5. Conclusions

The crops, livestock, and soils that make up our farms are immersed in air. They give out gases and particles that change the air's composition, both locally and far afield. At the same time, they take in and are affected by air that has been altered by industry and other human activity. As a result, farms are sensitive markers of the health of our air.

Current status

One of the main concerns in recent years has been the release of greenhouse gases into the atmosphere. We now know that farms account for about 10% of Canada's greenhouse gas emissions. About two-thirds of the emissions are in the form of N_2O and one-third CH_4. Livestock and manure account for about 58% of these emissions, cropping practices for 37%. At one time, agriculture was also an important source of CO_2, mostly from cultivated soils, but these emissions have abated to almost negligible levels. Some uncertainty remains in these emission estimates, particularly for N_2O, which is released in sporadic bursts, making precise estimates difficult.

Agriculture also releases other materials into the atmosphere. It is the main source of atmospheric NH_3 and may also release some nitric oxide, dust, and pesticides into the air, though amounts are usually small.

Although farms release some gases into the air, which affect its composition, they are also, in turn, influenced by emissions from other sectors of society. One example is the ground-level O_3 that causes crop damage in areas of high population density. This O_3 affects the yield and quality of produce on nearby farms, which, because of their proximity to population centres, often grow high-value crops. Another example is the potential effect of increased UV-B radiation, which arises when industrial chemicals such as CFCs deplete O_3 in the upper atmosphere. We do not yet know, precisely, the effects of the higher UV-B on crops and animal health, but some damage may occur, particularly if intensity of UV-B continues to increase, as expected.

Opportunities to reduce emissions

The net release of gases—N_2O, CO_2, CH_4, and NH_3—is usually a symptom of the inefficient use of resources. Release of excessive CH_4 from livestock means a waste of feed; loss of N_2O or NH_3 reflects inefficient use of N in fertilizers, crop residues, or manures; and excessive release of CO_2 reflects inefficient use of solar energy, stored as fossil fuel or plant C. Farmers can reduce emissions, therefore, by managing the farm N and C cycles more efficiently, to prevent gases from leaking into the environment. Because of improved efficiency, many practices that reduce emissions also have other favorable effects: reducing production costs, conserving soil and water, and improving ecosystem health.

Agriculture will always remain a source of some gases: CH_4, N_2O, and NH_3. Even the natural ecosystems replaced by farms release these gases. But, improved efficiency of N and C use can minimize the amounts of emission. Reductions as high as 20–30% may be possible. Improved farming practices can actually result in net removal of CO_2 from the atmosphere, by storing C in soils. This increased storage could even help Canada meet its targets for reducing this greenhouse gas.

Efficiency improvements

Market competition makes for more cost-effective production. Energy shortages and costs make producers more energy conscious. Similarly, faced with the possibility of global climate change, producers may be able to further increase their efficiency in using resources, thereby increasing the amount of food produced per unit of greenhouse gas emitted.

Examples of increased productivity in Ontario

Crops	1975	1991
Diesel fuel-equivalent of		
soybean produced (L/t)	174	95
corn produced (t/ha)	3.4	6.9

Dairy	1951	1991
Animals (million)	1.7	0.9
Milk (billion L)	2.4	2.5
Land area need to produce feed (million ha)	1.1	0.5
Manure generated (million t)	21.4	12.5

Eggs	1951	1991
Eggs produced (million dozen)	107	179
Land area need to produce feed (thousand ha)	129	61
Manure generated (kg/dozen eggs)	7.1	3.4

Chicken	1951	1991
Meat produced (million kg)	45	299
Land area need to produce feed (thousand ha)	96	117
Manure generated (kg/kg meat)	12.6	3.9

These tables show that productivity has increased considerably in the selected periods. Energy per kilogram of soybean has halved in 15 years; and manure per unit of milk, eggs, or chicken has halved in 40 years. It may therefore be expected that fossil CO_2 and manure N_2O emissions per unit of production have also decreased.

Future challenges

In much of this book, we have focused on current farm practices: how they affect our air and how, in turn, the changing atmosphere affects them. We have summarized estimates and processes that describe current agroecosystems. But we know that agricultural systems are always evolving; that many of the systems we have struggled to understand here may be obsolete just years from now. Thus, it is important to at least point to some impending changes and speculate about their possible effects.

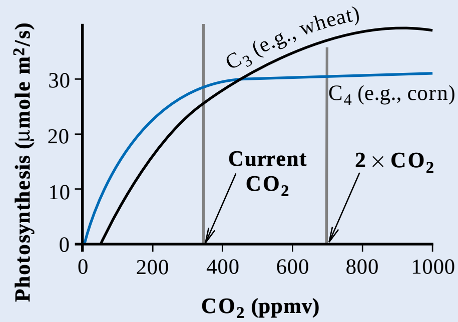
One important factor is the continuing drive for higher agricultural productivity. As global population climbs, demand for farm products increases. Moreover, the economic survival of farms often depends on ever-higher output of products. The resulting gains in productivity may have some benefits; for example, they may help to build soil C by producing more crop residue. At the same time, however, the higher yield targets may require more fertilizers and other inputs that could release more greenhouse gas.

Economic factors are another consideration. As cost of inputs and price of products change, farmers alter their farming systems to maintain profits. Consequently, the area of land devoted to certain crops changes from year to year, which affects the release of greenhouse gases and other emissions. Perhaps the most dramatic example is the recent shift toward livestock-based systems. This change has far-reaching implications. On the one hand, higher livestock numbers usually mean more land in forages, which reduce atmospheric CO_2 by storing more C in soil. At the same time, however, increased livestock numbers can lead to more release of CH_4, N_2O, and NH_3. If the trend toward higher numbers of farm animals continues, then many of our current emission estimates will need to be revised and new measures of reducing emissions may be needed.

But it is not only the farming systems that will change. Environmental conditions that affect farms will themselves change over the next decades. Many scientists believe that climate will be noticeably altered by the greenhouse effect over the next decades; even small changes in temperature or precipitation would affect Canadian farms. Another important environmental characteristic has already changed measurably: the CO_2 concentration, already about 30% higher than in pre-industrial times, will likely double within the next century. Since CO_2 is the raw material for photosynthesis, this increase may have important effects on crop yield. Some even predict an increase in yields through "CO_2 fertilization." Other environmental conditions may change as well, including concentration of ground-level O_3 in populated areas, and the intensity of UV-B radiation. These changes, some of which are not easily predictable, may affect the way we farm in the next century. As well, they will alter the emissions from farms, thereby continuing the cycle between farms and the atmosphere.

Carbon dioxide "fertilization effect"

Higher CO_2 concentration can enhance crop yield by increasing photosynthesis and allowing more efficient use of water. This CO_2 "fertilization" is more pronounced in C_3 plants (e.g., wheat, soybeans, and most grasses) than in C_4 (e.g., corn and some grasses). Some scientists think that CO_2 fertilization can largely offset yield losses arising from climate change. Others suggest that the benefits may be overstated, because they overlook the interaction between increased CO_2 and other environmental conditions. More research on these questions is needed.



Organic farming—an alternative approach

Organic farming minimizes the need for off-farm inputs. It employs systems that avoid or largely exclude the use of synthetic fertilizers, pesticides, growth regulators, and livestock feed additives. Many believe that greenhouse gas emissions may be less for organic systems than for conventional agricultural systems.

Organic farms attempt to harmonize with natural systems. They rely on renewable resources and less input from fossil energy. The holistic view of organic farmers follows a natural systems approach to agriculture. Individual growers take daily decisions to make a living from the land, based on both economic and ecological considerations. With time, agroecosystems reach a steady state, where living and nonliving processes are in balance. For many, it is a way of life as much as a way of making a living.

The holistic systems approach requires an intimate knowledge of the interrelationships between soil, water, climate, and biology of the agricultural system. In addition, these systems also consider off-farm effects such as rural economics and sociology.

Generally, families on organic farms have traditions of environmentalism and are careful consumers of all resources. The day-to-day on-farm decisions of organic farmers are complex and require an in-depth knowledge of many areas of science. Organic farmers believe that their philosophy provides a gentler approach to the earth.

Both conventional and organic systems of agriculture aim to provide society with high-quality food, but some feel that organic farming also attempts to improve quality of the on-farm natural resources and to reduce potential environmental damage.

(J. Dormaar, AAFC)

Remaining questions

The unpredictability of future changes in farm ecosystems, along with uncertainties about even our current estimates of emissions, leave room for further study of the ties between our farms and the atmosphere. The most urgent goals may be the following:

- To improve further our estimates of current gas release, especially for N_2O. We need better ways of taking data from local measuring points and extending them to larger areas, up to the national level.
- To find ways that will help Canada meet its international commitments for reduced emissions of potentially harmful gases.
- To understand better how C, N, and other elements move through and among plants, animals, soil, water, and air. Such understanding will show us how the various gases and environmental issues are linked together and how they interact. As well, it will help us to predict better how changing farm practices will affect the environment.
- To learn how changes in our atmosphere will affect Canadian farming in the future. Of particular importance may be the effects of climate change (temperature and precipitation), increased CO_2 concentration, enhanced UV-B intensity, and increased ground-level O_3. We need to know how these will affect yields, crop types, animal productivity, pests, and production costs. As well, we need to understand how these changes will alter future emissions from agriculture to the air.

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A listing of the principal investigators and their project titles are presented in Appendix I for those who wish more detailed information.

Reviewers

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Production team

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Program Management

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Appendix I

The principal investigators and their project titles are listed here for those who wish more detailed information.

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Desjardins, R.L. Tel.: 613-759-1522 Fax: 613-996-0646 E-mail: Desjardins@em.agr.ca	Assessment of ozone uptake by agricultural crops in critical areas along the Windsor–Quebec corridor
Ellert, B. Tel.: 403-327-4561 Fax: 403-382-3156 E-mail: Ellert@em.agr.ca	Contribution of representative prairie agroecosystems to greenhouse gas emissions
Izaurralde, R.C. Tel.: 403-492-5104 Fax: 403-492-1767 E-mail: Cizzaurra@rr.ualberta.ca	Quantification of nitrous oxide, methane, and carbon dioxide fluxes over managed and natural ecosystems of Alberta
Jackson, H.A. (see Sauer, F.)	Methane and carbon dioxide emissions from farm animals and manure
Knowles, R. Tel.: 514-398-7890 Fax: 514-398-7990 E-mail:	Methane and nitrogen cycle interactions in agriculture systems
Lapierre, C. Tel.: 418-657-7980 x 269 Fax: 418-648-2402 E-mail: Lapierre@em.agr.ca	Contribution of liming and tillage to N_2O and CO_2 emissions in eastern Canada
MacDonald, B. Tel.: 519-826-2086 Fax: 519-826-2090 E-mail: Macdonaldb@em.agr.ca	Characterization of agroecosystems in eastern Ontario for their potential to act as sources or sinks of greenhouse gases
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Paul, R.J. Tel.: 604-796-2221 x 215 Fax: 604-796-0359 E-mail: Paulj@em.agr.ca	Nitrous oxide and methane emissions in dairy and hog manure management systems
Pattey, E. Tel.: 613-759-1523 Fax: 613-996-0646 E-mail: Patteye@em.agr.ca	Impact of agricultural management on greenhouse gas fluxes
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Rochette, P. Tel.: 418-657-7980 Fax: 418-648-2402 E-mail: Rochettep@em.agr.ca	Contribution of agricultural practices to the atmospheric increase of greenhouse gases
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Tarnocai, C. Tel.: 613-759-1857 Fax: 613-759-1926 E-mail: Tarnocaict@em.agr.ca	Amount of organic carbon in Canadian soils
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