

Soil-emitted N₂O from summerfallowed land on the prairies

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IPCC approach for estimating soil-emitted N₂O (Tier I)

$$\text{Total N}_2\text{O-soil} = \text{N}_2\text{O Direct} + \text{N}_2\text{O Indirect}$$

Where:

$$\text{N}_2\text{O Direct} = \text{Ninputs} * \text{EF1}$$

$$\text{N}_2\text{O Indirect} = (\text{Nvolat}) * \text{EF2} + (\text{Nleach}) * \text{EF3}$$

IPCC approach for estimating soil-emitted N₂O (Tier I)

$$\text{Total N}_2\text{O DIRECT} = \text{Ninputs} * \text{EF1}$$

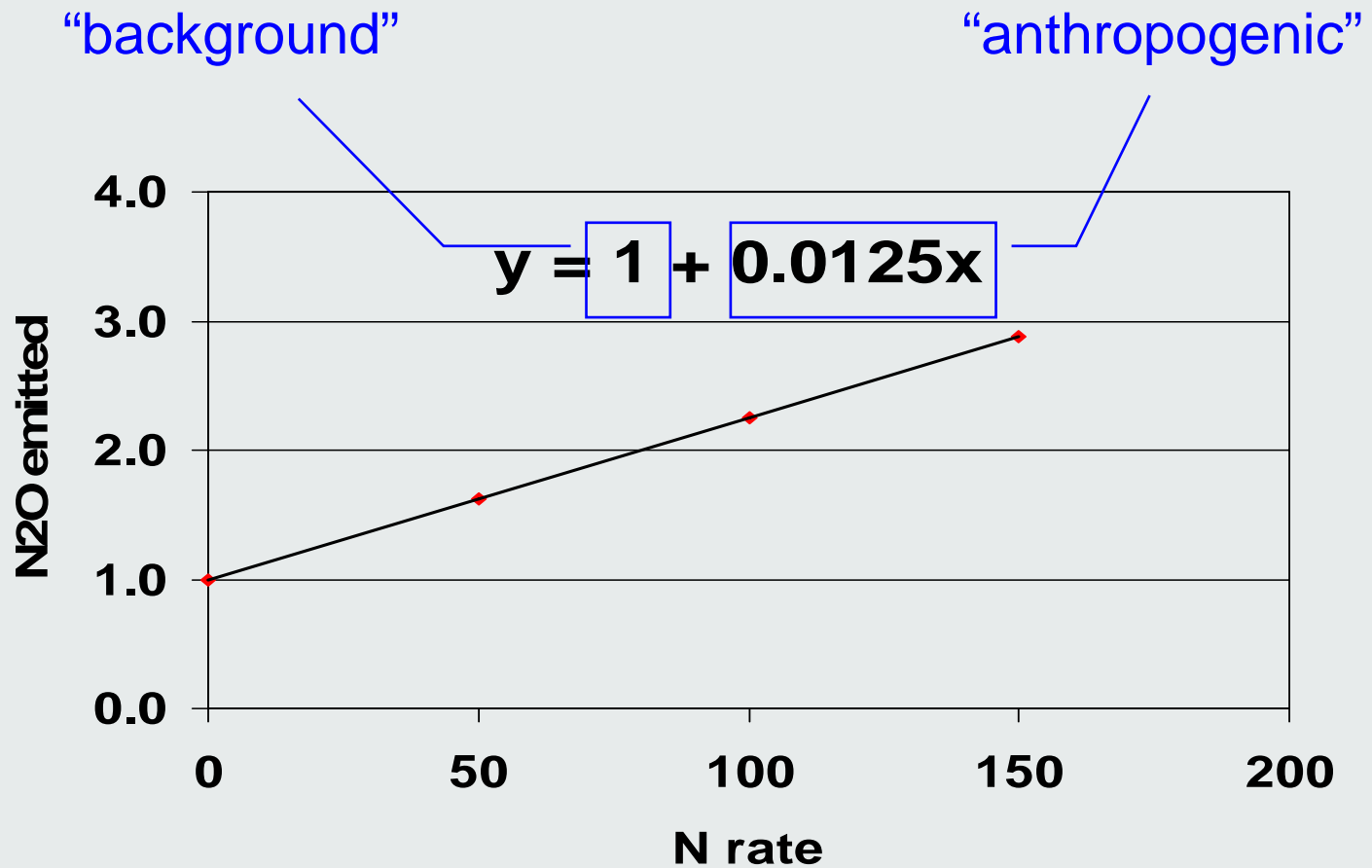
$$\text{Total N}_2\text{O DIRECT} = (\text{Nfert} + \text{Nres} + \text{Nman}) * \text{EF1}$$

where:

- Nfert = N added as inorganic fertilizers
- Nres = N in crop residues returned to soils
- Nman = animal waste N used as fertilizer
- EF1 = emissions factor for direct soil emissions

IPCC Tier I approach for estimating soil-emitted N₂O

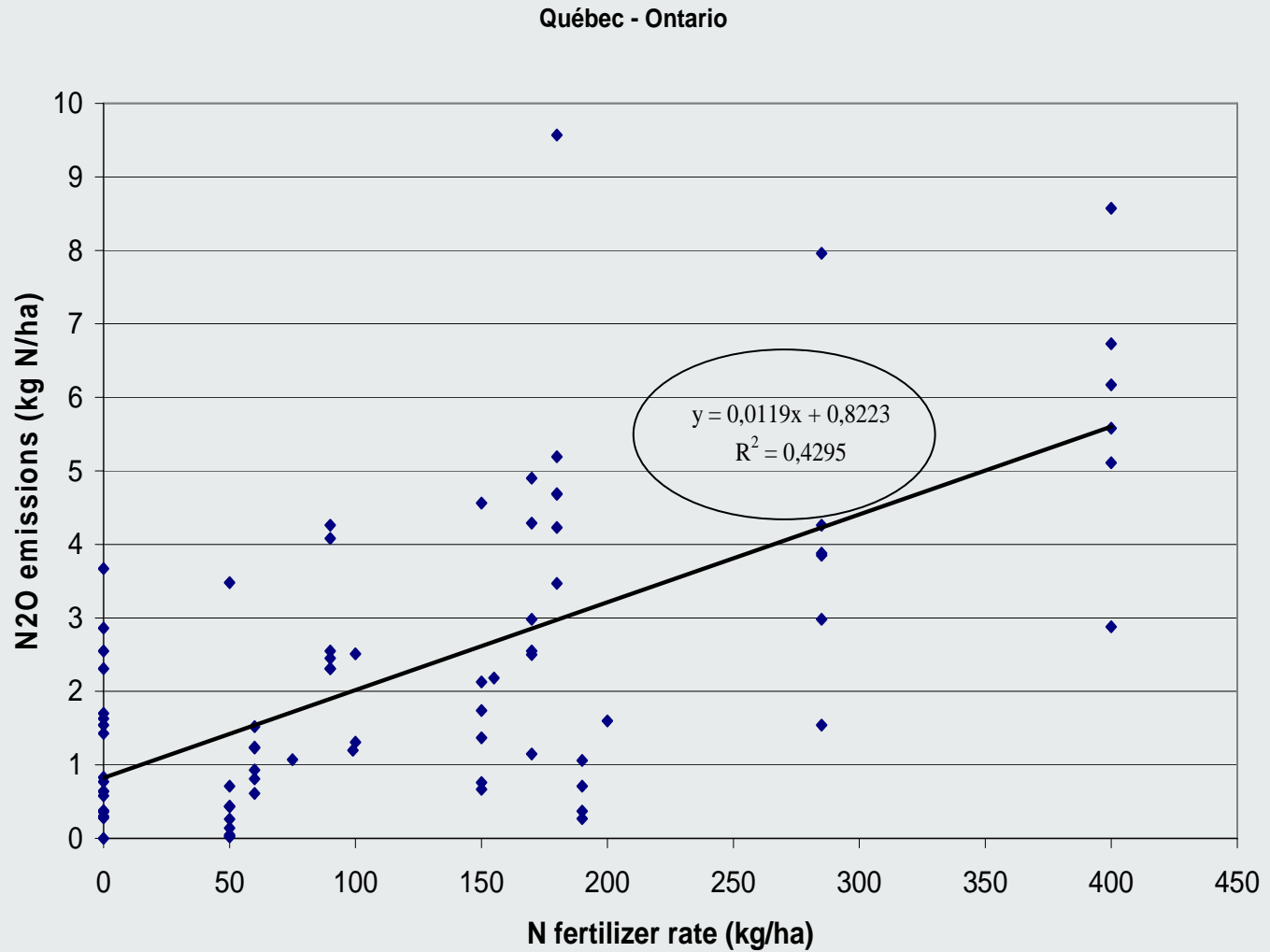
$$\text{Total N}_2\text{O DIRECT} = \text{N inputs} * \text{EF1}$$



Tier II Refinements/Additions

- A spatially- and temporally-variable emission factor determined as a function of the climatic moisture regime
- The contribution of emissions during winter and spring thaw is included (Eastern Canada)
- Emissions from summerfallow is added
- Modifiers included for:
 - soil tillage
 - Irrigation
 - landscape position
 - soil texture

EF for the Québec-Ontario Region



Soil N₂O Emissions

spring thaw

$$N_2O_{thaw} = N_2O_{inputs} \times (RF_{thaw} - 1)$$

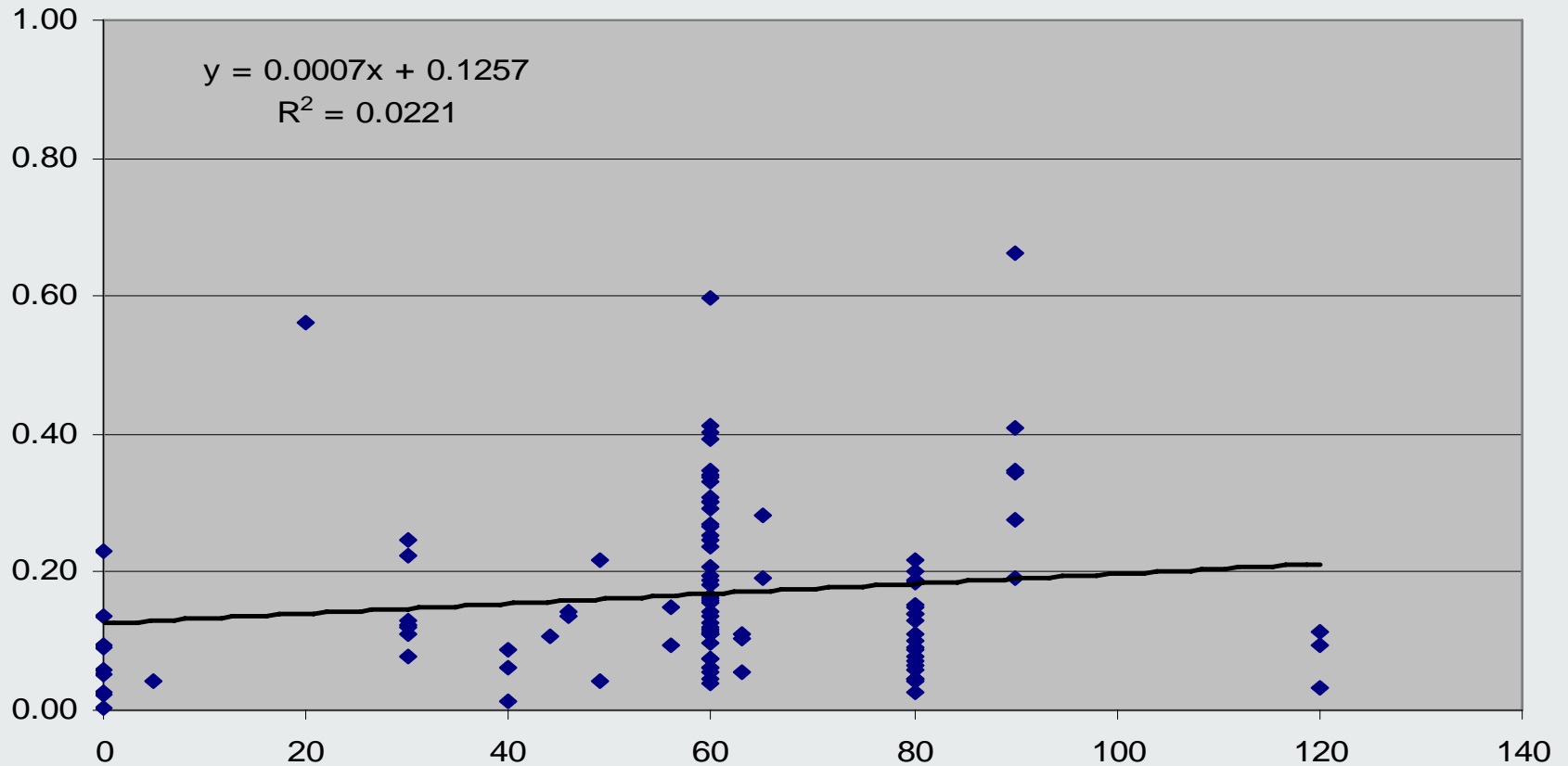
Emissions during snow-free season	Emissions * during spring thaw	RF _{thaw}
2.82 (kg N ₂ O/ha)	1.19 (kg N ₂ O/ha)	1.4

Adjusted EF for eastern Canada = **1.7** (1.2 * 1.4)

*as measured with micromet flux systems

Relationship between estimated N₂O loss and N application rate

Brown,D.Brown, T.Black

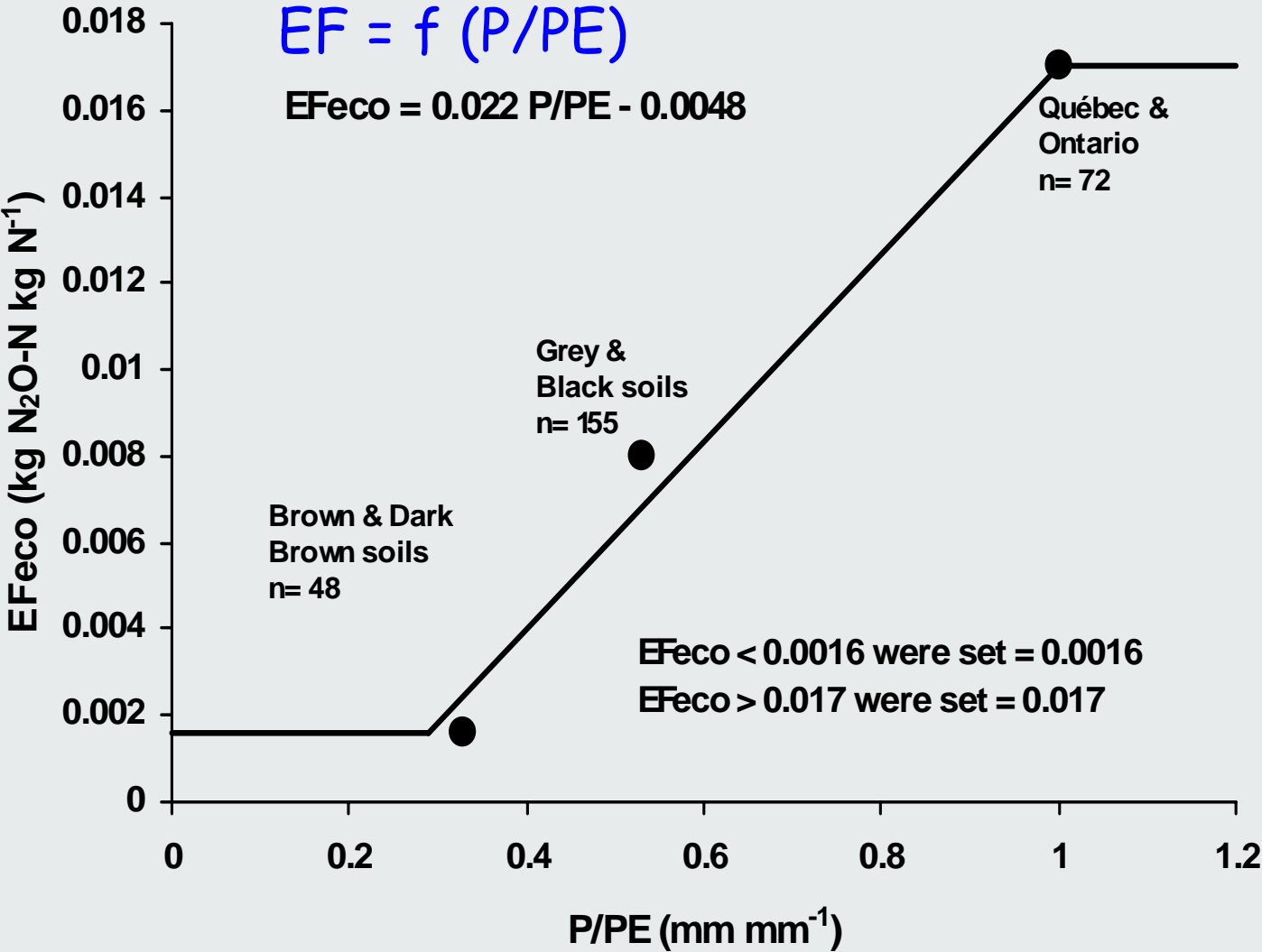


Percentage of fertilizer N lost as N₂O averaged across soil zones in western Canada

Soil Zone (Great Group)	% N lost as N ₂ O			number of studies
	Minimum	Maximum	Mean	
Brown	0.0	0.4	0.2	3
Dark Brown	0.0	0.4	0.2	3
Black	0.2	1.9	0.9	4
Grey/Dark Grey	0.1	1.0	0.4	2

(sources: Burton et al. 2003; Farrell et al. 2003; Lemke et al. 1999 & 2003)

Emission factor as a function of local climate



(Rochette et al., 2008)

Calculating N₂O Emissions:

$$\text{Soil_N}_2\text{O} = \text{Ninputs_N}_2\text{O} + \text{“modifiers”}$$

$$\text{Ninputs_N}_2\text{O} = (\text{Fertilizer N} + \text{residue N} + \text{manure N}) * \text{EF}$$

EFeco = **EF** calculated specifically for each ecodistrict

Ecodistrict

Ecodistricts are characterized by relatively homogeneous biophysical and climatic conditions including regional landform, local surface form, soil development, textural group, vegetation cover/land use classes, range of annual precipitation, and mean temperature.

Ecodistrict size ~150 000 ha

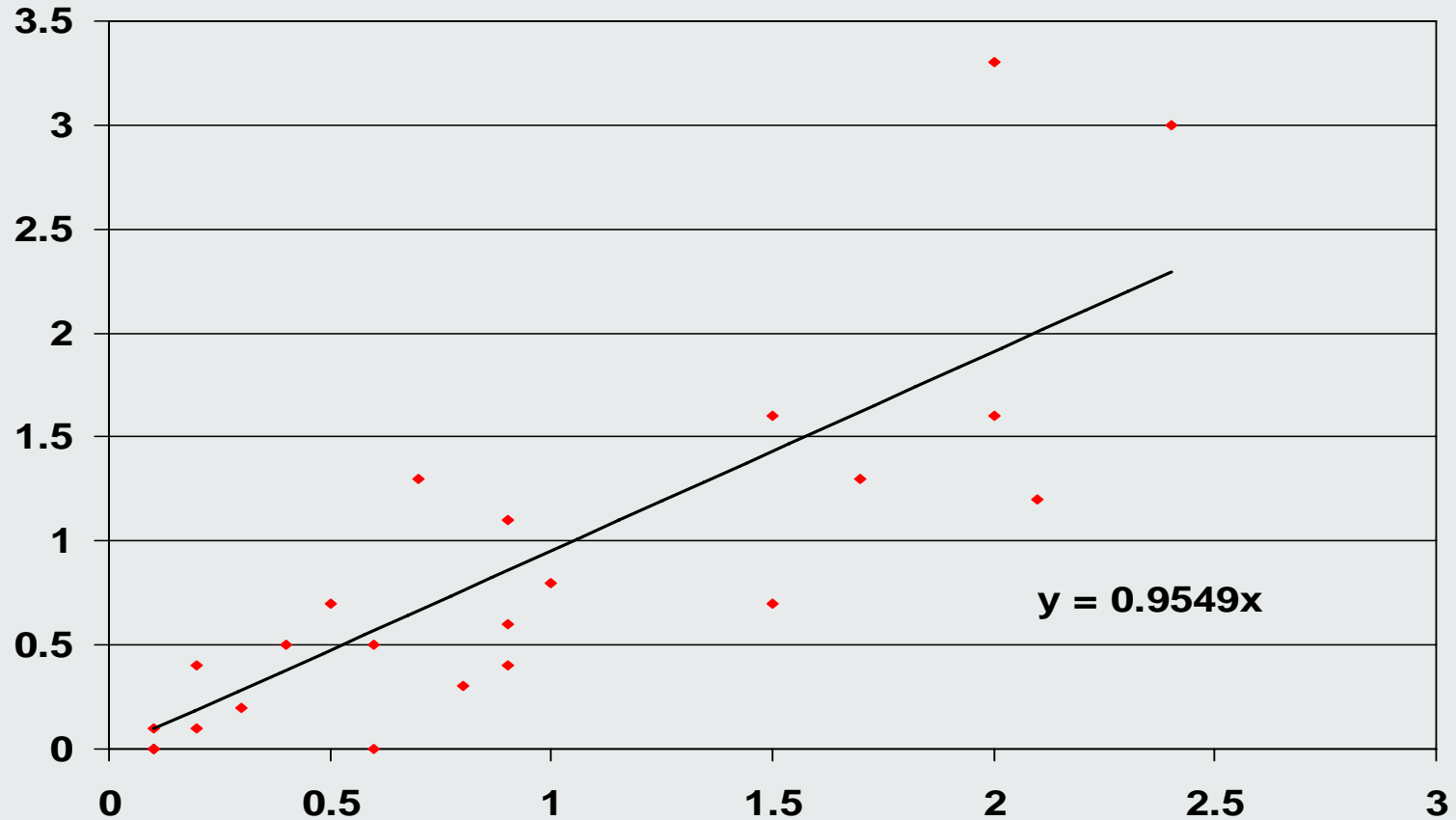
Calculating N₂O Emissions:

EF_{eco} = EF calculated specifically for each ecodistrict

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

$Soil_N2O = N_{inputs_N2O} + \text{“modifiers”}$

Annual N₂O loss from fertilized continuous wheat versus fallow at five sites in Alberta and Saskatchewan (n = 24; 12 site years x 2 tillage)



Lemke, published and unpublished data

N₂O loss from summerfallow

$$N_2O_{\text{crop}} = N_2O_{\text{back}} + N_2O_{\text{N inputs}}$$

$$N_2O_{\text{fallow}} = N_2O_{\text{back}} + N_2O_{\text{fallow_effect}}$$

$$N_2O_{\text{crop}} = N_2O_{\text{fallow}}$$

$$\cancel{N_2O_{\text{back}}} + N_2O_{\text{fallow_effect}} = \cancel{N_2O_{\text{back}}} + N_2O_{\text{N inputs}}$$

$$N_2O_{\text{fallow_effect}} = N_2O_{\text{N inputs}}$$

Soil N₂O emissions

Tillage

$$N_2O_{till} = N_2O_{inputs} \times (RF_{till} - 1) \times F_{till}$$

RF_{till} = Tillage Ratio Factor

F_{till} = Fraction of agricultural land under no-till

Region	tilled	no-till	RF _{till}
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 N₂O Emissions

Topography

$$\text{Topography_N}_2\text{O} = \text{N}_2\text{O}_{\text{inputs}} \times (0.017 - \text{EF}) / \text{EF} \times F_{\text{topo}}$$

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

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

We assumed that N₂O emissions in lower sections of the landscape are equal to those where P/PE = 1. Accordingly, an EF values of 0.017 kg N₂O kg⁻¹ N was used in these areas.

Indirect loss of N₂O

$$\text{Indirect_N2O} = (\text{Nvolat}) * \text{EF2} + (\text{Nleach}) * \text{EF3}$$

Nvolat = Fraction of N input lost via volatilization

- Fertilizer N = N applied * 0.1
- Organic N = N applied * 0.3
- EF2 = 0.1

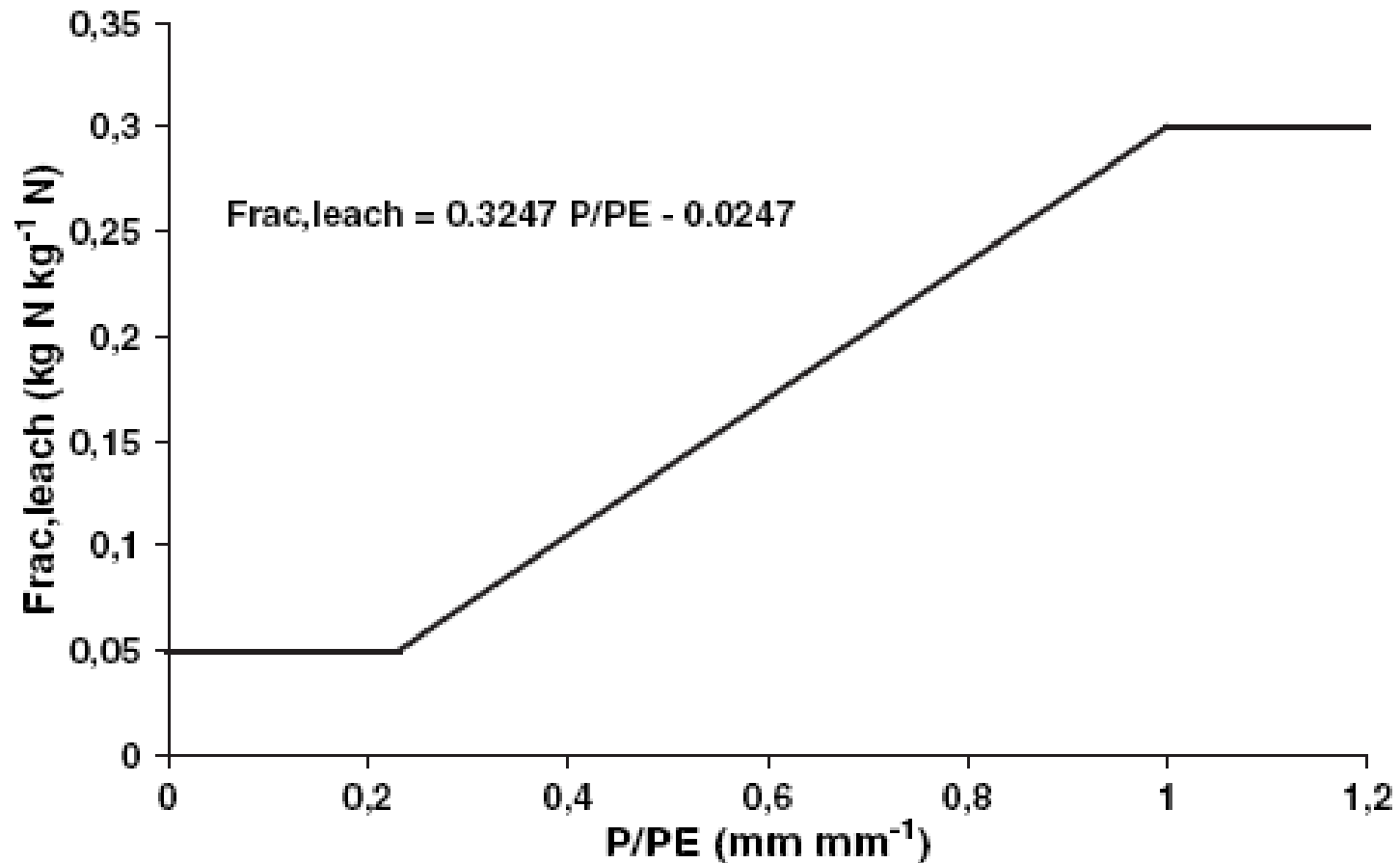
Indirect loss of N₂O

$$\text{Indirect_N2O} = (\text{Nvolat}) * \text{EF2} + (\text{Nleach}) * \text{EF3}$$

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
- EF3 = 0.075

Calculating Nleach – Canadian Tier II



Summary

- 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

Thank you for your kind attention!



Mean “pre-thaw” soil-nitrate concentration vs. estimated N₂O-N loss at six locations in Alberta

