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Calculation of NH_3 emissions from crop residues

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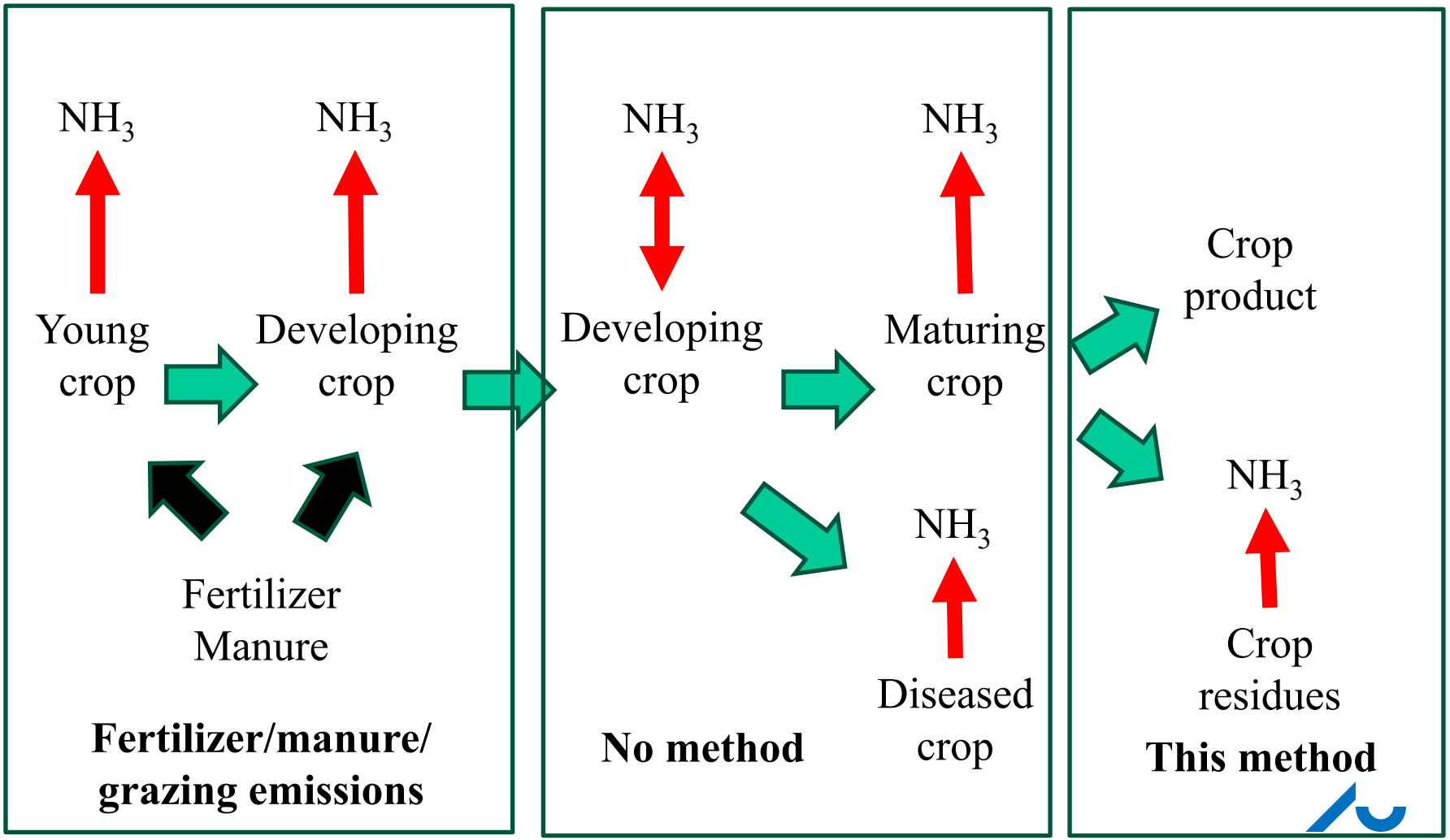
Format

- Step through the methodology
- Feel free to interrupt to ask for clarification
  - Raise hand or write question in Chat box
- Opportunity to ask questions
  - At the end of this webinar
  - Afterwards by email

NH_3 emissions from cropping



NH_3 emissions from crop residues

- Emissions occur under the following conditions:
  - plants/plant parts die or are killed and there is decomposition of protein to ammonium
  - the plant material is exposed to the atmosphere
  - the nitrogen concentration in the residue is above a threshold value
- Emissions are small (<1–3 kg ha^{-1} $year^{-1}$), but given the large areas of crops, the total may be significant at the national scale
  - <5% for The Netherlands (livestock intensive)
  - 1% for Taiwan

Calculation of NH_3 emissions from crop residues

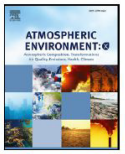
- de Ruijter and Huijsmans (2019) developed a robust methodology
  - now incorporated into The Netherlands emission inventory
- Methodology adapted for inclusion in the 2023 Guidebook

Atmospheric Environment: X 2 (2019) 100028

Contents lists available at ScienceDirect

Atmospheric Environment: X

journal homepage: www.journals.elsevier.com/atmospheric-environment-x



A methodology for estimating the ammonia emission from crop residues at a national scale

F.J. de Ruijter*, J.F.M. Huijsmans

Wageningen University and Research, Agrosystems Research, P.O. Box 16, 6700 AA, Wageningen, the Netherlands

Sources of crop residues

- Residues left on the soil surface after harvesting
- Residues left on or added to the soil surface after other management actions such as:
  - trimming pasture to stimulate fresh growth
  - killing crops with herbicides
  - desiccating potato haulms
  - mulching to controlling erosion
- Green manures (cover crops) that die after frost

Methodology builds on IPCC N_2O emissions from crop residues

- Minimize the need for new activity data
- Harmonize with greenhouse gas emission estimates
- Main differences from IPCC N_2O methodology:
  - Only surface residues are included
  - No emission from low N concentration residues
  - Residues present for ≤3 days are ignored

Calculation of NH_3 emissions from crop residues

Sum for each crop

Fraction of N_Load_T remaining on the surface for 3 or more days

$$NH_{3\_cropresidues} = \frac{17}{14} * \sum_{T=1}^{T_{max}} (A_T * N\_Load_T * F_T * EF\_cropresidue_T)$$

Conversion from kg NH_3-N to kg NH_3

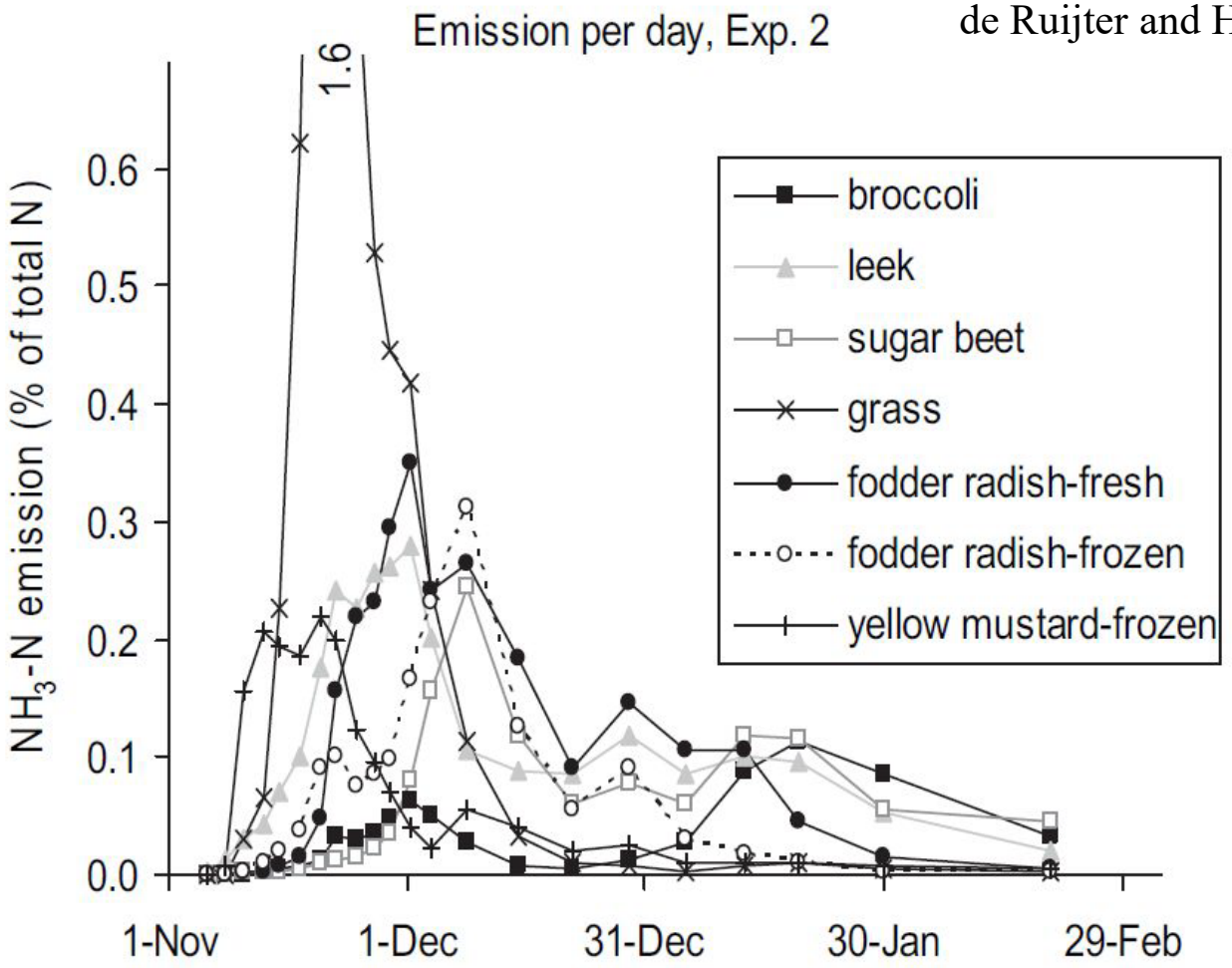
Area of crop T (ha)

Amount of N in the residues from crop T (kg N/ha)

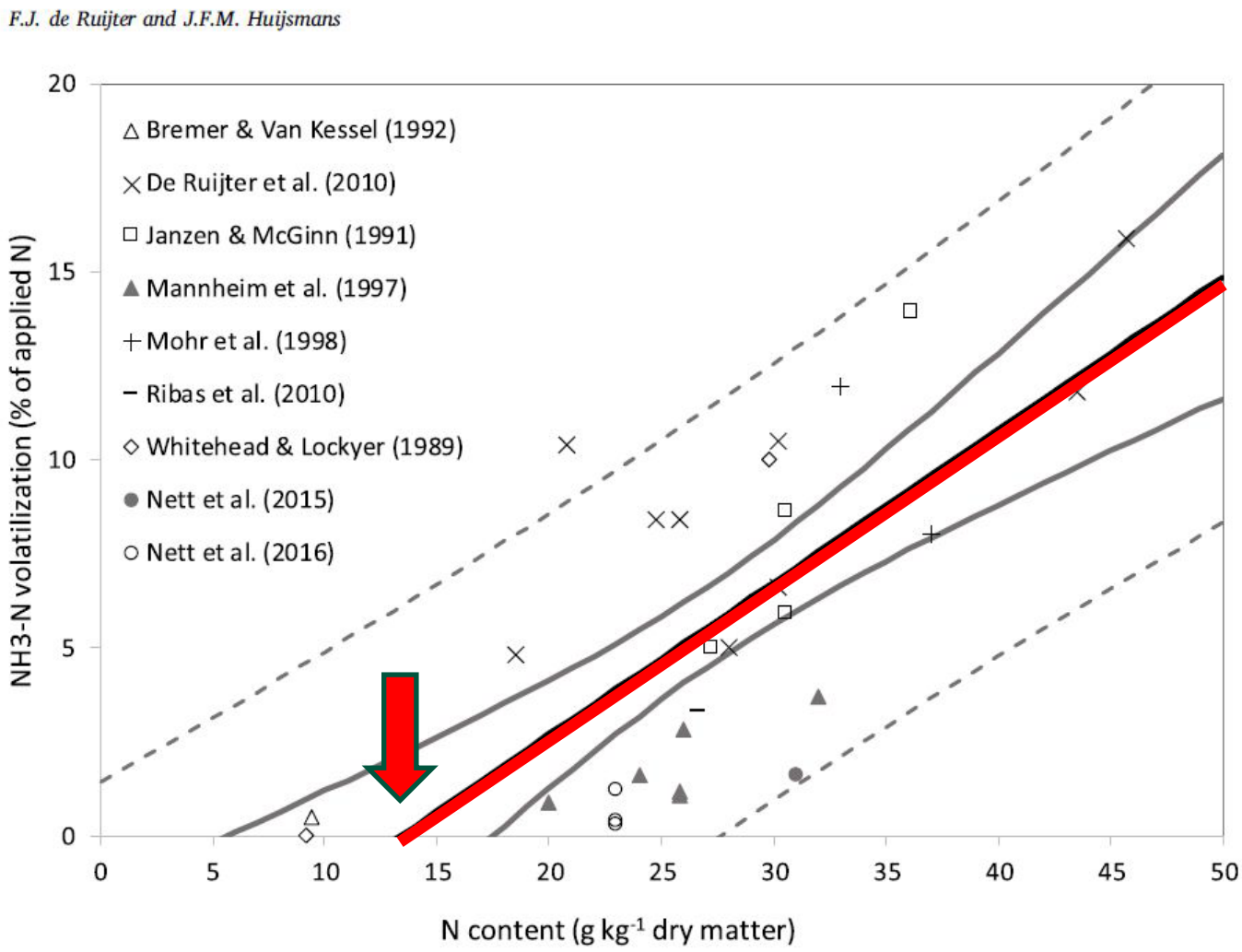
Emission factor for residues from crop T (kg NH_3-N/(kg N))

F_T - why the 3 day threshold?

de Ruijter and Huijsmans (2019)



Why a minimum residue N concentration?



NH_3 emissions from crop residues – using the IPCC N_2O format

$$NH_{3\_cropresidues} = \frac{17}{14} * \sum_{T=1}^{T_{max}} (A_T * N\_Load_T * F_T * EF\_cropresidue_T)$$

National total of N in above-ground residues of crop T

IPCC (2019)

$$F_{CR} = \sum_{T=1}^{T_{\max}} \left(\left\{ AGR_T N_{AG(T)} \left(1 - Frac_{\mathrm{Re}move(T)} - \left(Frac_{Burn(T)} C_f \right) \right) \right\} + BGR_{(T)} N_{BG(T)} \right)$$

National total of N in above-ground residues of crop T

Fraction removed removed/burnt for crop T

National total of N in below-ground residues of crop T

N FROM CROP RESIDUES AND FORAGE/PASTURE RENEWAL (TIER 1)

$$AGR_T = AG_{DM(T)} A_T$$

Total national above-ground residue production of crop T (kg DM)

Above-ground residue production of crop T (kg DM/ha)

Total national area of crop T (ha)

DM = dry matter

Above-ground: IPCC (2019)

$$A_T AG_T N_{AG(T)} \left(1 - Frac_{\mathrm{Re}move(T)} - \left(Frac_{Burn(T)} C_f\right)\right)$$

Total national above-ground residue production of crop *T* (kg DM)

Fraction of residues removed or burnt

Concentration of N in above-ground residue of crop *T* (kg N/kg DM)

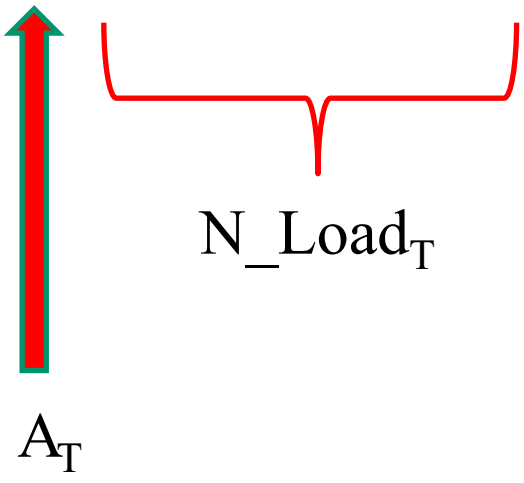
Calculation of NH_3 emissions from crop residues

$$NH_{3\_cropresidues} = \frac{17}{14} * \sum_{T=1}^{T_{max}} (A_T * N\_Load_T * F_T * EF\_cropresidue_T)$$

Emission source – crop residues

Above-ground source of N_2O in IPCC (2019):

$$A_T AG_{DM(T)} N_{AG(T)} \left(1 - Frac_{\mathrm{Re}move(T)} - \left(Frac_{Burn(T)} C_f\right)\right)$$



Calculation of NH_3 emissions from crop residues

$$NH_{3\_cropresidues} = \frac{17}{14} * \sum_{T=1}^{T_{max}} (A_T * N\_Load_T * F_T * EF\_cropresidue_T)$$

F_T

- Only crop residues remaining on the soil surface for 3 days or more are considered to emit NH_3
- Introduce an additional fraction ($Frac_{Incorp(T)}$), the fraction of residues incorporated within 3 days
- Introduce two new parameters:
  - α = fraction of $Frac_{Remove(T)}$ removed within 3 days
  - β = fraction of $Frac_{Burn(T)}$ burnt within 3 days

F_T

$$F_T = 1 - \left(Frac_{Incorp(T)} + \alpha Frac_{\mathrm{Re}move(T)} + \beta Frac_{Burn(T)} C_f \right)$$

$Frac_{\text{incorp(T)}}$ – fraction incorporated within 3 days

α = fraction of $Frac_{\text{Remove(T)}}$ removed within 3 days

β = fraction of $Frac_{\text{Burn(T)}}$ burnt within 3 days

Calculation of NH_3 emissions from crop residues

$$NH_{3\_cropresidues} = \frac{17}{14} * \sum_{T=1}^{T_{max}} (A_T * N\_Load_T * F_T * EF\_cropresidue_T)$$

$EF_{\_cropresidues}$

- The $EF_{\_cropresidues}$ depends on the N concentration in crop residues ($N_{AG(T)}$; kg N (kg DM)$^{-1}$):
- If the $N_{AG(T)} \leq 0.0132$ kg N (kg DM)$^{-1}$
  - $EF_{\_cropresidues} = 0$
- Otherwise
  - $EF_{\_cropresidues} = (410 * N_{AG(T)} - 5.42)/100$

Crop residue NH_3 emission - IPCC format

$$NH_{3\_cropresidues(T)} =$$

$$A_T AG_{DM(T)} N_{AG(T)} \begin{pmatrix} 1 - Frac_{Incorp(T)} - \alpha Frac_{\mathrm{Re}move(T)} \\ -\beta Frac_{Burn(T)} C_f \end{pmatrix} EF_{cropresidues(T)}$$

Activity data

- Most of the data should already be available
- Inputs used for IPCC Tier 1 methodology for N_2O emissions from crop residues will be available
  - See IPCC (2006 or 2019), Equation 11.6 N input in crop residues

Additional information required

- Proportion of residues incorporated within 3 days ($Frac_{\text{Incorp(T)}}$)
  - 1 = if all residues incorporated within 3 days after harvest
  - 0.5 = half of the residues covered or mixed with soil at harvest.
  - 0 = no covering by soil during harvest or through incorporation.
- α – fraction of $Frac_{\text{Remove(T)}}$ that is removed within 3 days
- β – fraction of $Frac_{\text{Burn(T)}}$ burnt within 3 days

Limited additional information required

- For many common crops, $EF_{cropresidue} = 0$

Crops whose residues are not sources

Generic Grains
Winter Wheat
Spring Wheat
Barley
Oats
Maize
Rye
Rice
Millet
Sorghum
Beans and Pulses
Soybeans

Main crops whose residues are potential sources

Potatoes and other root crops
Peanuts
Alfalfa
Non-legume hay
N-fixing forages
Non-N-fixing forages
Perennial grasses
Grass-clover mixtures
Most horticultural crops
All cover crops and green manures

N content of crop residues

- The IPCC methodology only provides data on the N content of a limited number of residues hence we include the greater range cited by de Ruijter and Huijsmans in a Guidebook annex.
- Alternative source is Feedipedia (https://feedipedia.org/)
  - search for the crop residue
  - click on the Nutritional tables tab
  - N content = Avg Crude protein/(6.25 * 100)

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Feed

All feed

Forage

- Cereal and grass forages
- Legume forages
- Forage trees
- Aquatic plants
- Other forage plants

Plant products/by-products

- Cereal grains and by-products
- Legume seeds and by-products
- Oil plants and by-products

Straws

Description | Nutritional aspects | Nutritional tables | References

Crude protein = 4.2%

N content = 4.2/(6.25*100) = 0.00672 kg N (kg DM)$^{-1}$

Main analysis	Unit	Avg	SD	Min	Max	Nb
Dry matter	% as fed	91.6	1.3	87.3	93.8	438
Crude protein	% DM	4.2	0.7	2.6	6.0	428

Limited additional information required

- For many common crops, $EF_{cropresidue} = 0$
- α – fraction of $Frac_{Remove(T)}$ that is removed within 3 days
- β – fraction of $Frac_{Burn(T)}$ burnt within 3 days

$Frac_{Remove(T)}$, $Frac_{Burn(T)}$ & $Frac_{Incorp(T)}$

- Only required for potential sources ($EF_{\_cropresidues} > 0$)
- $Frac_{Remove(T)}$ = same value as for IPCC N_2O
  - Assume $\alpha = 1$
  - Rapid harvesting likely, to preserve biomass quality
- Assume $Frac_{Burn(T)} = 0$
  - Burning is illegal in most of Europe
  - Residues that are potential sources are unlikely to be burnt (too wet and/or too useful as livestock feed)
  - Do not need to estimate β
- $Frac_{Incorp(T)}$
  - Need to consult local experts

Cover crops & green manures

- Should already be included in IPCC Tier 1
  - local estimates should be available
- Default, based on Ruis et al (2019)
  - Humic areas – 3.8 Mg DM ha^{-1}
  - Arid areas – 2.6 Mg DM ha^{-1}

Ruis, S.J., Blanco-Canqui, H., Creech, C.F., Koehler-Cole, K., Elmore, R.W. and Francis, C.A. (2019), Cover Crop Biomass Production in Temperate Agroecozones. Agron. J., 111: 1535-1551. https://doi.org/10.2134/agronj2018.08.0535

Final remarks

- Agriculture and Nature Expert Panel
  - www.tfeip-secretariat.org/agriculture-and-nature
  - Contact details for co-chairs
- Presentation will be available as a PDF file
- Example Excel spreadsheet