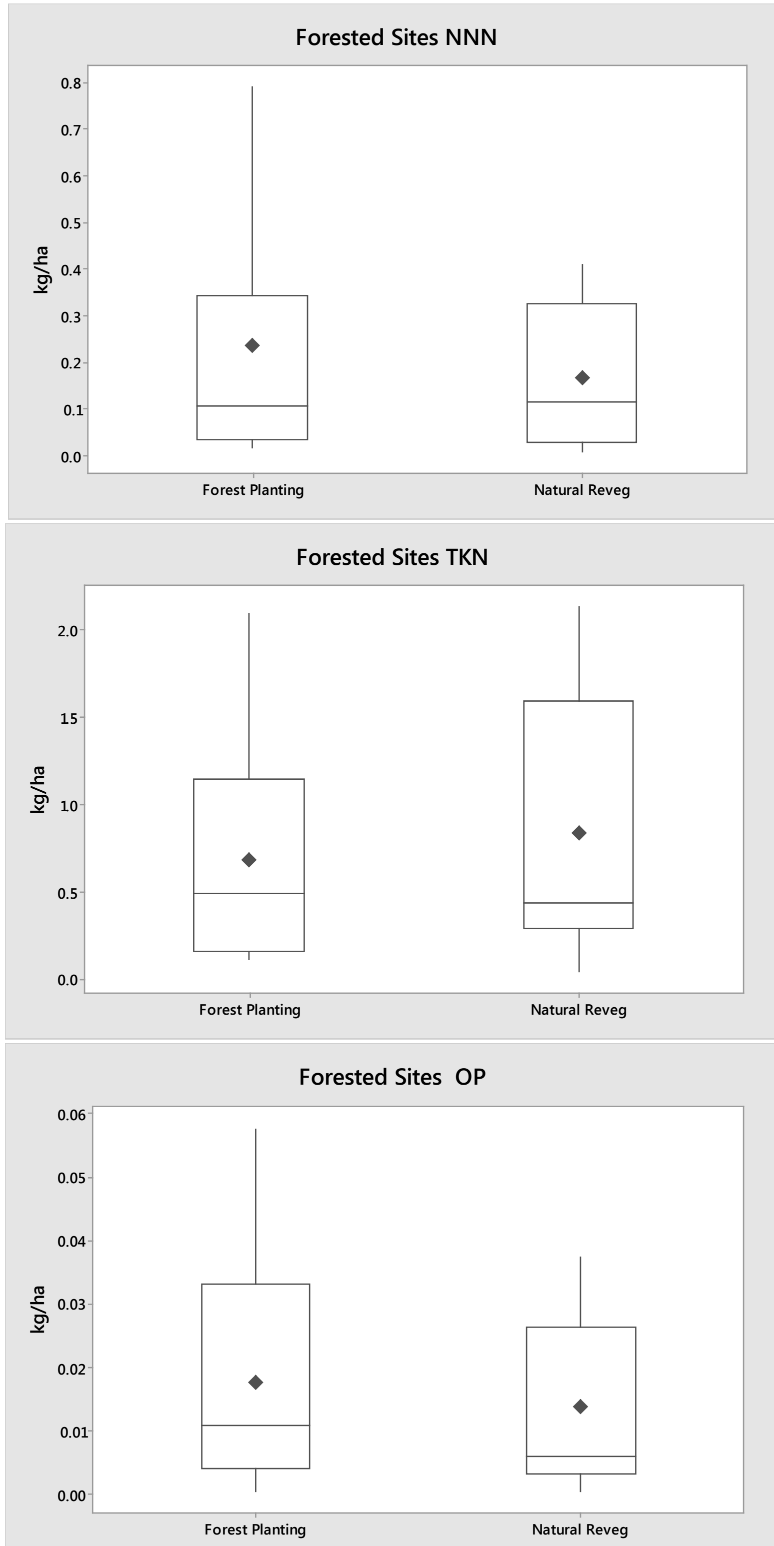
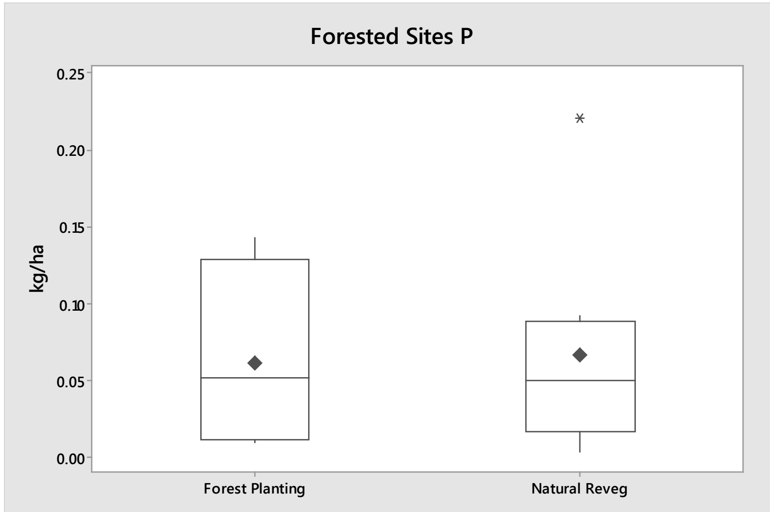
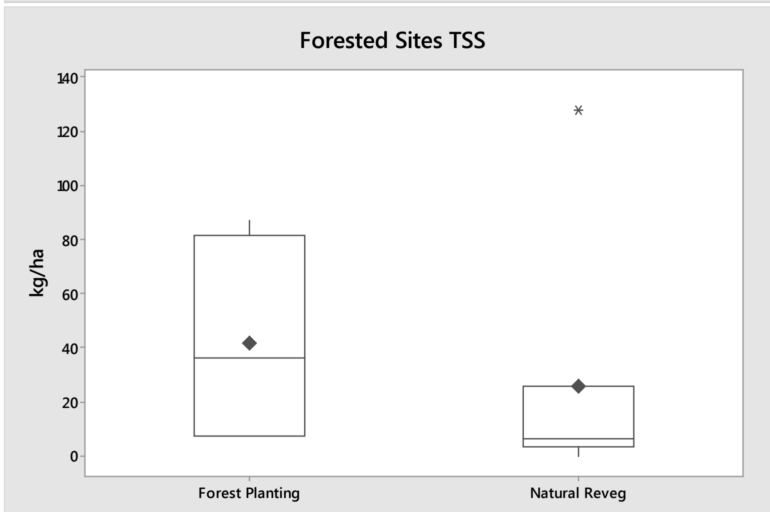


Figure 7. Nitrate-Nitrite Nitrogen, Total Kjeldahl Nitrogen and Ortho-Phosphorus loading box plots for natural revegetation vs. forest planting treatments in forest areas following logging operations





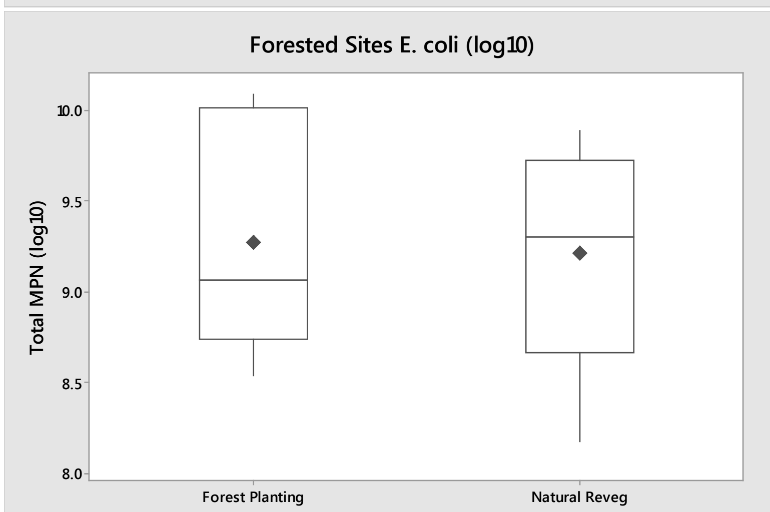


Figure 8. Total Phosphorus, Total Suspended Solids and *E. coli* loading box plots for natural revegetation vs. forest planting treatments in forest areas following logging operations

Instream Monitoring Results

Instream constituent loading concentrations varied considerably. Several large flood events during the monitoring period produced most large loading observations; however, constituent concentrations varied considerably across all flow regimes. Collectively, normalized total loads (kg/ha) were similar between watersheds with Boggy Creek yielding the larger load with the exception of TSS and *E. coli* (Table 5). Similarly, Boggy Creek also produced larger loads by volume due to its larger size except for TSS and *E. coli.*

Median constituent loads exhibited more variation between watersheds than total loads. Mann-Whitney Testing identified significant differences in median loads for TKN, OP, Total P, and *E. coli* ($p \leq 0.012$) while NNN and TSS were not statistically different ($p \geq 0.07$) (Figures 9 & 10). Median values of data from Boggy Creek were higher than those from Prairie Creek.

The annual loads measured in 2016 and the total loads recorded during the course of the project were quite different between Prairie and Boggy Creek. Watershed size is the driving force behind this differential in most cases. The land area draining to the monitoring site on Boggy Creek covers approximately 50,060 acres while the area draining to the Prairie Creek site is approximately 18,024 acres. Overall constituent loads are larger in Boggy Creek except for TSS and *E. coli.* No known reason for this difference exists; however, observational information provides some insight. Several large logging operations took place in the Prairie Creek watershed before monitoring began. Subsequent site preparation and tree planting caused considerable soil disturbance that likely increased TSS loading above normal levels.

Despite the fact that more NWQI program implementation activity occurred in the Boggy Creek watershed, constituent loadings were generally higher. The relatively low percent coverage of management practice implementation compared to the total watershed area contributed to this discrepancy. Additionally, the some practices take time to establish (pasture planting, tree plantings, etc.) and mature before the full effects are realized. The monitoring data presented reflects the first year or two of post implementation and is not a good representation of the true water quality effects of some practices.

Table 5. Total loading summaries for Boggy and Prairie Creeks

	NNN	TKN	OP	P	TSS	*E. coli*
Instream Sites	**Total kg/ha**					**MPN**
Prairie Creek	1.02	2.42	0.53	0.74	506.26	6.87E+14
Boggy Creek	1.08	3.03	0.60	0.81	150.39	1.77E+14
Instream Sites	**2016 kg**					**MPN**
Prairie Creek	5,732	12,889	2,757	3,447	2,313,432	6.70E+14
Boggy Creek	13,472	31,354	5,011	7,377	1,726,405	8.77E+13
Instream Sites	**Total kg (January 5, 2016 - August 31, 2017)**					**MPN**
Prairie Creek	7,423	17,622	3,838	5,371	3,692,882	6.87E+14
Boggy Creek	21,898	61,483	12,074	16,407	3,046,690	1.77E+14

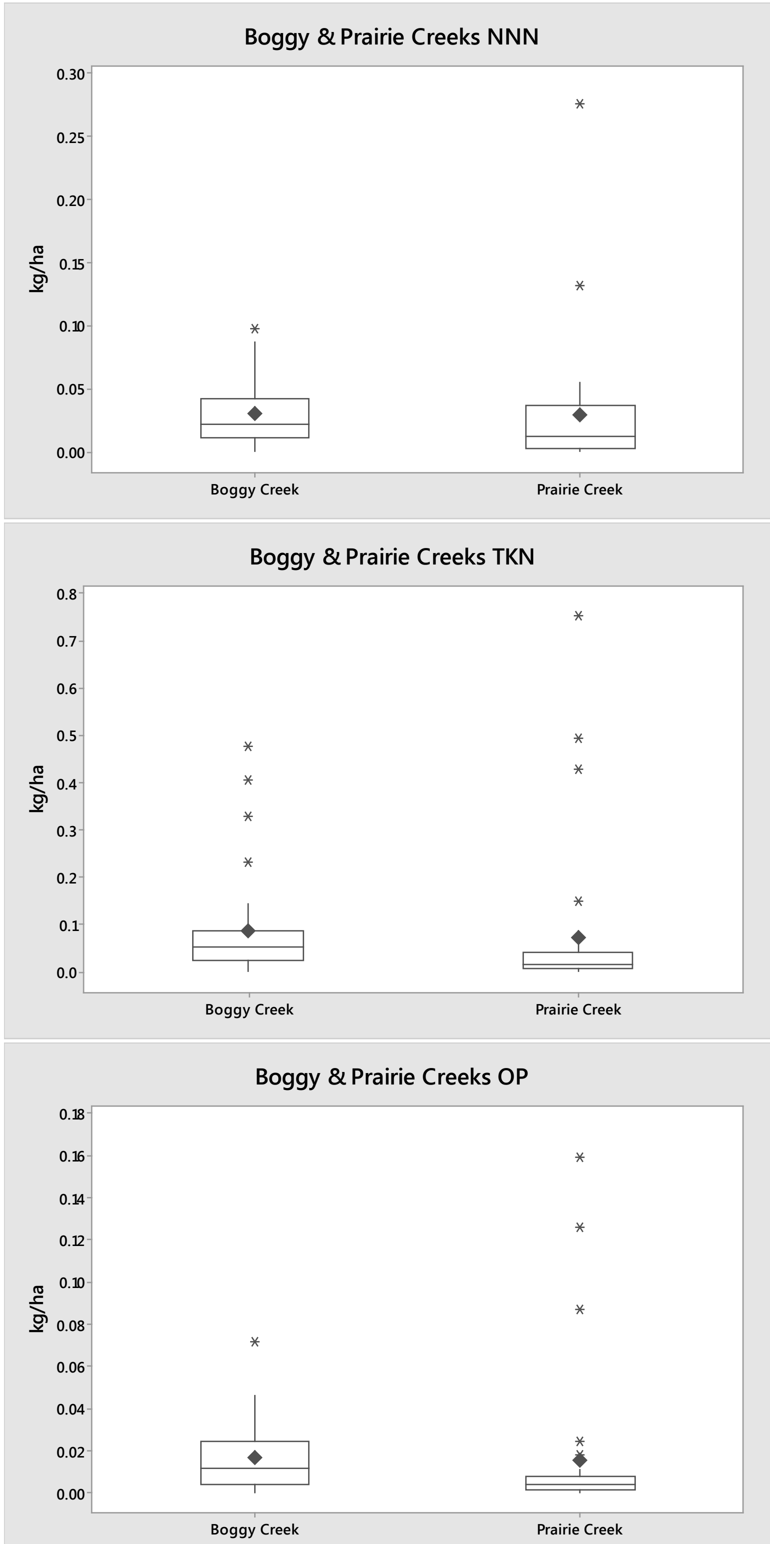


Figure 9. Nitrate-Nitrite Nitrogen, Total Kjeldahl Nitrogen and Ortho-Phosphorus loading box plots for Boggy Creek vs. Prairie Creek

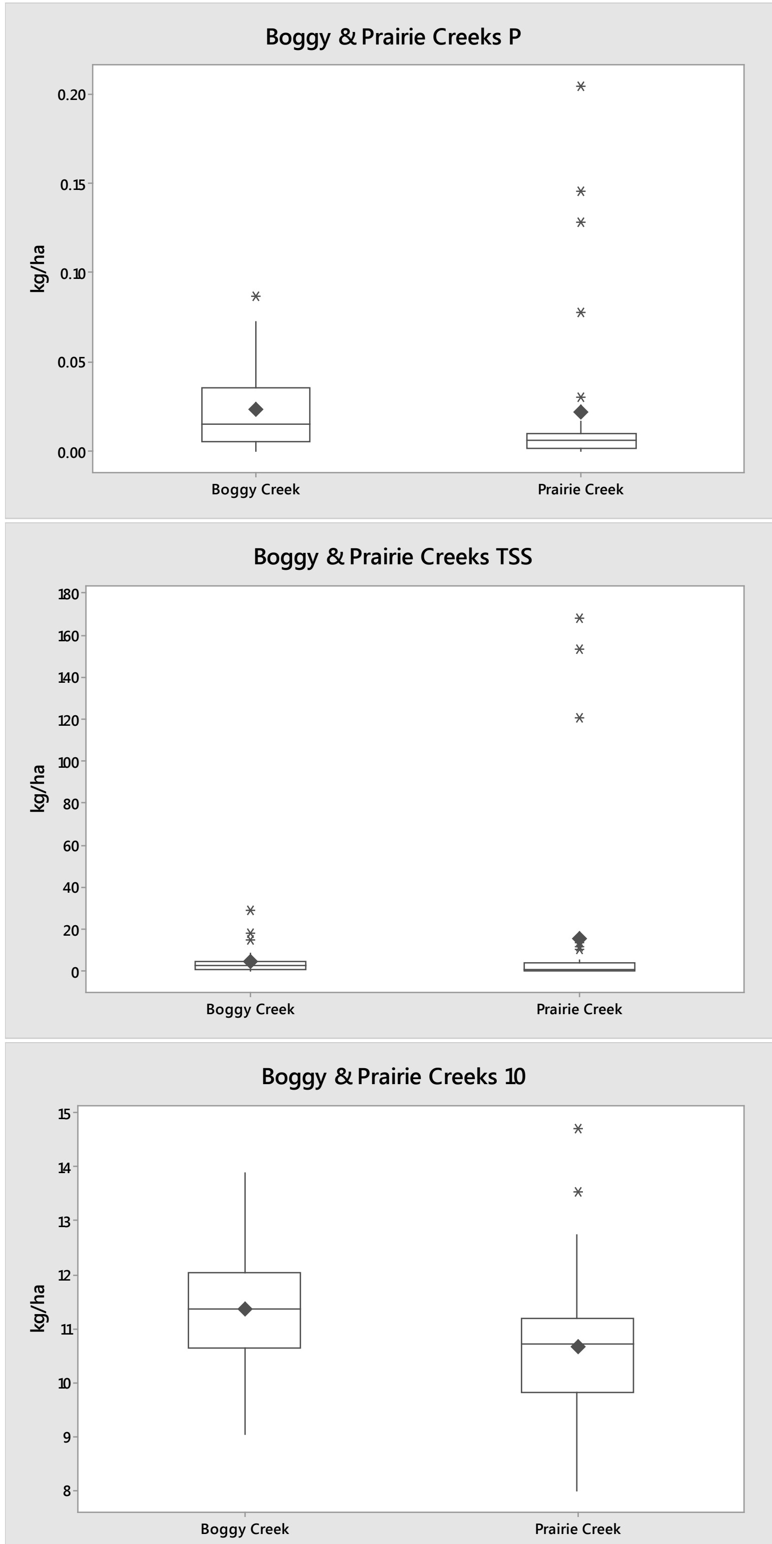


Figure 10. Total Phosphorus, Total Suspended Solids and *E. coli* loading box plots for Boggy Creek vs. Prairie Creek

Conclusions

This project was designed to evaluate the water quality benefits of implemented management practices. Monitoring data discussed demonstrates the findings from zero to two years post implementation and is not a reliable representation of the actual water quality effects. Some practices require time to establish (pasture planting, tree plantings, etc.) and mature before the full effects are realized. Other practices such as prescribed grazing, nutrient management, and others can have near immediate effects.

Forestry related practices take time to establish. Land disturbance during the harvesting operation and during planting preparation cause short-term detriments to water quality through loss of ground cover and mechanical soil disturbance. Proper management applied during these operations reduce adverse water quality effects; however, the risk of elevated constituent loading from an affected site remains high until sufficient ground cover regrows. In this demonstration, preliminary data do not demonstrate any clear difference in water quality results between natural and planned forest revegetation. Additional time is needed to define water quality benefits before a conclusion can be drawn regarding the effectiveness of prescribed practices versus natural regrowth.

Grazing management related practices focus on managing the forage resources to improve forage health and forage quantity to meet the needs of the livestock herd. Water quality is improved over traditional continuous grazing operations by maintaining more forage onsite. This leads to improved plant vigor, enhanced rainfall infiltration, reduced rainfall runoff, and reduced constituent loading moving offsite. While some practices in this portfolio may cause a period decline in water quality (soil disturbance from planting, fertilizer timing, etc.), implementing grazing management on a whole improves water quality. Result from this demonstration fully support these statements as median and total loads for most constituents measured were larger from the continuous grazed site than those under prescribed grazing paired with a combination of other practices. The exception was for mean and median ortho and total phosphorus loads. Longer duration monitoring is needed to better define the effects of applied management practices on water quality from grazing operations.

At the watershed scale, differences between the control (Prairie Creek) and treatment (Boggy Creek) sites due to implemented practices are not discernable. Insufficient monitoring time, the limited level of implementation coverage, and the inability to collect data pre-implementation precluded the ability to identify differences in water quality that are related to changes in management. At a minimum, two years of pre-implementation monitoring paired with at least two years of post-implementation monitoring are required to show statistically sound differences in water quality, but longer monitoring periods are preferred. In the absence of this type data collection, quantifying water quality changes due to implementation is not practical.

References

NRCS. 2003. National Water Quality Handbook. 450-VI-NWQH, September 2003.

Appendix A – Site Summary Data

Field Sites

Site	1A							2A					
Implemented Practices	Cover Crop, Prescribed Grazing, Nutrient Mgmt							Silvopasture, Prescribed Grazing, Nutrient Mgmt					
Loading (kg/ha)	NNN	TKN	OP	P	TSS	E. coli MPN/100mL		NNN	TKN	OP	P	TSS	E. coli MPN/100mL
Mean	0.1	1.33	0.684	0.92	12.08	8.21E+04		0.04	0.326	0.254	0.275	48.86	2.90E+03
Min	0.008	0.035	0.008	0.013	0.659	1.00E+03		0.003	0.052	0.019	0.023	1.2	1.00E+03
Median	0.041	0.339	0.245	0.328	4.302	4.61E+04		0.012	0.245	0.131	0.146	11.39	1.09E+03
Max	1.028	6.185	3.53	3.841	35.61	3.45E+05		0.136	0.971	0.812	0.822	214.8	7.94E+03
Std Deviation	0.241	2.08	1.007	1.197	14.65	9.23E+04		0.056	0.37	0.323	0.325	92.9	3.01E+03
n	17	14	17	14	11	13		5	5	5	5	5	5

Site	3A							4A					
Implemented Practices	Control, Natural Forest Revegetation, No Grazing							Silvoculture Planting, No Grazing					
Loading (kg/ha)	NNN	TKN	OP	P	TSS	E. coli MPN/100mL		NNN	TKN	OP	P	TSS	E. coli MPN/100mL
Mean	0.169	0.836	0.014	0.067	23.06	5.96E+03		0.237	0.68	0.018	0.061	41.82	4.47E+03
Min	0.01	0.048	0.001	0.004	0.148	2.00E+02		0.018	0.116	0.001	0.008	7.534	1.34E+03
Median	0.117	0.439	0.006	0.05	5.559	4.35E+03		0.106	0.493	0.011	0.052	36.46	4.35E+03
Max	0.409	2.128	0.037	0.221	127.7	1.89E+04		0.789	2.09	0.058	0.143	86.84	8.16E+03
Std Deviation	0.156	0.769	0.013	0.066	43.04	5.58E+03		0.278	0.713	0.021	0.055	40.55	2.64E+03
n	9	9	9	9	8	9		7	7	7	7	4	7

Farm Sites

Site	1B						2B					
Implemented Practices	Cover Crop, Prescribed Grazing, Nutrient Mgmt						Cover Crop, Prescribed Grazing, Nutrient Mgmt					
Loading (kg/ha)	NNN	TKN	OP	P	TSS	E. coli MPN/100mL	NNN	TKN	OP	P	TSS	E. coli MPN/100mL
Mean	0.058	0.88	0.535	0.604	11.8	3.32E+04	0.053	0.28	0.131	0.163	2.927	1.35E+04
Min	0.008	0.06	0.023	0.043	0.161	2.42E+03	0.002	0.016	0.006	0.007	0.665	1.00E+03
Median	0.033	0.278	0.23	0.282	7.06	2.44E+04	0.038	0.152	0.043	0.099	1.967	2.72E+03
Max	0.21	3.841	1.831	1.989	43.19	8.66E+04	0.233	0.935	0.713	0.641	7.067	7.27E+04
Std Deviation	0.062	1.201	0.664	0.683	13.26	2.87E+04	0.066	0.313	0.205	0.193	2.843	2.62E+04
n	16	15	15	14	12	12	12	10	12	10	7	7

Site	3B						4B					
Implemented Practices	Cover Crop, Prescribed Grazing, Nutrient Mgmt						Control: Intensive Grazing, Nutrient Mgmt					
Loading (kg/ha)	NNN	TKN	OP	P	TSS	E. coli MPN/100mL	NNN	TKN	OP	P	TSS	E. coli MPN/100mL
Mean	0.028	0.265	0.16	0.185	3.644	7.59E+04	0.11	0.907	0.387	0.411	60.28	3.28E+05
Min	0.001	0.021	0.011	0.007	0.353	9.87E+02	0.006	0.055	0.017	0.001	2.883	2.42E+03
Median	0.014	0.143	0.096	0.154	2.082	4.10E+03	0.054	0.329	0.116	0.121	12.26	5.87E+04
Max	0.13	1.259	1.025	0.972	13.05	7.27E+05	1.155	8.025	3.008	3.495	350.3	2.42E+06
Std Deviation	0.034	0.311	0.241	0.234	3.869	1.99E+05	0.239	1.748	0.692	0.763	99.29	7.38E+05
n	20	17	18	17	12	13	22	22	21	22	17	16

Stream Sites

Site	Boggy Creek						Prairie Creek					
Implemented Practices	N/A						N/A					
Loading (kg/ha)	NNN	TKN	OP	P	TSS	E. coli MPN/100mL	NNN	TKN	OP	P	TSS	E. coli MPN/100mL
Mean	0.0309	0.0868	0.017	0.0232	4.4285	1.26E+03	0.0299	0.0711	0.0155	0.0217	15.341	4.15E+03
Min	0.0001	0.0017	0.0002	0.0004	0.0397	1.09E+01	0.0002	0.0016	0.0003	0.0005	0.056	5.20E+01
Median	0.0215	0.0534	0.0116	0.0154	2.7855	3.87E+02	0.0124	0.0154	0.0039	0.0062	0.8308	4.57E+02
Max	0.0977	0.4753	0.0721	0.0869	29.201	1.57E+04	0.2761	0.7519	0.1596	0.2039	168.2	1.10E+05
Std Deviation	0.0281	0.1105	0.017	0.0223	5.9268	3.08E+03	0.0509	0.1622	0.0359	0.0465	42.982	1.91E+04
n	35	35	35	35	34	35	34	34	34	34	33	33