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Effects of Organic Farming on Water Quality

Reducing the effect of agricultural pollution on Lake Champlain is a major issue facing Vermont. Dairy farms along Lake Champlain use nitrogen and phosphorous to support crop growth through the use of manure and/or purchased fertilizers. Without proper management, these nutrients can runoff into the lake and excess amounts can have a negative effect on ecosystems, fish populations, and human health. The United States Geological Survey has concluded that widespread concentrations of nitrogen and phosphorous are between two to ten times higher than EPA recommended levels for protecting aquatic life.[1] Requiring dairy farms to adopt organic farming practices has been one proposed method for reducing lake pollution. This report addresses the efficacy of organic farming as a means to determine if a change from conventional farming will reduce nitrogen and phosphorous pollution in Lake Champlain.

What is Organic Farming?

The United States Department of Agriculture has developed specific requirements for farmers intending to run an organic farm. These regulations contain three categories: crop standards, livestock standards, and handling standards. Some important requirements are:

- Land must have no prohibited substances applied to it for at least 3 years before the harvest of an organic crop.
- Soil fertility and crop nutrients will be managed through tillage and cultivation practices, crop rotations, and cover crops, supplemented with animal and crop waste materials and allowed synthetic materials.
- Preference will be given to the use of organic seeds and other planting stock, but a farmer may use non-organic seeds and planting stock under specified conditions.
- The use of genetic engineering (included in excluded methods), ionizing radiation and sewage sludge is prohibited.
- Producers must feed livestock agricultural feed products that are 100 percent organic, but may also provide allowed vitamin and mineral supplements.

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[1] Neil Dubrovsky, Kara Capelli, "Elevated Nitrogen and Phosphorus Still Widespreead in Much of the Nations Streams and Groundwater", United States Geological Survey, 2010, accessed March 14, 2011, http://www.usgs.gov/newsroom/article.asp?ID=2599

- All organically raised animals must have access to the outdoors, including access to pasture for ruminants. They may be temporarily confined only for reasons of health, safety, the animal's stage of production, or to protect soil or water quality.
- Dairy animals must be managed organically for at least 12 months in order for milk or dairy products to be sold, labeled or represented as organic. (Dairy producers may use land that is transitioning during its third year of transition to organic certification to provide crops and forage for dairy animals during this 12-month period prior to the sale of dairy products as organic.)[2]

How Pollutants Form and Enter Waterways

The major pollutants from dairy farms that affect water quality are nitrogen and phosphorous based. These materials are produced both from fertilizers and from waste produced by livestock. When this waste is exposed to oxygen, nitrates, nitrites, and phosphates are formed. In addition, ammonia is created when nitrogen and hydrogen combine. These organic chemicals are then carried to bodies of water by runoff caused by erosion and rain water.[3]

As these nutrient levels increase within a water body, excess amounts can cause various problems for the ecosystem. According to the United States Environmental Protection Agency,

> Nutrient pollution, especially from nitrogen and phosphorus, has consistently ranked as one of the top causes of degradation in some U.S. waters for more than a decade. Excess nitrogen and phosphorus lead to significant water quality problems including harmful algal blooms, hypoxia and declines in wildlife and wildlife habitat. Excesses have also been linked to higher amounts of chemicals that make people sick.[4]

The chemicals from agricultural runoff tend to increase growth of algae, eventually leading to eutrophication, or the decrease of dissolved oxygen in the water. Eutrophication is the root of many of the problems associated with excess phosphorous and nitrogen runoff and can damage or destroy ecosystems contained within a body of water. In addition, ammonia can lead directly to fish kills.[5]

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[2] United States Department of Agriculture National Organic Program, "Organic Production and Handling Standards," accessed February 23, 2011, http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3004445.

[3] United States Environmental Protection Agency, "Basic Information, What is the Problem?" accessed February 20, 2011, http://water.epa.gov/scitech/swguidance/waterquality/standards/criteria/aqlife/pollutants/nutrient/basic.cfm.

[4] United States Environmental Protection Agency, "Water Quality Criteria for Nitrogen and Phosphorus Pollution," accessed February 18, 2011, http://water.epa.gov/scitech/swguidance/waterquality/standards/criteria/aqlife/pollutants/nutrient/index.cfm.

[5] Katherine Knowlton, "Environmental Issues Facing Dairy Farmers," accessed February 18, 2011 http://www.usjersey.com/Reference/Environment_1.pdf .

Methods for Reducing Agricultural Water Pollution

Reduction through Conventional Farming

According to Laura DiPietro, ARMES Deputy Director at the VT Agency of Agriculture, one of the ways in which conventional farms are managed may help to reduce pollution. In conventional farming, cows are kept "under roof," meaning they are under the shelter of a barn more often than the cows on organic farms. One of the requirements of organic farms is that the livestock remain outside and graze on the land already provided. When cows are under roof, the manure remains in one place and is protected from precipitation events, which enables the farmers to collect the manure and transport it to a single storage unit. It can then be "land applied" at the appropriate time and in appropriate quantities for crop uptake.

> The key is to ensure that this manure is land applied appropriately regardless of the type of farming operation, as the risk of nutrient losses to surface water increases when spreading bulk manure at the wrong time. On an organic farm, the majority of manure is distributed throughout the farm landscape by animals directly depositing manure as they graze, however if there are animal holding areas there may also be storage for manure that is then land applied. For grazing animals it is important to regulate the extent to which the cows interact with natural waterways. Access to surface water for the purposes of meeting daily watering requirements and accessing adjacent fields is an approved practice in Vermont, so long as the streambank remains adequately vegetated to minimize erosion. There are perennial, intermittent, and ephemeral streams bisecting Vermont pastures. Where livestock have access to these waters there is an increased risk of nutrient losses to surface water. [6]

There is a public push to require livestock exclusion from all streams in Vermont, which could significantly impact the need for additional infrastructure on organic dairies. A diverse committee of agricultural experts reviewed livestock exclusion in Vermont and determined that it would cost approximately $33,000,000 to provide the appropriate fencing, watering systems and stream crossings to exclude all livestock from all streams for the entire state of Vermont. [7]

Reduction though Organic Farming

In addition to increasing crop yield, organic or bio fertilizer has also been shown to reduce agricultural runoff of nitrogen and phosphorous. Organic and bio fertilizers create carbon rich soils, abundant in microbial activity. The philosophy of organic farming aims to feed the soil

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[6] Laura DiPietro, ARMES Deputy Director, in an interview with report authors Leah Marvin-Riley and Dean LoRusso, February 16, 2011, Department of Agriculture, Montpelier, Vermont.
[7] Laura DiPietro, ARMES Deputy Director, in an interview with report authors Leah Marvin-Riley and Dean LoRusso, February 16, 2011, Department of Agriculture, Montpelier, Vermont.

rather than the crop by creating rich, healthy soil capable of greater water retention, improved drainage and aeration, and increased resistance to erosion.[8]

A 2008 study, published in the *Journal for Sustainable Agriculture* studied the effect of applying organic fertilizer with varying levels of supplemental chemical fertilizers to maize both in pots and in field conditions. The study found that in both cases not only were yields and nutrient uptake levels increased significantly with the use of bio and organic fertilizers, but the soil held more water in each year of the study. This finding was supported by the slower mineralization rates of the organic fertilizer.[9]

Another long term study of organic versus conventional farming techniques was conducted at the Rodale Institute from 1981-2002. Soil nitrogen, carbon and water levels were measured in each case. One result of the study was that the organically treated soil had greater water content than the conventional counterpart. This supported the claim that organic practices lead to increased water retention. As a result, the soil that was treated organically held more nitrogen and had less runoff of nutrients.[10] Applying organic farming techniques in both studies had a significant effect on the soil's ability to resist runoff and hold nutrients. Therefore, using organic materials can allow for a slower release of chemicals into waterways. This makes managing waste more feasible for farmers.

Reduction through Management

Although there are environmental benefits to organic farming as opposed to conventional chemical farming, good farm management is essential for reducing runoff of waste. The United Nations' Food and Agriculture Organization states: "The investigation of eutrophication of surface water by agriculture must adopt a pragmatic management perspective."[11]

According to Laura DiPietro, Deputy Director of the Vermont Division of Agricultural Resource Management, the management and infrastructure of farms are the most important aspects in preventing excess pollution of Vermont waterways. Proper management includes the timing of crops, aeration of soils, the use of vegetative buffers, and the use of manure fertilizer at the appropriate times when the crop can fully absorb it. Effective infrastructure on farms can be

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[8] Dolceta, "Organic Farming," accessed February 28,2011 http://www.dolceta.eu/malta/Mod5/IMG/pdf/2010_organic_farming_pdf-2.pdf.

[9] Rizwan Ahmad, Muhammend Arsad, Zahir Azeem, "Effectiveness of Organic-/Bio-Fertilizer Supplemented with Chemical Fertilizers for Improving Soil Water Retention, Aggregate Stability, Growth and Nutrient Uptake of Maize" *Journal of Sustainable Agriculture* (2008).

[10] David Pimentel, Paul Hepperly, James Hanson, David Douds, Rita Seidel, "Environmental, Energetic, and Economic Comparisons of Organic and Conventional Farming Systems," Bio Science vol. 55 no. 7, July, 2005, accessed March 14, 2011

[11] United Nations Food and Agriculture Organization: Natural Resources Management and Environment Department, "Fertilizers as Water Pollutants," accessed February 24, 2011, http://www.fao.org/docrep/w2598e/w2598e06.htm.

equally important in reducing outputs. For instance, having a barnyard where animals are temporarily held is common on many small farms, conventional or organic, if uncovered and without proper diversions to collect dirty water, there is a potential that a discharge to surface waters could occur during a precipitation runoff event if a stream is nearby.[12]

A 1993 United Nations Food and Agriculture Organization (UN FAO) report concluded that the following farming practices would be most effective for reducing nitrogen and phosphorous outputs:[13]

- Rational nitrogen application: To avoid over-fertilization, the rate of nitrogen fertilizer to be applied needs to be calculated on the basis of the "crop nitrogen balance." This takes into account plant needs and amount of N in the soil.
- Vegetation cover: As far as possible, keep the soil covered with vegetation. This inhibits build-up of soluble nitrogen by absorbing mineralized nitrogen and preventing leaching during periods of rain.
- Manage the period between crops: Organic debris produced by harvesting is easily mineralized into leachable N. Steps to reduce leachable N includes planting of "green manure" crops, and delaying ploughing of straw, roots and leaves into the soil.
- Rational irrigation: Poor irrigation has one of the worst impacts on water quality, whereas precision irrigation is one of the least polluting practices as well as reducing net cost of supplied water.
- Optimize other cultivation techniques: Highest yields with minimum water quality impacts require optimization of practices such as weed, pest and disease control, liming, balanced mineral fertilizers including trace elements, etc.
- Agricultural Planning: Implement erosion control techniques that complement topographic and soil conditions. [14]

In Vermont the Agency of Agriculture, Food and Markets (VAAFM) has an extensive plan for regulation of phosphorous and nitrogen in farming. The agency requires all farms in Vermont to have a “nutrient management plan.” Small farms must take soil and manure samples and use those results to determine agronomic rates for crops they grow, maintain vegetative buffers, and meet soil erosion requirements. Farms with more than 200 dairy cows must meet similar requirements; however, they must have a physical plan that meets a specified standard and is kept on site at all times. The certified plan must also include other management tools such as the phosphorus and nitrogen indices, reduced erosion rates, and wider buffers. The VAAFM regulates these plans with annual inspections and evaluations of annual reports. Specific practices of nutrient management that help to promote increased organic matter and reduced soil erosion rates include conservation tillage (a specific way of plowing to prevent erosion),

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[12] Laura DiPietro, ARMES Deputy Director, in an interview with report authors Leah Marvin-Riley and Dean LoRusso, February 16, 2011, Department of Agriculture, Montpelier, Vermont.
[13] United Nations Food and Agriculture Organization: Natural Resources Management and Environment Department, “Fertilizers as Water Pollutants,” accessed February, 24, 2011, http://www.fao.org/docrep/w2598e/w2598e06.htm.
[14] J.C. Ignazi, “Prevention of Water Pollution by Agriculture and Related Activities,” 1993. Proceedings of the FAO Expert Consultation- Water Report 1. pp 247-261.

strip cropping or contour planting (planting hay between rows of other crops also to prevent erosion), crop rotation (alternating crops in different seasons), and vegetated buffers (plants grown to collect farm field runoff).[15]

Reduction through State Action

As Vermont attempts to control and reduce agricultural pollution statewide, other actors have enacted methods to regulate pollution of different waterways. The Environmental Protection Agency has initiated a program in order to increase awareness of nutrient management in the states. Since that program began, 25 states have implemented "numeric nutrient standards" for at least one of their water bodies.

Outside the United States, countries have used various control methods to reduce the problem of water contamination from agricultural runoff. "The nature of these measures varies by country; however the United Nations' Food and Agriculture Organization and the Economic Commission for Europe (1991) has summarized the types of voluntary and mandated control as:

- Maximum numbers of animals per hectare based on amount of manure that can be safely applied per hectare of land.
- Maximum quantities of manure that can be applied on the land is fixed, based on the N and P content of the manure.
- Holdings wishing to keep more than a given number of animals must obtain a license.
- The periods during which it is allowed to apply manure to the land have been limited, and it is obligatory to work it into the ground immediately afterwards.
- Establishment of regulations on minimum capacity for manure storage facilities.
- Establish fertilizer plans.
- Levies (taxes) on surplus manure.
- Areas under autumn/winter green cover were extended, and green fallowing is being promoted.
- Change in composition of feed to reduce amount of nutrients and heavy metals.
- Research and implementation of means of reducing ammonia loss."[16]

In the UK, these laws include the Protection of Water against Agricultural Nitrate Pollution Regulations[17], as well as The Control of Pollution Regulations[18] and The Water Resources

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[15]Agency of Natural Resources: Clean and Clear Program, "Nutrient Management," accessed March 3, 2011, http://www.anr.state.vt.us/cleanandclear/ag-nutrient.htm

[16] United Nations Food and Agriculture Organization: Natural Resources Management and Environment Department, "Fertilizers as Water Pollutants," accessed February, 24, 2011, http://www.fao.org/docrep/w2598e/w2598e06.htm

[17] "The Protection of Water Against Agricultural Nitrate Pollution Regulations," 2006, accessed February 28, 2011, http://www.legislation.gov.uk/uksi/2006/1289/contents/made.

[18] "The Control of Pollution Regulations." 2003, accessed February 28, 2011, http://www.legislation.gov.uk/ssi/2003/531/schedule/3/made.

Regulations.[19] DEFRA (The UK Department of Environment, Food and Rural Affairs) also runs the Catchment Sensitive Farming Program. This program includes "managing appropriately the use of fertilizers, manures and pesticides; promoting good soil structure and rain infiltration to avoid run-off and erosion; protecting watercourses from fecal contamination, sedimentation and pesticides; reducing stocking density; managing stock on farms to avoid compaction and poaching of land; and separating clean and dirty water on farms."[20] This program, along with existing legislation, provides regulations for UK farms to reduce pollution from entering waterways.

Conclusion

Converting dairy farms in Vermont to organic may help reduce pollution in Lake Champlain by increasing soil carbon levels and water retention periods; however, the biggest reductions are most likely to come from improvements in farm management. Indeed, the research suggests that simply changing to organic farming is unlikely to solve this problem. While there are benefits to using organic fertilizers, nitrogen and phosphorous runoff occurs regardless of what farming methods are used.

Prepared in response to a request by Senator Giard by Dean LoRusso and Leah Marvin-Riley, under the supervision of graduate student Kate Fournier and Professor Anthony Gierzynski on March 21, 2011.

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[19] "The Water Resources Regulations." 2010, accessed February 28, 2011, http://www.legislation.gov.uk/uksi/2010/639/contents/made.

[20] Department of Environment Food and Rural Afairs, "Catchment Sensitive Farming", June 2002, accessed February 28, 2011, http://www.defra.gov.uk/foodfarm/landmanage/water/csf/.