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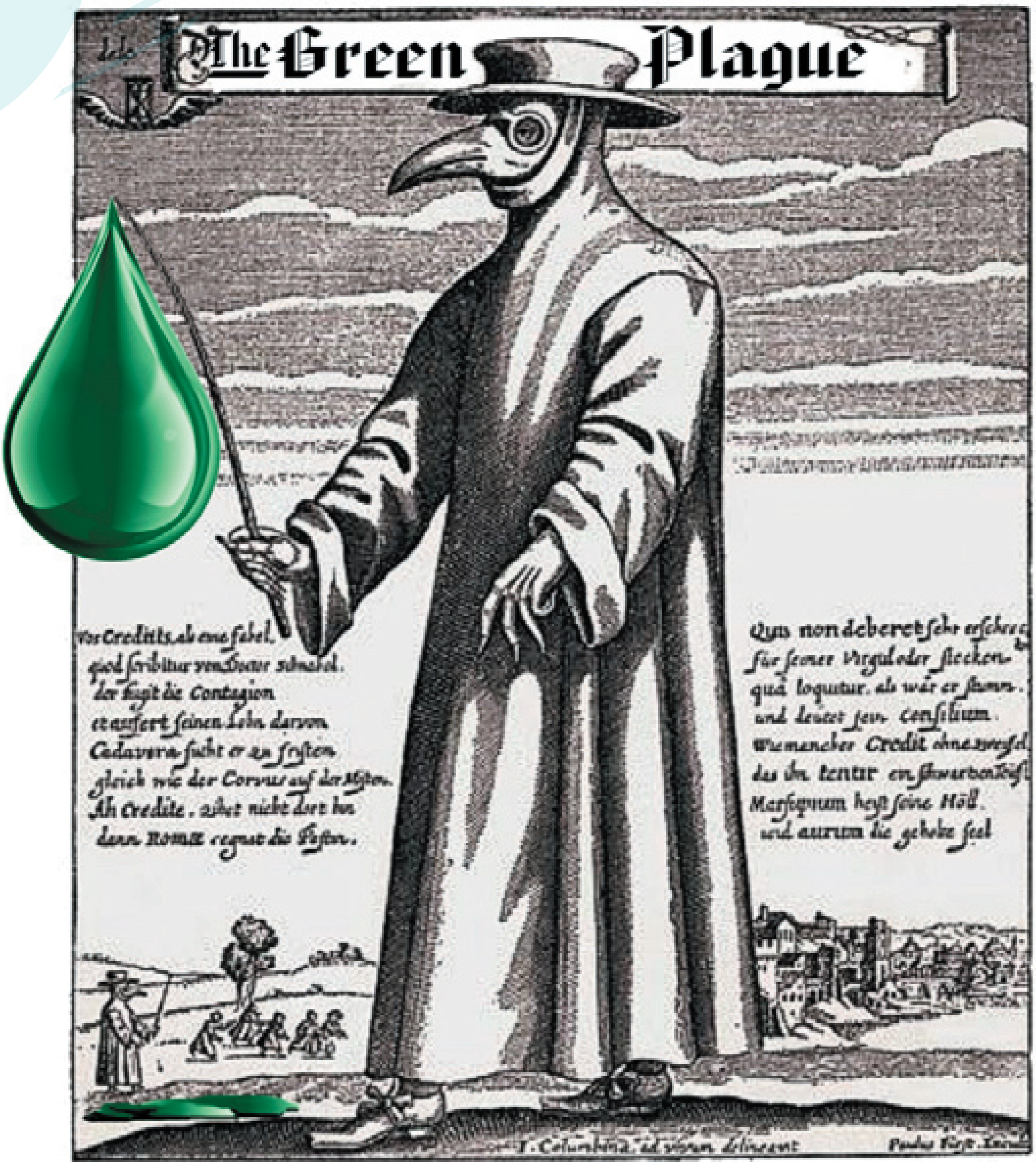

How Biofuel Policies Are Damaging the Environment

By Eric Merkley

About the author

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The Green Plague

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By Eric Merkley

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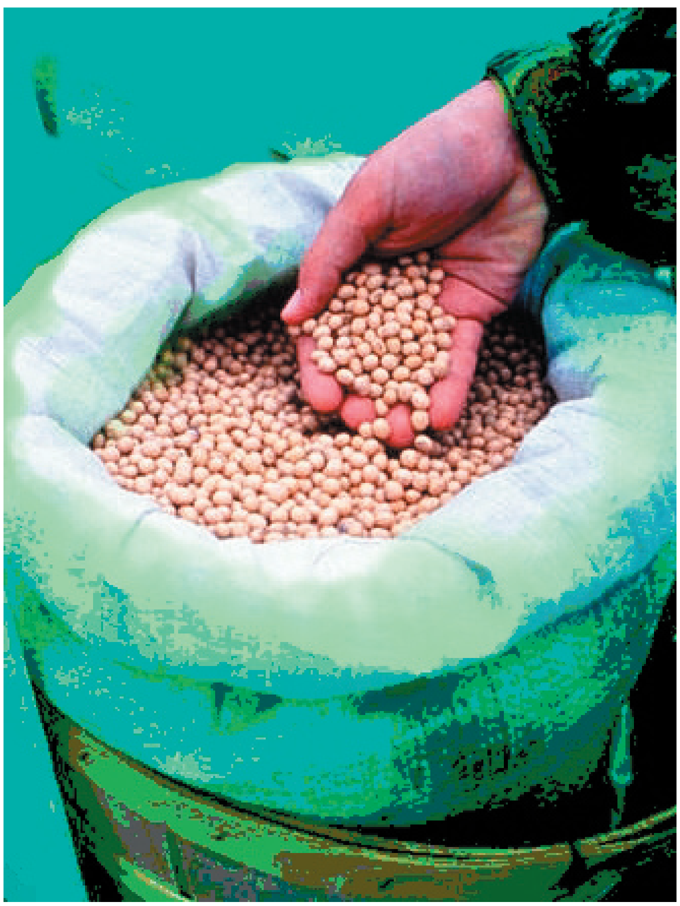
Executive Summary

- The production and use of biofuel produces more greenhouse gas emissions than fossil fuels do when factoring in direct and indirect land-use change and nitrous oxide emissions from the production process.
- The agriculture intensification necessary to maintain corn-ethanol feedstock will contaminate water systems with excess nutrients from fertilizer run-off. These nutrients, through a process called eutrophication, create hypoxic zones that are devoid of oxygen such as in the Gulf of Mexico and increasingly in Lake Winnipeg. These zones destroy marine ecosystems and harm local anglers.
- Biofuel production is far more water inefficient than fossil fuel is. The irrigation required to grow feedstock on more-marginal land as production expands will put increasing strain on freshwater stocks—a commodity of increasing demand and scarcity.

Introduction

In the past decade, Canada, the United States and the European Union have increasingly placed biofuel at the centre of their "green" strategies. Initial studies highlighted the potential for large reductions in greenhouse gas (GHG) emissions over the biofuel production. Rural leaders support potential job creation by developing ethanol and biodiesel industrial plants, and farmers hope biofuel can act as a permanent floor for agricultural prices. Canadian governments have spent hundreds of millions of dollars on subsidies.



In addition, with the mixture mandates, (laws that require a minimum percentage of renewable fuel in gas at the pump), biofuel has a guaranteed market share regardless of production costs. The cost of biofuel production is substantial, so it is important to explore fully whether there truly are environmental benefits to its production and the eventual replacement of fossil fuels.

The cost of biofuel production is substantial, so it is important to explore fully whether there truly are environmental benefits.

The drive toward biofuel production

The United States, Canada and Europe placed greater emphasis on energy security and the reduction of dependence on foreign oil since the oil shocks of the 1970s. Gasoline containing up to 10 per cent ethanol was increasingly common. This trend became even more relevant as concern rose in the 1990s about the impact of global warming, which many believe is caused primarily by GHG emissions. The price of oil remained low, ensuring a lack of profitability for biofuel and limited growth in the sector. The landscape began to change rapidly after September 11th, the war in Iraq, and the skyrocketing economic growth in India and China, which drove oil prices to sustained and unprecedented heights.

Canada, the United States and the EU set mandates for biofuel production in the hope of combating climate change and reducing the reliance on increasingly expensive oil. The United States hopes to reach 136 billion litres by 2022 (57 billion litres from corn-based ethanol) or approximately 25 per cent of the estimated motor-fuel usage. The EU set a general target for transportation fuels of 5.75 per cent by 2010 and 10 per cent by 2020, while Canada has a 5 per cent renewable content mandate for gasoline by 2010 and 2 per cent for diesel fuel by 2012.[1] In addition to mandates, the renewable-fuel industry benefits from a wide range of subsidies.

Currently, ethanol blenders in the United States receive a tax allowance of 14 cents per litre. Overall, tax subsidies and grants come to $7-billion a year.[2] In Canada, the industry is even more heavily subsidized. Ethanol received an estimated $366-million (24 cents/litre) in subsidies in 2008, which rose from $179-million (54 cents/litre) in 2006. The industry expanded, as the rise of oil prices caused an absolute increase in government funding, while subsidies per litre declined. Biodiesel support also increased, rising to $100-million (83 cents/litre) in 2008 from $31-million (78 cents/litre) in 2006.[3] In Canada and the United States, the market for biofuel is guaranteed, and its production is subsidized, which allows the industry to survive even in times of low oil prices. The government's role in propping up the industry is critical. As a U.S. Department of Agriculture report stated:

> Without the production incentives and additional support being provided by both the federal and provincial governments, it is unlikely that a Canadian renewable fuel standard would have been met by Canadian bio-fuels production instead of U.S. produced ethanol.[4]

Commonly accepted benefits of biofuel

The cost to the taxpayer for facilitating the development of biofuel production is substantial. Supporters of biofuel commonly cite the supposed environmental benefits to justify the cost. A study done at the University of Minnesota found that the Net Energy Benefit, or the biofuel energy content that exceeds fossil fuel energy inputs, was 25 per cent for ethanol and 93 per cent for soybean biodiesel. Ethanol produces 12 per cent fewer GHG emissions than gasoline does, while soybean biodiesel produces 41 per cent fewer emissions than petro-diesel does over their life cycles of production.[5]

The U.S. *Energy Independence and Security Act of 2007* mandates that corn-based ethanol produce 20 per cent fewer GHG emissions than fossil fuels, while cellulosic ethanol (biofuel produced from wood, grasses and inedible plants) was to reduce emissions by 60 per cent.[6] Another study measured the impact of developing technological processes for corn-based ethanol production. It found the emission reductions to be even greater: between 48 per cent and 62 per cent.[7] At first glance, it does appear that biofuel production can make a substantial contribution to the reduction of GHG emissions.

Ethanol produces 12 per cent fewer GHG emissions than gasoline does, while soybean biodiesel produces 41 per cent fewer emissions than petro-diesel...

Accounting for land-use changes and nitrous oxide (N_2O) emissions

Studies published in 2008 challenged the widely held notion that biofuel production was beneficial to the environment. In *Science* magazine, studies by Timothy Searchinger et al., and Joseph Fargione et al., contend that while biofuel production may reduce GHG emissions over its life cycle compared to fossil fuels, past studies ignored the impact of direct and indirect land-use change. Remedying this omission is critical to determining whether biofuel is truly beneficial for the environment.

Land-use change occurs when land designated for other purposes is used to grow feedstock for biofuel production. This process can have a significantly adverse impact on the environment. The burning of trees, grass or other crops to clear the land for feedstock and the microbial decomposition of organic carbon stored in plants and soils release large amounts of CO_2 into the atmosphere. Even after the land is cleared, there is a prolonged period of GHG release in which coarse roots and branches decay. The release of this CO_2 over a 50-year span is the carbon debt of land-use change. It is paid back over time, since the life cycle emissions of biofuel are less than those of fossil fuels.[8] Biofuel will have a limited, if not negative, impact on efforts to reduce GHG emissions if the carbon debt takes a substantial amount of time to repay.

Additionally, switching crops causes indirect land-use change. An acre of cropland for food that is converted into feedstock will need to be replaced somewhere else in the world on marginal lands with weaker yields to avoid taking food out of the food supply.[9] Marginal lands will be used due to the lack of available prime cropland. Both direct and indirect land-use changes must be taken into account in order to measure the full impact of biofuel on the environment.

Studies have shown that, in fact, direct and indirect land-use changes often have an adverse effect on the environment. A study by Joseph Fargione et al. estimated how many years it would take to offset the initial impact of land-use change with the GHG emissions advantage of biofuel over the life cycle in different ecosystems where feedstock growth is common. They found the following:

- Lowland tropical rainforest in Indonesia and Malaysia into palm oil: approximately 86 years
- Tropical peatland rainforest into palm oil: approximately 420-840 years, depending on the depth of the peatland
- Amazonian rainforest into soybean biodiesel: approximately 320 years
- Brazilian Cerrado (tropical savannah): approximately 17-37 years, depending on location
- U.S. central grassland: approximately 93 years[10]

According to the Fargione study, even converting fallow land will result in GHG emissions. For example, U.S. Conservation Reserve Program land that was fallow for 15 years gradually recovered its carbon stores over time. Converting reserve land into feedstock results in a carbon debt of 48 years.[11] Policy-makers must be conscious of the fact that all land traps CO_2 over time, so converting even the barest of landscapes for feedstock will lead to GHG emissions beyond the savings made through the biofuel life cycle.

This problem will emerge in Canada. As of 2008, Canada is a net importer of corn, with most imports coming from the United States. Canada will have to import more corn from the United States and potentially convert its grassland for feedstock to increase biofuel production. Roger Sampson, executive director of Resource Efficient Agricultural Production Canada, remarked in testimony to the House of Commons:

> New sources of corn land will be required for expanding ethanol production in both Canada and the U.S., which will include the conversion of pasture, hay and conservation reserve programs. The land conversion of carbon rich grassland to corn production could present a substantial risk to the global carbon cycle.[12]

Canadian biofuel production presents the same challenges as in the United States. With limited cropland, land-use change for biofuel production will affect our GHG emissions.

Another study by Searchinger et al. analyzed the indirect land-use change that resulted from increasing biofuel production. They found that corn-based ethanol results in a doubling of GHG emissions for 30 years and increases GHG emissions for 167 years, while switchgrass, converted from corn land, increases emissions by 50 per cent.[13] A study by Jerry Melillo et al. on cellulosic ethanol found that indirect land-use changes will have double the impact of direct land-use changes, while increased nitrous oxide use for feedstock fertilizer will end up being more harmful than CO_2 emissions will over the long term unless substantial changes are made in fertilizer use.[14] It is increasingly evident that one cannot separate land-use changes and nitrous oxide emissions from the study of the impact of biofuel on GHG emissions.

The agriculture intensification required to grow biofuel feedstock has implications beyond emissions loss during direct and indirect land-use change. The growth of feedstock requires the application of fertilizer. Corn, in particular, requires heavy nitrogen fertilization. This harms water quality, which will be addressed later in the paper. Nitrogen fertilization also produces N_2O emissions, which are a more potent greenhouse gas than CO_2. A study by P.J. Crutzen et al. found:

> When the extra N_2O emission from biofuel production is calculated in 'CO_2-equivalent' global warming terms, and compared with the quasi-cooling effect of 'saving' emissions of fossil fuel derived CO_2, the outcome is that … depending on N fertilizer uptake efficiency by the plants, [ethanol] can contribute as much or more to global warming by N2O emissions than cooling by fossil fuel savings.[15]

The General Accounting Office echoed these findings in 1997. It found that N_2O emissions will ensure that biofuel will have a limited impact on GHG emissions.[16] It can be argued that there have been advancements in the production of more-nitrogen-efficient fertilizer. Furthermore, second- and third-generation biofuel uses feedstock that requires less fertilization. At present, however, N_2O effects must be considered in order to give an accurate picture of the effect of biofuel on GHG emissions.

Implications

Since farmland is limited, it is not clear how biofuel will serve as an eventual replacement for fossil fuels. Converting cropland and clearing other land for feedstock growth will lead to GHG emissions beyond what is saved over the life cycle of biofuel production.

Repaying the carbon debt for land-use change is a decades-long process that is not affordable if one wants a near-term solution to curbing GHG emissions. If Canada wishes biofuel to be a made in Canada solution in the fight against global warming, it is going to have to import more corn from the United States or convert cropland at the expense of escalating food prices or convert grassland for corn cultivation. A combination of these solutions will be likely. Biofuel will be neither a made in Canada solution nor a solution for rising emissions.

Industry will point to several reasons why policy-makers should not be concerned about the effect of land-use change. First, increasing crop yields caused by advances in biotechnology can make more-efficient use of current cropland, thus limiting the need for its expansion. Second, improved agricultural practices could mitigate the emissions loss during land-use change, in particular no-till agriculture. With improved practices and investment in biotechnology, it is possible to limit the need for and damage done by land-use change.

The possibility that improved yields and agricultural practices will mitigate the damage done by land-use change cannot be discounted, but with corn yields improving a meagre 2 per cent over the past 10 years, an agricultural revolution in the near term seems unrealistic. For feedstock to become a suitable replacement for fossil fuels, it will have to grow almost exclusively on currently managed land while limiting the crop displacement that drives up food prices. This is a tough balance to achieve. More-advanced cellulosic biofuel could also help remedy this problem in the long term, but it is not certain whether it will become viable. For example, the United States has fallen well short of its cellulosic targets for 2022 (79 billion litres), and the Environmental Protection Agency has had to allow the production of more corn ethanol to make up the shortfall. Corn ethanol will likely continue to fill this void because it is supported by a powerful lobby with large political sway. Policy-makers in Canada, the United States and the EU need to ask hard questions about whether taxpayers' money is being used effectively by backstopping a non-viable industry for a seemingly endless period.

"For feedstock to become a suitable replacement for fossil fuels, it will have to grow almost exclusively on currently managed land while limiting the crop displacement that drives up food prices."

Water supply and quality

The negative impact of biofuel production on the water supply and quality, or the water footprint, is increasingly criticized. The production of biofuel requires an enormous amount of water, a commodity that has come under growing pressure with the heightening worldwide demand. Currently, the agricultural sector is responsible for 40 per cent of water withdrawal in the United States and 80 per cent of water consumption. In this context, water consumption for corn-based ethanol increased 246 per cent between 2005 and 2008 (1.9 trillion litres to 6.1 trillion litres).

This problem will become more acute, as feedstock is increasingly grown in the less water-efficient plains states such as Nebraska. Water consumption for biofuel in the United States increased 246 per cent while ethanol production went up only 133 per cent in the same span of time, highlighting increasing resource inefficiency.[17] Fulfilling the 2015 mandate of 57 billion litres of ethanol production is estimated to require the use of 3 per cent of the irrigated water in the United States.

Biofuel production is by far the most water inefficient form of energy production currently utilized. Table 1 shows the water requirements for different processes measured in litres per megawatt hour (L/MWh), with corn ethanol and soybean biodiesel far outdistancing petroleum, natural gas, coal and even nuclear power. Another effective way to visualize the vast amount of water needed to fuel ethanol production is the number of litres of water used per kilometre driven (lwpkm).

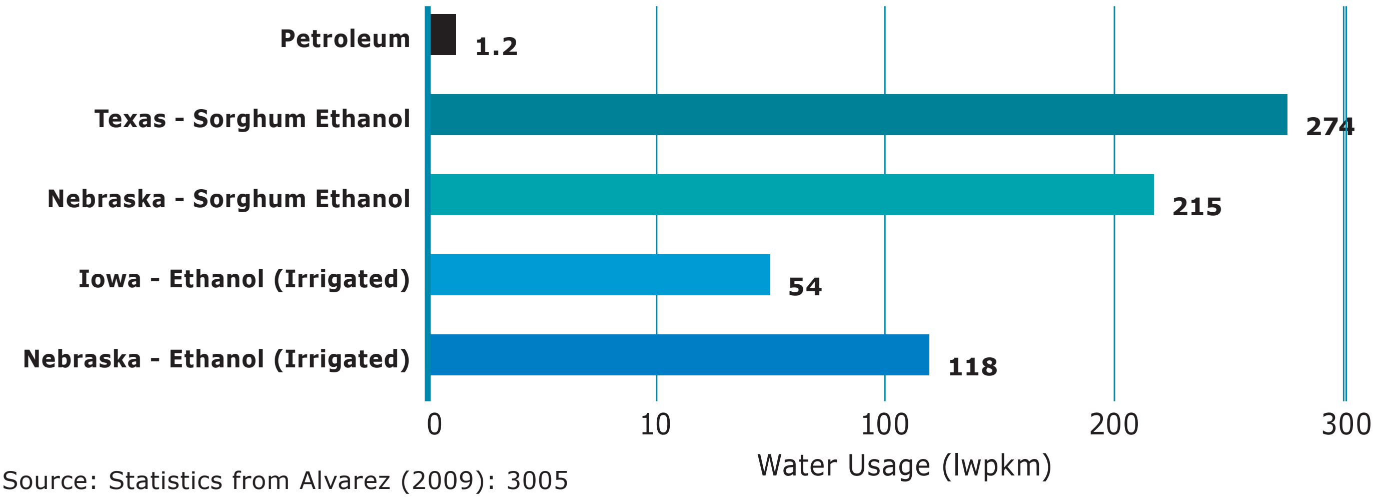
TABLE 1 **Water Requirements (L/MWh)**

Process	L/MWh
Petroleum extraction	10 - 40
Oil refining	80 - 150
Oil shale surface retort	170 - 681
Natural gas power plant - closed loop cooling	230 - 30,000
Coal integrated gasification combined-cycle	~900
Nuclear power plant - closed loop cooling	~950
Geothermal power plant - closed loop tower	1,900 - 4,200
Natural gas power plant - open loop cooling	28,400 - 75,700
Nuclear power plant - open loop cooling	94,600 - 227,100
Corn ethanol irrigation	2,270,000 - 8,670,000
Soybean biodiesel irrigation	13,900,000 - 27,960,000

Source: Statistics from Alvarez (2009): 3006

CHART 1

Water Usage Comparison



Source: Statistics from Alvarez (2009): 3005

This represents 118 lwpkm in a standard car that can drive seven kilometres on one litre of fuel. Table 2 shows the relative water efficiency of different fuels and their feedstock growth locations in lwpkm. The fossil fuel status quo is measurably superior when it comes to consuming one of our most important and increasingly scarce resources.

Problems with biofuel production do not end with straining our water supply. The ramping up of the growth of biofuel feedstock can also harm water quality. Corn requires more nitrogen fertilizer and more herbicide and pesticide use compared with other crops. Converting uncultivated land or even other cropland into corn feedstock therefore usually requires an increased use of herbicides and pesticides. In fact, fulfilling the 2015 mandate of 57 billion litres per year would lead to nitrogen fertilizer use on the order of 16 per cent of what is used for all cropland in the United States.[18] The process of eutrophication occurs when these nutrients in the soil wash into local waterways and create an algal bloom. The decomposition of dead algae robs the water of oxygen. A state of hypoxia occurs when deoxygenated water becomes uninhabitable for underwater wildlife.[19] This process poses a threat to the marine ecosystem of the Gulf of Mexico, and it threatens local anglers who are dependent on steady fish stocks.

A study done by Simon Donner and Christopher Kucharik assessed the impact of increased biofuel production on the Gulf of Mexico hypoxic zone, the area where the Mississippi River flows into the Gulf that is afflicted by hypoxia. The river’s water flow brings with it nitrogen nutrients acquired from nitrogen fertilizer runoff from the American Corn Belt. As of 2008, this hypoxic zone covered 20,000 km^2, and it continues to be a serious concern for the U.S. government. Further growth of this zone has the potential to destroy coastal fisheries, which generate $2.8-billion in economic activity annually and are cornerstones in the local economy.[20] Donner and Kucharik found that efforts to meet the 132 billion litres per year mandate by 2022 would lead to an increase of 10 per cent to 35 per cent of dissolved inorganic nitrogen washing into the Mississippi River watershed, depending on the level of corn-based biofuel production.[21] Other studies found different figures, but they are unanimous in showing that it will be next to impossible to meet U.S. government reduction targets of >5,000 km^2 or 30 per cent if biofuel production is increased.

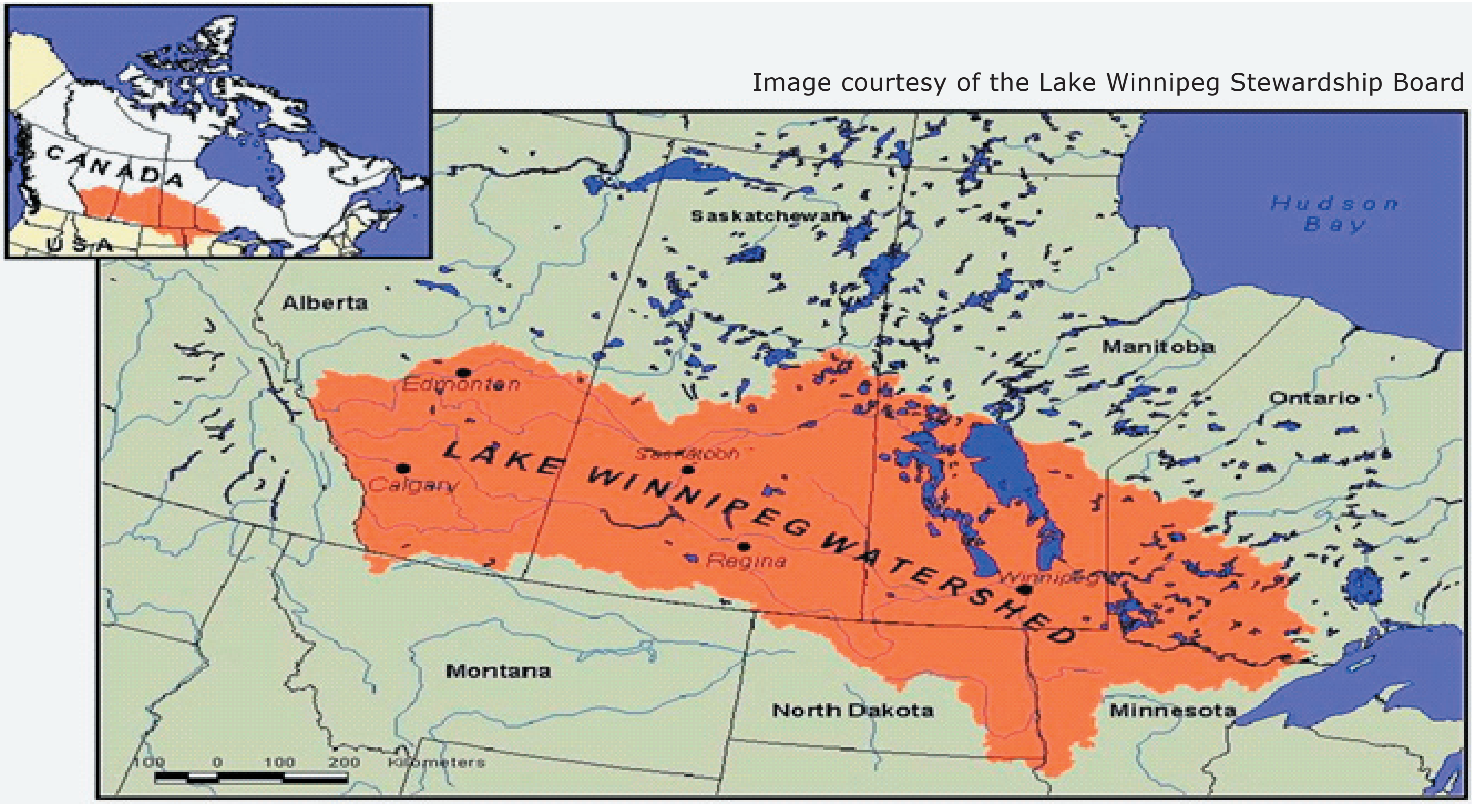


Image courtesy of the Lake Winnipeg Stewardship Board

There is a potential that switchgrass will minimize fertilizer use, but not enough is known to come to a definitive conclusion as to how well it responds to nitrogen fertilization.[22]

This problem is not contained to the Gulf of Mexico—one of the more-serious cases of eutrophication in North America is Lake Winnipeg. The Saskatchewan, Red and Winnipeg rivers, along with 60 other inflowing rivers and streams, feed the lake. In addition, the Lake Winnipeg watershed is the largest in Canada, covering 1,000,000 km2, and it spans the Prairies (see image above).[23] There are several possible causes of eutrophication in Lake Winnipeg, but one of the primary concerns is the impact of fertilizer use across the Prairies. Nitrogen and phosphorous nutrients flow into the lake from farmland across the vast watershed.[24] There is the potential that biofuel-driven cropland expansion and conversion will intensify the slow poisoning of the Lake Winnipeg ecosystem. While more research is required in Canada, the impact of biofuel production on the Gulf of Mexico hypoxic zone should be a cause for concern for Canadian policy-makers.

Implications

It is becoming increasingly clear that escalating biofuel production will have an effect on water use and quality. Currently, biofuel production dwarfs other methods of energy production. This is deeply problematic given that freshwater will be in greater demand, as the developed world intensifies its industrial development and increases its living standards. Additionally, water quality will suffer. Increasing agricultural intensity has caused great harm to the ecosystem of the Mississippi Delta due to eutrophication, and the problem will only become worse with increased feedstock growth. There is no research that estimates similar effects in Canada.

However, one would expect an analogous occurrence to intensify in Lake Winnipeg due to the vastness of its watershed, which stretches through Canada's agricultural heartland.

The industry would argue that comparisons between petroleum and biofuel for water consumption and land-use change are not adequate. Emissions over the life cycle and water consumption will increase, as oil prices continue to rise and petroleum is extracted from more-marginal areas. For a biofuel industry in its infancy, productivity will improve with technological advances that will ensure less water consumption and improved yields for feedstock. Further advances in the industry are, to a degree, narrowing the gap with fossil fuels in water efficiency. Additionally, cellulosic feedstock such as switchgrass needs far less water and theoretically zero fertilizer. These advances could serve to contain the environmental damage done by biofuel production related to water consumption and quality, but there is a long way to go.

This objection of course makes several assumptions:

- First, the world is running out of oil.
- Second, China and India's economic growth will be sustained permanently.
- Third, further oil exploration will prove fruitless.

The combination of these factors ensures that oil prices will rise for the foreseeable future. This is possible but not guaranteed. What is guaranteed is a rapidly expanding biofuel industry that is propped up by mandates and subsidies that allow for production regardless of economic conditions. This expansion will continue to occur regardless of the environmental damage it may cause. Policy-makers need to challenge the biofuel industry on its assumptions about the future efficiency of biofuel.

> ***For a biofuel industry in its infancy, productivity will improve with technological advances that will ensure less water consumption and improved yields for feedstock.***

Conclusions

The biofuel industry is thriving in North America due to generous government subsidies, government-imposed market mandates and high oil prices. Lawmakers hope this will form an important component of a strategy to reduce GHG emissions and provide energy security in the future. The environmental benefits of biofuel are substantial at first glance, providing both tailpipe emission reductions and emissions reductions over the life cycle. However, the studies neglected the direct and indirect land-use changes and the impact biofuel production has on water supply and quality. Instead of reducing GHG emissions compared with gasoline, the opposite is occurring. Our water resources are being taxed further, and hypoxia because of nitrogen fertilizer runoff is starving marine ecosystems. This is to say nothing of the massive loss of unique habitats and wildlife that comes with worldwide deforestation caused by the desperate scramble to plant more feedstock. At the very least, the research referred to in this paper should give governments pause before they continue to use taxpayer money to fund their environmentally destructive biofuel pipe dreams.

"*Instead of reducing GHG emissions compared with gasoline, the opposite is occurring.*"

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