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Poster Presentation

The Effect of Goose Management on Water Quality

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ABSTRACT: Canada geese are causing a growing concern regarding their impact on public health and safety risks. In Pennsylvania, USDA Wildlife Services manages geese in problematic areas. The purpose of goose management is to reduce damage to agricultural, urban, and natural resources, as well as reducing threats to public health. For this study, three impoundments were monitored bi-weekly from May to September along with a single sampling date in both October and November 2009. Two of the impoundments were managed by the USDA, while the third was an unmanaged control site. The objective of the study was to compare water chemistry and fecal coliform counts from the three sites. Dissolved oxygen, pH, and water temperature were measured, along with fecal and total coliforms, to monitor water quality from the nesting to migration seasons. Results from fecal coliform testing show strong evidence for the benefits of management, with coliform levels up to 3 times higher in the unmanaged impoundment. Based on these findings, we conclude that USDA's methods of management are effective in reducing health threats as well as improving water quality.

KEY WORDS: *Branta canadensis*, Canada geese, fecal coliforms, goose management, water quality

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INTRODUCTION

Management of Canada goose (*Branta canadensis*) populations is a common issue being dealt with across North America. Overall management of Canada geese are the responsibility of the Department of the Interior, United States Fish and Wildlife Service, while small-scale management programs are implemented by the USDA APHIS Wildlife Services (WS) wildlife biologists and staff.

Conflicts with waterfowl began in the early 1900s when agricultural land increased, creating an attractive source of food for waterfowl. Early management techniques focused on keeping waterfowl off and away from cut fields, where ducks and geese can damage twice as much as they consume (Knittle and Porter 1988). Preventing geese from using agricultural lands prevents crop depredation. To accomplish this, geese must be harassed intensively by the use of firearms, pyrotechnics, propane exploders, aircraft, chemical deterrents, and various visual scare devices. In some situations, lure crops and bait stations have been used to supply geese with a food source away from crop fields. Some of these management and harassment techniques are too labor intensive or expensive, depending on the size of the management area and number of geese (Knittle and Porter 1988).

Today, the need for wildlife management has extended beyond the protection of crops, as residential and commercial developments continue to encroach upon farms and wetlands. Management of Canada geese is an increasingly important issue, as goose numbers have increased substantial throughout North America, resulting not only in conflicts with geese in cities and towns, but also an increasing occurrence of goose collisions with aircraft. Such accidents have resulted in human fatalities, and they have a significant economical impact from damage to aircraft (Pochop et al. 1999).

Since the 1940s, wildlife biologists have developed new methods of goose harassment and management. Currently, the USDA's Wildlife Services division in Pennsylvania manages geese in problematic areas. The goal of this program is to reduce damage to agricultural, urban, and natural resources, as well as to reduce threats to public health and safety (USDA APHIS 2001). Management programs were developed after the implementation of the resident Canada Goose Nest and Egg Depredation Order, issued by the U.S. Fish and Wildlife Service in 2006 (USDA APHIS 2010). This order provides for landowners and local governments to implement management activities, after registering with the Fish and Wildlife Service (USDA APHIS 2009).

One method of management now used is the oiling of eggs with a 100% food-grade corn oil, during the nesting season in early spring, to reduce the growth of resident goose populations and decrease damage they cause. Simply removing the eggs from a nest will cause the female to lay another clutch, while spraying them with oil suffocates the eggs in the nest, but the female continues to incubate them (USDA APHIS 2009). Other treatment methods include egg puncturing, and egg shaking (addling). Egg puncturing is done with a long, thin metal object that is punched through the shell, and then swirled to break up the material inside. Shaking eggs is the most time consuming, taking 5 to 10 minutes per egg, without a guarantee of success.

In addition to destroying eggs, the reproductive inhibitor OvoControl™ G (Innolytics LLC, Rancho Santa Fe, CA) reduces the number of eggs hatched. This chemical is administered, only by licensed specialists, in a bait form, and its cost averages $12 per goose each breeding season. The cost and restrictions associated with this method of management make OvoControl™ G less practical and less efficient than other techniques to control resident goose populations. Overall, the most efficient and effective way to manage resident geese is to harass them before nests are built. If this is not possible, nest destruction and egg oiling are the best options (USDA APHIS 2009).

Wildlife Services encourages landowners in the management program to harass geese with scaring devices including dogs, pyrotechnics, strobe lights, lasers, and sound devices. It is recommended that more than one of these techniques be used at a given location to prevent geese from getting accustomed to a single technique. If a problem persists after 3 years of involvement with the management program, USDA WS may choose to do a round-up, where geese are netted, removed from the area, and humanely euthanized. Environmental deterrents may be used to make a property less inviting to geese. Geese prefer to rest and feed in short grass, so altering the landscape is a natural way to deter geese (USDA APHIS 2001). In some cases, geese may be live-trapped and relocated (USDA APHIS 2001); however, this is usually ineffective, as adult geese will return to the capture site (Holevinski et al. 2006). Although this method of management is expensive and complicated, translocation of juvenile geese has been proven to be effective. In a 2003 study in New York, nuisance juvenile geese were translocated more than 150 km to an area where hunting was permitted. The juvenile birds remained near the release site, where a relatively large percentage of them were harvested during the hunting season, thereby resolving the conflict (Holevinski et al. 2006). Hunting is a very effective way of managing goose populations; however, it must be done according to state and federal regulations, as geese are protected under the Migratory Bird Treaty Act of 1918 (USDA APHIS 2001).

In 1977, the United States Environmental Protection Agency (US EPA) amended the Federal Water Pollution Control Act of 1948, thereby creating the Clean Water Act. Two of the several amendments involved recognizing the need for planning to address the critical problems posed by non-point source pollution, and maintaining existing requirements to set water quality standards for all contaminants in surface waters. Since these amendments, the EPA has formed state partnerships, where water quality standards are set and monitored at the state level. The water quality standards specify acceptable levels of toxic substances, metals, minerals, bacteria, organic and inorganic compounds, pH, and dissolved oxygen (US EPA 2002, 2010). The current limits set for these parameters are based on the type of aquatic system and its intended uses.

STUDY PARAMETERS

The impoundments used in this research fall under the Warm Water Fishes (WWF) classification, implying that they are not suitable sources of potable water. In our study, the water quality parameters evaluated included pH, dissolved oxygen, coliforms, and fecal coliform counts. In Pennsylvania, the statute for dissolved oxygen in a WWF-classified impoundment is a minimum daily average of 5.0 ppm with none of the measurements less than 4.0 ppm. The acceptable range for pH is 6 - 9, which applies for all water classifications (USEPA 2002). Limits for fecal and non-fecal coliforms are set based on recreational usage. During the swimming season (May 1 through September 30), fecal coliforms should not exceed a mean of 200 units per 100 ml of water based on a minimum of 5 samples, each collected on a different day during a 30-day period. In addition, no more than 10% of the samples during the 30-day period may exceed 400 units per 100 ml. During the rest of the year, the maximum level of fecal coliforms may have a mean of 2,000 per 100 ml. Non-fecal coliforms may reach a maximum of 5,000 per 100 ml as a monthly average, and no more than 20,000 per 100 ml in more than 5% of the samples (US EPA 2003).

Fecal coliforms are bacteria that are commonly found in the intestinal tract and fecal material of humans and animals (US EPA 2006). The presence of these bacteria does not pose a direct threat to human health, but they may indicate the presence of enteric pathogens (Kirschner et al. 2004). Although there may not be a direct threat, the presence of fecal coliforms and *Escherichia coli* indicate the contamination of water by the feces of a warm-blooded animal (US EPA 1986).

Canada geese along with other waterfowl are important non-point sources of fecal contamination in water (Kirschner et al. 2004). Geese are known carriers of several potential pathogens including *E. coli*, *Salmonella* spp., *Staphylococcus* spp., and *Streptococcus* spp., along with the protozoan *Cryptosporidium* (Jellison et al. 2009). In addition to bacteria and other microbes, there is organic waste, nitrogen, and phosphorus in fecal material. If feces enter water, the input of contaminants can have immediate public health and economic effects where water is utilized for drinking and/or recreation. The amount of fecal material produced by a goose each day can vary. Geese defecate from 28 to 92 times per day, with wet weights of the fecal material averaging from 1 to 3 lbs. When in water, the decomposition of organic materials from the feces reduces dissolved oxygen levels. Canada geese excrete 521 g to 1,410 g (1.15 - 3.11 lbs) of Kjeldahl nitrogen per goose each year and 163 g to 638 g (0.36 - 1.41 lbs) of phosphorus per goose each year. The nitrogen and phosphorus act as fertilizers, which can cause eutrophication in a body of water (Manny et al. 1975, Kear 1963).

Studies have shown that goose feces can contain up to 10^4 colony-forming units (CFUs) of fecal coliforms per gram of feces (Kirschner et al. 2004). Large numbers of geese can quickly increase the load of fecal material and nutrients into a body of water, resulting in a decrease in water quality (Post et al. 1998). Although geese do not normally defecate directly into the water, runoff from rainfall events transports fecal material from shorelines to water (Kirschner et al. 2004). There are conflicting data regarding the extent that fecal runoff affects water chemistry and coliform counts. This may be due to factors that influence loading rates, such as vegetation, bank slope, settling rate, and precipitation amount. Vegetation along the banks of an impoundment or stream may shield the fecal particles from direct rainfall, reducing their presence in runoff. This could allow the fecal material to age, killing the bacteria. The slope of the bank can either facilitate or hinder the input of coliforms and nutrients during a rainfall event, regardless of the amount of vegetation. A study on the impact of nutrient loading by Canada geese found that fecal material settled quickly to the sediment, and turbidity decreased exponentially over time. This fecal material, although settling fast, may have effects during a turnover event. Rainfall intensity influences the rate at which nutrients and bacteria are released from a fecal pellet, while high amounts of rain result in high levels of nutrient and coliform release (Guber et al. 2006, Unckless et al. 2007).

METHODS

Sampling sites were recommended and arranged by the USDA APHIS Wildlife Services staff in Pennsylvania. The three impoundments used in this study were chosen based on the length of time in which the property has been in the USDA's management program, relative size, and location. Two of the impoundments were managed by the USDA, while the third was an unmanaged control site (Figure 1).

Managed Site 1 (MS1) is located in a small development located within the Pidock-Mill Creeks watershed at 40°22'17"N, 75°05'15"W. This site had been managed since April 2007 to discourage Canada geese, by both USDA WS and by the landowner, with the use of pyrotechnics, strobe lights (anchored in the center of the pond), and egg oiling. Approximately half of the pond's edge was covered in shrubby vegetation, while the other half was mowed to the water's edge through the course of this study. The absence of a vegetative buffer potentially increased the amount of fecal input along with other sources of nutrients. The banks of this pond were not steep, which may have reduced the load of fecal material and other nutrients after a rain event. Unlike the other two sites, this pond was fed by natural drainage, as opposed to storm-water and runoff drain pipes.

Managed Site 2 (MS2) is located within the Hearthstone Community Association (a large residential development) at 40°21'04"N, 75°05'33"W. This impoundment's primary input was storm-water runoff, supplemented by a small stream. This pond's overflow drains into the Neshaminy Creek Watershed. MS2 had been managed to discourage geese since April 2002 by USDA WS, along with intensive harassment by the community, using pyrotechnics, lasers, dogs, and egg oiling. The banks of this impoundment were steep, but it had a 6 to 8-foot vegetative buffer that was never cut or trimmed throughout the months of sampling.

The Unmanaged Site (UMS) was located between a horse farm and a small, more rural development at 40°22'09"N, 75°02'03"W, with its overflow draining into the Pidock-Mill Creeks Watershed. The input to this pond was primarily storm-water runoff from the nearby development and roads. The banks of this impoundment were steep, with no vegetative buffer along the banks. The grass on banks was cut up to the water's edge, further facilitating the fecal input to this pond.

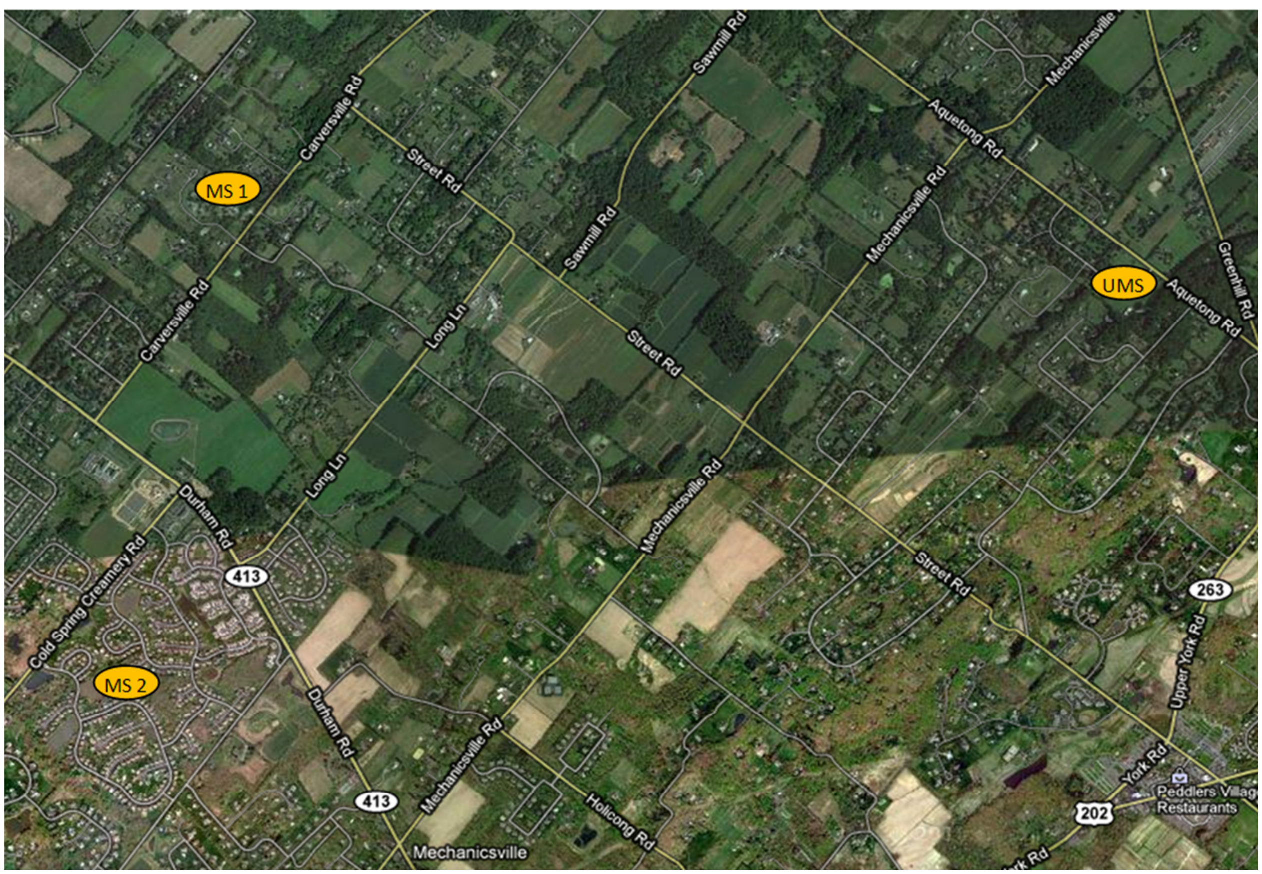

Figure 1. Satellite image of the three research sites and surrounding area. Managed Site 1 = MS1; Managed Site 2 = MS2; Unmanaged Site = UMS.

From May to August 2009, sampling was done every 2 weeks at each study site, and then done once per month in September, October, and November. Upon arrival at each of the study site, observations of weather and the numbers of various waterfowl were recorded. Water sampling was done at each site approximately 4 - 5 feet off-shore, and each procedure was done in a different place to minimize the amount of disturbed sediment that could interfere with results. Water temperature was taken with a standard thermometer 12 inches below the surface. For dissolved oxygen testing, a 25-ml water sample was taken within 6 inches of the surface and analyzed using a CHEMets Kit® (CHEMetrics, Inc., Calverton, VA). Two water samples were collected from surface water at each site in 2-L sterile plastic containers, for coliform counting and bacteriology. Fecal samples were collected at each site, when available, using BBL™ CultureSwab™ Plus (BD, Franklin Lakes, NJ) sterile swabs for the transport of aerobes and anaerobes. Samples were collected by penetrating a fecal dropping with the swab and rolling it, taking care that no surrounding soil was included. The number of samples collected was dependent upon the number of fresh samples available. In most cases, 5 to 7 samples were collected several meters apart, to reduce the occurrence of obtaining multiple samples from the same bird. On some sampling dates, no fecal samples were available for collection. Water and fecal samples were transported in a cooler to the laboratory to be processed within 4 hours, to comply with EPA procedures.

In the laboratory, an accumet® Excel XL15 system (Thermo Fisher Scientific, Waltham, MA) was used to measure the pH of each water sample. The results of the two samples for each site were recorded, then averaged together for the pH reading for that sample date. To ensure accurate results, the pH meter was calibrated after every two sampling dates, following the two-buffer protocol in the system manual. Water samples were then filtered at 0.1, 0.01, and 0.0001 dilutions on 0.45-µm pore filters for coliform analysis. Samples from each site were filtered twice at each dilution and plated both on mFC broth and agar (DIFCO Laboratories, Detroit, MI). Broth plates were incubated at 37°C while the filters on agar were incubated at 44.5°C. After 24 hours of incubation, an agar and broth plate were selected for each site, based on colony-forming unit (CFU) growth. Plates containing 20-100 well-separated coliform colonies were used for counts. Fecal and total coliforms were counted following EPA protocol, using a long-wave blue light to fluoresce non-fecal coliforms. Fecal and total coliform counts for each site were recorded from both broth and agar plates, and then averaged for the total number of fecal and total CFUs for each site for that sample date.

Fecal and water samples were stored at 4°C until they were analyzed the day after sampling. Mannitol Salts agar (MSA), Columbia Nalidixic Acid agar (CNA), Tryptic Soy agar (TSA), and MacConkey's agar (MAC) were used for the bacterial analysis of both fecal and water samples. Each fecal sample was swabbed onto each of the four mediums, numbered, and labeled with the site of collection. Water samples of 10 ml were filtered onto 0.45-µm pore membrane filters, then placed on the same mediums and labeled. These plates were then incubated at 37°C for 18 - 24 hours. Colonies on MSA plates were recorded as fermenters or non-fermenters, TSA plates were recorded as growth or no growth, and MAC plates were recorded as *E. coli* present or absent. CNA plates were used to select for Gram-positive bacteria. One CNA plate each, for both fecal and water samples, was selected for each site and then Gram stained. Gram-positive rods, cocci, or both were then recorded. The same plates used for Gram stains were stored an extra day to allow for the formation of spores. These plates were then used for spore stains, with results recorded as spore former or non-spore former.

Precipitation and temperature were recorded for the day of, and 6 days prior to, sampling. Weather data was obtained from The Weather Channel's online monthly records for Doylestown, PA. Precipitation for the week was summed, while the temperature was averaged.

RESULTS

Dissolved oxygen levels for MS1 ranged from 4 to 9 ppm (mean = 7.2 ppm) over the course of the study. MS2 ranged from 5 to 10 ppm (mean = 7.4). At the UMS, a range from 5 to 12 ppm was recorded (mean = 9.2). The dissolved oxygen levels at UMS were low in May, increased in June, and remained higher for the duration of the study.

Water samples for each impoundment had similar, alkaline pH measurements. The pH range at MS1 was 7.5 to 9.0 (mean = 8.2). At MS2, pH measurements ranged from 7.3 to 9.4 (mean = 8.0). Measurements of pH for UMS ranged from 7.3 to 9.3 (mean = 8.1).

Fecal coliforms were averaged for each site to illustrate the values over the course of the study (Figure 2). MS1 fecal coliforms averaged 373 CFUs per sampling date. Fecal coliform counts from MS2 averaged 802 CFUs. At the unmanaged site, fecal coliforms averaged 1,638 CFUs.

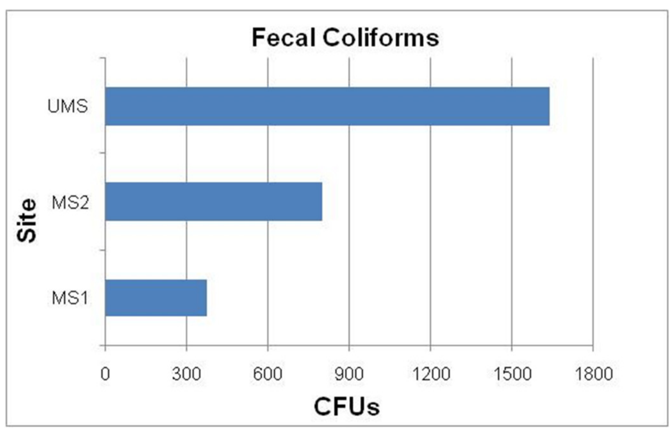

Figure 2. Average fecal coliform counts from May to November 2009, from Managed Site 1 (MS1), Managed Site 2 (MS2), and the unmanaged site (UMS).

Total coliform counts from the three sites followed a similar trend as the fecal coliforms (Figure 3). MS1 had the lowest average at 3,896 CFUs. At MS2, total coliform counts averaged 5,020 CFUs. UMS's average total coliform count was greater than 3 times that of the MS1 site, at 13,493 CFUs.

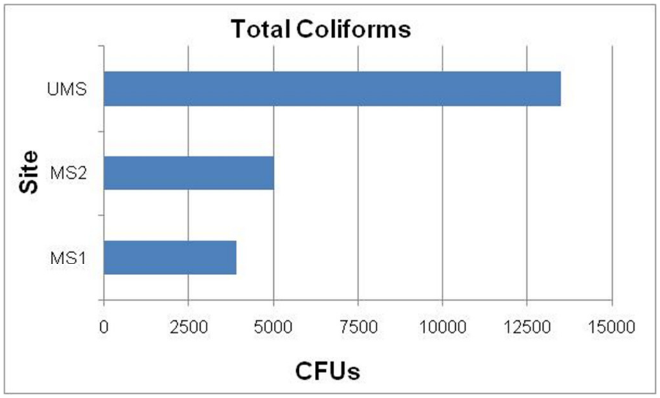

Figure 3. Average total coliform counts from May to November 2009, from Managed Site 1 (MS1), Managed Site 2 (MS2), and the unmanaged site (UMS).

Fecal bacteriology assemblages were consistent throughout the collection period and showed little variation between sites. Every fecal sample from all three sites contained bacteria including *E. coli*, as evidenced by growth on TSA and MaConkey's agar. All water samples (n = 12) from MS2 and UMS plated on MaConkey's resulted in 100% growth of *E. coli*. Fecal samples from sites MS1 and MS2 plated on MSA resulted in 69% positive for mannitol fermentation. UMS showed 70% positive for mannitol fermentors. Fecal and water samples from MS1, MS2, and UMS all contained Gram-positive rods and cocci.

DISCUSSION

Dissolved oxygen (DO) and pH are two water quality parameters that can be used as water quality indicators. The variation in DO and pH at each of the three study sites may be due to a combination of precipitation, temperature, and input source at the inpoundments. Frequent rainfall events throughout the summer may have contributed to the spikes and drops in water chemistry levels. One clear example of this is seen from a decrease in DO at each site during mid-August, which correlates with the warmest temperatures recorded during the sampling period. MS1 is a natural pond that drains a large grassy hill within a rural development. It was hypothesized that the DO levels would be higher in this impoundment, due the effects of shading and cooler water temperatures. However, MS1 had the lowest dissolved oxygen levels, potentially due to the slow, natural drainage into the pond that is not aerated by fast flow over rocks. MS2 and UMS are storm-water drainage ponds, which will aquire a larger amount of rainwater at a faster rate, potentially increasing dissolved oxygen after rainfall events.

The pH for each impoundment may have been affected by precipitation and storm-water run-off which has been recorded at levels less than 5 in Pennsylvania (Lynch et. al. 2007). Drops in pH levels occurred during times of increased precipitation. In late August, rainfall for 1-week period peaked at 3 inches, while pH measurements dropped from 9 to 7.5. An increase in pH at all three sites was recorded in late May, after weekly rainfall accumulations decreased from over 2.5 inches to less than 1 inch.

This study evaluated the fecal and total coliform counts because of the potential economic and public health factors. Because geese excrete 1 to 3 lbs of feces a day, depending on the current food source, there is the potential for large amounts of fecal material to enter the water (Kear 1963). Bi-weekly data showed irregular patterns of *E. coli* (fecal coliforms) and total coliform levels at each impoundment. Fecal coliform levels showed variability between sites throughout the sampling period. MS1 consistantly had the lowest fecal and total coliform counts, spiking less than the other two impoundments. Although coliform counts did not spike as much in MS1 as they did in MS2 and UMS, increases and decreases in coliform counts usually occurred at each site simultaneously. Spikes in both fecal and total coliform counts, correlated with major rainfall events, affected the load of fecal material into the ponds. Grass height along the banks of impoundments impacts the amount of fecal material leaching into the water. A tall grass buffer of 1 to 2 feet along the banks gives fecal runoff more time to be filtered by the soil and utilized by plants. This buffer will also keep geese further away from the water's edge, as they prefer shorter grass. Average coliform counts for the impoundments illustrated the difference between managed and unmangaged sites. This study showed that deterring goose populations from an impoundment does play a role in the improvement of water quality.

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