Agricultural practices and environmental conservation

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Contents

Land used for agriculture makes up one of the largest environmental units managed in Canada today. New technology and genetic improvements to plants and animals have increased farm productivity dramatically over the past three decades. Land management is the main factor that often determines whether the environmental effects of agriculture are positive or negative.

Little attention has been paid to the possible environmental consequences of many newly developed, intensified farming activities. Land deterioration and the resulting environmental problems may be difficult to recognize on individual farms because the processes involved are so widely distributed and insidious. When problems are recognized, many people are unaware that anything can be done to rectify them.

The agricultural community should take precautions to protect the environment from any degradation arising from its activities. Farmers should act on their own behalf and develop an understanding of the impact that various farming practices can have on the environment. This publication is intended as an introduction to the subject, and readers are encouraged to seek more detailed information related to their own situations from regional specialists.

Some agricultural practices can cause water and air pollution and the deterioration of the land. Of these three problems, by far the most well documented is how agriculture can affect water quality. Water pollution is therefore dealt with here in more detail than are the other two topics.

Water pollution

Farming is just one of the many possible sources of water pollution that must be considered in trying to maintain good water quality nationally. It is not, however, as obvious a source of pollution as industrial waste or municipal sewage disposal. Because pollution from farming activities can originate from many different sources, it is more difficult to quantify and control than that from localized sources of contamination. Farming has not been traditionally pictured as a major polluter. However, if modern farming techniques are not tempered with appropriate environmental management, this situation could change.

Agriculture has considerable potential for becoming a diffuse source of pollution because of the large area of land involved, the regular exposure and cultivation of the soil surface, the widespread use of pesticides and fertilizers, and the need for disposal of livestock manure. The risk of water pollution is increased by farming activities that result in:

- soil erosion, runoff, and sediment transport
- inefficient use of plant nutrients
- poor handling and storage of manure
- improper or careless use of pesticides
- drainage from saline soils
- increased water temperatures, causing thermal pollution
- other miscellaneous pollution problems.

A brief discussion of each of these problems follows to clarify how agricultural management can affect water quality.

Soil erosion, runoff, and sediment transport

Soil erosion, runoff, and sediment transport are natural processes. In many areas, man's activities on the land have accelerated the rate of these natural processes. Some areas of Canada are also experiencing the problems that arise when too much nutrient-rich topsoil reaches streams and lakes (Fig. 1).

Soil erosion occurs on all cropland to varying degrees, as well as on irrigated land when water applications are excessive or inadequately controlled. When soils become compacted, water from rainfall and snowmelt infiltrates more slowly, and runoff and erosion tend to be increased. This phenomenon often occurs on land repeatedly used for intensively tilled crops such as corn. Management practices that cause deterioration of the soil structure usually also increase the potential for water pollution by runoff and sediments.

Soil can be transported to rivers or lakes in runoff that has originated from uniform movement of water over the land surface, a process known as sheet erosion, or from concentrated flow resulting in formation of rills and gullies. Water erosion is often difficult to identify when no visible rills or gullies are formed. Uniform erosion from either wind or water action may go unnoticed. A loss through soil erosion as great as 22 t/ha (tonnes per hectare) would only remove an average of 0.17 cm of topsoil evenly distributed across the surface. In fact, one tonne of soil uniformly distributed over a hectare would be about as thin as a single page from this publication.

Fig. 1. River water laden with sediment is clearly discernible where it mixes with clearer lake water in this aerial photograph. Photograph courtesy of Ontario Ministry of the Environment.

About 75–80% of the suspended sediment transported annually by streams in Canada occurs in February, March, and April. These months are usually characterized by snowmelt runoff, rain with low impact energy, and soil with frozen or saturated layers near the surface. The soil has little resistance to erosion in early spring and cultural practices that leave it unprotected make the situation worse (Fig. 2). Soil erosion can generally be reduced by increasing the protection offered by ground cover.

Land characteristics such as soil type, surficial geology, slope, and drainage are just as important as land use in determining the extent of soil losses to streams. For example, the quality of surface water in areas with sandy soils is generally good, whereas drainage basins with clayey soils tend to have poorer water quality despite similar land use.

Although farmland may contribute only a relatively small amount of sediment per unit area, the total sediment load from all agricultural land is generally significant. The presence of sediment decreases both the physical and chemical quality of water. Once the eroded soil particles are carried into waterways they create problems such as:

- the accumulation of silt, causing reduced channel capacity
- the alteration and destruction of the aquatic habitat
- increased turbidity
- excessive rates of growth of plants and algae, accelerated by increased nutrient levels
- decreased recreational values
- increased levels of heavy metals, pesticides, and other toxic compounds
- increased costs of water treatment incurred by efforts to return water quality to standards suitable for human consumption.

Fig. 2. Considerable erosion is caused by snowmelt runoff over bare ground before the soil has thawed sufficiently to allow infiltration. Furthermore, as the surface frost thaws, the soil is often very wet and unstable, making it highly susceptible to erosion. Trapping much of the sediment load by seeding the area to hay reduces the amount of sediment reaching the waterway.

Although problems caused by the presence of sediment in a waterway are well known, generally the costs to the farmer and the rest of society are not. The most direct cost to the farmer is that incurred by the regular cleaning of drainage and irrigation channels (Fig. 3). Other less obvious costs are borne by the public as a whole. Loss of fish-spawning grounds can reduce business for neighboring fishing and tourist industries. Commercial and recreational fishing can be adversely affected in both the coastal and the inland lake and river systems. Furthermore, the dredging of harbors that becomes necessary to maintain shipping activities is expensive, costing more than $100 million annually in the Great Lakes Basin alone.

Sediment also lowers water quality by serving to bind and transport phosphorus, heavy metals, pesticides, and other toxic compounds. For example, phosphorus bound to soil particles eroded from farmland has been shown to account for the bulk of the phosphorus pollution in farmland runoff draining into the Canadian Great Lakes Basin.

The phosphorus content of sediment is generally higher than that of the field soil from which it originates because the erosion process is selective. Organic matter and the fine-grained mineral materials, two soil components that have a high phosphorus content, are the most easily eroded and transported.

Phosphorus is the key nutrient causing the excessive growth of plants and algae in streams and lakes. Fortunately, 65–95% of the total phosphorus is bound to sediment and is not readily used by such plants.

Heavy metals such as mercury, lead, arsenic, cadmium, and selenium and toxic organics such as PCBs are also moved from agricultural lands into surface water bound to sediment. Mercury and PCBs have been detected in the tissues of fish in the Great Lakes Basin and other freshwater systems

Fig. 3. An obvious indication of farmland erosion is the decreased water capacity of drainage ditches and irrigation channels.

in Canada. Some fish species are now considered unfit for human consumption because of this contamination. Lead is a potential hazard because it can undergo a chemical change in sediments, forming very toxic, methylated compounds. Although heavy metals are not often used agriculturally, they find their way onto farm fields through atmospheric deposition and the addition of sewage sludge to agricultural soils. For example, airborne lead originating from automobile exhausts, as well as from urban and industrial emissions, can be deposited on agricultural lands. There are no farming practices that can reduce such contamination. Reducing farmland sediment can, however, help reduce the movement of heavy metals and toxic organics off the land into streams and lakes.

Farmers can adopt some measures to help reduce water pollution from soil erosion, runoff, and sediment movement—some at little or no cost. At the same time the farmer can benefit from reduced energy costs, reduced fertilizer bills, better soil, and improved yields. Cropping practices that provide protection from the shattering impact of raindrops on the soil help reduce the soil detachment that starts the erosion process. Crops that provide cover for the greatest proportion of the soil surface or that give protection for the longest periods are highly desirable. For example, hay crops and fall-seeded small grains protect the soil over winter and provide a good, nonerosive cover on slopes. Hay fields next to a stream or ditch, or even narrow strips of hay 3–4 m wide, often called buffer strips, combined with grass-seeded banks, reduce erosion along channels. They also help filter out sediment from runoff before it is carried into the stream.

In areas where fine-textured soils are cropped, where wide-spaced row crops are grown, or where slopes are cultivated up and down, the following management practices are recommended, all of which incur very little cost.

- Rotate crops and include a sod crop in the rotation whenever possible.
- Cultivate across slopes rather than up and down.
- Use tillage methods that retain as much surface residue as possible over the winter and early spring (Fig. 4).
- Keep tillage to the minimum required to obtain a good crop.

The following steps are also recommended to help reduce soil erosion, runoff, and sediment movement, although these practices generally incur some added expense to the farmer.

- Plant winter cover crops that can be chemically killed or worked into the soil in the spring or left until harvest (Fig. 5).
- Use contour cropping.
- Use contour strip cropping.
- Use grassed waterways to prevent gulley formation.
- Seed narrow strips of hay along ditches or streams.
- Fence off streams and ditches to exclude livestock and protect the stability of the banks.
- Use tile drainage to reduce overland flow.
- Provide improved surface and subsurface drain inlets to streams and ditches (Fig. 6).

Fig. 4. Tillage practices that leave a high percentage of residue on the surface in the fall provide increased protection from wind and water erosion during the nongrowing season.

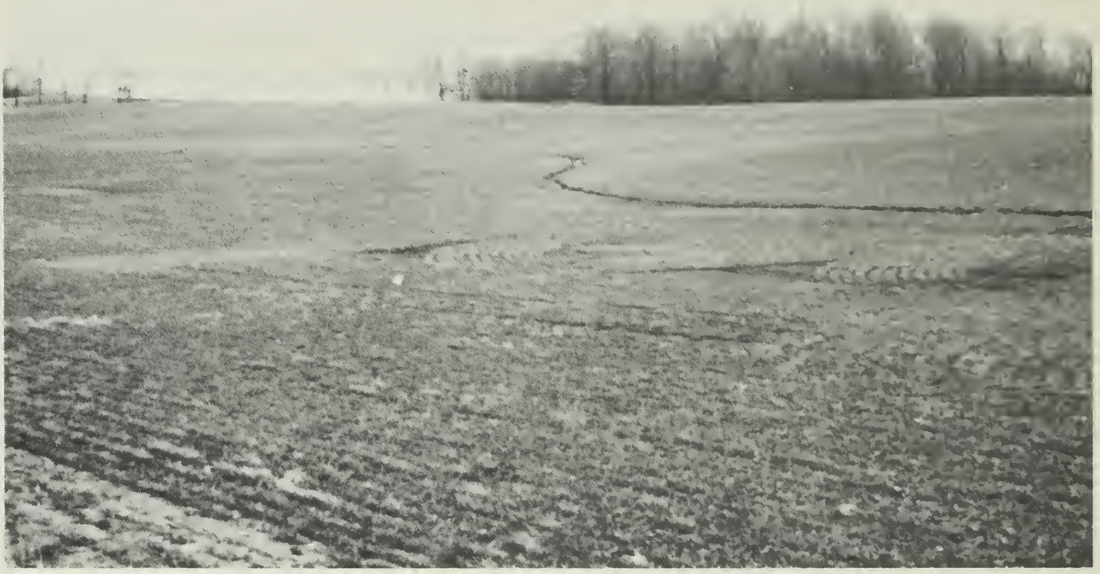

Fig. 5. Winter grain crops that become well established in the fall provide excellent protection from soil erosion during winter and early spring.

Farmers must decide which practices or combinations of practices are best suited to their operation. They have the best knowledge of local conditions and of their farms. The acceptability, cost, and effectiveness of the various measures are highly dependent on soil types, slopes, current livestock and cropping practices, and the economic status of the farm. The availability of markets for crops not currently grown on the farm must also be considered. Farmers can consult with local specialists in farm management, soils, or crops for assistance in determining which remedial measures are best suited to their farms.

Fig. 6. The tile outlet, culvert headwall, and unvegetated ditchbank pictured on the left all contribute to increased soil erosion.

The right-hand picture illustrates how erosion is effectively reduced by protecting the outlet and ditch banks.

Plant nutrients

Annual additions of nutrients to soil are becoming necessary on most modern farms across Canada today. High-yielding crop varieties now available, combined with improved farming practices, have increased production so much that the natural nutrients found in soil are being rapidly depleted. This nutrient depletion can be partially offset by the addition of fertilizers. However, fertilizer applications can lower local water quality if more nutrients are supplied than the crop can efficiently use. Applying fertilizers improperly can also cause nutrients to move away from crop roots and into surface and ground waters.

The phosphorus in fertilizer that is not worked into the soil tends to move off fields with runoff, either attached to soil particles or dissolved in the water. This loss of phosphorus is greatest from fields close to streams and drainage ditches and from fine-textured soils.

Nitrogen can also be lost in runoff or can leach downward through the soil profile beyond the reach of crop roots. Nitrogen not taken up by crops or not lost through denitrification to the air can contaminate groundwater or leave the shallow subsurface zone through tile drains. Tile drains are common on many farms in the humid regions of Canada. These systems drain water rapidly from the soil before it can infiltrate deeply. Thus removal from this water of nitrogen through the process of denitrification, and phosphorus through the fixation of phosphates, is reduced. Therefore concentrations of both these nutrients tend to be slightly higher in water from land drained intensively by subsurface systems. Such soils, however, tend to produce slightly less surface runoff and associated sediments.

As well as causing excessive growth of plants and algae in streams and lakes, nutrient pollution can reduce water quality to the point where it is unfit for human or livestock consumption. Nitrate, an important fertilizer component and aquatic-plant nutrient, only occasionally causes excessive growth of algae. However, once in the water supply it can create health problems for both man and animals. When the nitrogen level in drinking water (as nitrate plus nitrite) rises above the recommended level of 10 mg/L, there is a risk that it may interfere with oxygen transport within the body. Children under 1 year old are particularly susceptible, as are cattle and young animals. There have also been cases where excessive nitrate levels in the water supplies of farm animals have reduced conception rates and decreased the number of live births. Only isolated cases of nitrate pollution of water supplies have occurred in Canada. Most have been traced to farm wells with faulty casings located close to manure storage areas. Nevertheless, every precaution should be taken to reduce nitrogen movement to groundwater, to prevent a wider problem from developing.

Phosphorus does not appear to be toxic even at the high concentrations sometimes found in open waters. However, only a small quantity of phosphorus is required to stimulate the growth of blue-green algae and other organisms to a level where they interfere with man's use of the water. Some lakes receive enough phosphorus and other nutrients from natural sources to produce nuisance algal growths. Pollution from runoff aggravates the problem. Excessive aquatic plant growth is unsightly and spoils beaches; depletes oxygen concentrations while undergoing decay, killing fish and aerobic organisms; produces unpleasant odors and tastes; and clogs water intake filters at treatment plants.

The degree of nutrient pollution caused by agriculture has been found to vary with the watershed region, climate, and yearly fluctuations in weather. In the Lower Fraser Valley in 1976, for example, it was reported that agricultural land-use practices did not contribute significantly to nutrient pollution in the main river. In the same year, however, agriculture contributed approximately 40–60% of the total phosphorus that entered the Great Lakes in tributary rivers.

Nutrient pollution from agricultural activities can be reduced in many ways. Establishing a regular program of soil testing determines the levels of fertilizer phosphorus necessary to promote optimal crop growth. Limiting phosphorus applications to levels recommended from soil testing may, with time, reduce phosphorus levels in streams draining agricultural areas. However, for those soils that contain high levels of natural or accumulated phosphorus, this measure may have little effect. In the case of nitrogen, there is as yet no satisfactory soil test to determine the amounts available to plants in the soils of the humid regions of Canada. Therefore, follow the rates of fertilization recommended for nitrogen for a particular crop grown in a given area. Such rates are based on crop uptake and utilization, as well as on local soil conditions and expected yields. Applications beyond the recommended levels seldom increase yields profitably. On the other hand, over-application of nitrogen increases the amount of nitrate available for leaching to groundwater and runoff to streams.

Other practices are also recommended for reducing nutrient pollution from farms.

- Incorporate fertilizer and manure into the soil as soon after application as possible.
- Reduce or eliminate fertilizer and manure applications on sites close to streams and on sites prone to flooding.
- Ensure proper management of manure (refer to next section).
- Reduce soil erosion, runoff, and sediment movement.
- Improve the timing and placement of fertilizer applications to promote increased efficiency in plant uptake.
- Plant winter cover crops that utilize nitrate in the fall and early spring, before it can leach beyond the root zone of a spring-seeded crop.

Careful use of fertilizers and animal manures allows the farmer to gain the maximum benefits from the nutrients they provide, while helping to protect water quality.

Livestock manure

Although highly beneficial as a soil amendment, animal manures sometimes cause serious water pollution. These problems are generally the direct result of mismanagement. The practice of raising livestock in large, confinement operations situated on small areas of land has aggravated the problem in many parts of Canada. Especially serious consequences can arise when an urban community requiring large quantities of potable water expands close to an intensive livestock-producing area. Nevertheless, more pollution can result from a small, poorly managed livestock operation than from a large, well-managed facility.

Manure is a valuable source of nutrients for crop production; however, careful and correct management is essential to the safe and proper use of this resource. Manure can degrade water quality by increasing phosphorus and nitrogen concentrations of surface and ground water; increasing biological oxygen demand (BOD) in streams, resulting in the death of species requiring plentiful oxygen; producing toxic ammonia levels, which kill fish; and introducing disease organisms into the water that restrict its use for recreation and water supplies. Runoff and seepage from manure spread on fields and from storage areas (Fig. 7) can seriously degrade surface waters.

Lakes and streams located near cattle feedlots absorb a considerable amount of ammonia from the air. To reduce the amount of ammonia volatilized from manure, minimize the moisture content by keeping excess water out of the lot, and include straw or other fibrous material; spread the manure frequently, and incorporate it immediately into the soil whenever possible.

Salmonella, a common infectious bacterium, can survive for up to a year in liquid manure and can be readily transmitted to people. Other bacterial infections that can be transmitted to man by manure include anthrax, tularemia, brucellosis, erysipelas, tuberculosis, tetanus, and colibacillosis.

Fig. 7. Manure storage areas and livestock yards that are not adequately separated from ditches and streams, either by distance or structural means, reduce the quality of the local water.

To prevent direct contamination keep livestock out of all open water, including streams and ditches, by installing fences and by providing alternative watering facilities or fenced access ramps.

To decrease the risk of both surface and ground water pollution, semisolid slurry and the liquid portion of manure from confined livestock should be contained in proper manure-storage facilities (Fig. 8). A minimum distance of 122 m between storage tanks and water courses is desirable to prevent accidental pollution. This leaway provides an opportunity for phosphorus and bacteria present in any surface runoff from leaks or spills to be retained by the soil and allows nitrate nitrogen that seeps into shallow groundwater to undergo some denitrification.

Locate any subsurface drainage pipes that discharge into open water courses well away from barnyards, feed areas, or manure storage areas. This precaution helps prevent the rapid movement of pollutants from source areas to water bodies, a situation in which the natural soil purification process is bypassed.

Other practices can be implemented to reduce water pollution and to retain the valuable nutrients in manure.

- Avoid applying manure to soils from which runoff has easy access to open water, for example along streambanks or on snow-covered or frozen slopes that rapidly drain into streams in the spring.
- Work manure into the soil as soon after spreading as possible.
- Apply manure at rates consistent with crop nutrient requirements.

Fig. 8. Proper manure-storage facilities such as these help prevent dilution of the manure. Surface runoff and roof runoff are rerouted away from the storage area. In areas with high precipitation a roof might be necessary to keep excess water out.

- Avoid the storing and spreading of manure on flood-prone areas.
- Minimize the volume of liquid to be handled, by preventing excess additions of rainwater and runoff. Note: Manure cannot be diluted sufficiently to make an effluent safe enough for disposal directly into a stream.

These practices not only benefit farmers by reducing their requirements for fertilizers, but regular use of manure also improves soil structure. In watersheds with large animal populations, many water-quality problems could be reduced or prevented through conscientious manure management, at little additional cost to farmers.

Pesticides

Pesticides, which include herbicides, insecticides, and fungicides, are now widely used throughout Canada. The benefits from increased yields and improved product quality are enjoyed by producers and consumers. Water pollution can occur, however, when pesticides are carried off the land into surface waters. The degree of the problem presented by a particular pesticide is determined by its persistence, that is, its ability to remain unaltered in the environment; rate of application and frequency of use; mobility, or degree of retention by soil particles and solubility in water; ability to be concentrated in living organisms (bioaccumulate); and tendency to be toxic to nontarget species (possibly causing cancer, mutations in species, or the deformation of fetuses).

The fact that a chemical is considered safe by one criterion does not necessarily mean it is safe in all circumstances. For example, DDT gained widespread exceptance because it was a highly effective insecticide with a low mammalian toxicity. Only after many years did scientists discover that it was accumulating in the tissues of aquatic organisms and being passed on to birds and other animals. Once it exceeded a threshold level in these higher organisms, it upset their reproductive processes. The product was banned from use in Canada, but because of its persistence it remains in the environment. Traces of the compound, which accumulated in soil and aquatic sediments over the years, continue to be detected in drainage water, streams, and lakes. Levels of DDT detected in water and fish samples are now declining steadily. This experience, however, emphasizes the long-term problems of dealing with persistent pesticides.

Pesticides now in use are much less likely to cause long-term problems because of stricter regulations governing their formulation, registration, and use. Pesticides currently sold in Canada undergo rigorous testing to determine not only their impact on the target organism but also their persistence and possible side effects on other segments of the environment.

Human carelessness appears to be the major cause of pesticide-related water-quality problems. Most pesticides are relatively immobile once they have been sprayed on a field. For most commercial pesticides the total pesticide content of runoff waters, including that of associated sediments, is seldom measured at more than 0.5% of the amounts applied. However, when pesticides applied to the land surface are not worked into the soil, losses are somewhat greater if heavy rain occurs within 2 weeks of application.

Spills along streams, spray drifting directly into streams, and the disposal near water of surplus spray, tank rinsings, and empty pesticide containers are responsible for most farm-related, localized, pesticide-pollution problems in Canada. Several isolated cases of animal and human health problems have arisen from pesticide contamination of water supplies on farms. If a pesticide spill occurs near a well or the water supply used by livestock, have the water tested to ensure that it is still safe for consumption.

Careful use of pesticides reduces the chances of pollution of surface and ground waters. Some important precautions are listed below.

- If unsure of the concentration required, check with someone knowledgeable about pesticides and their use.
- Prepare a small test batch first when mixing chemicals to ensure their compatability and reduce problems of their disposal if they prove incompatible.
- Mix only as much spray as is required.
- Do not overfill the sprayer and take extra precautions to avoid spillage near open water or wells, or on permeable soils.
- Clean sprayers carefully after use and apply tank rinses to the field rather than dumping them in a ditch or at one location.
- Make sure the sprayer is properly calibrated, to avoid an incorrect rate of application.
- Avoid spraying on windy days (Fig. 9) or close to open water.
- Avoid spraying when forewarned of approaching storms.

Fig. 9. Spray operations are best carried out on calm days to prevent chemicals from drifting and to ensure the optimum pest control for the target area.

- Reduce the number of applications and volume of pesticides used, through careful use of integrated pest management including physical, biological, and chemical methods of control.
- Substitute less persistent pesticides, when available.
- Minimize pest infestations by using crop rotations.
- Reduce erosion, runoff, and sediment losses, to help retain pesticides on the field.

All these techniques improve the efficiency of the pesticide and minimize the chance of water contamination. Because most modern pesticides are rapidly degraded in the natural environment, the most serious water pollution incidents caused by pesticides occur by accident and the problems generally remain localized. Such events can be greatly reduced through careful handling and application of pesticides and cleanup of equipment.

Salinity

Salts degrade the quality of water for domestic, livestock, and irrigation purposes. In areas with saline soils, mainly in Western Canada, water quality can be impaired if salts move from the soil to streams, lakes, or groundwater aquifers.

Some irrigated areas have been damaged by the accumulation of salts at the soil surface. To reduce salinity that has already developed, subsurface drainage systems can sometimes be installed, after which increased amounts of irrigation water can be applied to leach salts from the soil surface. However, much of the drainage water eventually reaches downstream rivers and lakes. Here, its high salt content increases the salinity of water that may be the only source for many agricultural and municipal uses, including further irrigation. Ways to irrigate more efficiently and avoid these problems are now being assesssed.

Saline soils in nonirrigated areas are also sometimes reclaimed by drainage. Saline water from reclamation drainage can also degrade the quality of surface and subsurface water in neighboring, downslope areas.

Water-quality specialists in some provinces are monitoring the situation to determine the need for controls on drainage from reclaimed saline soils. There is a potential for expansion of subsurface drainage in salt-affected soils in Western Canada, especially in irrigated areas.

Thermal pollution

Streams flowing from agricultural land are often warmer than those from forested or other undisturbed land. The higher water temperature is partly due to a greater proportion of surface runoff, compared with groundwater flow, to streams draining farmlands. Streams in agricultural areas are also less well-shaded, where trees have been cleared from swampy land and ditch banks. Thermal degradation of water quality can harm some valued fish species. To reduce thermal pollution, leave trees growing along streams and avoid the clearing of swampy areas. Planting trees along ditch banks to provide additional shading may be helpful in some instances.

Miscellaneous problems

Other farming practices have also been known to cause water pollution in Canada. Although these cases have not presented national or even regional problems, they can result in localized water-quality deterioration. Examples include: seepage and runoff from feed-storage areas; effluent from milk houses draining into open water; seepage from improperly buried livestock; and runoff containing contaminated sewage sludge used as a soil amendment.

Avoid seepage and runoff from silos and areas used to store moist livestock feed, for example food-processing wastes, if there is a risk of water pollution. Liquids from these sources have a very high biological oxygen demand (BOD) and can easily deplete the oxygen in small bodies of water. They also contain high levels of phosphorus and nitrogen. Paved storage areas and retaining walls help reduce the chances of pollution of both surface and ground water. To reduce seepage from silos, do not ensile material having a high moisture content.

Spills of liquid feed additives, such as molasses, should never be washed down drains or into open water. Instead, absorb the liquid with other feedstuffs such as grain or hay and where possible feed it to livestock as part of their ration. Alternatively, incinerate the material used to absorb the spill, send it to a sanitary landfill, or spread it on the land and plow it into the soil.

Waste water from dairies has a high pollution potential because of its high nutrient level and biological oxygen demand. Route the drains from milk houses away from streams and avoid connections to field drains.

Have dead animals removed by a livestock disposal firm, incinerated, or buried in a location and manner in which seepage of pollutants to groundwater is avoided. Avoid burying livestock in areas with high water tables or very permeable soils. Never bury carcasses near a water supply.

Some farmers in Canada have been using wastewater and sludge from municipal sewage treatment plants on their land. In arid regions such wastewaters are also being used for irrigation. When applying sludge and wastewater, follow the same good management guidelines used for manure.

- Have the wastewaters tested to ensure that they meet regional guidelines for agricultural land application.
- Apply them only at a safe distance from open water.
- Apply them only to level land, away from streams and ditches, especially when they are spread in winter.
- Incorporate sludge as soon after application as possible.

Air pollution

Air pollution from agricultural activities is not a widespread problem. Cases are usually localized and short term. Consequently the phenomenon has attracted less attention among researchers and environmental agencies than has water pollution.

Air pollution can be a physical problem, such as is caused by dust; an aesthetic problem, such as an offensive odor; or a chemical problem, caused, for example, by pesticides. It can result from poor management and adverse weather conditions, for example, by spraying herbicides on a windy day.

Soil erosion

The "dirty thirties" were a time of unprecedented air pollution, resulting from wind erosion in the prairies. Since then, less droughty conditions have generally prevailed and practices have been widely adopted by farmers to bring the wind-erosion problem under control. However, in the past decade wind erosion has returned periodically. Drier conditions and more relaxed attitudes toward strip cropping, wind breaks, and other wind erosion control measures have recently made drifting soil once again an intermittent problem in some parts of Western Canada (Fig. 10). In Eastern Canada, too, wind erosion is occasionally a problem on soils left bare of vegetation and in areas where fence rows and other windbreaks have been removed to accommodate modern machinery.

Fig. 10. Wind erosion degrades air quality, damages vegetation and structures on neighboring land, and can result in water-quality problems.

Blowing soil is abrasive, damaging buildings as well as machinery and vegetation. It carries nutrients and pesticides through the air, which may eventually aggravate water quality and health problems in downwind areas.

Air pollution from wind erosion can be reduced by altering management practices to reduce the susceptibility of the soil.

- Plant cover crops or provide residue cover for overwinter protection.
- Decrease summerfallow wherever possible.
- Provide windbreaks and orient strip cropping across the prevailing wind direction.
- Decrease tillage to prevent the pulverization of soil aggregates.
- Use snow-trapping techniques to increase soil-moisture levels.

Livestock manures

Odors emanating from livestock operations often present air-quality problems (Fig. 11). Although odors do not produce physiological damage, some courts have upheld claims of nuisance and loss of property values. Whether or not an odor is offensive is a personal judgment. There is no equipment available that can evaluate odor. Odors considered acceptable by a farmer are often considered unacceptable by his neighbors. Although generally harmless, odors do indicate that ammonia is being dispersed into the air. The nitrogen thereby dispersed may enrich rain and open water surfaces downwind. It may also combine with other elements to form weak acids that aggravate the problem of acid rain. Dust raised from cattle movement and the ventilation fans in barns can also contaminate air downwind of large livestock operations.

Fig. 11. Barnyard odors are more a nuisance than a health hazard. Complaints could, however, be reduced by better zoning regulations that prevent homes being built near livestock facilities and manure storage areas.

Air-quality problems can also arise when liquid manure is applied by irrigation. Manure particles and health-related organisms can drift downwind in fine liquid droplets or aerosols when liquid manure is sprayed onto the land using large sprinklers or rainguns on windy days.

Although some odor from livestock operations is unavoidable, good management can help reduce the frequency and severity of episodes. Solid manure systems with low water content are least offensive because there is less anerobic decomposition of the manure. Liquid manure is usually more offensive because of the production of hydrogen sulfide, methane and other gases, and associated aromatic compounds.

Liquid storage units often seal over with a dry crust of organic matter, and few gases escape until the contents of the tank are agitated in preparation for spreading. Floating and fixed covers over liquid holding tanks have had some success in reducing complaints about odors. Odor can be reduced during field applications by injecting the manure into the soil or by incorporating it as soon after spreading as possible. Although keeping odors down may increase costs, many farmers benefit in the long run by reducing complaints from their neighbors.

Pesticides

Since pesticide sprays and dusts now have relatively short-lived toxicities, wind-blown soil containing these compounds is less hazardous than are the droplets, mist, or powder carried in the wind during pesticide applications. Airborne chemicals can produce illness in man and animals when they are inhaled directly or eaten with food that has inadvertently become contaminated just before harvesting. They can also damage nontarget crops and beneficial insect populations such as honey bees.

To minimize this type of pollution, apply pesticides only on calm days. Use equipment that is designed to place the chemical as close to the target as possible, with a minimum of loss to the environment.

Soil pollution and soil degradation

Soil pollution occurs when harmful chemicals are added in quantities that adversely affect soil quality. Soil degradation occurs when the changes in the depth or physical or chemical properties of the soil reduce its quality. Soil degradation includes loss of the nutrient-rich topsoil through erosion, loss of organic matter, salinization, acidification, and loss of structural stability. These processes tend to be accelerated by poor agricultural practices.

Problems develop only over long periods. The short-term, negative effects of various farm management practices on the soil are often hard to identify. In the long term, cumulative effects reduce soil productivity. When nutrient-rich topsoil is lost, the problem can be overcome in the short term by increasing fertilizer input. However, this practice adds to production costs. Other forms of degradation are less easily remedied even in the short term. For example, using more fertilizer does not increase crop yields if plant growth is limited by compacted soil layers hindering root development.

Besides the negative effect experienced by the farmer, soil pollution and soil degradation also have long-term implications for society. Not only is the land's potential for food production reduced, but other large-scale environmental impacts, such as the spread of desert lands and flooding, could occur.

Wind and water erosion

Erosion is caused by a combination of unfavorable weather and poor land-use practices that leave the soil unprotected. For example, summerfallowing (Fig. 12), tilling excessively, and leaving large areas of land without windbreaks can all cause erosion, which may be aggravated by high winds and heavy rains. Besides contributing to pollution, soil eroding onto other properties creates a nuisance. It can also clog drainage and irrigation channels. Wind and water erosion removes the fine topsoil and associated nutrients from farmlands. If not controlled, it decreases the productivity of land as the subsoil content of the plowed layer increases. As subsoil is incorporated into the cultivated layer, soil fertility and water-holding capacity are reduced. Root growth and development are also limited, resulting in variable crop growth. Soil transported by erosion and redistributed within the field can increase localized ponding, smother young seedlings, and cause a crust to form on the surface after drying. In severe cases erosion produces such extensive gullies that workable land is lost completely.

Tillage practices that increase surface roughness and leave the larger soil aggregates intact can reduce soil movement. In fact, adequate use of vegetation or residue covers can almost eliminate wind and water erosion.

The farmer benefits directly from preventing erosion, since topsoil is critical for crop production. Some suitable practices that help prevent erosion have already been discussed in previous sections.

Fig. 12. Runoff from this summerfallow field has deposited topsoil in the lower portion of the field, and offsite on a road and in a slough.

Compaction and structure loss

Soil compaction is a serious concern because it limits air and water movement in the soil and root development of plants (Fig. 13). Soil compaction and deterioration of structure can result from continued, poorly managed cultivation of the soil. Most soils naturally have a well-aggregated structure, with high levels of organic matter and sufficient nutrients for native vegetation. These soils have high infiltration rates, well-aerated root zones, and good load-bearing capacity. A few soils, however, are naturally dense and limit plant growth. Man can create similar, undesirable soil conditions by working the soil when it is wet and by using farm machinery with excessive weight or at excessive speeds. Repeated cultivation can also increase oxidation rates and microbial decomposition. These phenomena reduce the organic matter content, making it easier for tillage to pulverize soil aggregates and destroy soil structure. Loss of structure makes the soil more susceptible to wind and water erosion and to further compaction.

The following recommendations are suggested for reducing soil compaction and structural loss in a farming operation.

- Use crop rotations.
- Use livestock manure and green manure.
- Maintain crop residues at or near the soil surface.
- Reduce tillage.
- Vary tillage depth.
- Work the soil only when it is at the proper moisture content.
- Reduce the weight and speed of field equipment, when possible.

Fig. 13. Loss of soil structure and increased compaction in this field have reduced its rate of infiltration, thereby increasing the duration of ponding and decreasing subsequent crop yields.

Salinization

Soil salinization occurs when soluble salts, which are common in the subsoils of many prairie soils, are moved to the surface and become concentrated there as the soil water evaporates. Alkalinization is sometimes associated with salinization. It occurs when the concentration of sodium salts becomes excessive. In some soils naturally high in soluble salts, removal of native vegetation and subsequent cultivation aggravate salinity and cause it to spread. Deep-rooted native vegetation uses more soil moisture than annual crops and summerfallow. Some of the unused water in upslope cultivated fields migrates downslope in shallow groundwater, transporting salts to lower topographic positions where they may become concentrated near the surface.

Salinity also occurs in irrigated areas when the water table is raised because of canal leakage or excessive applications of water. The elevated water table brings salts to the surface, where they remain after the water evaporates.

Contamination of the soil with salts reduces germination and growth of many crops. Increased sodium levels cause deterioration of soil structure by inducing the formation of dense soil layers that restrict water movement.

Control and prevention of soil salinization helps to maintain crop production and averts the loss of valuable crop land. To reduce the spread of soil salinization, eliminate situations where water tables are raised in soils that contain salts. Specifically, prevent seepage from irrigation canals, for example by lining them with impermeable materials, and use more efficient methods of irrigation to prevent excessive applications of water. In dryland agriculture, salinization can be decreased by practicing more intensive cropping and reducing summerfallow. Draining depressions where runoff collects can also sometimes be effective but may lead to other environmental problems downslope, such as erosion and flooding. More research is needed to determine the extent to which lands already salinized can be reclaimed.

Acidification

Acidification progresses naturally in soils of humid areas. However, it can be accelerated by the application of fertilizers containing nitrogen and sulfur and through the presence of atmospheric nitrogen and sulfur deposited by acid rain.

Accelerated acidification reduces the availability of macronutrients such as phosphorus and calcium. It also increases the solubility of some microelements, aluminum and manganese for example, sometimes to toxic levels. These effects cause concern because they reduce crop growth and lower yields.

Good soil management can help reduce the development of acidity.

- Apply only enough fertilizer to meet crop needs.
- Avoid strongly acidifying fertilizers, such as ammonium sulfate, unless specifically recommended by soil tests.
- Make additions of lime when necessary to maintain the optimum soil pH.

Contamination

Agricultural soils can be contaminated by chemical compounds and heavy metals not normally used in agriculture. Soils can also contain high levels of pesticide residues, accumulated over the years through improper use or added accidentally by spillage or improper disposal.

One cause of soil contamination is the disposal of municipal sewage sludge and industrial waste on agricultural land. Sludge can be beneficial as a soil amendment because of the nutrients and the organic matter it contains. However, not all sewage sludges are acceptable for farmland application. Those from some municipalities contain excessive levels of heavy metals. These contaminants become immobilized by soil minerals and organic matter, sometimes accumulating to levels toxic to plants. Some plants may concentrate these heavy metals to levels dangerous to those that consume them. Heavy metals may also move off the land with runoff and soil erosion into open water. In some provinces, soils on which wastes are spread are being monitored for buildup of contaminants.

Contaminants can reduce crop growth and yield. They may also cause health problems for man and animals, if they get in the food chain. The following practices can help reduce soil contamination.

- Accept only those sludges that contain safe levels of heavy metals, as proven by chemical analysis.
- Adhere rigorously to provincial guidelines on maximum tolerable levels for application.
- Verify the rates being applied by the sludge carrier.

Farmers benefit directly from ensuring that materials deposited on their land do not restrict the use of that land for crop production.

Subsidence of organic soils

Although organic soils are common throughout Canada, there are only a few locations where they are currently important for agricultural production. Such soils have usually been extensively drained to allow the cultivation of high-value crops. Once drained these soils begin to subside in volume (Fig. 14). This shrinkage occurs as a result of drying and oxidation of the soil material and the subsequent loss of carbon.

Once it is no longer saturated with water, the soil is easily lost through wind erosion. Volume is also decreased through compaction by farm machinery. Sometimes organic soils are deliberately or accidentally burned.

The rates of subsidence of organic soils can be reduced by appropriate management techniques. An integrated water-table management program can be used to lower the water table while the fields are being worked and to maintain it at as high a level as possible at other times. Some provinces now recommend the addition of copper to organic soils to inhibit the bacterial and enzymatic activity associated with oxidation.

Unless some efforts are made to reduce subsidence, the useful life of many areas where organic soils are now being intensively managed will probably be limited to 50–100 years.

Fig. 14. Intensively cultivated organic soils similar to this one have exhibited a measured subsidence rate of 2.1 cm annually over the first 38 years of cultivation.

Summary

The farm industry has not yet caused major degradation problems for water, air, or soil anywhere in Canada. However, given the large land base occupied by agriculture, the increasing use of modern technology, and the pressures for intensification of production, the likelihood of environmental pollution from agricultural activities persists. Modern technology has enabled fewer farmers to feed more people than ever before. Canadians now spend less of their earned income on food than at any other time in history. But maintaining this efficiency of production will become increasingly difficult as more high-quality agricultural land is converted to other uses and farming is relegated to poorer-quality soils. At the same time farmers must work within an environmental system that must not be abused.

Farmers need to learn how to manage their operations in ways that do not degrade the surrounding water, air, or soil environment, either for their own use or for that of the rest of society. Many problems of maintaining a healthy environment could be reduced or eliminated by using the proper techniques for managing the land and for conserving the quality of soil and water. Eliminating unnecessary additions of plant nutrients, pesticides, and other materials can reduce pollution without increasing capital expenditure. Changing crop rotations, tillage practices, and timing of field operations is also effective, although the new practices may require reassignment of capital. The most serious problems, however, such as those caused by erosion, runoff, and sediment transport can only be satisfactorily alleviated by the adoption of practices that may increase costs of production.

Maintenance of high-quality water, air, and soil is important for every part of our society. Everyone, including the farming community, needs to work together to help protect and improve the quality of our environment.

Additional technical information

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For additional information specific to local regions, contact the appropriate department of your provincial government.