Finger Lakes National Forest
Water Quality Report
A Summary of 2000 – 2009 Monitoring Initiatives

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Introduction

The Finger Lakes National Forest (FLNF) includes numerous streams and ponds within the Cayuga and Seneca Lake basins. Over the past 10 years forest service personnel have undertaken measures to improve the quality of these waters. Protection of riparian areas in pasture ponds and streams has been the primary focus of this effort. As part a of this project a monitoring program was established to measure physical, chemical and biological attributes of streams and ponds as indicators of water quality.

Waters of the Finger Lakes National Forest:

The FLNF contains many creeks and intermittent streams that flow into waters that are important for the local population. Seneca and Cayuga lakes are designated Class AA drinking water sources. Also, both lakes are critical to the local economy. Seneca Lake alone generates over $100 million per year in revenues from recreation and tourism. Recent studies of the Finger Lakes have found the waters of both Cayuga and Seneca Lakes to be in decline (Halfman and Franklin, 2008). Nutrient levels are on the rise leading to fears of eutrophication. Chemical pollutants also threaten water quality. The main sources of contamination appear to be agricultural runoff and inadequately treated municipal waste water (Halfman and Franklin, 2008). Given the slow cycling of nutrients in lakes impairment of these waters could take generations to repair.

Within the FLNF a number of ponds provide opportunities for recreational fishing. Several ponds are managed as cold water fisheries and stocked annually with brook, brown and rainbow trout. These populations are usually depleted through fishing by early summer and virtually no trout survive the summer due to high water temperatures. Other ponds are managed as warm water fisheries and contain sustained, reproducing populations of largemouth bass.

The Forest Service Manual directs staff to protect waters within National Forest Lands and manage riparian areas to conserve soil and improve water quality. This directive takes on greater urgency in the Finger Lakes Forest in the face of serious threats to Cayuga and Seneca Lake.

Grazing Activities and Impacts:

The FLNF includes roughly 5,000 acres of actively grazed pasture lands divided into 40 separate grazing allotments. The Hector Cooperative Grazing Association manages grazing activities with oversight from the FLNF staff. Pastures are grazed from May through October. Grazing livestock consist primarily of low intensity herds of beef cattle and dairy heifers.

Pastures are periodically mowed to control goldenrod and other undesirable forage species. They are also limed at irregular intervals as deemed necessary and within budgetary constraints. Beginning in 2009 some pastures are being treated with herbicides to control non-native invasive plants.

Historically, cattle were allowed full access to ponds and streams within grazing allotments. This resulted in streambank erosion, sedimentation, direct contamination with animal wastes and increases in water temperature. In the late 1990's Forest Service staff and members of the public identified livestock impacts on water quality as a cause for concern. As a result the Forest Service began restricting livestock access to ponds and streams and established vegetative buffer strips in the riparian zones around several

streams. These riparian buffers act as barriers to contaminated pasture runoff. They also provide shade to regulate water temperature, stabilize streambank soils and provide a food source to the benthic macroinvertebrates that are an important component of healthy aquatic ecosystems.

Concern over grazing impacts on water quality also led to the institution of the water monitoring program discussed within this report and continues to be the primary focus of water resource management within the FLNF.

Objectives

This study aims to analyze trends in water quality based on 2000 through 2009 monitoring data and make recommendations for future monitoring and management activities.

Methods

After identifying the need to better manage water quality in pasture streams and ponds Forest Service personnel established 16 monitoring sites that were sampled periodically during the spring, summer and fall of 2000, 2002 and 2003. The sample sites included one control pond, one control stream, and 2 pasture ponds. Streams were also sampled at 12 sites located upstream, within and downstream from pastures. Measurements taken in the field with portable meters included pH, dissolved oxygen (DO), temperature, conductivity, and total dissolved solids (TDS). Flow measurements for streams were estimated by measuring width, average depth and flow rate at the monitoring site. Samples were collected at each site and analyzed within 24 hours for nitrates, nitrites, phosphates and turbidity. Additional samples were collected in May and October of 2000 to measure E. coli concentrations. These samples were collected, stored on ice and transported to the Ithaca Water Treatment Plant within 6 hours for analysis.

In 2004 sampling was discontinued at all of these sites except the control stream and pond. At this time 9 new sites were selected for monitoring including 2 additional control streams and 7 fishing ponds. Of these ponds Ballard and Burdick are bordered by pastures. Approximately half the perimeter of Teeter Pond is separated from an adjacent pasture by a narrow forested buffer and the rest of the pond is surrounded by forest. The remaining ponds are located in forested settings. All ponds have a thin strip of mowed grass around part of the perimeter to maintain access for recreational use. These 11 sites were sampled for the same attributes as the previous group of monitoring sites using the same methods at a similar frequency from 2004 through 2009. E. coli samples were collected in 2006, 2008 and 2009. The 2008 and 2009 samples were analyzed at the Community Science Institute in Ithaca due to the discontinuation of those services at the Ithaca Water Treatment Plant.

For the purposes of this study the data are divided into two cohorts. The 2000 through 2003 samples are grouped together and will be referred to as the pasture samples while the 2004 through 2009 data will be treated as a separate cohort and referred to as the fish pond samples.

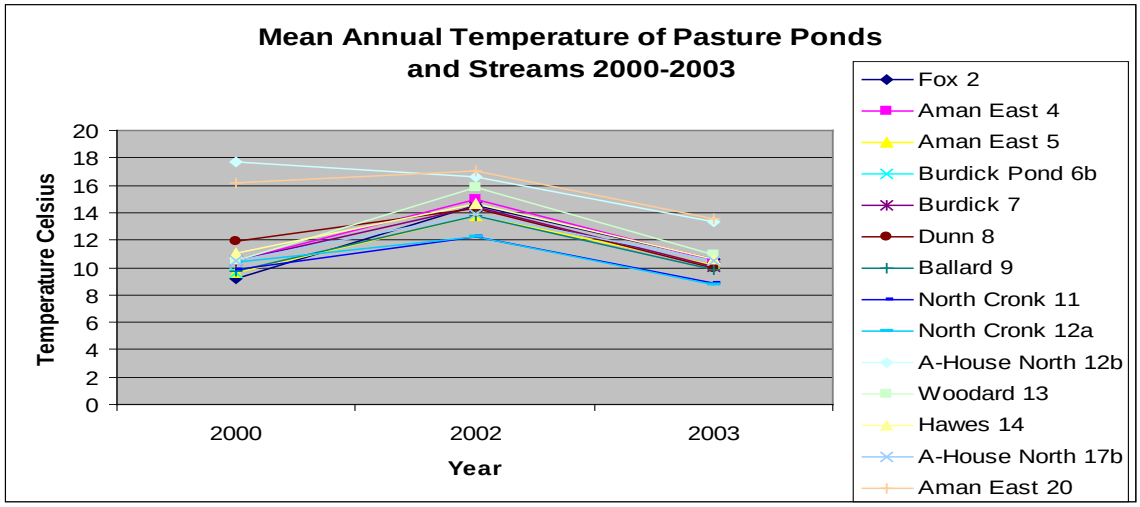
Results

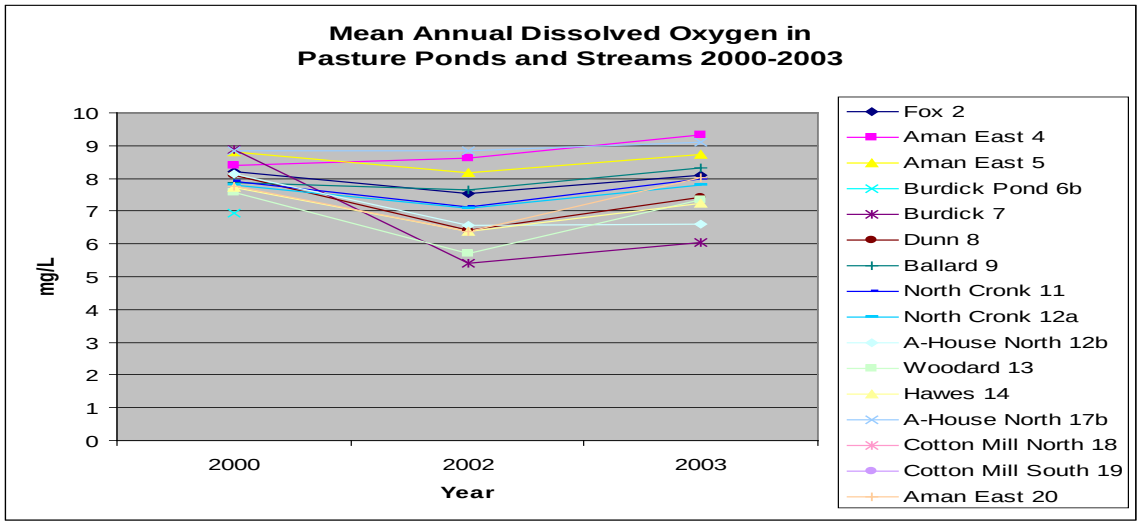
Dissolved Oxygen and Temperature

All of the pasture and fishing pond monitoring sites were at desirable levels for DO during the 2000 – 2009 sampling period. Values ranged from 5.16 mg/L to 12.76 mg/L. These values are all well above the 3.0 mg/L lower limit for Class D waters. Pasture sites had a lower average DO level of 7.67 mg/L compared to 9.50 mg/L for fish pond samples. If control site data is excluded the averages are 7.64 mg/L for the pasture sites and 9.62 for the fishing pond sites suggesting slight possible impairment of pasture sites. However, the exact relationship is difficult to determine due to the chronological gap between samples, irregularity of sample timing and the lack of corresponding climate data.

While DO levels are above the minimum thresholds for fish survivability (greater than 3.0) and above the minimum for Class A through C water designation the levels at some sites including control sites are elevated above the ideal maximum of 8.5 to 9.5 mg/L. Of the sites with high DO levels 3 are observed to support observably high populations of algae or plant growth that may be raising oxygen levels. Control stream 17a exhibits a thick algal mat on sections of the stream bed near the sample site where the stream is wide and runs over large sections of exposed bedrock. Much of the surface of South Burnt Hill Pond P-8 is covered with a layer of floating vegetation during the summer months and Ballard pond supports a dense growth of benthic plants including both submerged and emergent vegetation. This could be indicative of nutrient loading and raises eutrophication concerns.

Figure 1.





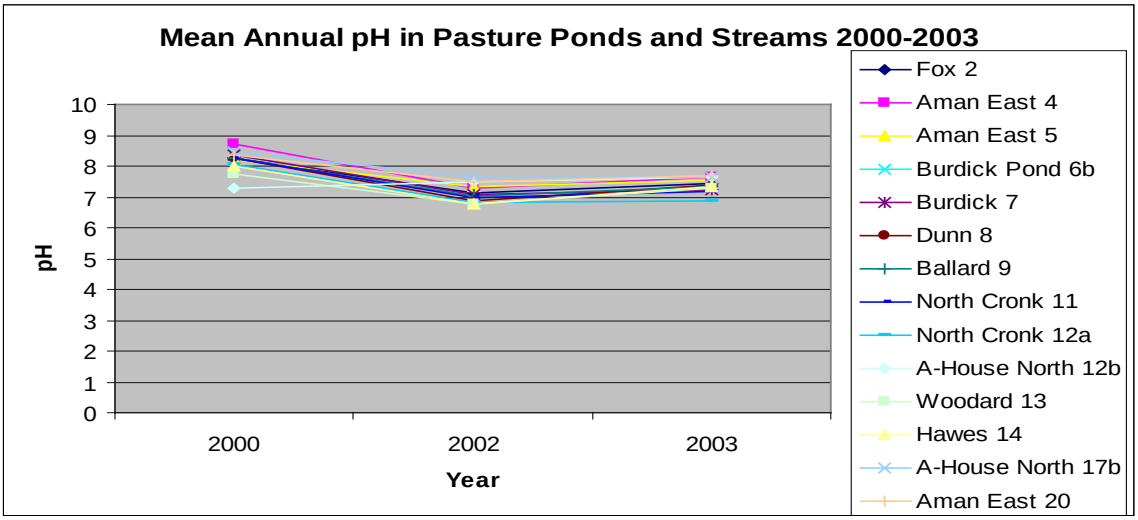
An adequate amount of dissolved oxygen is essential to the survival of aquatic organisms. DO levels are inversely related to water temperature because cold water is capable of holding more oxygen in solution than warm water. This relationship is clearly demonstrated in **Figure 1**. DO levels are also influenced by aquatic organisms such as bacteria, invertebrates and fish which act as sinks and aquatic plants that act as sources. DO levels can quickly drop to extremely low levels when excessive nutrient levels lead to increased growth of algae and phytoplankton. When the algae begins to die decomposing bacteria populations spike and quickly consume dissolved oxygen leading to fish kills and other deleterious affects.

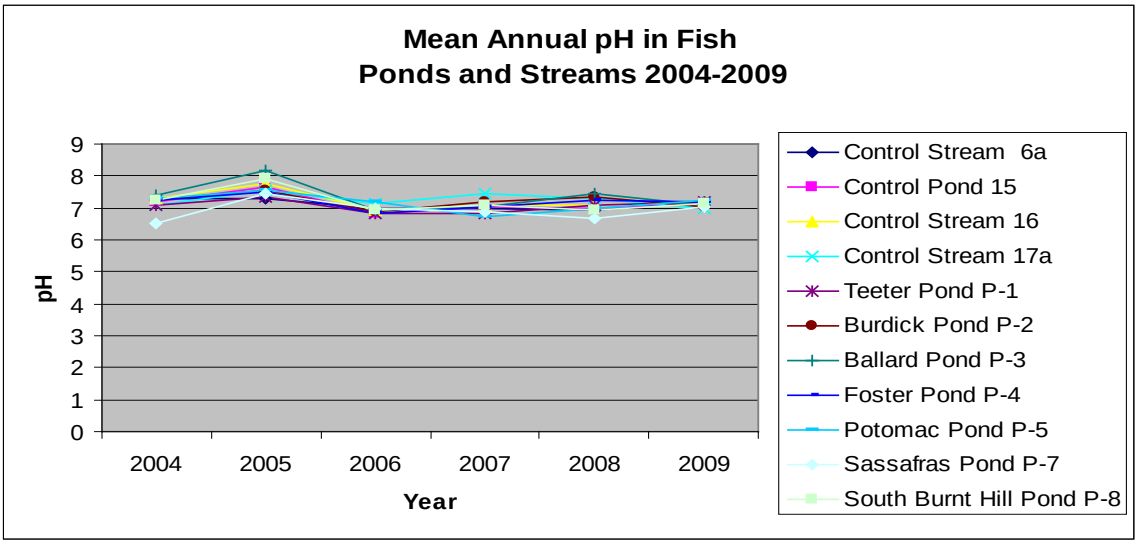
pH

Although average pH values fluctuate from year to year no discernable trends are apparent (**Figure 2**). Measured values range from 8.7 to 6.5 for the 2000 – 2009 time frame across all sites with an overall mean pH of 7.4. All measurements fall within the range of 6.0 to 9.5 for Class D waters. The yearly average for most sites is also inside the acceptable range for Class AA through C waters of 6.5 to 8.5. The lone exception is Aman Stream #4 for the year 2000 which averaged 8.7. All values from the year 2000 are significantly higher than other years with an annual mean of 8.2 compared to the ten year average for all sites of 7.4. This may result from sampling error. After eliminating 2000 data the long term average for all sites is 7.2.

Overall the data indicate that forest management and use activities are not significantly impairing the pH levels in either pasture waters or fishing ponds. Also, there do not appear to be adverse affects on pH caused by acid precipitation which can have a pH of 4.1 to 4.4 in the Finger Lakes region

Figure 2.



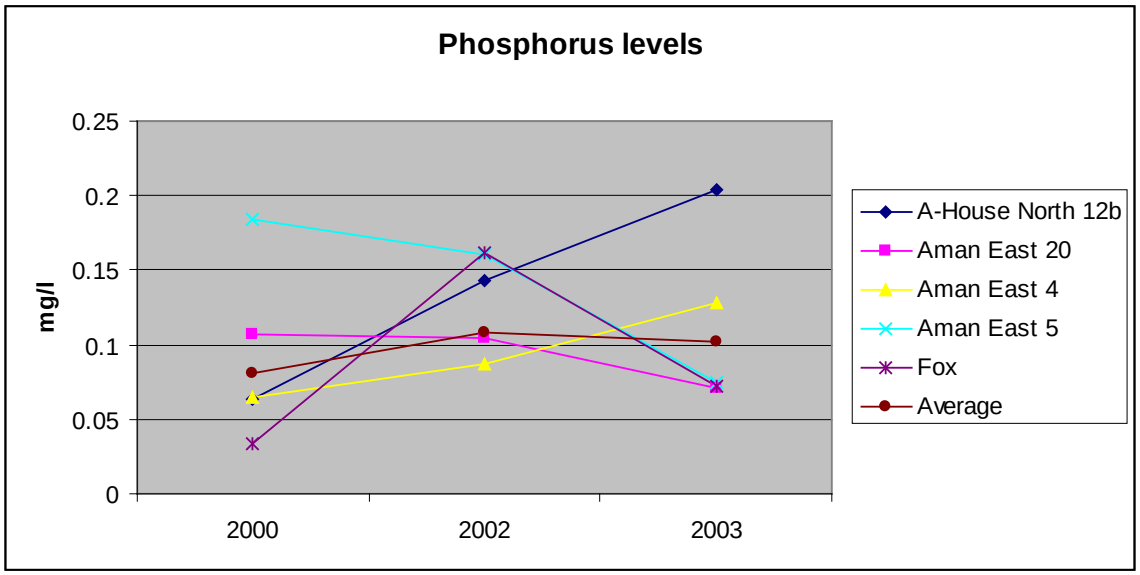


Nutrients and runoff

All sites in both the pasture and fish pond cohort have elevated levels of Phosphorus. The standard for Class D waters is 0.00 to 0.02 mg/l. The average for all sites over the entire sample period is 0.10 mg/l with range of 0.02 to 0.34 mg/l. A previous study of the pasture stream and pond data (Donna, 2004) has found a relationship between pasture runoff and elevated P levels.

Donna also noted increased streambank stability and decreased P levels at sites where fenced riparian areas have been established. The data do not yet demonstrate a marked decrease in P levels in pasture waters within riparian areas fenced between 2000 and 2001 (**Figure 3**). The benefits of riparian zones in reducing nutrient runoff are well established as cited by Donna. However, improvements in nutrient levels may take a number of years as the streambank vegetation becomes established.

Figure 3. Phosphorus Levels in Streams and Ponds with Riparian Buffers.



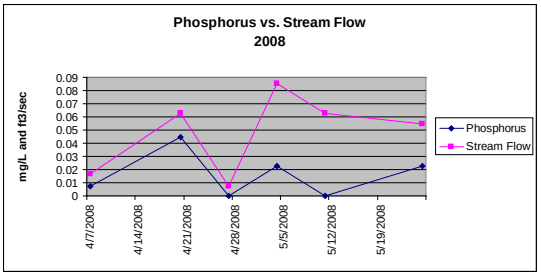
Donna's study noted elevated P levels in control streams and ponds. That trend is also apparent in the fishing pond data with some of the highest P values occurring at control streams that are exposed to little or no pasture runoff.

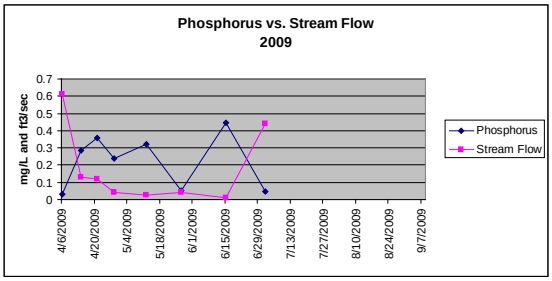
Donna theorized a possible P source deriving from soil and bedrock attributes or some past land use as an additional cause of elevated P levels. The control stream data lend credence to that hypothesis and suggest a potentially complex process behind the P levels. If the soil or soil parent material is the source of P then a higher concentration in control streams would be expected after storm events or during wet periods with significant groundwater discharge into the stream channel. However, the data show a highly irregular correlation between stream flow and P levels suggesting no direct relationship between these variables (Figures 4 and 5).

Figure 4. **Correlation between stream flow and Stream Phosphorus Levels.**

	Correlation Coefficient	
Site	2008 Data	2009 Data
Control Stream #6	0.53	-0.69
Control Stream #16	0.71	-0.32
Control Stream #17a	0.50	0.05

Figure 5.





The lack of correlation between P levels and streamflow hint at a possible biological source. Terrestrial, soil and aquatic biota can all impact Phosphorus levels in streams. For example, Frelich and Reich (2010) found that soil invasion by exotic earthworm species could alter soil nitrogen and phosphorus levels by up to 40%. Large scale insect impacts such as the cyclical forest tent caterpillar wave currently affecting the FLNF could also alter soil nutrient levels. The relatively short life cycles of some aquatic plants and algae may lead to rapid fluctuations in stream nutrient levels as their populations quickly respond to conditions such as temperature, stream flow and available sunlight.

Water nitrogen levels are not as elevated as phosphorus levels. The desirable range for Nitrites is <1.0 mg/l. The average level for the pasture cohort was 1.0 mg/l and the average for the fish pond cohort was 0.2 mg/l. These values exclude the 2007 sample year due to an equipment malfunction during that period. These values are detailed in **Figures 6 and 7** and show a relatively stable level of nitrites.

Figure 6.

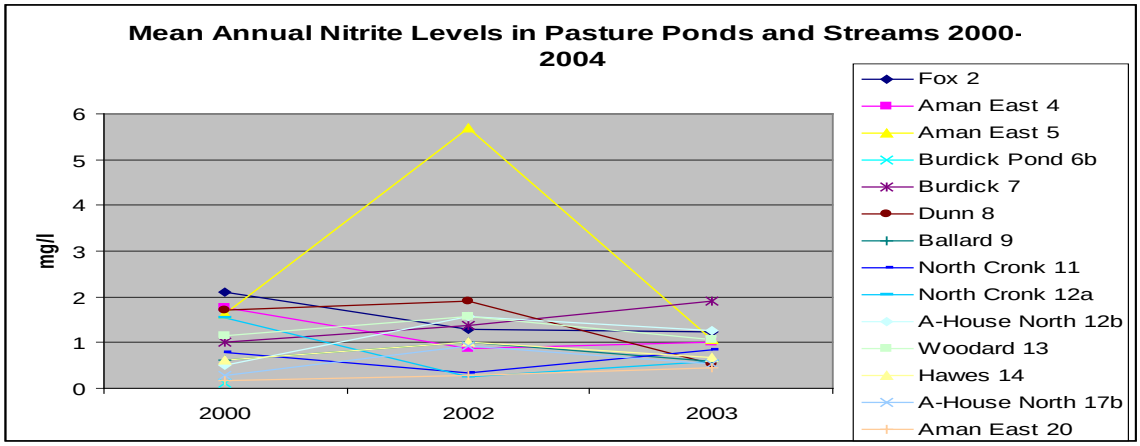
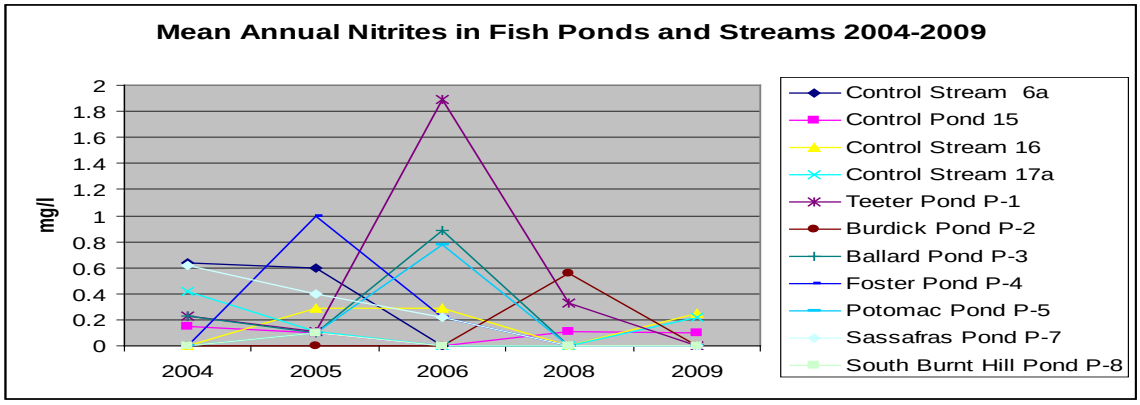


Figure 7.



Conductivity and Total Dissolved Solids:

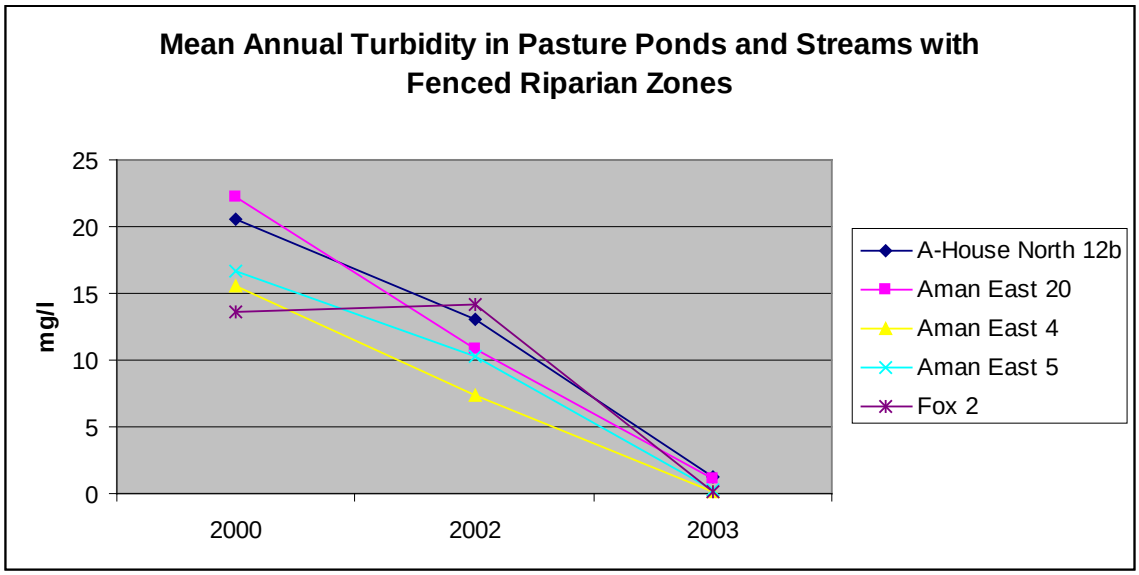
Water hardness as measured by conductivity and total dissolved solids is within the acceptable range (<200 mg/l for Class A waters) across all monitoring sites. Values

peak during low flow periods when groundwater slowly percolating through soil and bedrock constitutes all stream water and values dip during storm events when surface runoff contributes significantly to stream flow.

Turbidity

Turbidity on FLNF waters arises from several chief sources. In pasture ponds and streams the primary contributor is erosion caused by livestock damage to streambanks, streambeds and livestock access to ponds. The severity of this impact as well as the effectiveness of fenced riparian buffers is clearly demonstrated in pasture data (**Figure 8**).

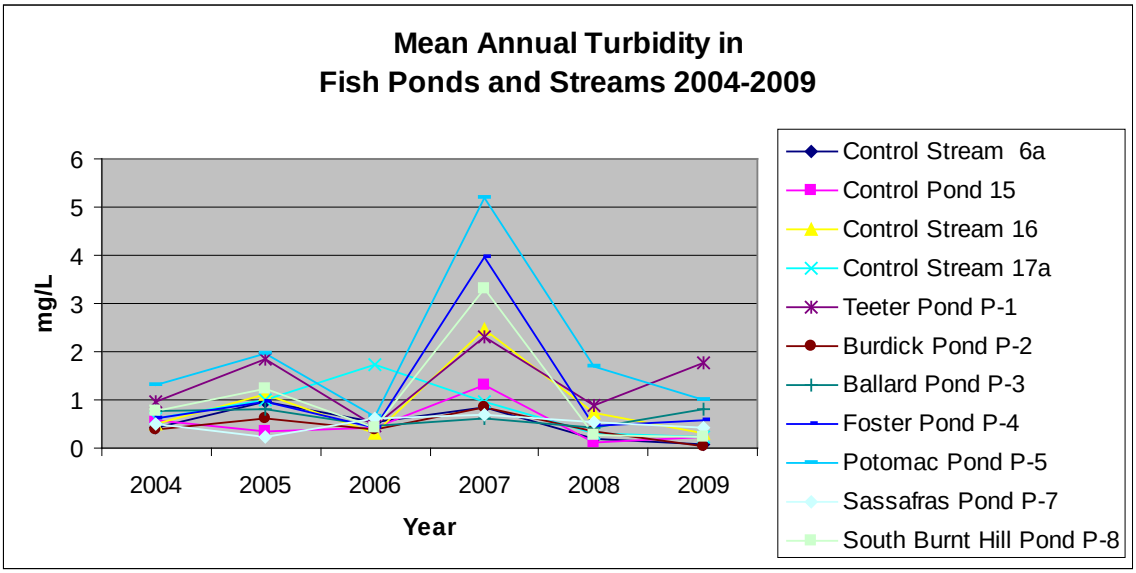
Figure 8.



Turbidity levels steeply decline for each of these sites after riparian buffers were established in 2000 and 2001.

Other sources of sediment include roads, trails, campsites and timber harvesting activities. Generally, the levels of turbidity are low in streams and ponds outside pastures (**Figure 9**). The highest average levels were observed in Potomac Pond and Control Pond #15. These high averages stem from a single event in June 2007 with extremely high turbidity readings. The cause of this event is unknown. However, high turbidity levels at other sites during this same sample period suggest a heavy precipitation event as the likely cause.

Figure 9.



E. coli

All pasture ponds and streams have at least one measurement of fecal coliforms above the quality Class A – D limit of 200 per 100ml. Values range as high as 6040 per 100 ml in the Woodard stream outlet.

Samples collected for the fish pond cohort exhibit lower bacterial concentrations. Only Teeter pond has E. coli levels above 200 with a May 2004 measurement of 204 per 100 ml.

Conclusions and Recommendations

Water quality data collected during the 2000 – 2009 period show promise for improved water quality and higher water quality standards but also point to several areas of concern. Addressing these issues will warrant changes in future monitoring efforts. Some adjustments to forest management activities may eventually be necessary to achieve water quality objectives.

Water Quality Standards

No noteworthy trends are apparent in DO, pH, conductivity and TDS data. These are positive signs that indicate good baseline water quality. These data also suggest that the best use of many FLNF waters may be a higher use class designation than previously thought.

In the past Class D water quality has been suggested as the proper designation for FLNF streams. However, for most parameters the forest streams measured in this study are within the water quality range for Class C waters. Indeed, nearly all major tributaries within the Finger Lakes drainage basin are designated as Class C (NY DEC, 2010).

Class C waters are open to most uses aside from primary contact (swimming) and drinking water. On a qualitative level FLNF waters outside of pastures would seem to lend themselves to this type of use. A higher standard may be out of reach for the time being. However, given the resolution of high nutrient levels and continued improvement of turbidity through riparian buffers, a higher standard may be attainable in the future for select ponds and streams.

Collaboration with NYDEC Division of Water is recommended in setting specific water quality goals for clarification of standards and general guidance. Water quality regulation is a complex framework of federal and state law. Within New York water quality standards are determined and enforced by a number of groups within DEC. Collaboration with DEC staff will simplify the process of setting water quality objectives.

Riparian Buffers

The full impact of riparian buffers established in FLNF pastures is unknown at this time. Future sampling at buffered streams and ponds sampled in the pasture cohort is recommended to determine changes in nutrient levels, turbidity and E. coli. Also, some sampling should be timed to coincide with heavy precipitation events during the grazing season. A high percentage of the nutrient runoff from pastures often occurs during a few heavy precipitation events (McDowell, et al., 2001). Sampling buffered streams and non-buffered pasture streams during runoff events will provide a better measure of the capability of buffer strips to filter nutrients and capture E. coli.

If riparian buffers prove ineffective in improving water quality then grazing management options may need revisiting. Reduced grazing intensity, wider buffer zones, more rigorous streambank stabilization efforts and alterative grazing regimes such as rotational grazing are potential options.

Elevated Phosphorus Levels

Data collected thus far have been unable to pinpoint the cause of consistently elevated P levels throughout the forest. Determining the source is crucial to future water management decisions. Possibilities include residual impact from historic use, natural geochemical site characteristics and sampling error. Additional research will be necessary to address this issue.

Sampling Method

Sampling efforts have been hampered by equipment malfunctions and human error. Portable meters are subject to extreme conditions in the field and require frequent cleaning and recalibration. Forest Service personnel and independent contractors have reported equipment problems, inconsistent reagent quality and confusion about the location of sampling sites. Equipment maintenance and training of personnel must be improved to address these deficiencies. Another alternative is to contract some of the analysis to an established laboratory with more reliable equipment and testing procedures. The Community Science Institute in Ithaca is relatively close to the FLNF and performs stream water testing. Other firms within the region may also provide these services.

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