Evaluation of the Ecological Impact of a Shoreline Restoration

By Nathaniel Wise and Adrienne Daeger

Prepared for The Watershed Foundation by The Lilly Center for Lakes & Streams

December 2020

Introduction:

Canada geese (*Branta canadensis*) are well-known nuisance birds in many urban parks, particularly those which contain or are bordered by bodies of water. They can behave aggressively towards visitors, and their droppings foul lawns, present a health and safety concern to many communities due to potential *E. coli* and other bacterial exposure and can negatively impact water quality by contributing excess nutrients. Mitigation, however, is difficult due to their protection under the International Migratory Bird Treaty Act. One potential method of reducing unwanted goose habitation is the installation of a native vegetative barrier to thwart the easy movement of the geese between water and land and to obstruct clear sightlines for predator detection. Native shorelines provide numerous additional benefits as they effectively stabilize shores, capture and filter runoff, and provide pollinator habitat.

In 2019, The Watershed Foundation (TWF) restored a shoreline along a lawn in Winona Lake Limitless Park and Splashpad. Situated on the lakeside, this portion of the park includes a large expanse of grass which was plagued by Canada geese whose droppings inhibited recreation there and could negatively impact water quality and the health of humans and pets. In 2018, TWF requested assistance from the Lilly Center for Lakes & Streams (Lilly Center) to detect and quantify alterations in the ecology surrounding the project, particularly regarding any change in goose habitation before and after the restoration. This monitoring effort involved weekly counts of goose droppings on the shoreline and surveys of the aquatic plants in the lake along the shoreline. Lilly Center staff conducted these surveys in the summer of 2018 prior to the restoration project and again in 2019 and 2020 following its completion.

Methods:

Surveys were performed every 1-2 weeks starting in mid-July in 2018, 2019, and 2020, for four surveys each year. The on-land portion of the study area was sampled for goose droppings as a proxy for counting individual birds. Running parallel to the shoreline and spaced approximately 3 meters apart, three 100-meter transects were established. The locations of the transects are outlined in Figure 1. For each survey, 10 sample locations per transect were randomly selected using dice, and a 1-meter-by-1-meter quadrat was placed at the corresponding locations. We recorded the presence or absence of goose droppings in each quadrat. Goose droppings were identified by their tube shape which is distinct from splatter-like duck and gull droppings. If a quadrat was randomly selected but could not be sampled due to a tree or other obstacle, the nearest meter was used. In 2019, plastic fencing was present along the shoreline to protect newly established plants for the restoration. The surveys were repeated in 2020 when the fencing was removed in order to ensure the results reflected the impact of plants rather than fencing and since some sample locations fell within the fenced off area and were not sampled.

To determine the species composition and abundance of aquatic plants in the off-shore study area, three 100-meter transects were again established and 10 sample locations per transect selected with dice. The locations of the transects are approximated in figure 1. A 1-meter-by-1-meter quadrat was taken to each location and a garden rake swept from one corner of the quadrat to the opposing corner. The rake was then brought to the surface and the contents examined. The presence or absence of plants was noted and if any were found each species was identified and recorded. In 2019, fencing was present in the southern portion of the lake study area to protect aquatic plants established there. This area was not sampled even when randomly selected so new plants would not be disturbed.

Figure 1: Map indicating the approximate locations of the three land and three aquatic transects (blue lines).

Results:

In 2018, 55 out of the 120 land quadrats sampled during the 4-week survey period were found to contain goose droppings. This number dropped to only 10 in 2019 but increased slightly to 24 in 2020 (Table 1). Thus, while 45.83% of the samples taken in 2018 were populated with droppings, 8.33% and 20.00% of the 2019 and 2020 samples were populated, respectively (Fig.

2). The points on the transects of all the dropping-containing samples in each year may be found in appendix A.

Year	*Samples With Droppings*	*Samples Without Droppings*	*Total*
2018	55	65	120
2019	10	110	120
2020	24	96	120
Total	89	271	360

Table 1: Comparison of the presence/absence of goose droppings in samples from each year of the study.

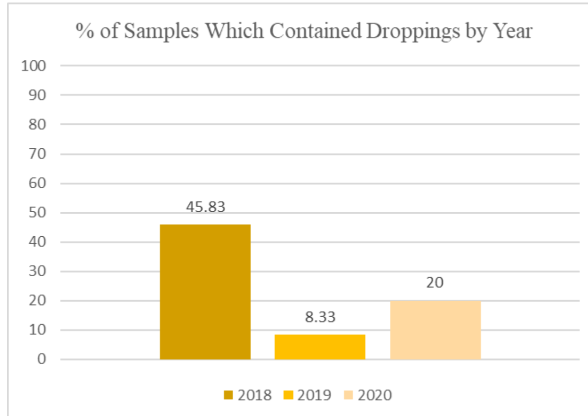


Figure 2: Comparison of the proportion of dropping-containing samples from each year of the study.

Plants were found in 79 out of the 120 aquatic samples taken during the survey period in 2018, increasing to 104 in 2019, with a similar count of 101 in 2020 (Table 2). Plants were present 65.83% of the time in 2018, 86.67% in 2019, and 84.17% in 2020 (Figure 3).

Year	*Samples With Plants*	*Samples Without Platns*	*Total*
2018	79	41	120
2019	104	16	120
2020	101	19	120
Total	284	76	360

Table 2: Comparison of the presence/absence of plants in samples from each year of the study.

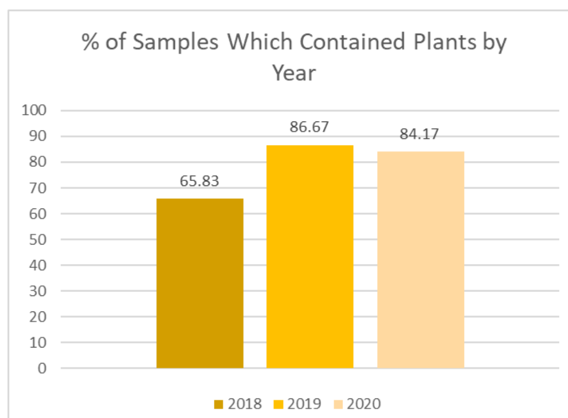


Figure 3: Comparison of the proportion of plant-containing samples from each year of the study.

Five species were encountered: sago pondweed (*Stuckenia pectinata),* eelgrass *(Vallisneria spp.*), slender naiad (*Najas flexilis*), Eurasian watermilfoil (*Myriophyllum* *spicatum*), and hornwort (*Ceratophyllum demersum*), the relative abundances of which are provided in Appendix B. Sago pondweed was the most commonly encountered aquatic plant species and became increasingly dominant each year, occurring in 75.95% of the total plant-containing samples in 2018, then expanding to 98.08% and 99.01% in 2019 and 2020, respectively (Figure 4).

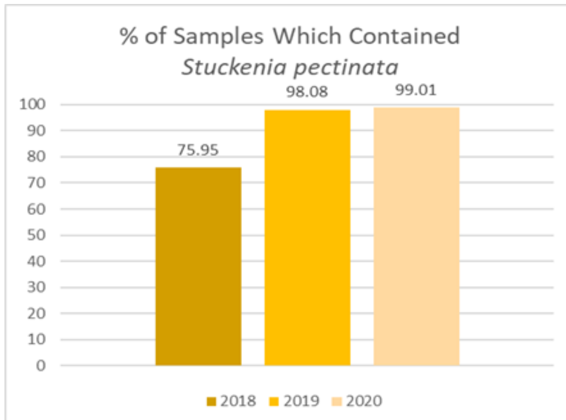


Figure 4: comparison of the proportion of Stuckenia pictinata-containing samples from each year of the study.

<u>Statistical Analysis:</u>

The land sample data may be analyzed using a Chi-Squared test with the following null and alternative hypotheses:

H_0: There is no difference in the proportion of samples with goose droppings present between the three years.

H_A: There is a difference in the proportion of samples with goose droppings present between the three years.

The random selection of sample locations using dice ensures independence of the samples, and since H_0 postulates that the proportion will remain consistent across all three years the expected value for the number of samples with droppings present in 2019 and 2020 is 55 – the value for 2018 –the requirement that each scenario have at least 5 expected cases in order to safely assume a normal distribution is exceeded. (Table 3) A 99% level of confidence will be used.

Year	2019	2020
Observed	10	24
Expected	55	55

Table 3: Comparison of the observed quantity vs the expected quantity of dropping-containing samples in 2019 and 2020.

The Chi-Square test statistic, X^2, may thus be calculated as follows:

$$\underline{\mathbf{X^2}} = [(O_{2019}-E_{2019})^2/E_{2019}] + [(O_{2020}-E_{2020})^2/E_{2020}] = [(10-55)^2/55] + [(24-55)^2/55] = (2025/55) + (961/55) = 36.8182 + 17.4727 = \underline{\mathbf{54.2909}}$$

The use of a Chi-Square table at 1 degree of freedom (df = k-1 = 2-1 = 1) yields a p value ≤ 0.001 for an X^2 value of 54.2909, exceeding the 0.01 p value of a 99% level of confidence.

This indicates that *if the null hypothesis were true* there would be less than a 0.1% likelihood of observing data at least as favorable to the alternative hypothesis as that which was observed in this study.

The aquatic sample data may likewise be analyzed using a Chi-Squared test with the following null and alternative hypotheses:

H_0: There is no difference in the proportion of samples with aquatic plants present between the three years.

H_A: There is a difference in the proportion of samples with aquatic plants present between the three years.

The random selection of sample locations using dice ensures independence of the samples, and since H_0 postulates that the proportion will remain consistent across all three years the expected value for the number of samples with plants present in 2019 and 2020 is 79 – the value for 2018 – the requirement that each scenario have at least 5 expected cases in order to safely assume a normal distribution is exceeded. (Table 4) A 99% level of confidence will be used.

Year	2019	2020
Observed	104	101
Expected	71	71

Table 4: Comparison of the observed quantity vs the expected quantity of plant-containing samples in 2019 and 2020.

The Chi-Square test statistic, X^2, may thus be calculated as follows:

$$\underline{\mathbf{X^2}} = [(O_{2019}-E_{2019})^2/E_{2019}] + [(O_{2020}-E_{2020})^2/E_{2020}] = [(104-79)^2/79] + [(101-79)^2/79] = (625/79) + (484/79) = 7.9114 + 6.1266 = \underline{\mathbf{14.0380}}$$

The use of a Chi-Square table at 1 degree of freedom ($df = k-1 = 2-1 = 1$) yields a p value ≤ 0.001 for an X^2 value of 14.0380, exceeding the 0.01 p value of a 99% level of confidence. This indicates that *if the null hypothesis were true* there would be less than a 0.1% likelihood of observing data at least as favorable to the alternative hypothesis as that which was observed in this study.

<u>Discussion:</u>

Given these results, there is strong evidence that the difference in the proportion of land samples containing droppings in 2019 and in 2020 from the proportion in 2018 is statistically significant, and similarly that the difference in the proportion of aquatic samples containing plants in 2019 and in 2020 from the proportion in 2018 is also statistically significant. Fencing was installed after the restoration to protect the young plants and remained in place during the 2019 survey. The larger difference in 2019 suggests that the fencing represents a confounding variable which altered the results from that year, but that it was itself effective at dissuading geese from spending time in the study area.

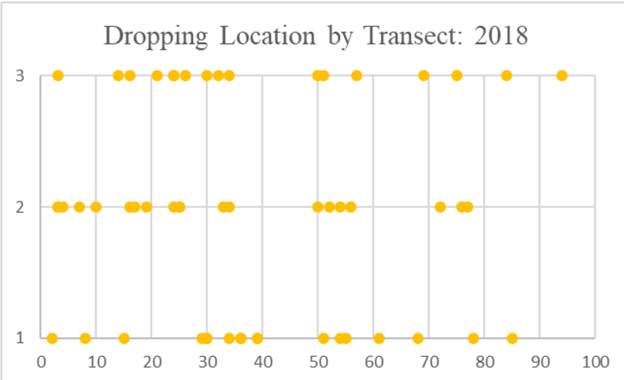
Opportunities for further research abound. Other variables, including *E. coli* counts and goose presence in nearby areas could be surveyed to assess more fully the impact of the natural shoreline at this location and others. Most importantly, similar studies could be conducted in multiple locations in order to replicate the findings under differing circumstances. Other confounding variables could be investigated. For example, the goose population may have experienced decline overall between these three years, or they may by chance or some unknown preference choose to spend time on one shoreline rather than another. Future studies could also monitor the sand portion of the beach to see if the same population has moved to a nearby area with clearer sightlines such as the beach, grassy area long a concrete seawall, or if some other shoreline location on this lake is preferred. Lastly, the use of stratified sampling rather than simple random sampling would ensure that samples were taken more evenly across the study area, mitigating the potential for accidental oversight of areas with high dropping density as a result of randomly selected sample locations being clustered in areas of lesser density.

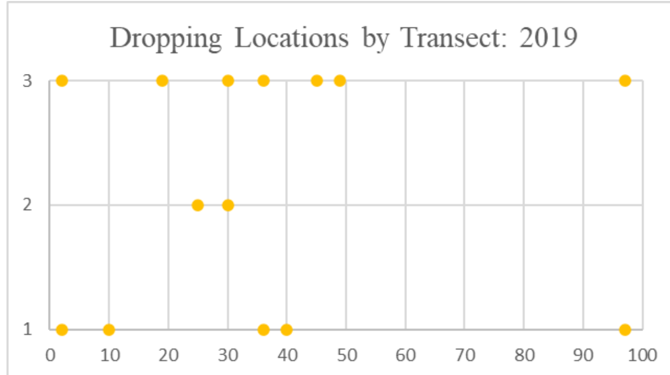
Conclusion:

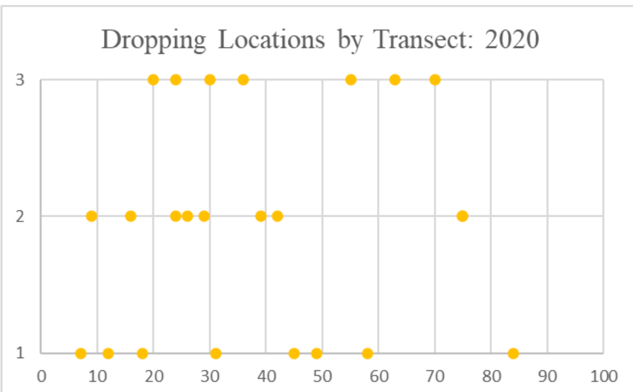
In this study, we observed a significant decrease in Canada goose droppings in the two years following the Winona Lake Limitless Park shoreline restoration, as well as an increase in plant presence during the study years. A decrease in goose droppings of 56.36% and an increase in aquatic plant presence of 27.86% were observed between the first and last years of the study. These findings are consistent with the hypothesis that the vegetative barrier created by the restoration would affect the ecology of the surrounding area. Due to the brevity of the study, as well as the presence of fencing during the 2019 surveys, it would be advantageous to continue yearly surveys in order to determine long-term trends and investigate potential changes as the plants mature.

Appendix A – Additional Land Data:

In these graphs, 1, 2, and 3 on the Y-axis represent the three transects, with 1 being nearest the lakeshore. The X-axis represents the meters of the transects.







Appendix B – Additional Aquatic Data:

This table lists the abundance of each species by year, calculated as the number of times that species was recorded in a year divided by total number of plant-containing samples from that year.

Species	*Sago*	*Eelgrass*	*Slender Naiad*	*Hornwort*	*Milfoil*
2018	75.95%	0.00%	40.51%	32.91%	5.77%
2019	98.08%	10.58%	57.69%	34.62%	4.81%
2020	99.01%	25.74%	57.43%	16.83%	10.89%