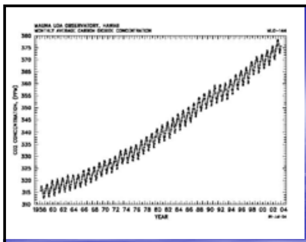

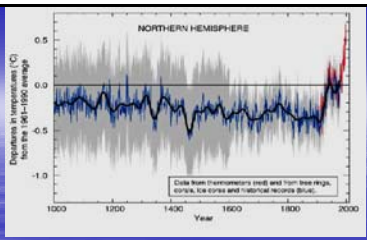

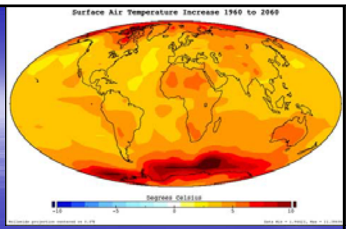

Climate Change

& Crop Productivity

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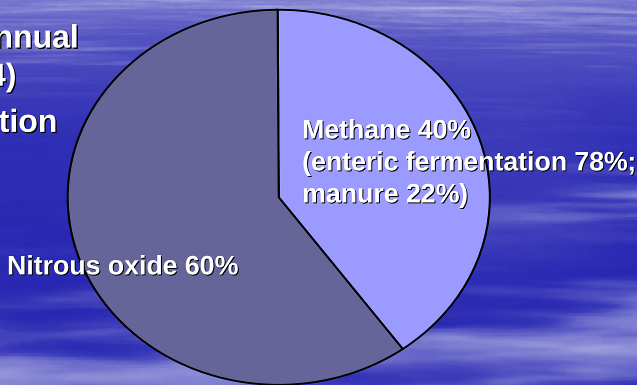
Photo: P.H. Graham

Agriculture Contributes 60 Mt of 726 Mt total

- 8.3% of Canada's total annual GHG production (EC 2004)
- Not including transportation fuel emissions

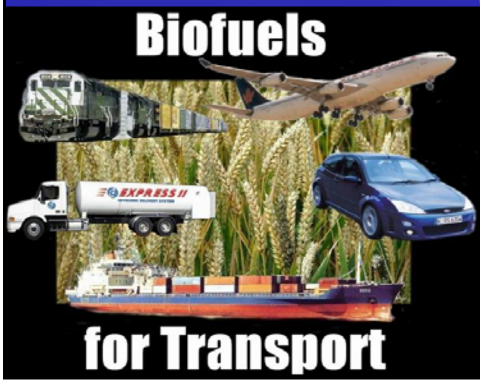


Heat trapping:
CO_2 = 1
CH_4 = 21
N_2O = 310

Canada has committed to reduce its production of greenhouse gases (GHGs) over the next decade to 6% below the 1990 levels by the end of the first Kyoto period, 2008 - 2012

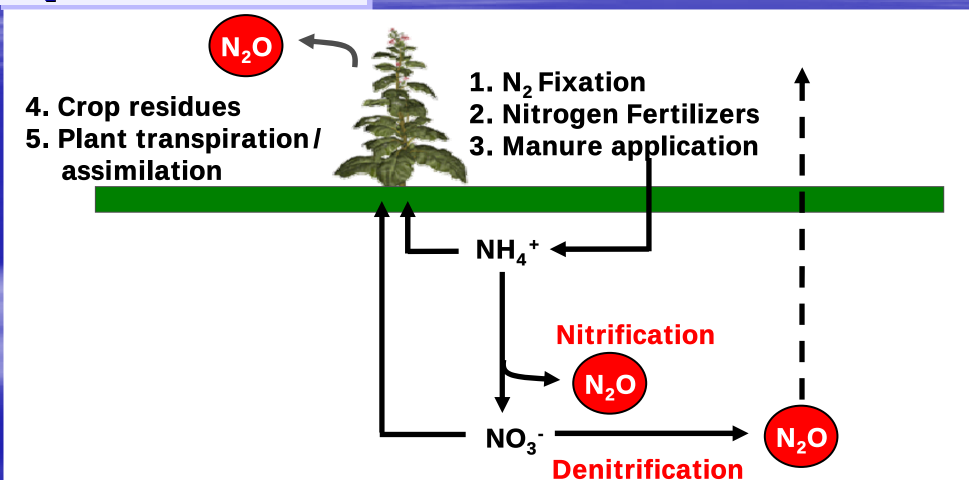
Mitigation

- Three possible areas
  - N_2O emissions
  - Soil C stocks
  - Biofuel Crops



N_2O emissions

- Agricultural soils leak N_20

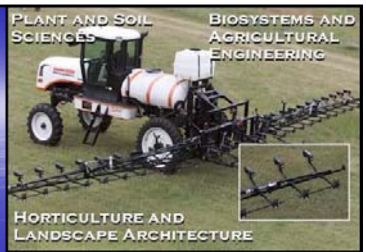


Careful Assessment of Need

- N fertilizer levels in soil are difficult to determine
  - Mineralization from soil organic matter varies with season
- Tests just prior to planting or during crop growth are available
  - Soil nitrate tests
    - Post harvest (fall)
    - Preplant
    - Pre-side dress
  - Petiole nitrate test
  - Leaf greenness analysis
  - Developing soil mineralization

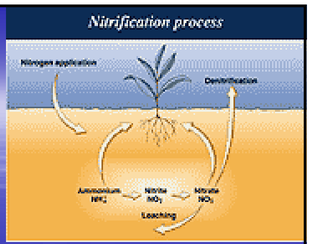
granular ammonium nitrate

Fertilizer timing



- Split applications
  - When all added at seeding:
    - Greater loses so greater amounts needed (N fertilizer costs are rising)
  - Environmental effects of losses
    - Leaching and ground water contamination
    - Denitrification leading to N_2O production
      - Spring conditions tend to be wet and wet soils favour denitritification
  - Apply some N at seeding and the rest at one or more key growth stages, depending on the crop and desired outcome
  - Can increase crop protein content

Gradual Availability

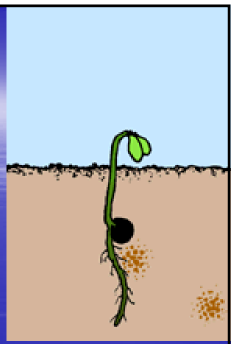


- Nitrification inhibitors:
  - slow conversion of NH_4^+ to NO_3^-
  - NO_3^- that is the substrate for denitrification
  - Less denitrification reduces the pool of NO_3^- and therefore the amount of denitrification
  - Example: Nitrapyran, but these are costly
- Slow release formulations:
  - Release N closer to the time needed by the plants so more is taken up and less available for denitrification

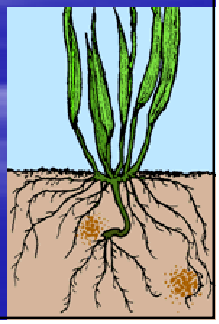
Variable Rate Application

- Precision farming
  - Satellite based global positioning system (GPS)
  - Global information system maps (GIS)
  - Crop response models
  - Computers
- Allows higher applications to parts of the field where a response is likely, and less in other areas
- Better total yield response for fertilizer added
- Less fertilizer added

Fertilizer Placement



- Banded or injected next to rows
- Crop roots will encounter this sooner and miss less
- Initial banding and subsequent side dress (timing) can improve efficiency



Manure Management

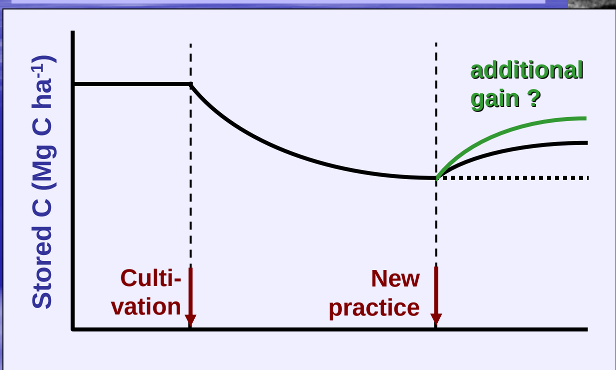
- Know the nutrient level in the manure and do not over apply (especially N)
  - Match manure testing, soil testing, crop requirements, so less N is applied
- Added organic matter may contribute to soil organic matter thereby sequestering carbon into soils

Water Management

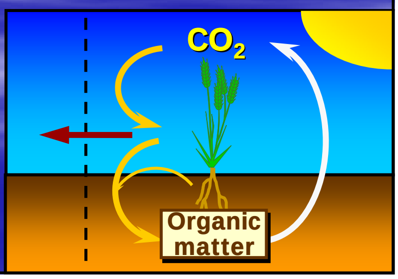
- Good drainage leads to soils that are low in oxygen less often, so less denitrification
- Avoiding over irrigation can have the same effect

Soil C Sequestration

- some lost C can be re-gained with better farming practices



- cultivated soils have lost carbon



Post-cultivation losses:

~ 1 Pg C in Canada

(Smith et al. 2000; Janzen et al. 1998b)

Tillage Practices


No-Till

- Reduced tillage, no-till, reduction in summer fallow
- Soil less “stirred” by tillage
- Less air into the soil so less organic matter break down
- Soil particles larger so less surface area for microbes to work on
- Soil organic matter increases due to deposited crop residue
- Net transfer of carbon (CO_2) from the air to the soil

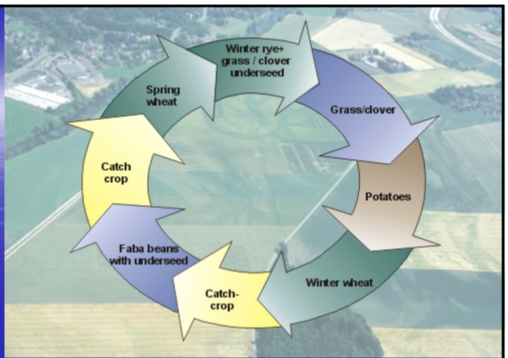
Reforestation

- Trees constitute standing biomass that contains carbon
- Poor land could be reforested
- Wind breaks and shelter belts are also a form of this
- Considerable standing biomass and below ground carbon in extensive root systems

Cover crops

- Grow in fall after main crop harvested
- Reduce soil erosion (top soil contains most of the soil organic matter)
- Because of photosynthetic activities, transfer carbon from the atmosphere to the soil
- Can be N fixing
- Plow in later in spring so less N denitrified

Rotations



- Inclusion of deep rooted perennials (e.g. alfalfa)
  - Deep root system adds carbon to soil at depth where there is less microbial activity
  - Roots are more lignified so break down more slowly
  - As is perennial, no tillage for several years
- Reductions in summer fallow

Bio-fuels

- Result in less fossil fuel use
  - Biomass for direct combustion
  - Fermentation of starch and cellulose to ethanol
  - Bio-diesel
  - Hydrogen from bio-mass

Bio-fuel Considerations

- Benefits of bio-fuels:
  - Sustainable energy source
  - No net CO_2 emissions
- Problems:
  - Crop plants designed for food production and have small positive or even negative life cycle analyses for energy and greenhouse gases
  - A large part of this is related to nitrogen: fossil fuel use during manufacture on the energy side; CO_2 release during manufacture, and N_2O release from fields on the greenhouse gas side

Co-benefits

- N management:
  - More efficient N use (less applied, less lost) so improved economics
  - Less CO_2 production during manufacture
- C sequestration:
  - Higher soil organic matter, leading to better water and nutrient retention
- Biofuels:
  - Crop diversity
  - A place in the energy sector

Adaptations: *Living With It*

Alternative Crops & Cropping Systems

- More C_4 crops can be grown in temperate areas
- Winter wheat, with its higher yield potential, could move into areas where spring wheat is now produced
- Cultivars with longer times to maturity (and therefore greater yield potentials) can be grown
  - This will bring management changes such as earlier seeding
- In the mid latitudes the increase in season lengths may be sufficient to allow the adoption of double cropping practices

Fertilizer Use Will Change

- In areas where crop production potential is increased higher levels of fertilizer application will be required to meet the potential
- The increases will be greatest for N

People Will Move

- Northward migration of crop production
- Will require the development of rail infrastructure in the north, and probably the ability to ship more grain out of the Port of Churchill
- The new area to the North is as large as the one going out of production, but the soils are younger and less fertile

Tillage Systems

- With warmer soils no-till and minimum-till systems will become more feasible
- These systems will store soil water better, and store soil carbon better, with the latter leading to less potential for soil erosion

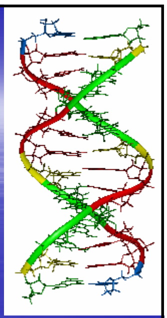
Pesticides

- Insect pests and diseases will migrate with changing climate
  - In our case they will move up from the south
  - There will also be time for more generations of insects
  - This will lead to a greater need for applications of various pesticides (insecticides, fungicides, herbicides)
- Genetically modified crops may help out in this area

Irrigation

- In some areas there will be the potential to expand the use of irrigation
  - infrastructure costs
- However, in others, as river flows decrease (more evaporation and glacier disappearance), irrigation use will decrease
- The competition between urban and agricultural uses of water will intensify

Genetics



- Conventional breeding and genetic engineering can develop plants more tolerant of heat, drought and pests, and that take more advantage of elevated CO_2 levels
- Plants better at sequestering carbon in soil and/or producing materials that substitute for fossil fuels could be developed

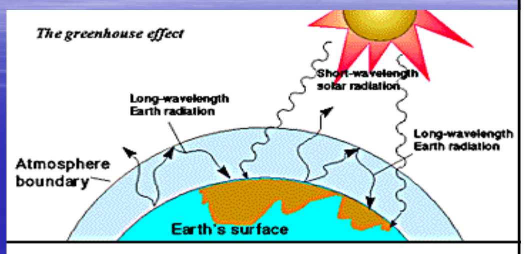
Some Others

Policy

- Policies that promote the production of established crops in a given area must be made flexible to allow the introduction of new crops and cropping practices

The Green Crop Network

- Four integrated themes
  - N_2O emissions
  - Soil C stocks
  - Plant CO_2 responses
  - Biofuel Crops



- This is a "real world" problem and the parts can not be examined in isolation, so there will be constant and necessary interactions among the themes and projects

Natural Resources Canada
McGill
Environment Canada
BIOCAP CANADA
Green Crop Network
NSERC CRSNG

General Background

- As part of a research effort to use the biosphere to manage Canada's greenhouse gas emissions we have established a national research network
  – 55 researchers at 18 universities
  – $1.2 million per year for 5 years
  – Premise that plants have untapped in this regard

- The focus is R & D
- The approach is networking