Agriculture and Agri-Food Canada
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Greenhouse Gas Management in Agriculture

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Canada

Background…….

"Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG concentrations."

"Unmitigated climate change would, in the long term, be *likely* to exceed the capacity of natural, managed and human systems to adapt."

Climate Change 2007:Synthesis Report - (IPCC: http://www.ipcc.ch/)

Climate change..... a difficult policy issue

- Long lag between cause (GHG emissions) and effect (climate change)
- Cannot <u>prove</u> that current actions will cause future interference with the climate system
  - Sound theoretical basis for concern (physics); compelling supporting evidence (measurements and modelling)
  - Ultimately, requires decisions based on uncertain predictions
- UNFCCC/IPCC have taken "precautionary approach"
  - If consequences are irreversible and potentially dangerous, it is reasonable to take mitigative action even with uncertainty
  - prevention requires action now
  - There are many win-win opportunities – at least act on those

A particular dilemma for agriculture

- By 2050 projected global population will approach 9 billion
- Food production will need to double possibly in addition to increased demand for bioenergy production
- 80% of the future increases in food production will have to come from intensification (FAO)
  - Cannot rely on area expansion *but*
  - Yield growth rates are decelerating, and
  - Land and water resources are already stressed
  - Peak oil is on the horizon (or already here?)
- Greatest impact of climate change in most vulnerable countries that lack adaptive capacity

International challenge for agriculture

How to mitigate agricultural emissions and ensure food security in spite of climate change impacts?

Current State of Play - Copenhagen Accord

- Key outcome of Copenhagen meeting
  - COP only 'taking note of' but can be the basis for a legally-binding agreement
  - Drafted by countries that represent 80% of global emissions (Kyoto countries only represent 30% of global emissions) and 4 billion people

Copenhagen Accord

- Copenhagen Accord supported by vast majority of countries
  - Limits warming to 2ºC globally
  - Sets economy-wide emission reduction targets for developed and developing countries
  - Contains financing and new mechanisms for climate action
    - $30 billion US fast – track
    - $100 billion by 2020
    - Adaptation, technology and REDD mechanisms to help least developed and vulnerable countries
- Work will continue throughout 2010 with goal of legally binding agreement in Mexico in December 2010 – including a goal for action in the agriculture sector

Domestic policy challenge

- How should Canadian agriculture sector react to international climate policy?

- What actions can farmers take to mitigate agricultural emissions?

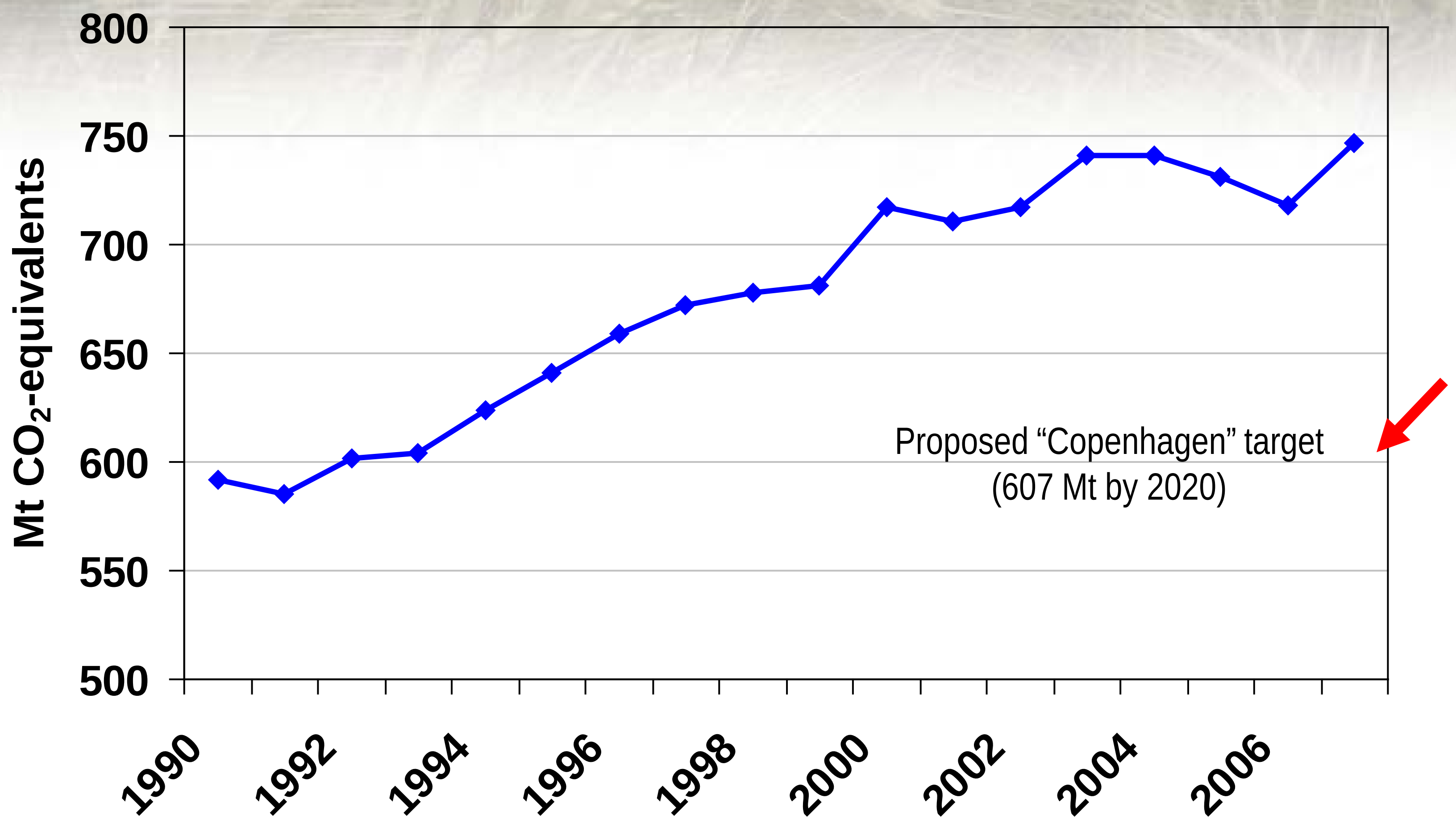
Mitigation policy for agriculture in the context of the precautionary principle

- Focus on practices that mitigate climate change and provide economic and/or other environmental benefits

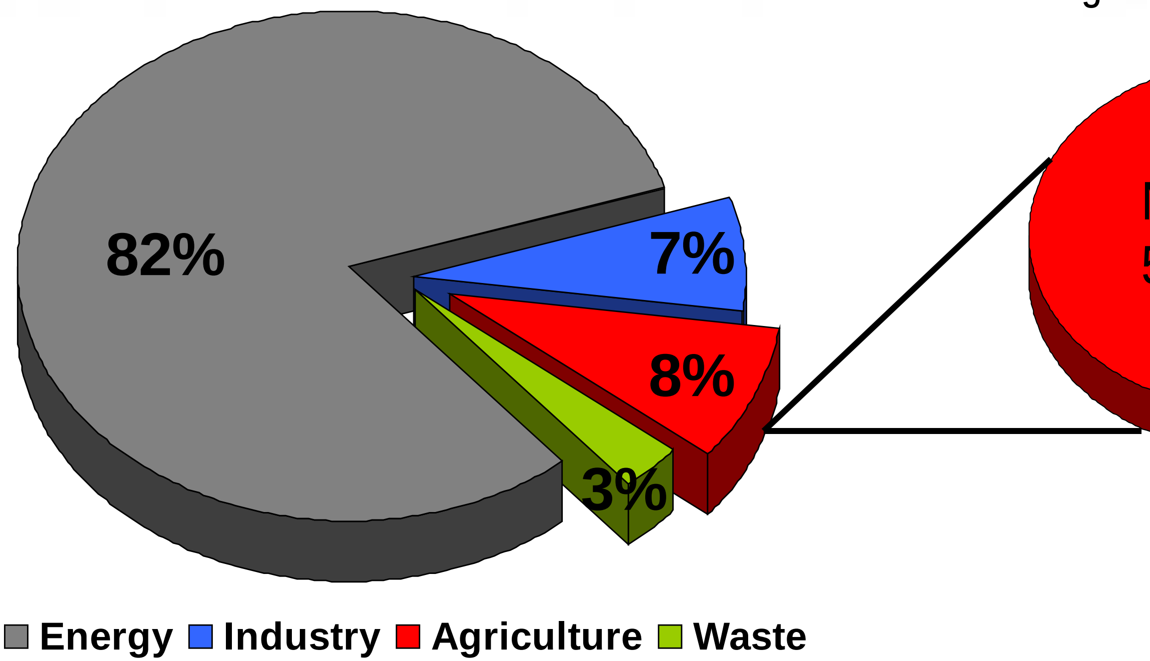
  Examples

  - Improve input use efficiency
    - Less N_2O emissions from N fertilizer is more N for the crop
    - Less CH_4 loss from livestock is more feed converted to biomass
  - Improve resilience to impacts of climate change
    - Farming systems that are vulnerable to climate change impacts will not survive in the long-term
  - Low-GHG intensity
    - Reducing GHG emissions per unit of product to ensure that food is produced with greatest efficiency possible
    - Increasing international interest - carbon footprint, life cycle analysis of food systems.

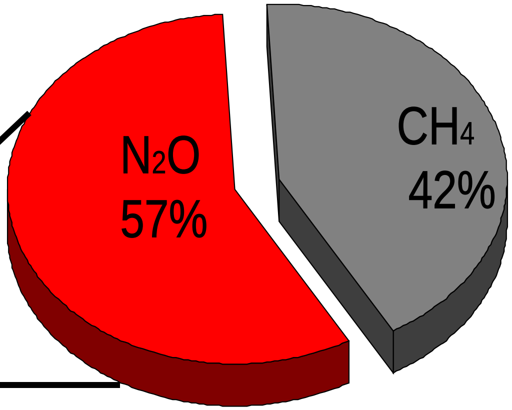
Canada's Greenhouse Gas Emissions Trend



Canada's anthropogenic GHG emissions by sector

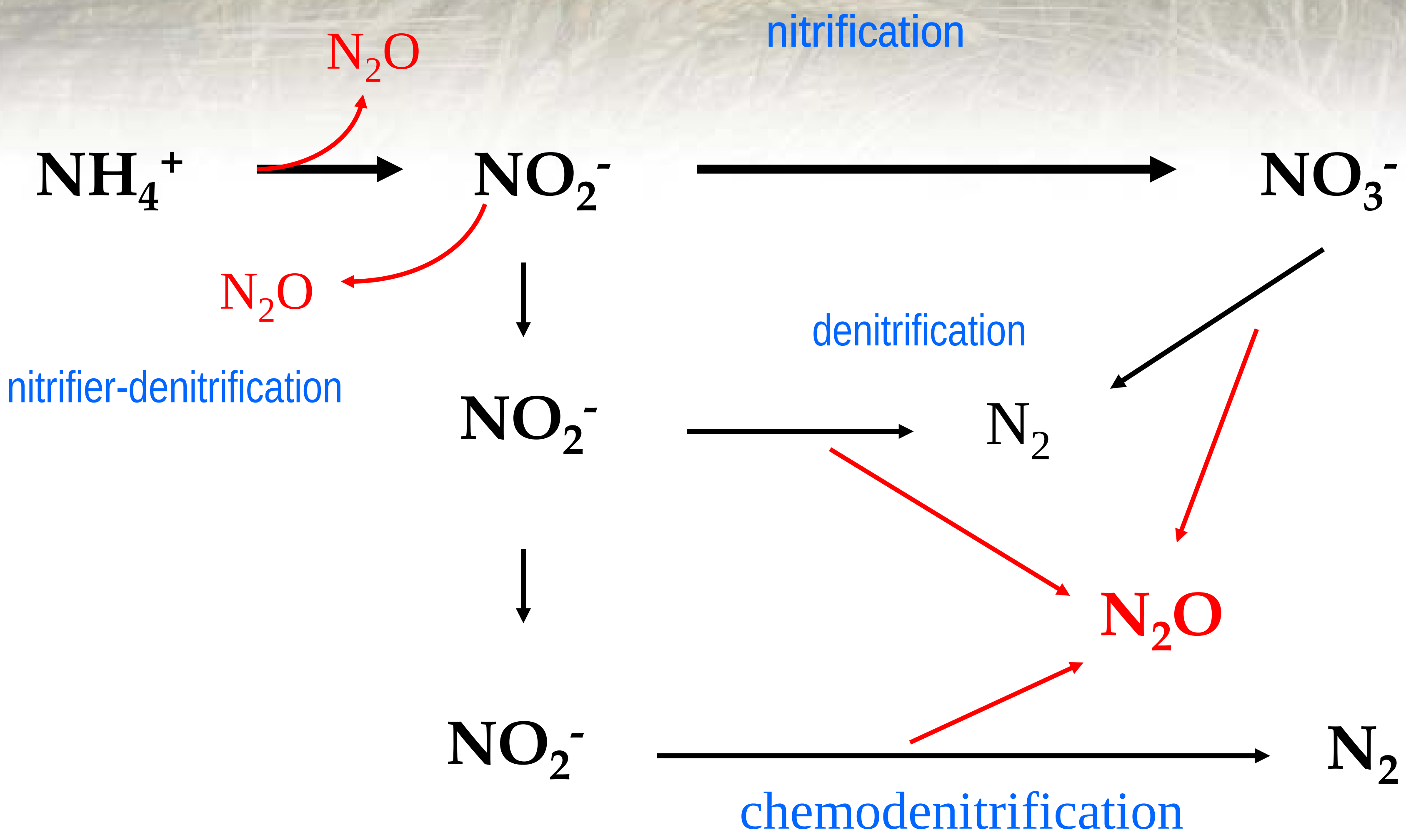


Agriculture emissions by gas



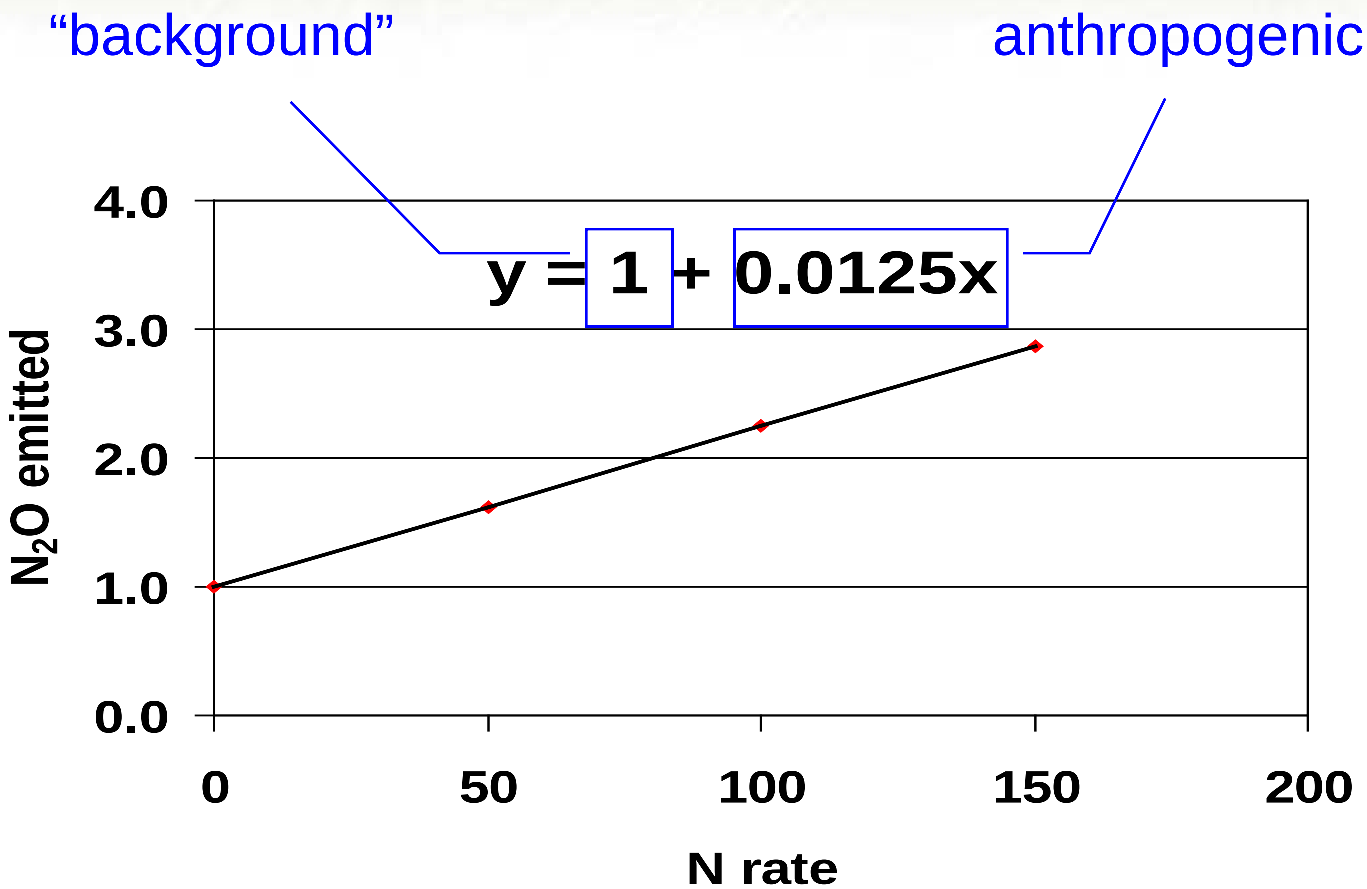
Environment Canada, *National Inventory Report: 1990-2007, GHG Sources and Sinks in Canada*

Sources of soil-emitted N_2O

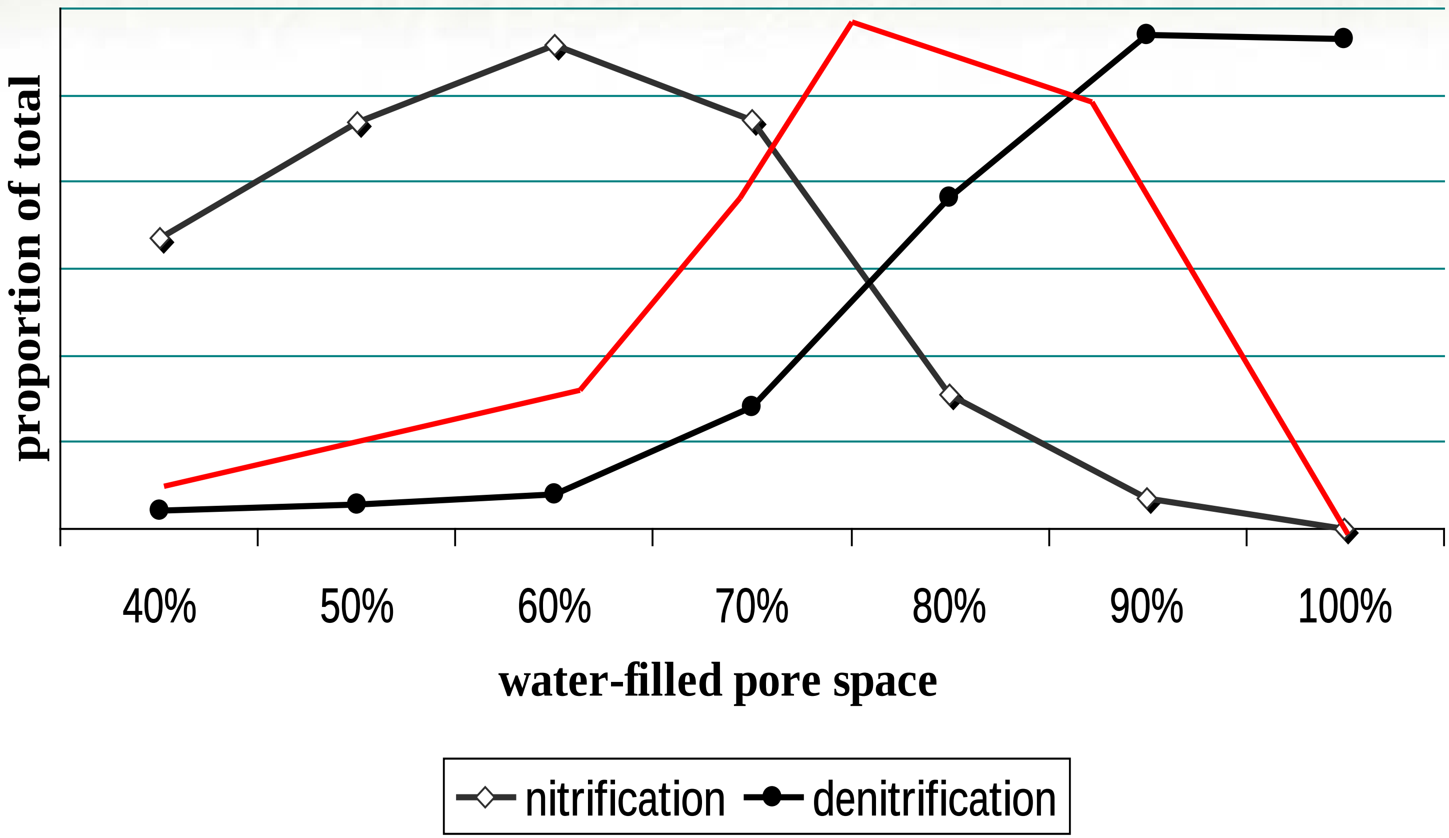


Original derivation of IPCC coefficient for soil-emitted N_2O

Total N_2O DIRECT = Ninputs * EF1



Conceptualization of the influence of WFPS on nitrification, denitrification, and N_2O emission rates

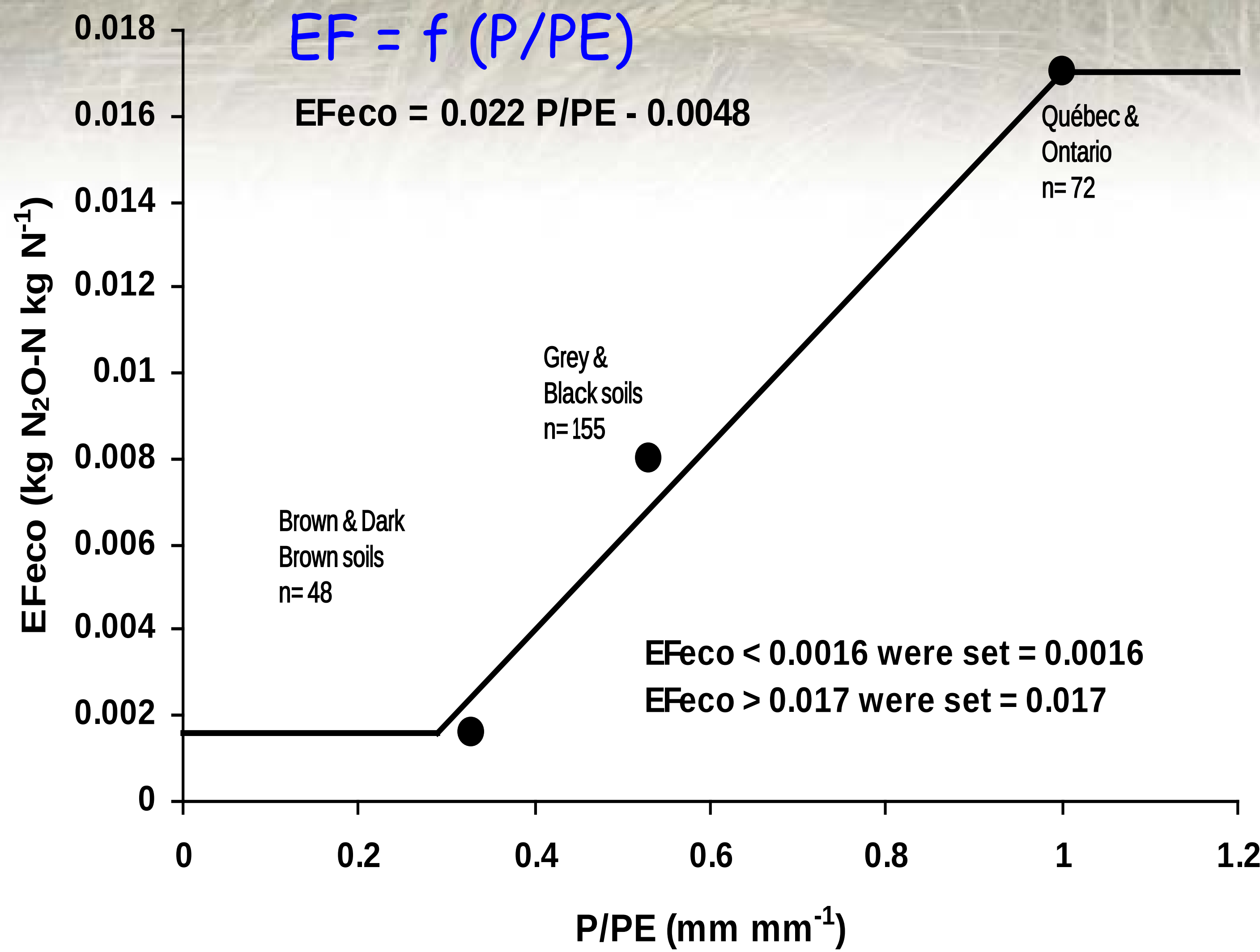


Tier II methodology for calculating N_2O Emissions.

$Soil_N_2O = Ninputs_N_2O + $ "modifiers"

$Ninputs\_N_2O = (Fertilizer\ N + residue\ N + manure\ N)*EF$

Emission factor as a function of local climate



(Source: Rochette et al., 2008)

Calculating N_2O Emissions

EFeco = EF calculated specifically for each ecodistrict

Reference situation = "a non-irrigated soil located in
well- drained portions of the landscape
under conventional tillage practices"

Calculating N_2O Emissions

$$\text{Soil\_N}_2\text{O} = \text{Ninputs\_N}_2\text{O} + \text{fallow\_N}_2\text{O}$$

$$+ \text{irrigation\_N}_2\text{O} + \text{topography\_N}_2\text{O}$$

$$+ \text{tillage\_N}_2\text{O} + \text{texture\_N}_2\text{O}$$

Source: Rochette et al. (2008)

Soil N_2O emissions: *Tillage*

$$N_2Otill = N_2Oinputs \times (RFtill - 1) \times Ftill$$

RFtill = Tillage Ratio Factor
Ftill = Fraction of agricultural land under no-till

Region	tilled	no-till	RFtill
East	1.71 kg N ha^{-1}	1.90 kg N ha^{-1}	1.1
Prairies	0.53 kg N ha^{-1}	0.44 kg N ha^{-1}	0.8

Soil N_2O emissions: *Summerfallow*

$N_2Ocrop = N_2O\ back + N_2O\ N\text{-}inputs$

$N_2Ofallow = N_2O\ back + N_2O\ fallow\text{-}effect$

$N_2Ocrop = N_2O\ fallow$

$\cancel{N_2O\ back} + N_2O\ fallow\text{-}effect = \cancel{N_2O\ back} + N_2O\ N\ inputs$

$N_2O\ fallow\_effect = N_2O\ N\ inputs$

Soil N_2O emissions: *Topography*

$$Topography\_N_2O = N_2O_{inputs} \times (0.017 - EF)/EF \times F_{topo}$$

F_{topo} = Fraction of agricultural land where soil moisture is likely to remain high

Lanscape type	**Positions associated with F_{topo}**	**F_{topo}**
Inclined +Dissected	none	**0**
Steep	none	**0**
Undulating	Depressions	**0.08**
Level	Depressions	**0.06**
Terraced	Depressions	**0.10**
Hummocky + Knoll + Kettle	Depressions + ½ lower slope	**0.16**
Rolling	Depressions + ½ lower slope	**0.16**
Ridged	Depressions + ½ lower slope	**0.10**
All cultivated land		**0.10**

Assumed that N_2O emissions in lower sections of the landscape are equal to those where P/PE =1. Accordingly, an EF value of 0.017 kg N_2O kg^{-1} N was used in these areas.

(Source: Rochette et al., 2008)

Indirect N_2O emissions

Indirect_N2O = (Nleach)*EF + (Nvolat)*EF

Nvolat = Fraction of N input lost via volatilization

- Fertilizer N = N applied * 0.1
- Organic N = N applied * 0.3

- EF = 0.1

Indirect loss of N_2O

Indirect_N2O = (Nleach)*EF + (Nvolat)*EF

Nleach = Fraction of N input lost via leaching

IPCC Tier I - Nleach varies between 0.3 and 0.05

Canadian Tier II – accepted 0.3 and 0.05 as upper and lower boundaries and developed relationship with P/PE

EF = 0.075

Summary: Inventory of soil-emitted N_2O

- Emissions factor now calculated for each year and each ecodistrict based on a relationship with P/PE
- Emissions for summer fallow assumed equal to cropped situation (N_2O from “crops” a proxy for N_2O from fallow)
- Emission factor adjusted for landscape position and a modifier included for tillage
- Leaching losses calculated based on relationship with P/PE

The Alberta example …

Climate Change and Emissions Management Act

"Establishing market demand through regulated emission reduction targets for large emitters;" and

" Enabling market supply through allowing emission offsets as a compliance option for regulated emitters."

Alberta Offset System Protocols

- Quantification protocol for tillage system management (approved)
- Draft nitrous oxide emission reduction quantification protocol
- Draft summerfallow reduction agricultural practices quantification protocol

http://carbonoffsetsolutions.climatechangecentral.com

Alberta Offset System Protocols

Quantification protocol for tillage system management (approved)

- - Principle motivation is carbon sequestration

  - Nitrous oxide reduction calculation is included

Draft summerfallow reduction agricultural practices quantification protocol

- principle motivation is carbon sequestration

- neutral for nitrous oxide emissions

Draft nitrous oxide reduction quantification protocol

- based on the "4R Nitrogen Stewardship Plan"

www.ipni.net/4r

Nitrogen fertility management

- Fall applied N increases risk of N_2O loss during spring thaw and pre-plant period
- Risk of N_2O loss greatest from lower slopes & depressions
  - Precision application?
  - coated products or nitrification inhibitors ?
- N applied in excess of crop needs will increase risk of N_2O loss
  - Rate determined by soil test or N balance calculation ?
- Pulse crops in rotation reduces fertilizer N requirements and N_2O emission

Negotiating challenge: two views of the future of agriculture

Productivity and efficiency (how to feed 9 billion people)	*versus*	Diversity and resilience (how to adapt)
Agribusiness Biotechnology High input Global markets	*versus*	Traditional methods Organic Low input Local markets
Developed countries Industry	*versus*	Developing countries ENGOs, indigenous people

This is not a dichotomy - practical solutions will have to draw from both sides to meet local conditions and needs

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