

# Soil N<sub>2</sub>O Emissions

## Possible refinements to the IPCC 2006 Guidance

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# Outline

- Soil N<sub>2</sub>O Production - Controls
- Possible refinements to the 2006 IPCC Guidance
- Actions needed



# Soil N<sub>2</sub>O production - Conceptual Model

Distal  
factors

Accounting for all direct and interactive impacts of controlling factors on soil N<sub>2</sub>O production and emission is a daunting task!

... and we can't

... but could we go beyond a "one-fits-all" EF1?

irrigation

management

Soil N<sub>2</sub>O  
production

structure,  
porosity

crop type  
fallow

moisture  
pH

C

landscape

manure  
(amount/properties)

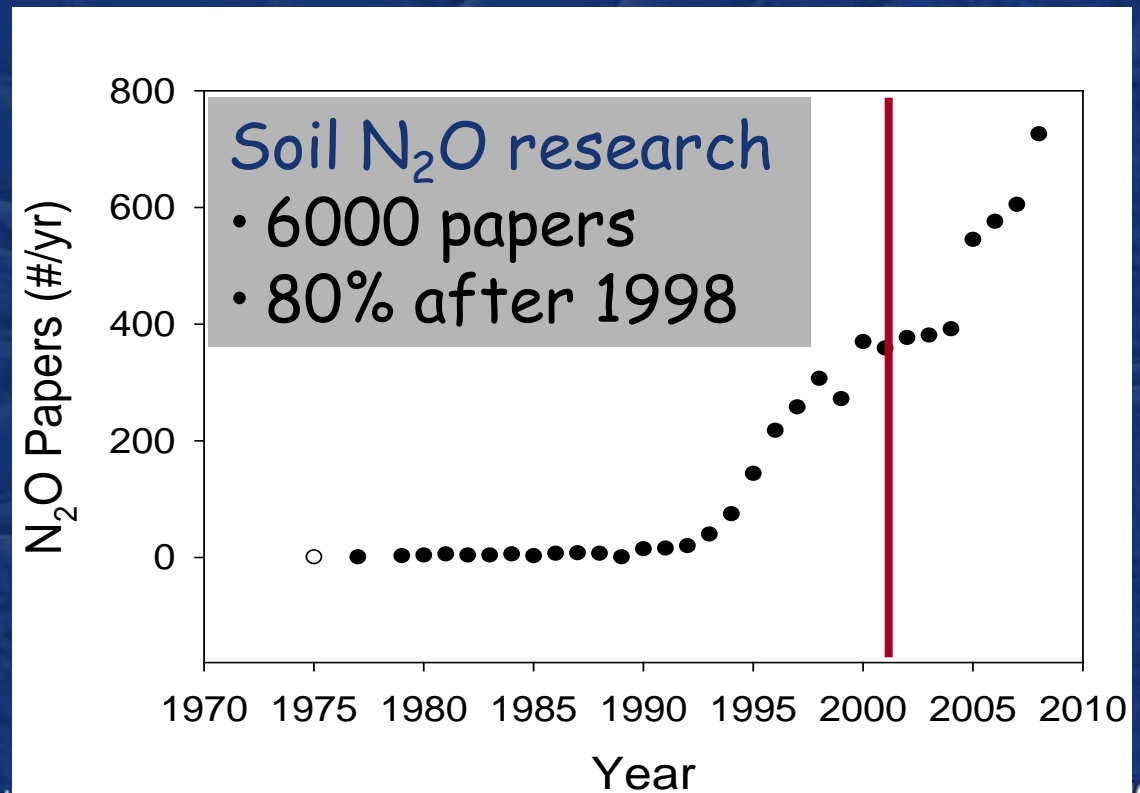
climate/weather

crop residues  
(amount/properties)



# Beyond a "one-fits-all" EF1?

- EF1 = 1 % of added N as synthetic fertilizers, manure and crop residues
- Current EF1 is based on 50% of literature
- Revisit?



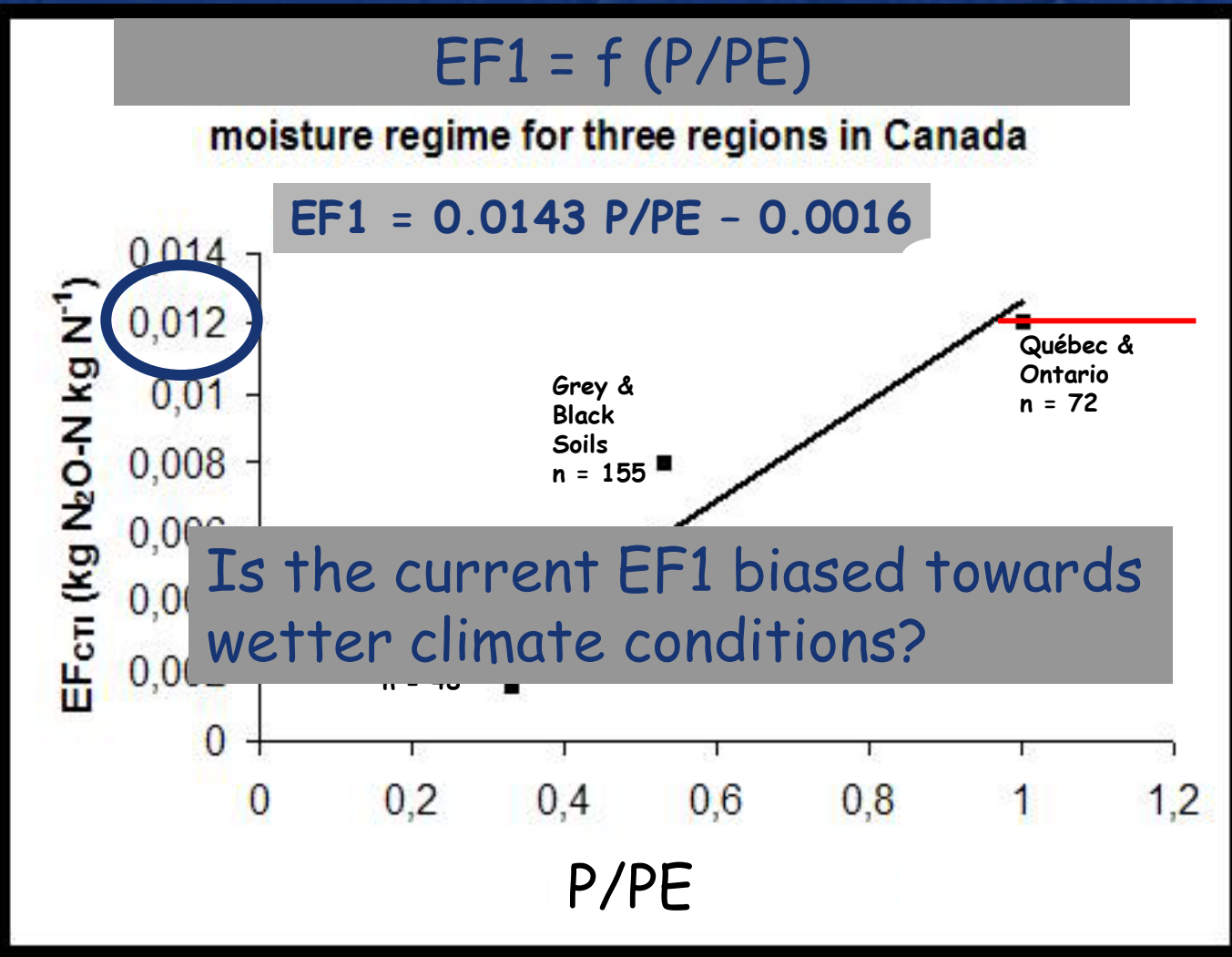
# Beyond a "one-fits-all" EF1?

- Regional variations

Canadian Region	Emission Factor (kg N <sub>2</sub> O-N kg <sup>-1</sup> N)
Québec-Ontario	0.012
Prairies (Black soil zone)	0.008
Prairies (Brown soil zone)	0.0016

# Beyond a "one-fits-all" EF1?

- Account for local climate?





# Beyond a "one-fits-all" EF1?

- Account for soil texture?
  - A fine-textured soils' problem?
  - In Canada, emissions on clay soils double those on sandy soils



# Beyond a "one-fits-all" EF1?

- Could mathematical models help in estimating local EF1s?
  - Account for local climate, soils and practices
    - o DNDC
    - o DayCent



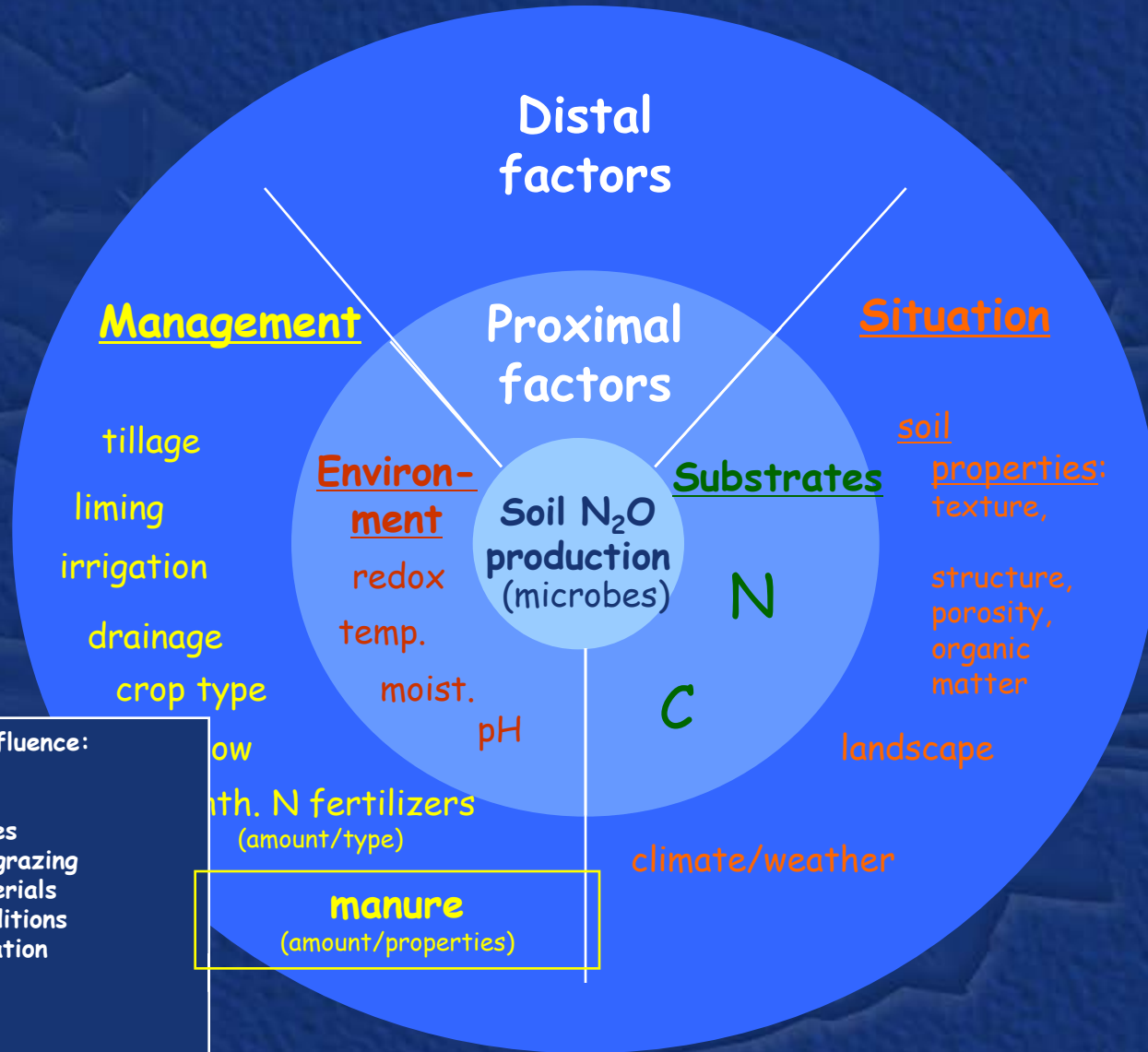


# Beyond a "one-fits-all" EF1?

- EF1 specific for manure and crop residues?



# Soil N<sub>2</sub>O production - Conceptual Model



## Manure properties influence:

### C and N substrates

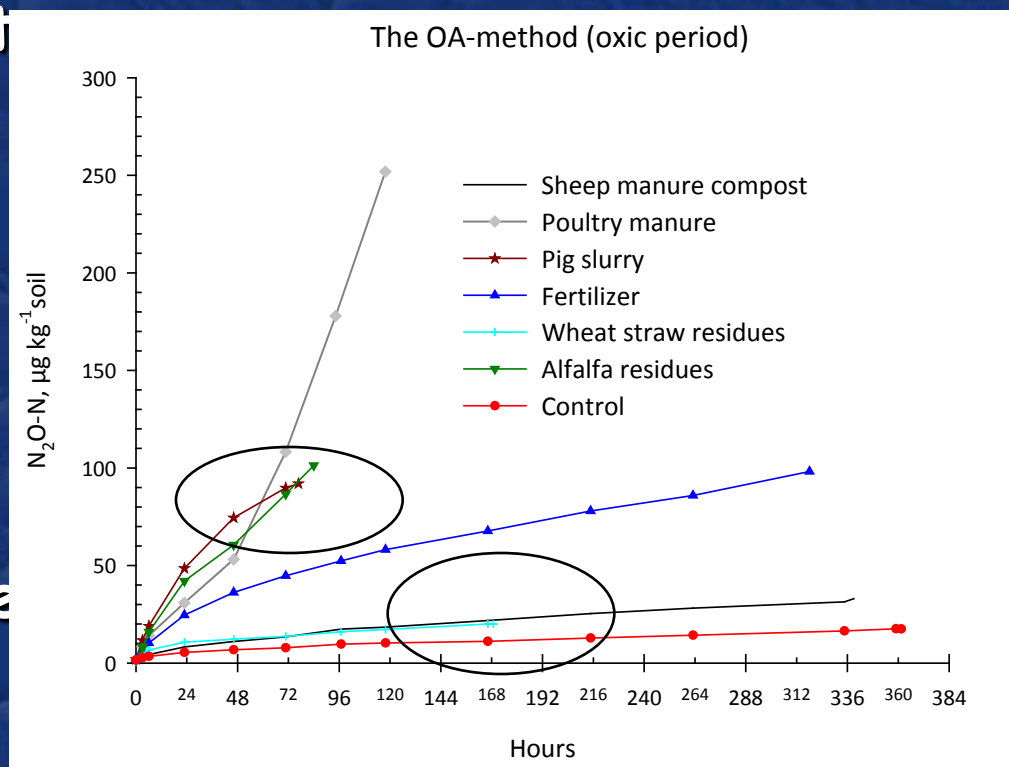
- Diet
- Animal species
- Confined or grazing
- Bedding materials
- Storage conditions
- Storage duration
- Treatment

### Soil environment

- Mode of application
- Time of application
- Crop type
- History

# Beyond a "one-fits-all" EF1?

- Most often EF is different for organic N than for synthetic N
- Account for C:N ratio or other properties of manure and residues?



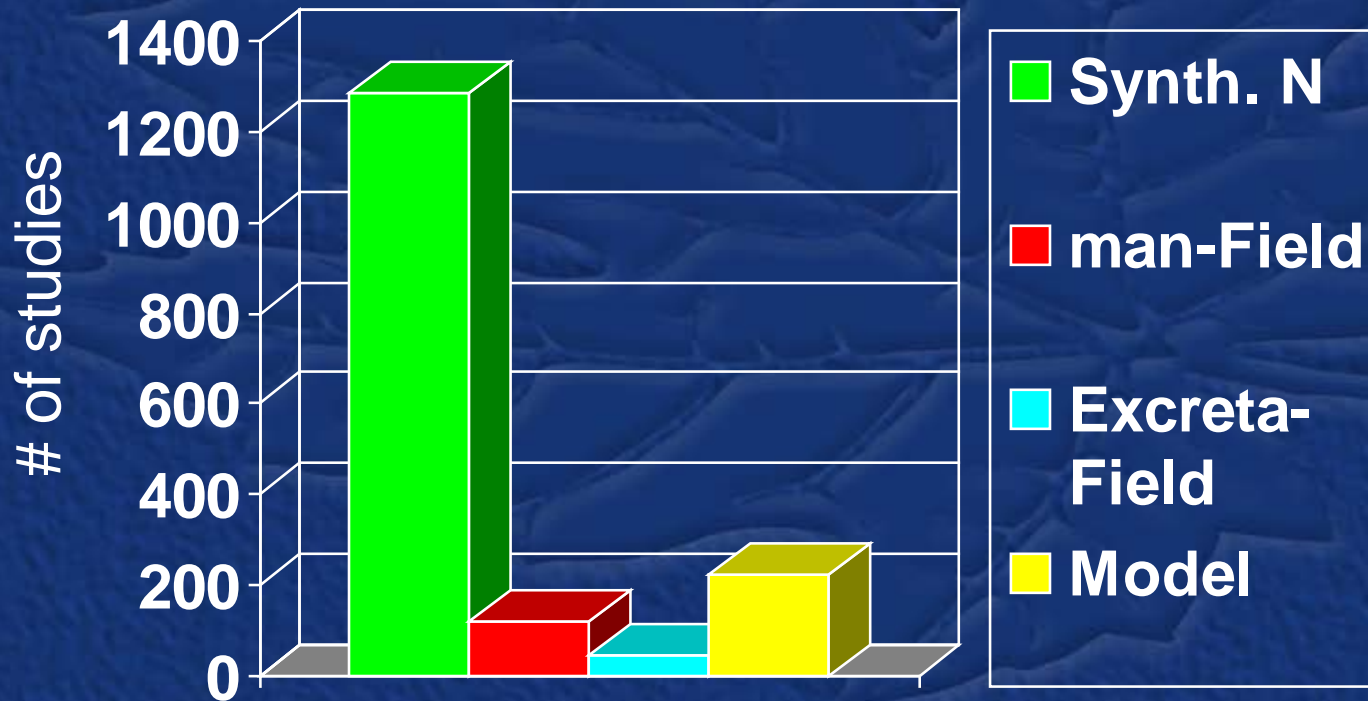
(Anaïs Charles, unpublished)





# Few studies on organic N sources may be a limiting factor

Not likely to improve estimate of  $EF3_{PRP}$



# EF2 Managed Organic soils

- Maljanen et al. (Biogeo. 2010)
  - 9.6 kg N<sub>2</sub>O-N ha<sup>-1</sup>
  - Close to current factor



# Indirect Emissions

- Crutzen et al., (ACPD, 2007)
  - Top-down approach
  - 3-5% of N inputs
  - Argue that IPCC Tier I is underestimating indirect agricultural sources of  $N_2O$
- Several other papers recently addressed the Indirect Emissions
- Revisit indirect methodology?





# Other sources?

## Some BNF N input?

- Account for N inputs by BNF in legume-grass improved pastures?
- Evidence from NZ that BNF increases background emissions



# Other sources

## Small-scale features?

- Matthews et al (AEE, 2010)
  - Livestock farms (watering holes, gateways, leaking manure storage, ditches, etc)
  - Hotspots (up to 300 kg N<sub>2</sub>O-N ha<sup>-1</sup>)
  - Up to 15% of total farm emissions
- 
- Modify PRP?
  - Modify indirect emissions?



# Actions needed

- EF1
  - Review recent literature
  - EF1 that accounts for soil texture, climate, chemical properties of organic N sources?
  - Use models to derive local EFs?
- EF2
  - Temperate seems OK
  - Tropical?
- EF3<sub>PRP</sub>
  - Not likely to have enough new studies to revisit
- Indirect emission methodology
  - Revisit
- Other sources
  - BNF-N inputs in grass-legumes pastures?
  - Small-scale features?







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# Is the current advice clear?

- Error in equation 11.7A

## EQUATION 11.7A

ALTERNATIVE APPROACH TO ESTIMATE  $F_{CR}$  (USING TABLE 11.2)

$$F_{CR} = \frac{\sum}{T} \left\{ \frac{AG_{DM(T)} \cdot (Area(T) - Area_{burnt(T)} \cdot CF) \cdot Frac_{Renew(T)} \cdot \left[ N_{AG(T)} \cdot (1 - Frac_{Remove(T)}) + R_{BG-BIO(T)} \cdot N_{BG(T)} \right]}{N_{AG(T)} \cdot (1 - Frac_{Remove(T)}) + R_{BG-BIO(T)} \cdot N_{BG(T)}} \right\}$$

### 1. Units mismatch.

$AG_{DM}(T)$  calculated from Table 11.2 is in Mg/ha while  $F_{CR}$  is defined as being in kg/ha.

**Need to multiply  $AG_{DM}(T)$  by 1000.**

### 2. Underestimating root biomass N.

$$F_{CR} = \frac{\sum_T \{ AG_{DM}(T) * 1000 * (Area(T) - Area_{burnt}(T) * CF) * Frac_{Renew}(T) * N_{AG}(T) + (AG_{DM}(T) * 1000 + Crop(T)) * R_{BG-BIO}(T) * N_{BG}(T) \}}{N_{AG}(T) * (1 - Frac_{Remove}(T)) + R_{BG-BIO}(T) * N_{BG}(T)}$$

