

The Otsego County nitrogen budget:
A county-wide denitrification footprint with a feasibility study at
Cooperstown, NY

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INTRODUCTION

An ecological footprint depicts the geographic space required to supply a resource used by a region, or to assimilate pollution liberated by that region, out of the surrounding available resources. This is useful to show the impact of a region on its resource base. Once an area has been incorporated into a footprint, the resource(s) within it are unavailable to any other region (Luck et. al., 2000).

The objective of our study was to determine an ecological footprint for nitrogen assimilation in Otsego County, NY, on the basis of the amount of wetlands necessary to denitrify the county's total nitrogen. Although not all nitrogen produced within the county will be processed by Otsego County wetlands, the comparison of production versus uptake allows available denitrification resources to be recognized.

Three major sources of nitrogen output for Otsego County are measured in this study: 1) Municipal point-source pollution; 2) non-point source pollution from cow waste and 3) fertilizer application. It should be noted that our estimates are likely to be high, as some nitrogen is considered more than once (for instance, much of that originally supplied in commercial fertilizer is later generated as manure waste), and losses, such as that incorporated in exported agricultural products, are not considered. However, these output estimates allow for a conceptual model which provides an approximation of the area of wetlands required to denitrify average yearly nitrogenous waste, compared to available wetlands in Otsego County.

MODELS

Municipal nitrogen output model

A model to determine the wastewater nitrogen output for the Otsego County population was created using direct correlation between municipal nitrogen output for the city of Oneonta population. The daily average influent water for the Oneonta wastewater treatment plant (WWTP) is 6.7 million l/day. It was assumed that water discharge is equivalent. Average nitrogen concentration from the WWTP is 9.5 mg/l; that value multiplied by water discharge equals a total nitrogen output of 63.6 million mg/day or 23,200 kg N/year (Couden, 2002).

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To determine Otsego County wastewater N output, it was assumed that N output per Oneonta resident is comparable to Otsego County residents, and septic filtration is comparable to treatment in the WWTP. Dividing the yearly total N output for Oneonta (23,200 kg N/year) by the average population of 22,000, gives a total of 1.06 kg N output/person/year into the environment. This number was multiplied by the Otsego County population of 61,676, giving a total N output for the county of 65,000 kg N/year.

Livestock waste nitrogen output model

There are 22,300 cows in Otsego County (NYS Farm Bureau, 1997). It was assumed that they produce the average amount of manure and urine (totaling 42.7 kg/day) (Alice Ferguson Foundation, 2002). This multiplied by the cow population totals 950,000 kg waste/day for the entire population of Otsego County cows. Using the average N content for manure and urine of 1.22% (Alice Ferguson Foundation, 2002), cows contribute 11,600 kg N/day or 4.2 million kg N/year as waste.

Fertilizer waste nitrogen output model

Otsego County has 34,200 ha of harvested cropland (NYS Farm Bureau, 1997). Assuming that fertilizer is applied in average amounts, (.865 T/ha), the total amount of fertilizer applied is 29,600 T/year. Assuming that the fertilizer contains the average amount of nitrogen (46%) (Hanson, 2002), this value multiplied by total tonnage gives 13,600 T nitrogen or 12 million kg N applied to Otsego County cropland each year.

Total nitrogen output for Otsego County

Once amounts in kilograms have been determined for all three Otsego County nitrogen sources, they were summed to provide the total Otsego County nitrogen output per year. This value was calculated as 16,265,000 kg(N)/year.

Otsego County wetland uptake model

Total land area in Otsego County is 262,915 hectares (American Factfinder, 2000). Assuming wetlands in Otsego County correspond with hydric soils, the area is 19,836 hectares, or 7.5% of the county (Pullano, 2002). Denitrification in freshwater wetlands was assumed to occur at rate of 3.5 kg (N)/ha/day or 1277 Kg (N)/ha/year (Sloey et.al, 1978). Using the denitrification number multiplied by the area of wetlands, the county has a denitrification potential of 25,330,572 Kg (N)/year. The area of Otsego County wetlands required to denitrify all three sources of nitrogen wastes (for 16 million Kg/yr) is 13,039 ha assuming that each hectare removes 1277.5

kg of nitrogen annually. The denitrification footprint requires 65.7% of available wetlands.

Runoff model

We used the data nitrogen loading data, collected as part of a nutrient budget for Otsego Lake that was collected by the Biological Field Station, to estimate the total runoff of nitrogen in the county. That study provided an average value of 1.9 kg(N)/a/year (Albright, 1996). We made the assumption that the entire county had the same rate of nitrogen runoff. The size of Otsego Lake's watershed is 46,482 acres, or about 7.2% of the county (Albright, 1996). Nitrogen runoff (1.9 kg(N)/a/year x 649,400ac) gives 1,233,860 kg(N)/year for the entire county of Otsego. Using this value, the ecological footprint is only 5% of the county's wetlands for denitrification processes.

SUMMARY

While the ecological footprint for the county is 65% of wetlands being used for denitrification, the actual number may be much lower because the actual amount of nitrogen getting to wetlands in Otsego County may be much lower. The numbers generated from municipal waste, commercial fertilizer and cow manure do not take into account nitrogen uptake by vegetation or the microbial community, or that lost through volatilization that occurs before nitrogen enters the wetlands.

Using a study done at the Biological Field Station in Cooperstown NY (Albright, 1996) these other considerations can be taken into account. The study took nitrogen samples entering the Otsego lake region from the surrounding area. The numbers recorded were after nitrogen had been lost to vegetation growth and wetland denitrification prior to entering the lake.

Case Study: Cooperstown, New York

Cooperstown, NY is a rural village located on the southern tip of Otsego Lake. Every summer the population of 2200 nearly triples as tourists flock to the village. Currently the Wastewater Treatment Plant (WWTP) is nearing maximum capacity, limiting its capability to expand to new homes and businesses.

At present, 12-month rolling flow average from the wastewater treatment plant is 20% above permitted flow levels. As a result, the New York State DEC integrated a Schedule of Compliance, requiring that 12-month average flow remain under 750,000 gallons per day, though this number will not be considered in this study. The original

permitted flow was 520,000 gallons per day; this will be considered the permitted flow for this study (GEIS, 2002).

MODELS

Flow rates and Nitrogen output

To determine excess summer time nitrogen output from the Cooperstown WWTP, nitrogen output was calculated from permitted flow of 2 million l/day effluent, multiplied by average nitrogen concentration for the Cooperstown WWTP of 4.5 mg/l N, giving 9 kg/day N (Cankar, 2002). The high-end summer flow of 3.5 million l/day water, multiplied by 4.5 mg/L N, equals 15.5 kg/day N.

Wetland Requirements

An average northern wetland denitrifies at a rate of 3.5 kg/ha/day during the growing season (Sloey et.al, 1978). Using this denitrification rate the wetland requirements for Cooperstown can be determined. By dividing the summer nitrogen output of 15.5 kg/day by the denitrification rate of 3.5 kg/ha/day, a wetland of 4.5 ha (11.1 ac) is required for denitrification of the summer nitrogen effluent.

In northern areas, wetland productivity occurs primarily during the warmer, growing season. This would be problematic if wetlands were used as a primary form of wastewater treatment. However, Cooperstown excess wastewater flow occurs during the summer months, making wetlands an ideal form of treatment for the area.

Summary of Models and Calculations

The models and calculations were used to determine the nitrogen outputs from the Cooperstown Wastewater Treatment plant, and the wetlands required to mitigate excess summertime flows. According to the wastewater treatment plant, 4.5 mg of nitrogen is contained in each liter of treated water leaving the wastewater treatment plant. By multiplying the liters of water treated each day by this number, the total nitrogen output per day can be calculated.

The models and calculations used to determine wetland requirements were based on the average nitrogen uptake in northern wetlands of 3.5 kg of nitrogen taken up by each hectare of wetland per day (during the warm months) (Sloey, 1978). By dividing total daily nitrogen during the summer, by the wetland uptake, the total hectares of wetland required can be determined.

DISCUSSION

During the summer the WWTP treats a high-end average of 900,000 gpd of wastewater (3.42 million liters/day). The current 12-month rolling average is 640,000 gpd (2.5 million liters/day) is about 20% higher than DEC permitted flow of 520,000 gpd (2 million liter/day) (Generic, 2002). According to WWTP records, the average concentration of nitrogen in the output of treated water is 4.5 mg/l. Using these data, the wetland requirements can then be determined based on a nutrient cycling rate for northern wetlands of 3.5 kg/ha/day of nitrogen. Therefore, Cooperstown would require a constructed wetland of approximately 4.5 ha (11 acres), in order to remove excess nitrogen from summer-time wastewater effluent, before it reached the Susquehanna River. This number represents the summer time flow rates, which are much higher than the 12-month average flow.

The denitrification rate represents the wetland removing all nitrogen from the effluent. Therefore, this is a high-end requirement, which would allow some room for growth, before more treatment would be required.

CONCLUSION

Otsego County has three main sources of nitrogen output: Non-Point sources, which are cow waste and fertilizer application; and point source, which is municipal waste. Municipal nitrogen output is the least, at approximately 65,000 kg each year, while fertilizer application produces the most nitrogen, at over 12 million kg per year. The total nitrogen output for Otsego County is around 16 million kg per year. Using this number, the total hectares of wetland that would be required for filtration can be determined.

Nitrogen uptake in northern wetlands, such as those found in Otsego County, is 1277.5 kg per hectare per year (Sloey, 1978). Using this model Otsego County requires 13,039 ha of wetland to meet its denitrification requirements, or 65% of all available wetlands.

If the county requires more wetland than is currently available, it would be forced to cross into the wetlands of other counties, possibly overlapping their wetland requirements. This would be critical, since once a wetland is being used it becomes unavailable for other sources. This could lead to nitrogen run-off into lakes and streams, causing serious damage to those ecosystems.

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