

LECTURE 16:
JUNE 3, 2014

AGRICULTURE

**CURRENT AGRICULTURAL SYSTEMS AND
THEIR IMPACTS &**

**CANADIAN AGRICULTURE AND RELATED
ENVIRONMENTAL IMPACTS &
SUSTAINABLE FOOD SYSTEMS**

Text Reference: Dearden and Mitchell (2012), Ch. 10, pp. 332-347; & 347-368

Outline

2

□ Upcoming:

□ June 4 (Field trip):

- Urban/Suburban Thunder Bay:
- MNR Research Forest
- Details tba



Source: Dearden and Mitchell (2012)

□ Today:

□ (lecture)

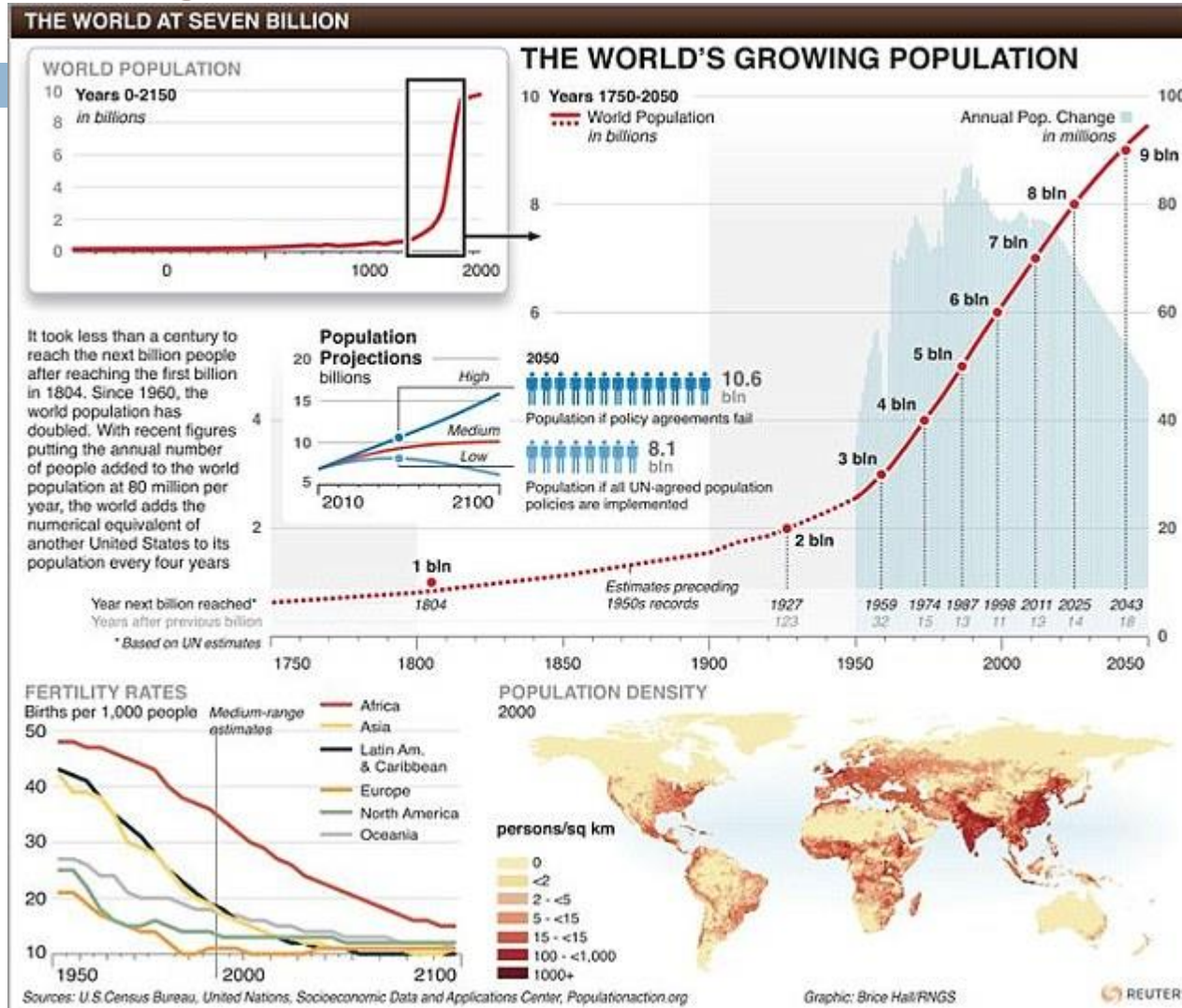
- Part 1: Current Agricultural Systems and Their Impacts
- Break:
- Part 2: Canadian Agriculture and Related Environmental Impacts & Sustainable Food Systems

□ Presentations (Thursday June 12th)

Part 1: Current Agricultural Systems and Their Impacts

- Preamble – challenges around feeding an increasing population
- Arable Land
- Impacts of Global Climate Change
- Intensification of Production
- Competition for viable agricultural land
 - ▣ With urbanization
 - ▣ With bio-fuel production

Rise in global population



http://i.dailymail.co.uk/i/pix/2011/10/26/article-2053652-0E815BCE00000578-831_634x539.jpg

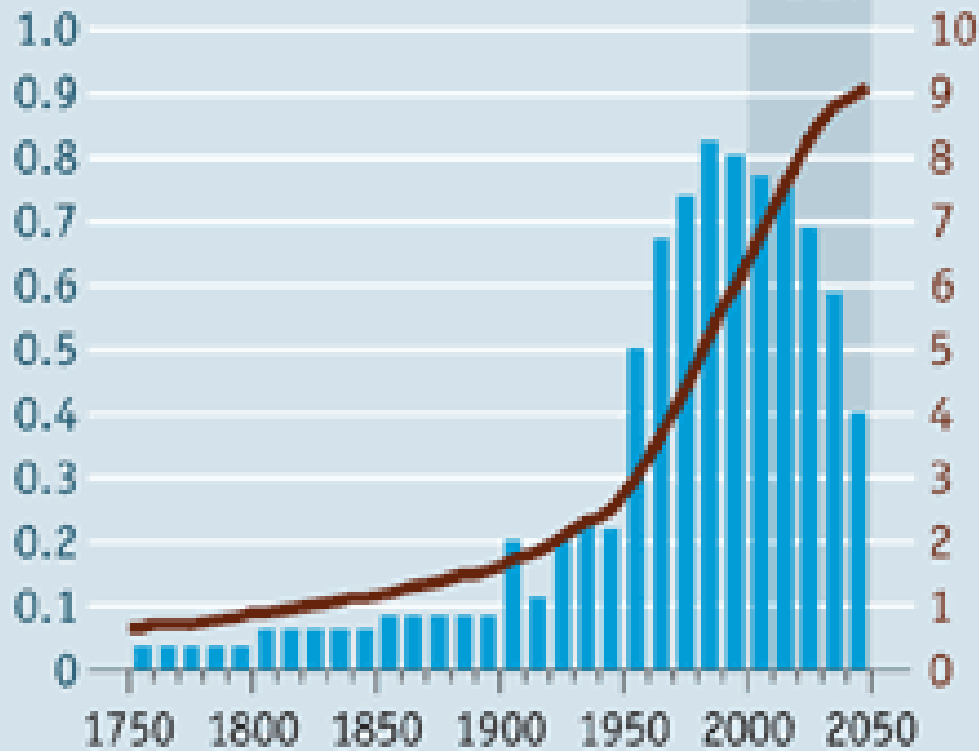
Rising, but falling

1

World population

Ten-year increments, bn

Total, bn



Source: UN Population Division

<http://www.americanlivewire.com/wp-content/uploads/2012/04/world-population-growth-and-forecast.gif>

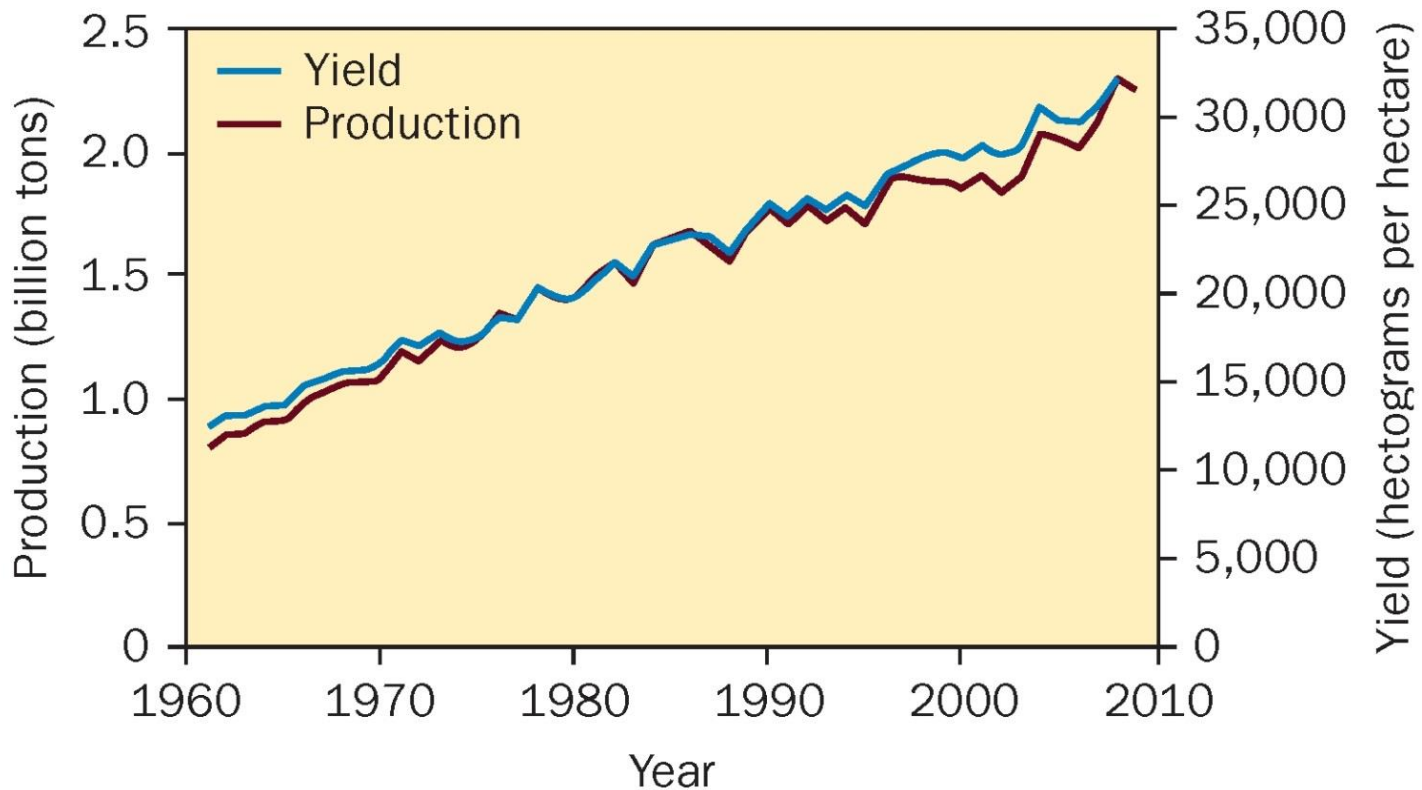


Figure 10.1 | World grain production and yield, 1961–2009.
 Source: *Worldwatch Institute (2011: 56)*.

Modern Farming Systems in the Industrialized World

The Green Revolution

- Combination of inputs or agricultural techniques that has increased food production per unit area (includes the introduction of **higher-yield seeds** and a **reliance on auxiliary energy flows – i.e., fertilizer**)
- The development and commercialization of higher-yielding seeds through **hybridization** led to significant grain yields throughout the world
- **Hybridization** is the crossbreeding of two varieties or species of plants and animals
- Without the GR, many more people in the world would be suffering chronic food shortages

Dramatic rise in use of fertilizers in Canada

- Western Canada, a five-fold increase 1970 to 2000;
- Rates of application (kg per hectare) in Canada (see table) still lower than 2000 values for US (103.4); Australia (151.7); and Japan (301.0);

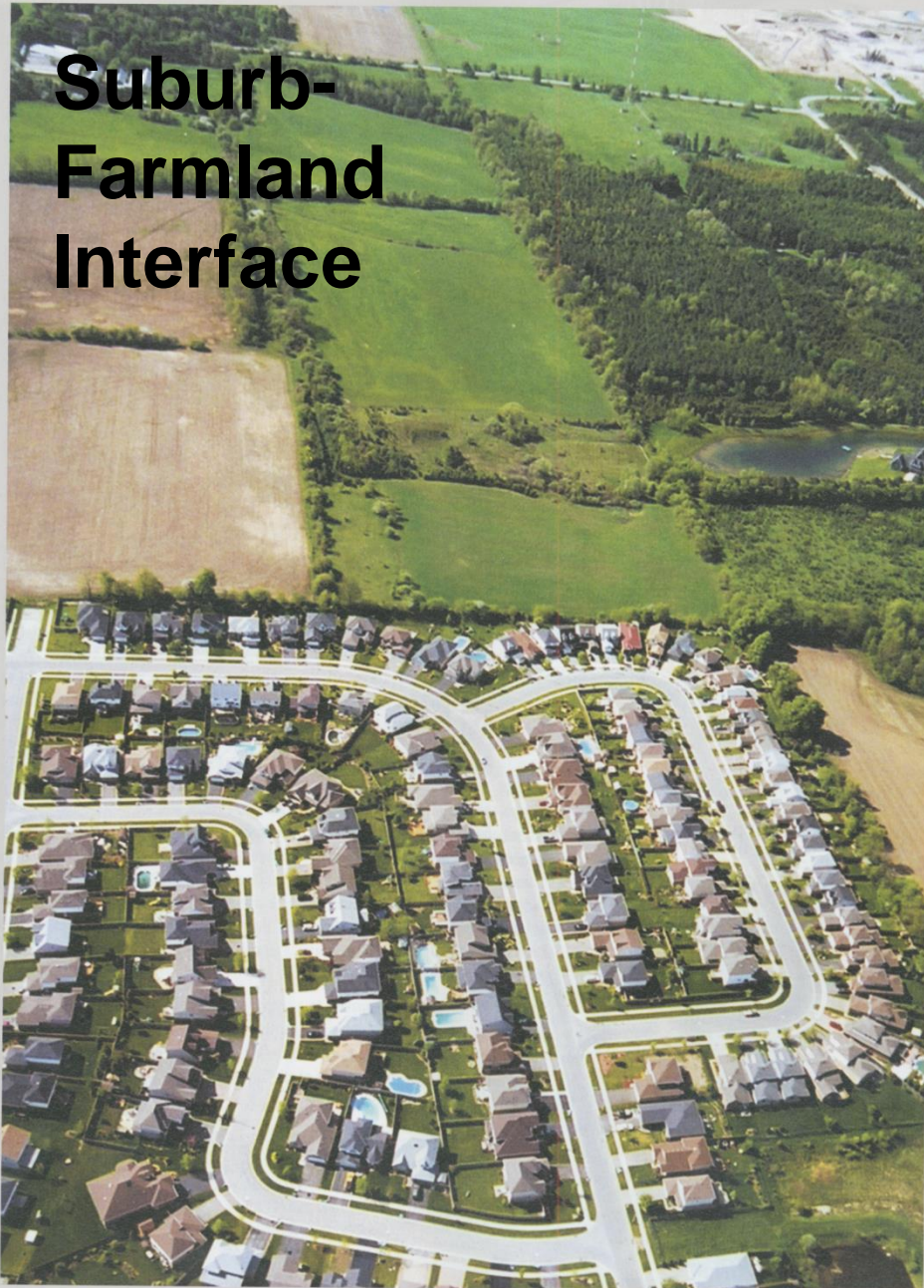
	1970	1980	1990	2000
Canada	18.4 kg/ha	42.4 kg/ha	45.1 kg/ha	54.2 kg/ha

Competition for a limited land resource



- Encroachment of cities, suburbs, on productive rural landscapes or valuable forest
- Food versus Fuel production (Biofuels)

Suburb- Farmland Interface



University of Guelph

1954



1963



1976

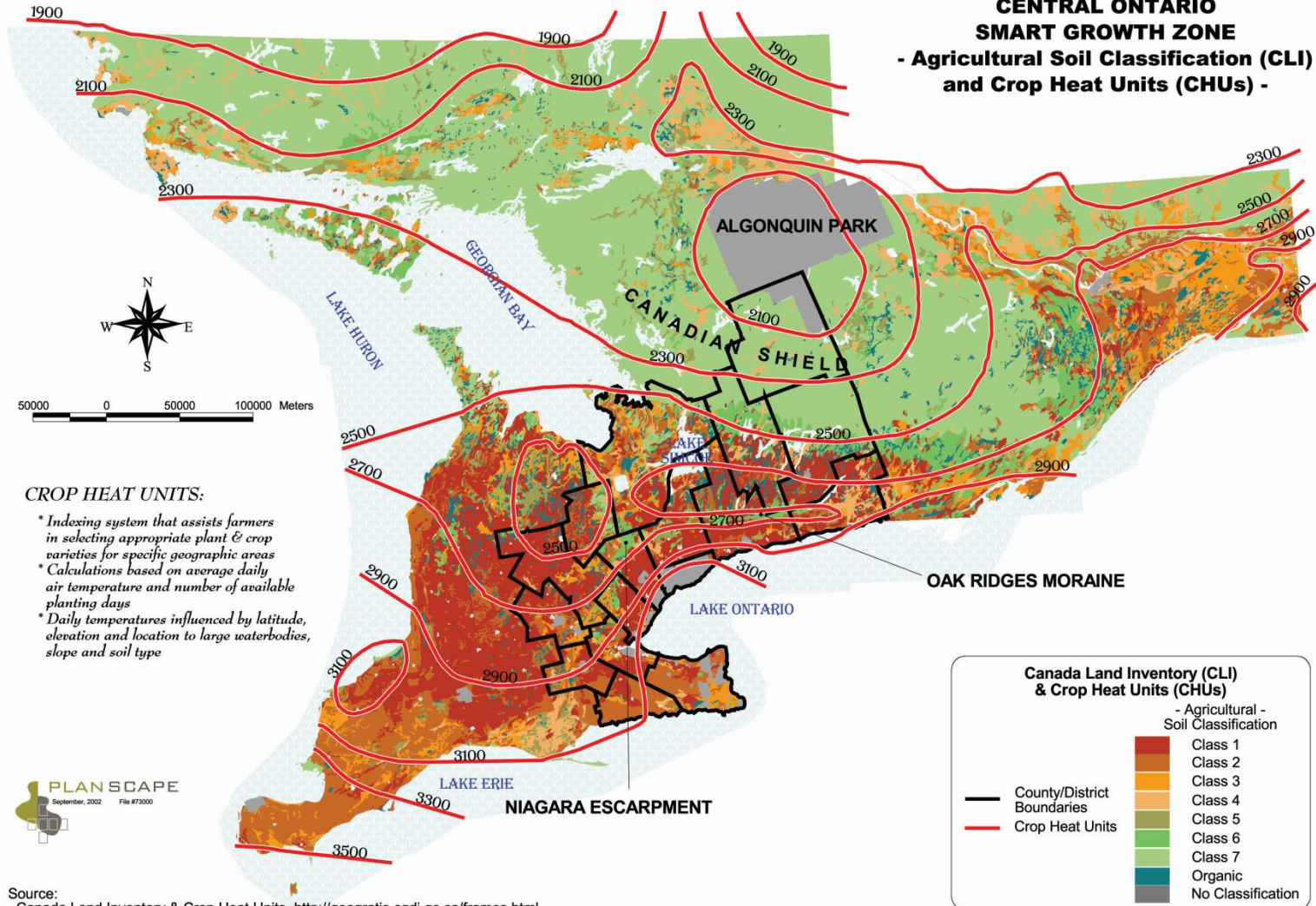


2008

South Richmond, BC

Photo credits: *Alternatives Journal* Vol. 34 Issue 3, 2008

FIGURE 2
CENTRAL ONTARIO
SMART GROWTH ZONE
- Agricultural Soil Classification (CLI)
and Crop Heat Units (CHUs) -

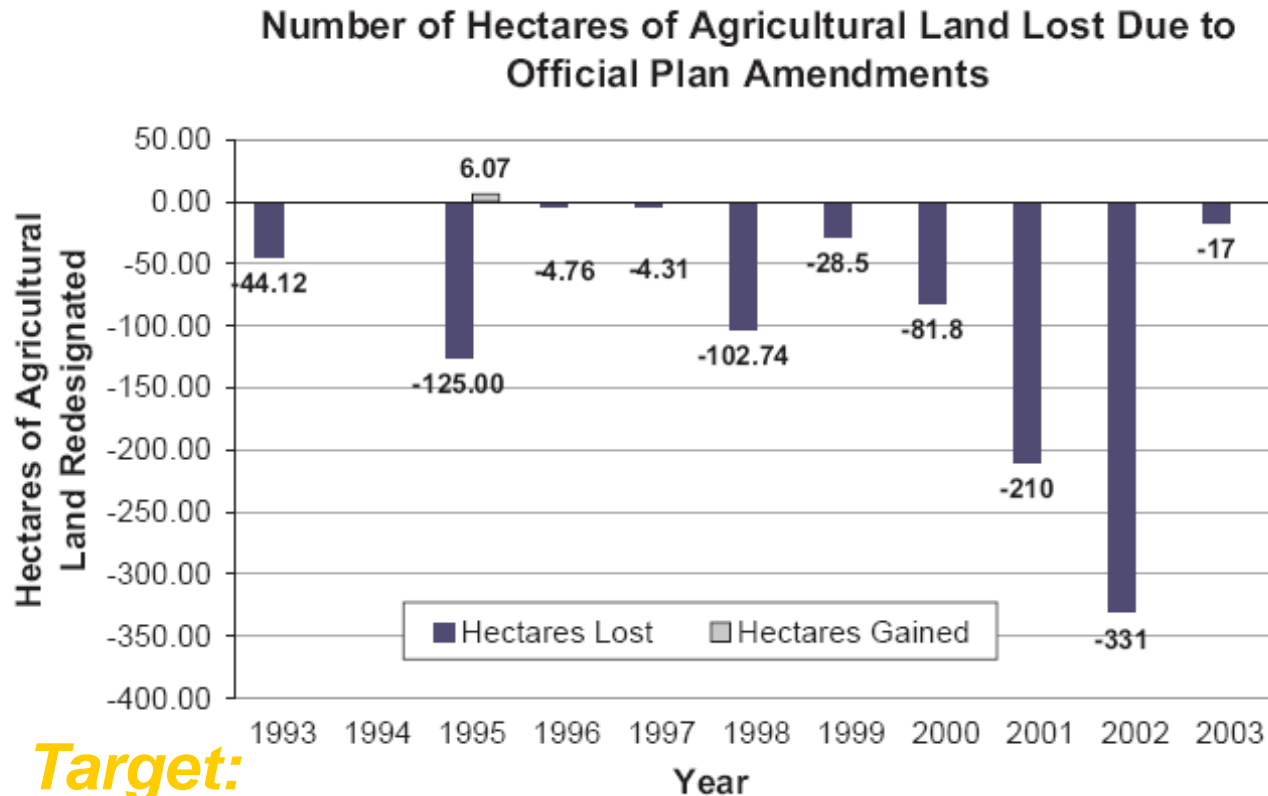


Source:
 Canada Land Inventory & Crop Heat Units <http://geogratis.cgdi.gc.ca/frames.html>
 National Atlas Bases Data <http://geogratis.cgdi.gc.ca/frames.html>
 Ontario Municipal Directory, Ontario Ministry of Municipal Affairs, 2002.

NOTE: Area in white not available digitally.

Only 0.5% of it (Canada's land base) is Class 1. **The Central Ontario Zone is fortunate to contain a significant portion of this very limited resource.** Source: www.neptis.org

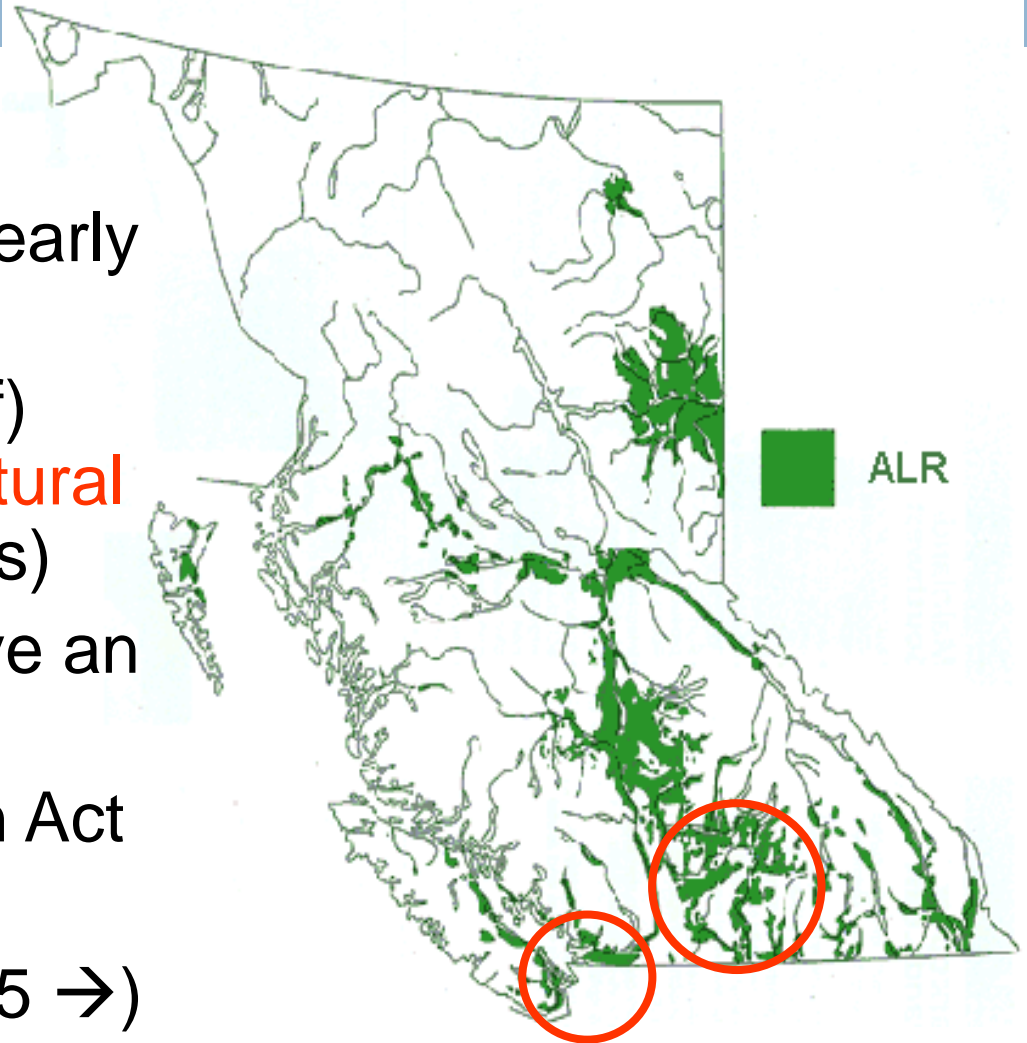
Agricultural Land Lost (Region of Hamilton Wentworth, 1993 to 2003)



- No loss of land. A decrease in the amount of land removed from agricultural designation is a positive step.

BC's Agricultural Land Reserve (ALR)

- Established by Dave Barrett (BC Premier early 1970s)
- Lack of (or waning of) **protection for agricultural land** (recent BC govts)
- Not all provinces have an **ALR**;
- QC: Agric. Protection Act
 - ▣ (1978 →)
- ON: Green Belt (2005 →)



Quebec Agricultural Protection Act

- Cropland <2% of Quebec's land base
- Much of it **concentrated around the Province's six largest urban centres**; thus face land use pressure for use other than agricultural
- Originally passed in 1978

Québec 

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Updated to 1 January 2014
This document has official status.

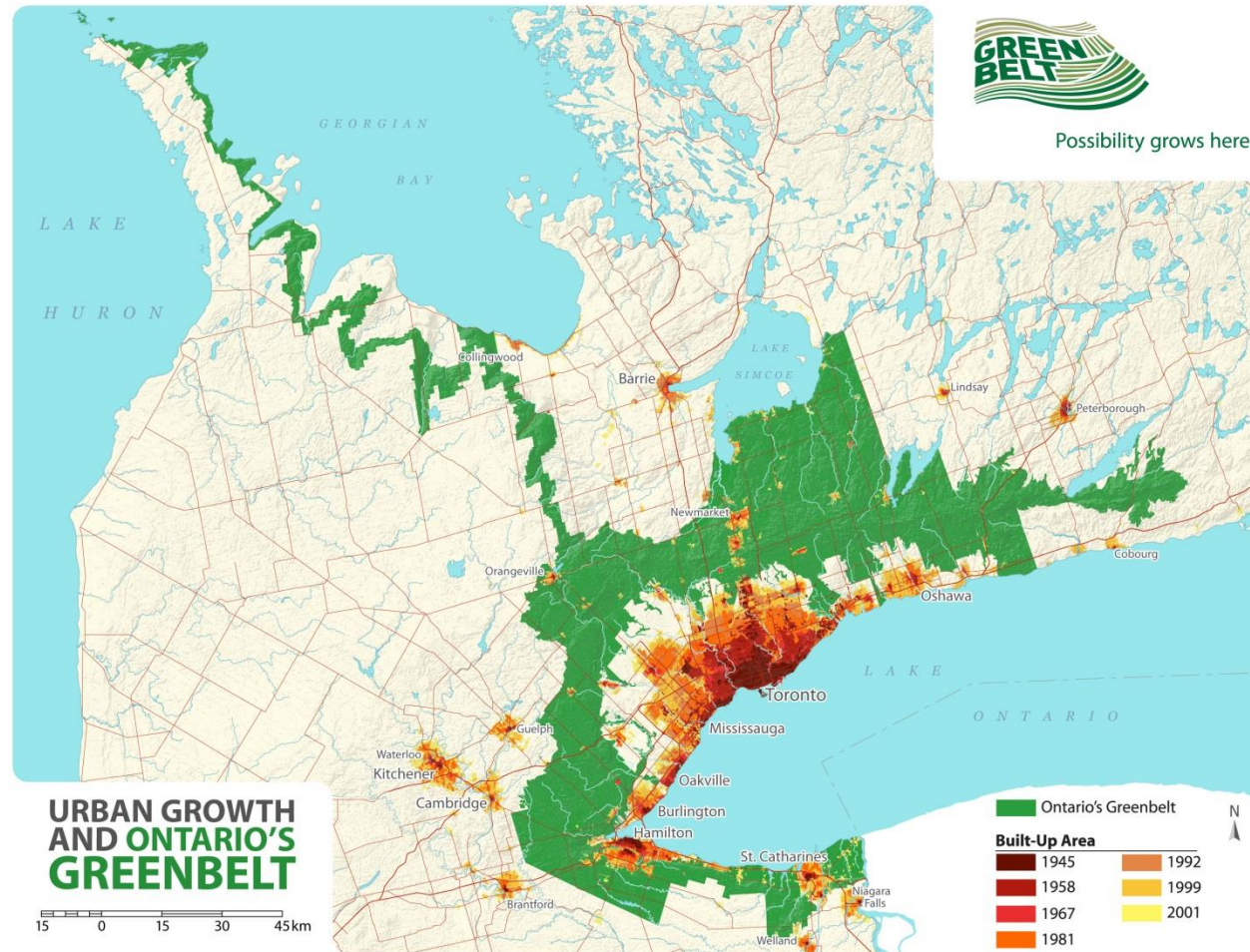
chapter P-41.1

**AN ACT RESPECTING THE PRESERVATION OF AGRICULTURAL LAND AND
AGRICULTURAL ACTIVITIES**

http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=2&file=/P_41_1/P41_1_A.html

Ontario Green Belt (Greater Golden Horseshoe)

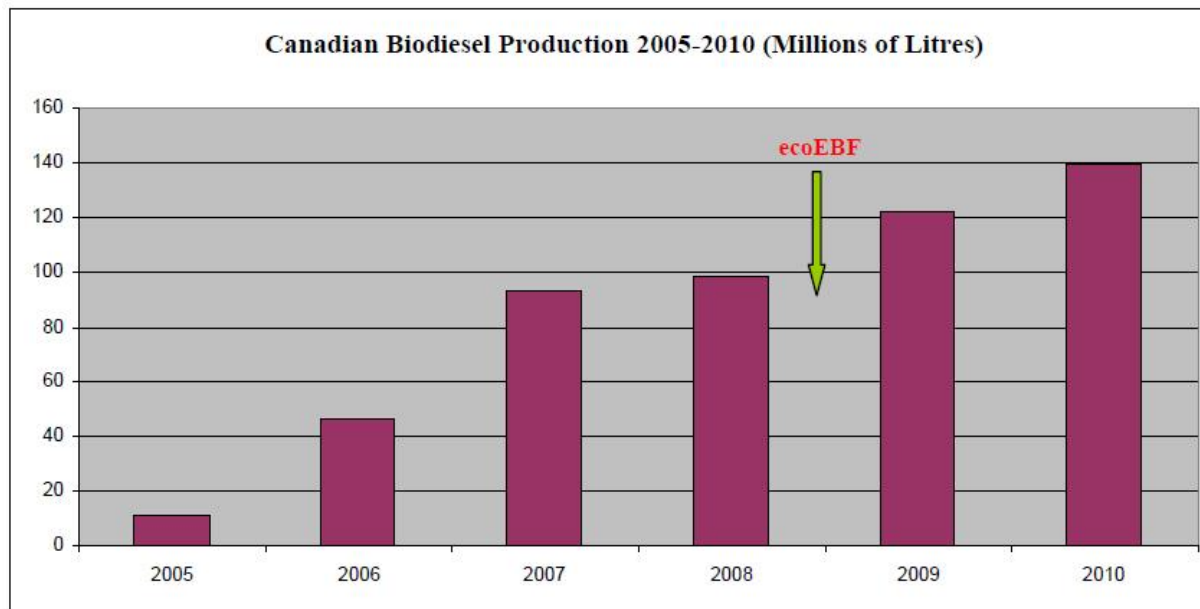
- Created 2005
- Includes: Oak Ridges Moraine; Niagara Escarpment; and other valuable agricultural lands



The Built-Up area data is shown only for areas south of Collingwood and east of Cambridge (with the exception of Kitchener/Waterloo). The Built-Up areas shown on this series of maps should be considered illustrative only; they were derived from numerous sources, based on different assumptions and covered different geographic extents. Data shown for the years 1945 and 1958 was not available for areas outside of the Greater Toronto Area, and therefore was approximated. These areas likely show smaller Built-Up area extents than actually existed at the time. Road network from DCRB, Geomatics Office, Ministry of Transportation, Ontario, 2009. Roads shown based on 2008 data with Hwy 407 removed. Greenbelt, Oak Ridges Moraine and Niagara Escarpment Boundaries © Queen's Printer for Ontario, 2005. Reproduced with permission. Built-Up area 1981 © Department of Natural Resources Canada. All rights reserved. Built-Up area 2001 provided by the Hepco Foundation. Urban growth area based on Municipal Official Plans ca. 2001. Map design by A. the Crow Files, CARTography

The Biofuel Revolution

- Biofuel production has become **more feasible in light of the rising cost of crude oil** and the availability of **improved processing technologies**
- **Biofuels** are derived from plants and other organic material; appear to have great potential to help curb GG



NR Canada (2012)
<http://www.nrcan.gc.ca/evaluation/reports/2012/792>

The Biofuel Revolution

- *Advantages of biofuel:*
 - a fraction of the pollutants of traditional petroleum-based fuels,
 - reduce foreign oil dependency
 - lower fuel prices
 - increase income for farmers
 - provide new jobs
- **Critiques:**
 - inputs used to grow many of the crops used for biofuels
 - More profitable biofuel production removes land from food production
 - large-scale biofuel production can threaten biodiversity

Agriculture's Impact on the Global Landscape

- A variety of impacts associated with the development of agriculture and modern farming systems:
 - ▣ Humans ... the major influence on species distribution
 - ▣ large areas of **monoculture cropping**
 - ▣ Monoculture cropping is the **cultivation of one plant species over a large area**, which leaves the crop highly susceptible to disease and insects, especially when all of the individual plants are genetically identical
 - ▣ Genetically-modified organisms (GMO) – dramatic growth since 1995 (post Rio'92); Canada a lead player

Global area of transgenic crops

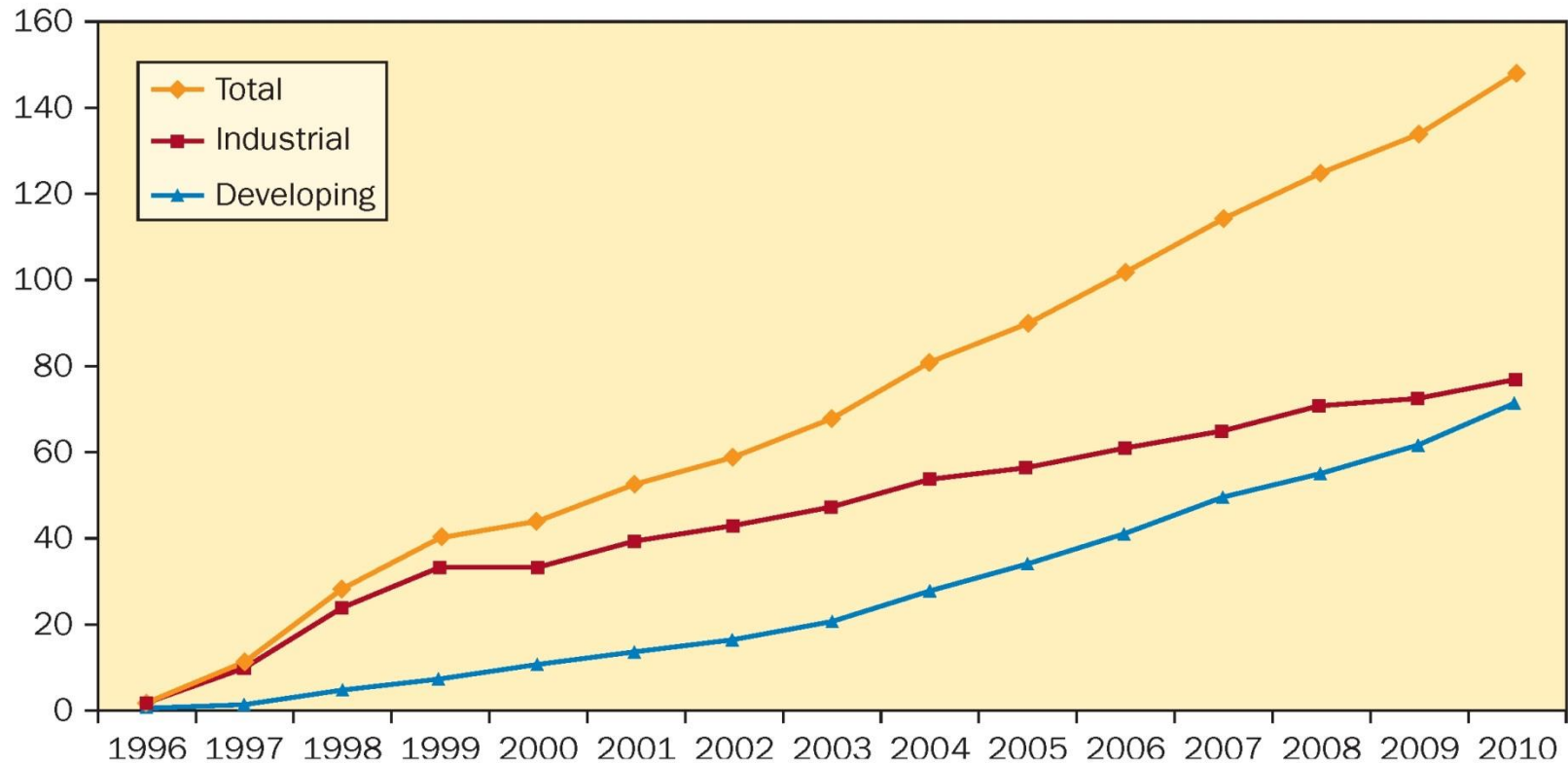


Figure 10.3 | Global area of biotech crops, industrial and developing countries (million hectares).
Source: James (2010).

Box 10.4 (GMOs, course text) (p.341)

- Several areas of uncertainty remain with use of GMOs:
 1. **Pleiotropic effects:** unexpected side effect suffered by target organism (Q: is there an effect when U Guelph scientists engineer a pig that produces feces 20-50 times less Phosphorus?)
 2. **Environmental effects:** impacts on natural processes (e.g., pollination; reproduction; biogeochemical cycles or unintended “gene flow” to other organisms)
 3. **Unintentional spread:** from transgenic crops to lands where they are not intended to grow (Q: potential contamination of organic farmers)

Other impacts associated with modern agriculture

- **Need for irrigation systems** (→large-scale water diversions) resulting in changes in groundwater, soil characteristics, precipitation patterns, and water quality
- **Soils** are changed chemically and physically, while natural food chains are truncated
- **Processes of Natural succession** are altered or suppressed in agricultural landscapes ;
- A greater number of **domesticated herbivores** compared to natural herbivores
- The **industrial system of livestock production** directly affects land, air, water, and biodiversity through the emission of animal waste, use of fossil fuels, and substitution of animal genetic resources

To summarize ... issues with our Agricultural Systems

- High energy and capital intensive
- Globally-integrated
- Increasingly economically-consolidated
- Environmental Degradation and Economic Disaster for:
 - Family Farms
 - Community Processes
 - Downstream Businesses
- “People have become disconnected from their source of sustenance” ... is this a problem?

Source: (Feenstra 2002)

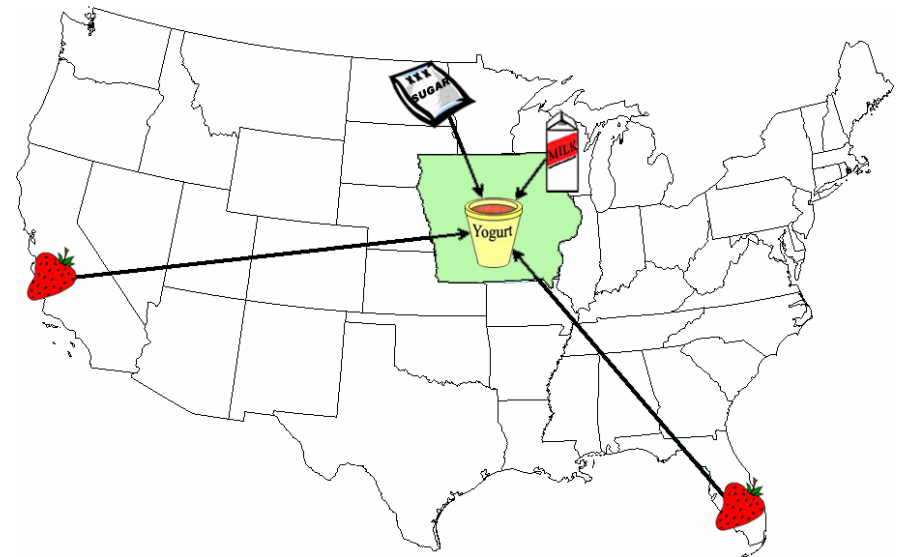
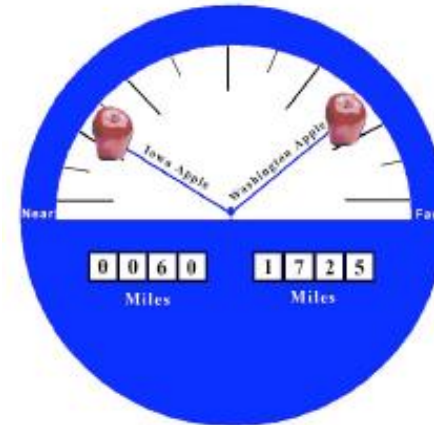
To summarize ... issues with our Food Systems

- **Food is our fundamental input**, and ... as the saying goes ... “You are what you eat”
- **Food quality is degrading** (genetically-altered, laced with chemicals, overly processed, ...)
 - ▣ Q?? Need we be concerned about potential **long-term health implications** ...
- Food travels **immense distances to reach us** (average product in a US supermarket travels 2000 km between production and point of consumption) → **enormous energy demands** !!

Weighted Average Source Distance (WASD)

Table 1. Comparison of local versus conventional source WASD (food miles) for produce

Produce Type	Locally grown WASD (miles)	Conventional Source Estimation WASD (miles)
Apples	61	1,726
Beans	65	1,313
Broccoli	20	1,846
Cabbage	50	719
Carrots	27	1,838
Corn, Sweet	20	1,426
Garlic	31	1,811
Lettuce	43	1,823
Onions	35	1,759
Peppers	44	1,589
Potatoes	75	1,155
Pumpkins	41	311
Spinach	36	1,815
Squash	52	1,277
Strawberries	56	1,830
Tomatoes	60	1,569
WASD - for all produce	56	1,494
Sum of all WASDs	716	25,301



From: Pirog and Benjamin (2003, 2005) – study on the Food Odometer done for Iowa

Troubling Points about Sustainable Agriculture

- In cold climates like Thunder Bay, we are **reliant on distal sources** like Florida, California, S. Ontario ...
- Precious **local farmland continues to be lost** to residential and development (e.g., California, southern Ontario)



LU - Orillia Campus

References

- Dearden, P and Mitchell, B. 2012. *Environmental Change and Challenge*, Fourth Edition, Don Mills, Ontario: Oxford University Press {Chapter 10: 'Agriculture'}

Part 2: Canadian Agriculture and Related Environmental Impacts & Sustainable Food Systems

- **Trends in Canadian Agriculture**
- **Environmental Challenges for Agriculture in Canada**
 - ▣ {Land Degradation; Soil Erosion; Soil Compaction, Acidification & Salinization; Organic Matter & Nutrient Losses; Biocides; Biomagnification; }
- **Sustainable Food Production & Organic Farming**
 - ▣ {Integrated Pest Management; Integrated Plant Nutrient Systems; No-Till/Conservation Agriculture}

Trends in Canadian Agriculture

- 7% of Canada's total land area is agricultural land – relatively unchanged fraction in past 50 years;
- Decrease in number of family farms with corresponding increase in farm size (see Fig. 10.5)
- Only 3% of employment in Canada in farming (cf 80% earlier in our history)

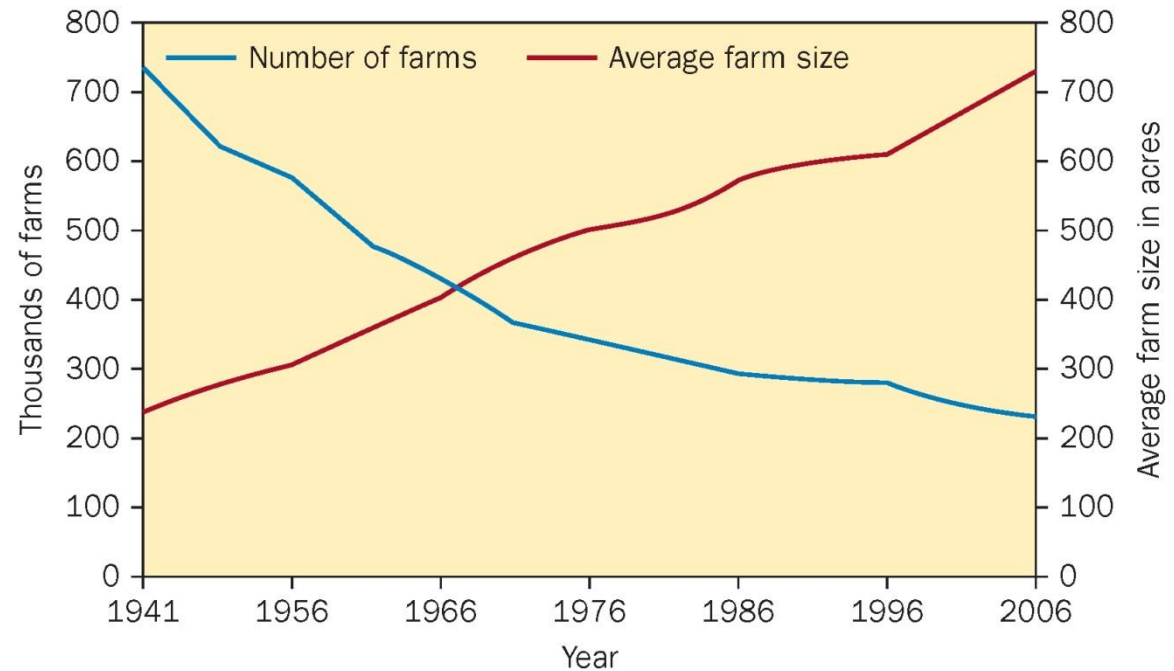


Figure 10.5 | Number and size of farms in Canada, 1941–2006. Source: Statistics Canada. *Census of Agriculture, various years.*

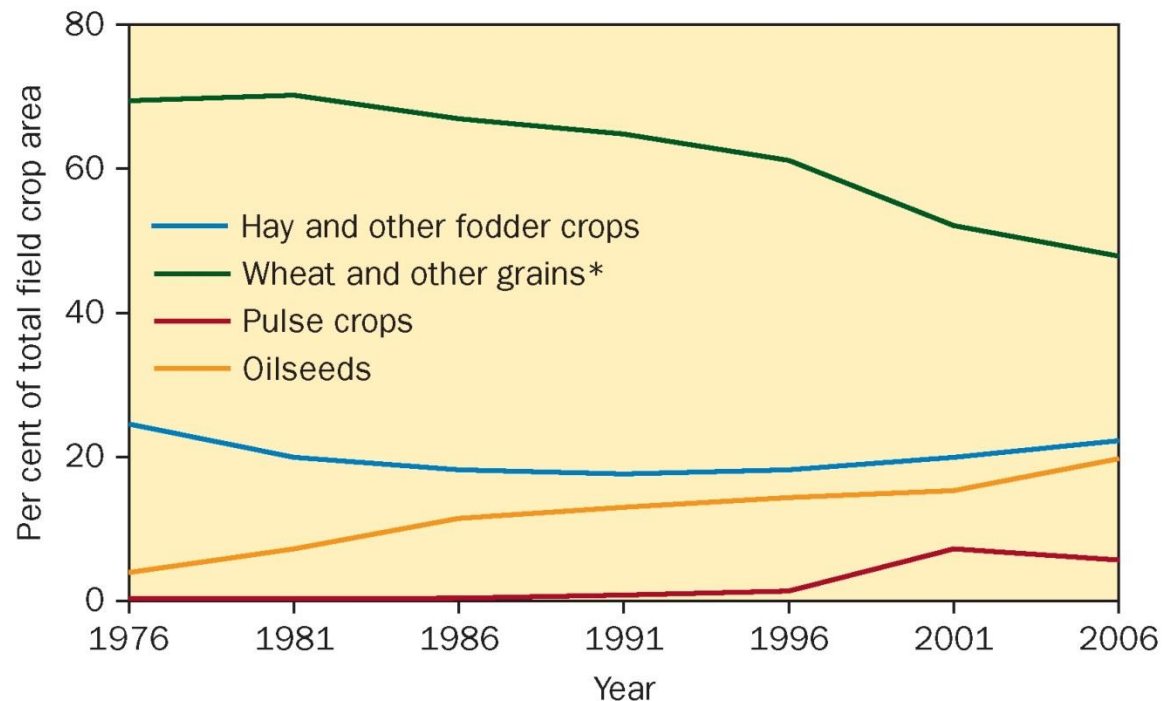
Note: It is interesting that although Canada officially uses metric units, Agriculture and Agri-Food Canada continues to use imperial units (acres) even in recent publications such as this graph. In a sense, this can be seen as symbolic of the inertia in Canada's agricultural sector.

From: Dearden and Mitchell (2012)

Trends in Canadian Agriculture



- **Wheat** is still the dominant crop in Canada
- The **agricultural and agri-food sector** is a \$86-billion industry, exporting more than \$28 billion in products annually;



* Other grains include oats, barley, mixed grains, corn for grain, rye, and buckwheat.

From: Dearden and Mitchell (2012)

Figure 10.6 | Crop area allocation, 1976–2006. Source: Statistics

Canada's 5 largest agricultural production sectors

Five Largest Agricultural Production Sectors.^[23]

Sector	per cent cash receipt	Primary market
grains and oilseeds (wheat, durum, oats, barley, rye, flax seed, canola, soybeans, rice, and corn)	34%	domestic and export
red meats – livestock (beef cattle, hogs, veal, and lamb)	24%	domestic and export
dairy	12%	domestic
horticulture	9%	domestic
poultry and eggs	8%	domestic

Canadian Federation of Agriculture (2007).

Trends in Canadian Agriculture



Crop Dusting
theperiledsea.ning.com

http://www.deere.com/common/media/images/product/tillage/r4d021995_2600_tillage_942x458.jpg

- Unfortunately, many innovations & technologies in use on Canadian farms have **negative implications for ecosystem health**;

From: Dearden and Mitchell (2012)



Ottawa Citizen
syndicom.com

Environmental Challenges for Canadian Agriculture

- **Land degradation** includes a number of processes that reduce the capability of agricultural lands to produce food:
 - Soil Erosion
 - Soil Compaction
 - Soil Acidification
 - Organic Matter and Nutrient Losses

Land Degradation (1)

- **Soil erosion** is a natural process whereby soil is removed by gravity and water & wind processes
- **Soil compaction** is the compression of soil as a result of frequent heavy machinery use on wet soils or the overstocking of cattle on the land



.... “that erosion has a double impact on the planet - washing away vital nutrients from the soil but also, surprisingly, helping lock carbon into the soil and preventing it from reaching the earth's atmosphere”.

Soil erosion – the forgotten player in the global change debate

Lancaster University News Archive
news.lancs.ac.uk

30 April 2010

Land Degradation (2)

- **Salinization** is the deposition of salts in irrigated soils, making soil unfit for most crops; caused by a rising water table due to inadequate drainage of irrigated soils
- **Summer fallow** is a practice common on the Prairies in which land is ploughed and kept bare to minimize moisture losses through evapotranspiration but which leads to increased salinization
- Soil degradation, including erosion and **nutrient depletion**, is undermining the long-term capacity of many agricultural systems worldwide

Nitrogen inputs required to maintain grain yields in the Prairies

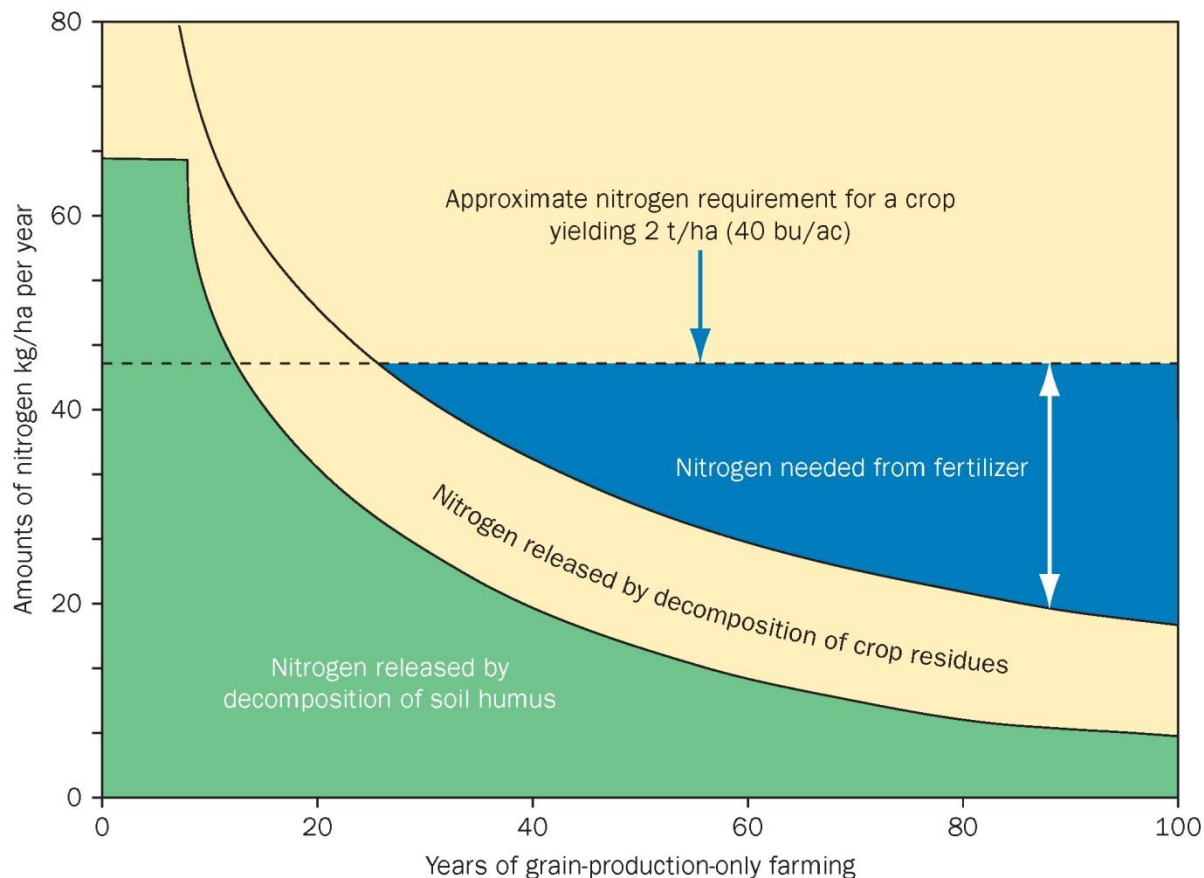


Figure 10.7 | Diagrammatic illustration of approximate sources of nitrogen needed to maintain grain yields of about two tonnes per hectare (40 bushels per acre) of barley under a system of continuous grain production in the prairie region.

Note that this diagram illustrates plant requirements, not supply—i.e., the amount of fertilizer nitrogen applied would normally be greater than the plant requirements because of losses due to denitrification and/or leaching. Source: Bentley and Leskiw (1985).

Biocides

- **Biocides** are chemicals that kill many different kinds of living things (include: pesticides, herbicides, insecticides)
- Controversial use since the publication of *Silent Spring* (1962):

Positive outcomes

- Boost in **global food yields**; preventing more serious starvation issues;
- **Saved countless lives** through control of infectious diseases (e.g., attack on malaria-carrying mosquitos)

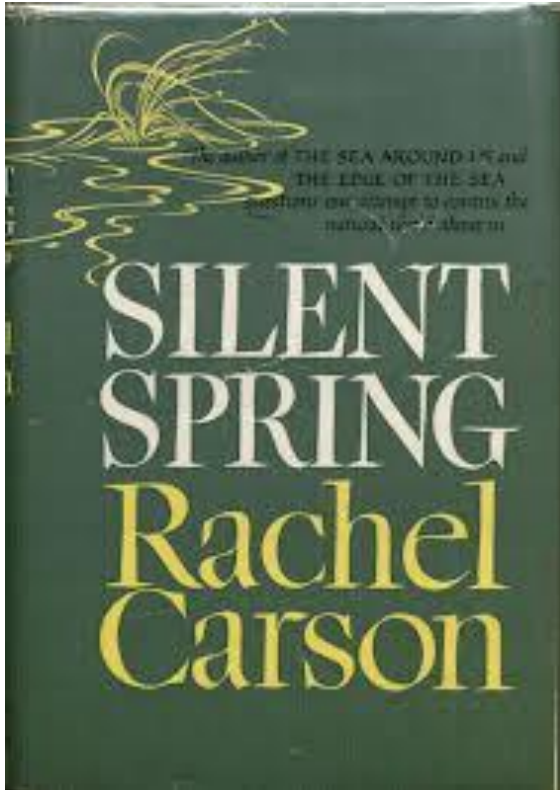
Negative consequences

- Possible **environmental problems & health impacts**; (e.g., resistance, mobility, persistence, bio-concentration)



"We spray our elms and the following springs are silent of robin song, not because we sprayed the robins directly but because the poison traveled, step by step, through the now familiar elm leaf-earthworm-cycle."

Rachel Carson Silent Spring (1962)



'Silent Spring' Is Now Noisy Summer

Pesticides Industry Up in Arms Over a New Book

By JOHN M. LEE

The \$300,000,000 pesticides industry has been highly irritated by a quiet woman author whose previous works on science have been praised for the beauty and precision of the writing.

The author is Rachel Carson, whose "The Sea Around Us" and "The Edge of the Sea" were best sellers in 1951 and 1955. Miss Carson, trained as a marine biologist, wrote gracefully of sea and shore life.

In her latest work, however, Miss Carson is not so gentle,



Rachel Carson Stirs Conflict—Producers Are Crying 'Foul'

fending the use of their products. Meetings have been held in Washington and New York. Statements are being drafted and counter-attacks plotted.

A drowsy midsummer has suddenly been enlivened by the greatest uproar in the pesticides industry since the cranberry scare of 1959.

Miss Carson's new book is entitled "Silent Spring." The title is derived from an idealized situation in which Miss Carson envisions an imaginary town where chemical pollution has silenced "the voices of spring."

Aspects of the biocide issue:

□ **Resistance**

- a constant need to develop new biocide products to keep one step ahead of biological adaptation

□ **Non-selective**

- Many biocides are popular because they are broad-spectrum poisons; there is no need to identify the specific pest, because a broad-spectrum poison will kill most insects

□ **Mobility**

- The effects of the chemical application are often felt over a much wider area

The US Department of Agriculture estimates that less than 2% of applied insecticides reach their targeted destination.



Much enters the hydrologic cycle.



usatoday30.usatoday.com

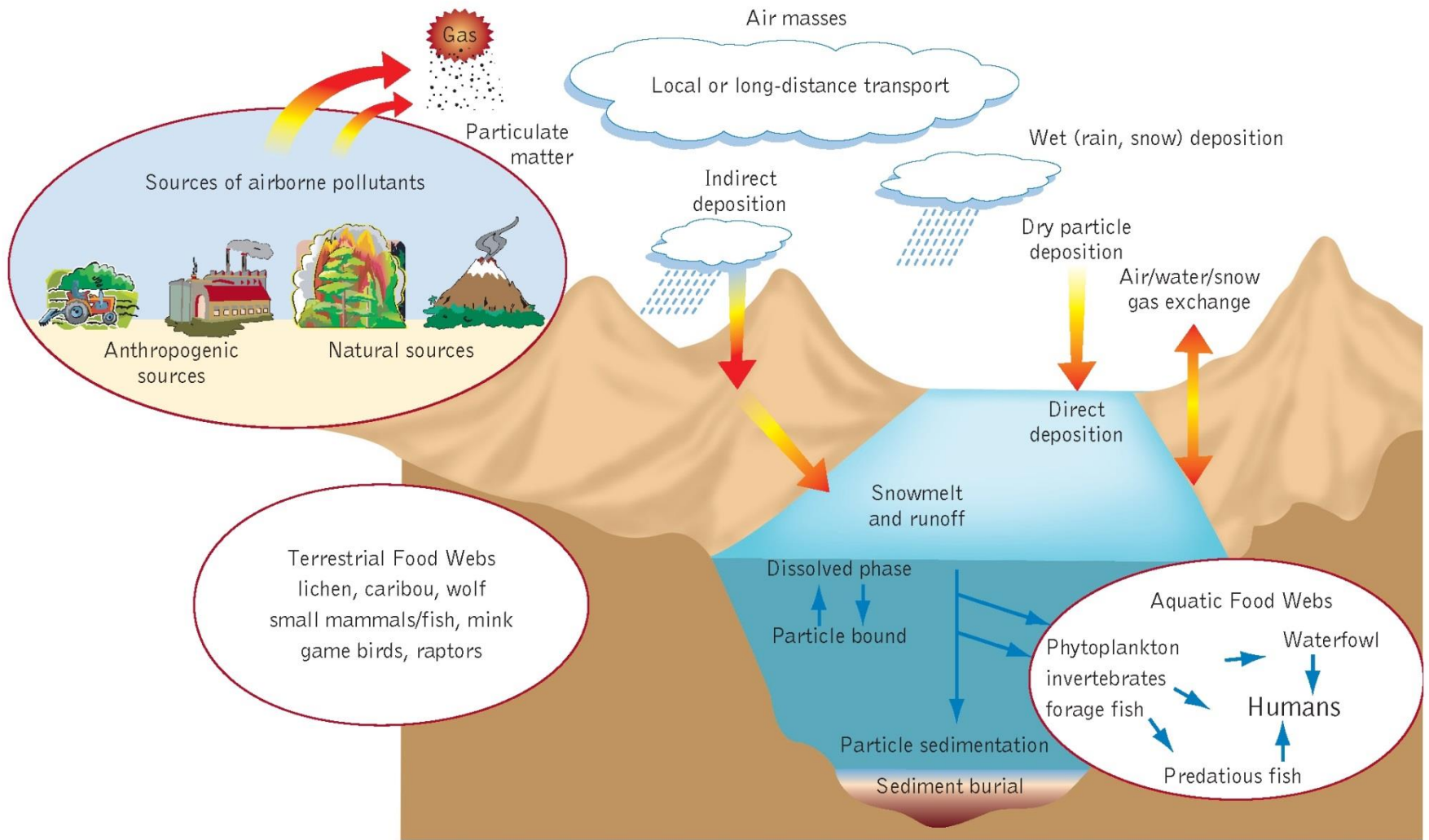


Figure 10.9 | Pesticide transportation in the environment. Source: Adapted from Indian and Northern Affairs Canada (1997b). Reproduced with the permission of the Minister of Public Works and Government Services, 2004.

From: Dearden and Mitchell (2012)

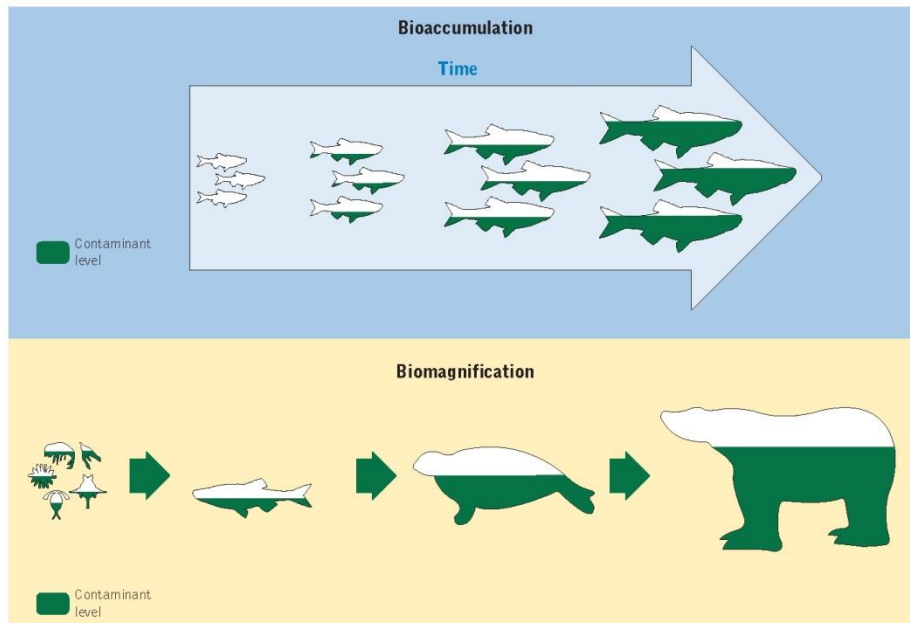
Impacts of biocide use

□ Persistence

- Biocides contaminate through time, as many of them are very persistent, such as DDT
- Became widely used in the 1940s; peaked in 1970; use banned in US (in 1972); use of DDT products ended circa 1985;

□ Biomagnification

- High concentrations of persistent organic pollutants (POPs) have been detected in top predators of the Arctic food chain



Concentrations increase 5x to 10x with each step in the food chain.

From: Dearden and Mitchell (2012)

Sustainable Food Production Systems

Three Components of:

1. Integrated Pest Management
2. Integrated Plant Nutrient Systems
3. No-Till/Conservation Agriculture



Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management

Integrated Pest Management

- Its is to avoid or reduce yield losses caused by diseases, weeds, insects, mites, nematodes, and other pests while minimizing the negative impacts of pest control;
- The presence and density of pests and their predators and the degree of pest damage are monitored, and no action is taken as long as the level of pest population is expected to remain within specified limits;
- IPM considers the crop and pest as part of a wider agro-ecosystem

Integrated Plant Nutrient Systems

- Imbalances in nutrient availability can lead to depletion of nutrients, with corresponding reductions in crop yields
- The goal of IPNSs is to maximize nutrient use efficiency by recycling all plant nutrient sources within the farm and by using nitrogen fixation by legumes
- Soil productivity is enhanced through the use of local and external nutrient sources, including manufactured fertilizers

No-Till/Conservation Agriculture

- Refers to **zero, minimum, or low tillage** to protect and stimulate the biological function of the soil while maintaining and improving crop yields;
- Includes direct sowing or drilling of seeds instead of ploughing, maintenance of permanent cover of plant material on the soil ("**cover crops**"), and **crop rotation**;

Advantages:

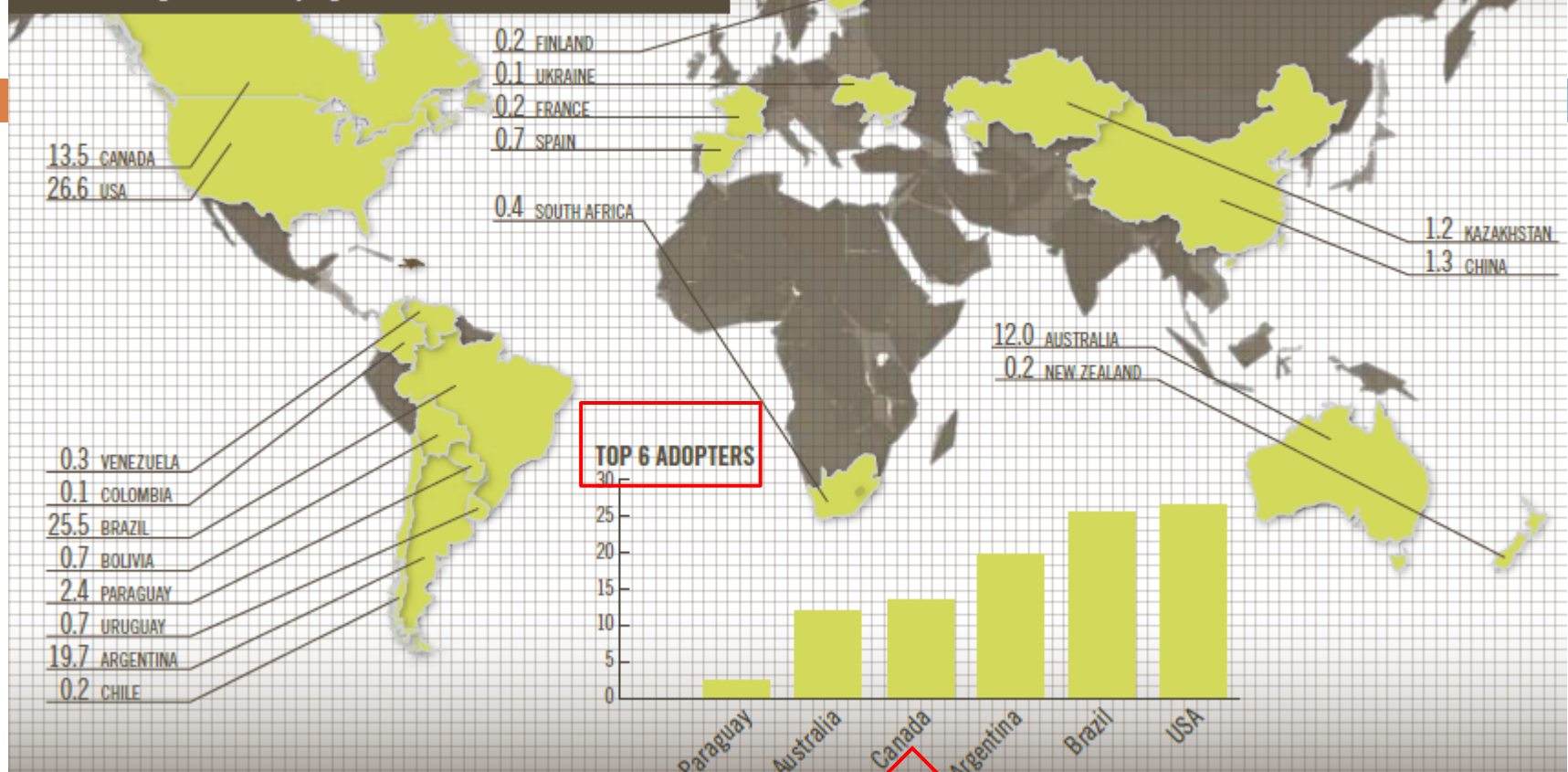
1. Inhibit germination of weed seeds;
2. Minimize build up of pests → reducing need for herbicides and pesticides, respectively;
3. Increase crop yields;
4. Lower labour costs and machinery costs;



<http://www.cbf.org/how-we-save-the-bay/issues/agriculture/best-management-practices/chesapeake-farmers-reducing-pollution-and-improving-business>

NO-TILLAGE ADOPTION WORLDWIDE [IN MILLIONS OF HECTARES]

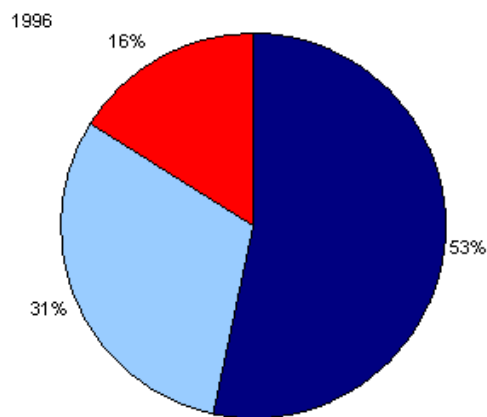
About 105 million hectares worldwide are now farmed using conservation agriculture or no-till farming. Users are mostly large-scale farmers.



http://insights.ifpri.info/files/2012/06/infographic_notillage.pdf

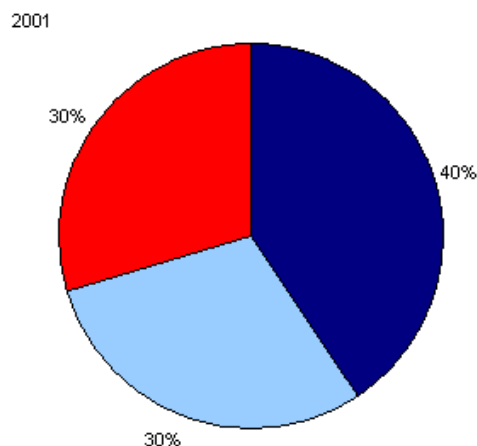
Source: R. Derpsch and T. Friedrich, "Development and Current Status of No-Till Adoption in the World," paper presented at the 18th Triennial International Soil Tillage Research Organisation conference, Izmir, Turkey, June 15-19, 2009.

- **Despite advantages of No-Till Agriculture**, conventional tillage still dominates worldwide:
 - Reluctance to change from what has worked for decades;
 - Lack of knowledge on damage to soil via plough-based techniques;
 - Complex management skills required to successfully transfer over to No-Till
- **Canada (16% No-Till in 1996 → 46.7% in 2006)**



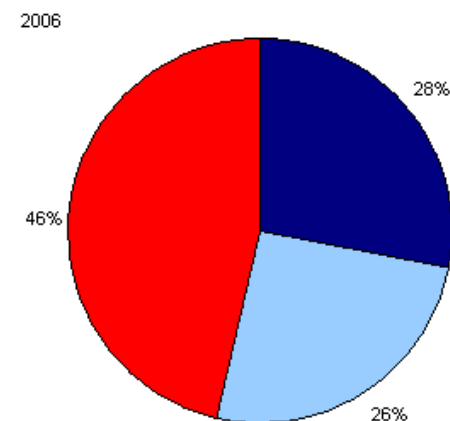
■ Conventional ■ Conservation ■ No-till

Source: Statistics Canada, Census of Agriculture, 1996 to 2006.



■ Conventional ■ Conservation ■ No-till

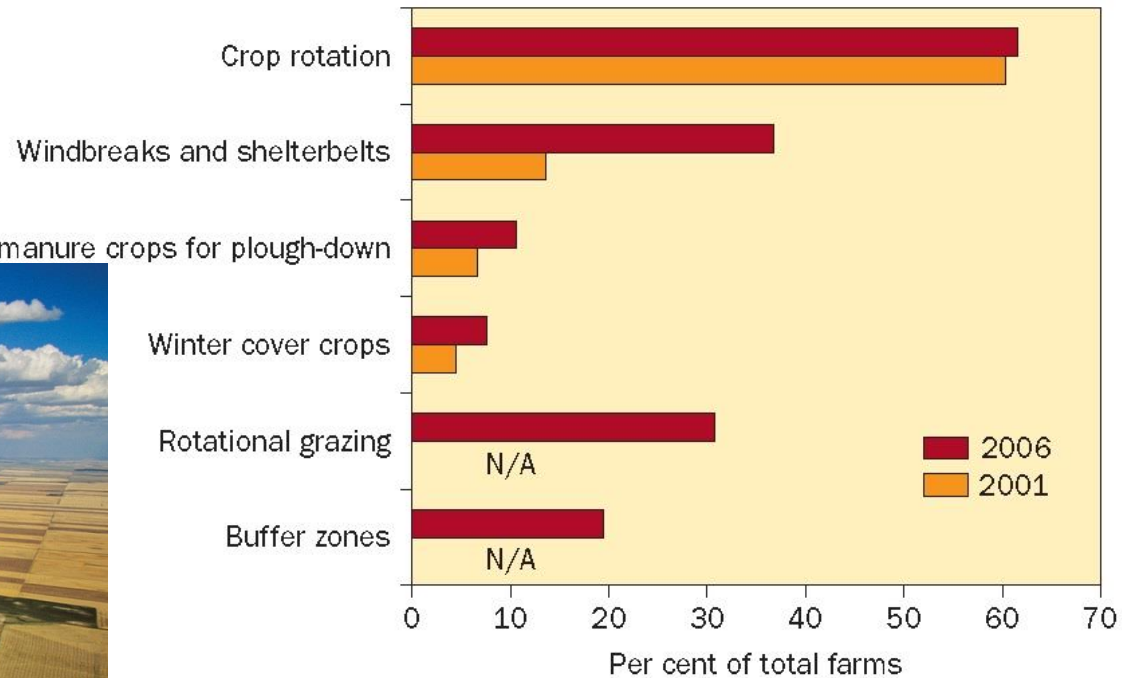
Source: Statistics Canada, Census of Agriculture, 1996 to 2006.



■ Conventional ■ Conservation ■ No-till

Source: Statistics Canada, Census of Agriculture, 1996 to 2006.

Other conservation practices (change in)



Soil conservation practices, 2001 and 2006. Source: Statistics Canada

Strip farming: different crops planted in strips parallel to slope; crops harvested at different times to provide some protection against erosion.

From: Dearden and Mitchell (2012)

Organic Agriculture ... one sustainable approach

- It combines current approaches to sustainable agriculture (including IPN, IPNS and No-Till Agriculture) and other management strategies into a single approach;
- It is a production management system that aims to **promote and enhance ecosystem health**;
 - ▣ Based on minimal use of external inputs, relying more on locally available resources
 - ▣ Minimizes air, water and soil pollution;
- **Standards** are set to **regulate organic agriculture** with respect to pesticide and fertilizer use; GMOs; sewage sludge, etc...
- Has become a **large industry in Canada** and elsewhere ... now a \$50 billion per year industry worldwide, but ...
- **Still not a solution for global food security** for poorer nations.

References

- Dearden, P and Mitchell, B. 2012. *Environmental Change and Challenge*, Fourth Edition, Don Mills, Ontario: Oxford University Press {Chapter 10: 'Agriculture'}
- Canadian Federation of Agriculture (2007). "CFA – Canadian Federation of Agriculture – Commodities". Archived from the original on 10 April 2007. Retrieved 6 April 2007

Looking Ahead to the next lectures

June 4 (Wednesday): Field Trip

June 5: Water: Interventions in the hydrological cycle; water quality

Read ahead (Chpt 11, pp. 374 →)