Never doubt that a small group of concerned citizens can change the world. Indeed, it is the only thing that ever has.

.... Margaret Mead

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To: Chairman Dr. Wayne Stobo and Members, Halifax/Halifax County Watershed Advisory Board (**WAB**), HRM

From: S. M. Mandaville (Professional Lake Manage.), Chairman and Volunteer Exec. Director

Date: March 16, 2000

Subject: **A gaggle of geese ...... or maybe a glut: Cultural eutrophication of lakes and related bacterial problems!!**

Table of Contents

Introduction

It has been unfortunate that some professional staff at NSDoE, HRM, other Government agencies, or for that matter some select researchers, have been blaming residential lawn fertilizers exclusively for the enrichment of our urban and urbanizing lakes, both in areas served by `central' systems as well as those by `onsite' (i.e., septic tank area) systems. I am not for one minute claiming that fertilizers are not a source of phosphorus to our lakes, but I question the wisdom of placing total blame exclusively on lawn fertilizers. Lawn fertilizers may or may not be the major cause of nutrient enrichment depending upon the runoff characteristics, etc. Sure, agricultural fertilizers and pesticides may be a major source of phosphorus inputs, but it does not automatically hold true for urban and suburban areas.

In the case of urban and suburban areas, there may be a whole range of other causes, some of them of more significance than fertilizers, dog feces and/or decaying leaves (one has decaying leaves as well as pollen contributions in totally undisturbed lakes as well)!

Canada Geese have become one of the major sources and in several published papers, the most significant source of phosphorus (as well as bacterial) inputs into urban and suburban lakes. There has been a significant number of papers published in several leading Limnology as well as Lake Management journals, and I herewith summarize a select number of them. Other aquatic birds could also be major sources of P-enrichment:

Potential Problems

It can be argued that suburban-urban lakes are already phosphorus-enriched from human activities, and additional inputs from geese represent an insignificant biogeochemical perturbation. This view, however, neglects the aquatic jewels in the urban landscape- the rare oligotrophic lakes receiving groundwater only or circumscribed by protected watersheds. These lakes, unlike their common, phosphorus-enriched counterparts, may be the most vulnerable to the aireal threat of nutrient enrichment from Canada geese. Even in small numbers, geese are likely to supply more phosphorus to these lakes than any other source.

Furthermore, phosphorus enrichment of oligotrophic reservoirs of drinking water may create human health problems if the growth of bacteria is stimulated. (Moore et al., 1998 [cf. Currie, 1990])

Variability and interactions among phytoplankton, bacterioplankton, and phosphorus (Currie, 1990)

> "The data are most consistent with an alternative model postulating that P directly influences both algal and bacterial abundance, that algae and bacteria directly influence each other's abundance, and that a third factor (temperature or perhaps bacterivore abundance) also influences both algal and bacterial abundance in the same manner." (Currie, 1990)

The models were first tested in a field study of 36 U.S. and Canadian lakes. Some of the lakes were located on Precambrian rock on the Canadian shield in Ontario and Québec, and others were located in the St. Lawrence lowlands and the eastern Québec uplands of Ontario, Québec, New York, and Vermont. These lakes were selected to include as much variability as possible in chemical and morphological conditions:

- Mean depth, m= 1.6 - 55
- Surface area, ha= 11 - $1.8*10^6$
- Watershed area, ha= 170 - $5.1*10^6$
- DOC conc. $mg.l^{-1}$= 1.7 - 17.4
- Conductivity, $\mu mhos.cm^{-2}$= 26 - 2,600
- Light extinction coefficient, m^{-1}= 0.25 - 2.4
- pH= 5.6 - 8.9
- Bacterial abundance, $x10^6$ $cells.ml^{-1}$= 2.2 - 10.1
- Chl *a*, $\mu g.l^{-1}$= 1.5 - 74.1
- PO_4^{3-} uptake constant, min^{-1}= 0.008 - 0.42

There is evidence that the nature of the relationship between algae and bacteria may change with trophic status. Bacterial abundance and Chl both vary nonlinearly with TP such that the ratio of the two changes in a complex manner. Beginning in the most oligotrophic lakes, one sees that as TP increases bacteria increase in abundance more rapidly than do algae to a maximum near 5-7 $\mu g.l^{-1}$ TP. As TP increases above this level, algal abundance increases more rapidly than does bacterial abundance.

This polytonic relationship may be due to changes in the way algae and bacteria interact for nutrients in lakes of differing trophic status.

- ♦ In very oligotrophic systems both bacterial and algal growth is P limited. Because bacteria are better competitors when orthophosphate is very scarce, bacteria obtain a larger share of the P, and they increase in abundance relatively more rapidly than do algae.
- ♦ In richer lakes, bacterial growth becomes simultaneously P and C limited. Algae then obtain greater portions of the P, and algal abundance begins to increase more rapidly than bacterial abundance.

Nutrient additions by waterfowl

Nutrient additions by waterfowl to lakes and reservoirs (Manny et al., 1994)

The additions to the Wintergreen Lake (15 ha), Michigan by over 6500 Canada geese (*Branta canadensis*) and 4200 ducks (mostly mallards, *Anas platyrhynchos*), mostly during their migration, were 69% of all carbon, 27% of all nitrogen and 70% of all phosphorus that entered the lake from external sources.

- The annual P loading rate (in g y^{-1}):
    - annual P loading rate by geese = 0.49 A
    - annual P loading rate by dabbling ducks = 0.22 B
    - annual P loading rate by diving ducks = 0.19 C
    - where:
        - 0.49 = daily P loading rate per goose
        - A = effective goose-use days y^{-1}
        - 0.22 = daily P loading rate per dabbling duck
        - B = effective dabbler-use days y^{-1}
        - 0.19 = daily P loading rate per diving duck
        - C = effective diver-use days y^{-1}

Table 0006-1: Characteristics of Canada Goose Pellets (Bland, 1996)

Parameter	Source: Manny (1975)	Source: Kear (1963)
Average Wt.	2.56 kg	4.64 kg
Dropping frequency	28/day	92/day
Dry Wt. Droppings	1.17 g	1.9 g
Dry Phosphorus	1.34%	1.0%
Dry Nitrogen	4.38%	2.2%
Dry Carbon	75%	---
Dry Ash	24%	---
Moisture	79%	83%

Phosphorus Loading of an Urban Lake by Bird Droppings (Scherer et al., 1995)

Total phosphorus in bird droppings constituted 27% of the total phosphorus loading to the lake from all sources in 1992, 25% in 1993, and 34% in 1994. Based on the behavior of the birds, their high metabolic rate, and the paucity of forage in the surrounding urban area, 87% of the phosphorus in bird droppings was estimated of having originated from food items in the lake and represented internal cycling. However, birds may potentially increase the productivity of water bodies by changing the form, rate, and pathways of cycling, and physical compartment of phosphorus.

Equation used to estimate phosphorus loading by bird droppings:

$$P = (B)\ (D)\ (C_d)\ (p)$$

P = phosphorus loading rate (kg P t^{-1})
B = Number of bird-days (bird-d t^{-1})
D = dry weight of droppings produced per bird per day (mg DW droppings bird-d^{-1})
C_d = total phosphorus content of droppings as a percent dry weight (mg P mg DW droppings^{-1})
p = probability that droppings enter the lake

- Number of Bird-Days (B): These are ascertained using a 7x42 binoculars and a 25-power spotting scope. Counts were recorded while walking around the lake between 6 and 9 a.m.
- Rate of Production of Droppings (D): Production of droppings (dry weight) by all bird species was estimated to be 2.25% of their body weight per day.
- Total Phosphorus Content of Droppings (C_d): The phosphorus concentration of droppings was assumed to be 1.87% of the dry weight of droppings based on the average of concentrations reported for ducks, gulls, and geese.
- Probability that Droppings Enter the Lake (p): The probability that bird droppings entered Green Lake was considered to be proportional to the frequency the birds were flying over the water. The respective probabilities for each group of birds assumed was as follows:
    - 80% for the droppings of mallards, gadwalls, the category of “other ducks”, and coots.
    - 0.5 for wigeon droppings because wigeons frequently forage on shore.
    - 0.5 for Canada geese also because during the summer they were usually on the water but during the winter the geese frequently grazed on the shore.
        - Geese and other waterfowl may spend less time foraging on shore at Green Lake than at lakes in undeveloped areas due to lack of habitat and disturbance by people and dogs.
    - 1.0 for cormorant droppings because cormorants are always found on water.
    - The category, “other waterbirds”, was also assigned a probability of 1.0 because nearly all the birds in that grouping were grebes, which spend all their time on water.
    - 0.6 probability for gull droppings because they spent the day at Green Lake but the night at the nearby Lake Washington.
    - 0.125 for droppings from non-waterbirds assuming that the birds spent 25% of their time at the lake and half of the droppings produced during that time were deposited in the water.

Table 0006-2: Estimated bird weight and rate of production of droppings (adaped from Scherer et al., 1995)

Bird	Body weight (kg)	Droppings (g dry weight/d)	TP g/d	p	Loading to an urban lake/yr kg P/bird/year
Mallard	1.14	27.0	0.50	0.8	0.146
Gadwall	1.0	22.5	0.42	0.8	0.123
American and European Wigeon	0.75	16.9	0.32	0.5	0.058
Other Ducks	0.8	18.0	0.34	0.8	0.098
American Coot	0.6	13.5	0.25	0.8	0.074
Canada and Domestic Goose	3.63	81.6	1.53	0.5	0.278
Cormorants	2.0	45.0	0.84	1.0	0.307
Gulls	0.69	15.6	0.29	0.6	0.064
Other Waterbirds	1.0	22.5	0.42	1.0	0.154
Rock Dove	0.25	8.3	0.16		
Other Non-water Birds	0.125	2.8	0.05	0.125	0.002

Potential Effects of Canada Geese and Climate Change on Phosphorus Inputs (Moore et al., 1998)

Inputs of total phosphorus (TP) to a small lake (0.4 km^2) located in western suburban Boston were compared during a drought (fall 1995) and a normal rainfall period (fall 1994) to explore potential effects of Canada geese (*Branta canadensis maxima*) and climate change on phosphorus loading to suburban lakes of the Northeastern U.S.A.

- In fall 1994, the watershed supplied 18 times more TP than Canada geese, but during the fall drought of 1995, TP from Canada geese exceeded that from the watershed by more than 7 times.
- Differences in the relative importance of TP loading from Canada geese and the watershed were caused by variation in streamflow between years.
    - Under conditions of climatic warming, annual streamflow in the Northeast (U.S.A.) is projected to decline by ~30% with greatest reductions (~60%) occurring in the fall. At this time of year, Canada geese are most abundant and are likely to become the major contributor of TP to urban lakes.
    - Furthermore, annual absolute inputs of TP from geese to suburban and urban lakes of the Northeast are likely to increase with warmer conditions associated with climate change, because ice cover in winter is unlikely to form on lakes in this region. Consequently, geese are likely to remain on such lakes during the winter rather than moving to open coastal waters as they do presently when lakes freeze.
- Thus, both the warmer and drier conditions predicted to accompany climate change may exacerbate effects of Canada geese on the water quality of suburban-urban lakes in this region of North America.
- ☞ "Unlike Scherer et al. (1995), however, we assumed that phosphorus in goose droppings originated from outside the watershed (e.g., adjacent golf course where goose forage) and did not represent internal cycling. Because geese visited the lake at night, the lack of light should have prevented foraging on aquatic macrophytes, and hence, internal cycling of phosphorus."

Feeding of ducks and their effects on water quality (Gere and Andrikovics, 1994)

Birds possess fast metabolism, and therefore they ingest and egest relatively large quantities of organic materials. Mallards of different ages have different ecological roles. In the beginning of their individual life they reduce the trophic level but later they contribute to the eutrophication processes.

Possible solutions (Moore et al., 1998)

☺ Nuisance goose problems in suburban-urban areas of the New England/Mid Atlantic region are likely to increase, making alleviation necessary. Accomplishing this, however, will be difficult. Geese habituate rapidly to fear-provoking techniques including pyrotechnics and acoustical harassment., and a relocation of geese is both expensive and limited to a narrow time period when birds are flightless during moulting. Currently, the method offering the greatest long-term success is landscape modification of foraging sites adjacent to water.

- Studies of geese foraging suggest that planting tall trees, hedges, or tall grasses around the body of water can alleviate problems. Such plantings make sites less attractive to geese by creating obstacles for flight (tall trees and hedges), reducing the ability of geese to detect predators (tall grasses), or both.
- Another study of goose foraging suggests that replacing lawns with unpalatable vegetation (i.e., Japanese pachysandra, English ivy, or common periwinkle) may discourage geese from frequenting such sites.
- Additional measures available to waterfront property owners include shutting off airators and allowing ponds or pools to freeze in winter or constructing a vertical concrete ledge (18 to 60 cm) around the pond.

"Lake managers in this region of North America may need to implement such measures, because geese are likely to become the major external supply of phosphorus to these lakes when weather is dry during the stratified season."

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