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Carbon Sequestration, N_2O, Taxes and Reduction Targets from a Grower's Point of View

www.soilecology.ca

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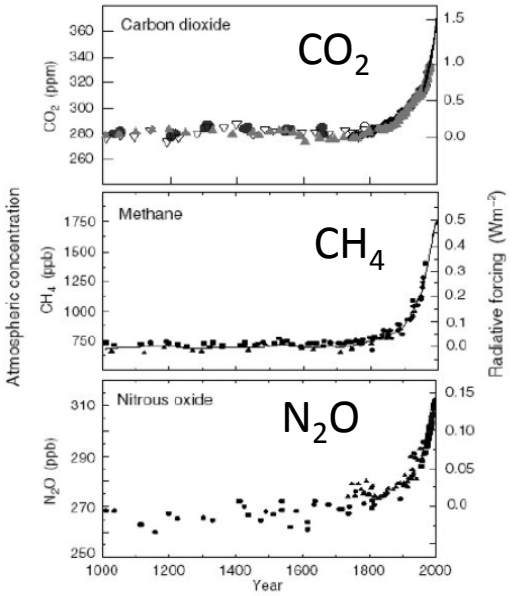
Presentation to IHARF Soil & Crop Management Seminar
Weyburn, Saskatchewan
February 1, 2017

UNIVERSITY OF MANITOBA

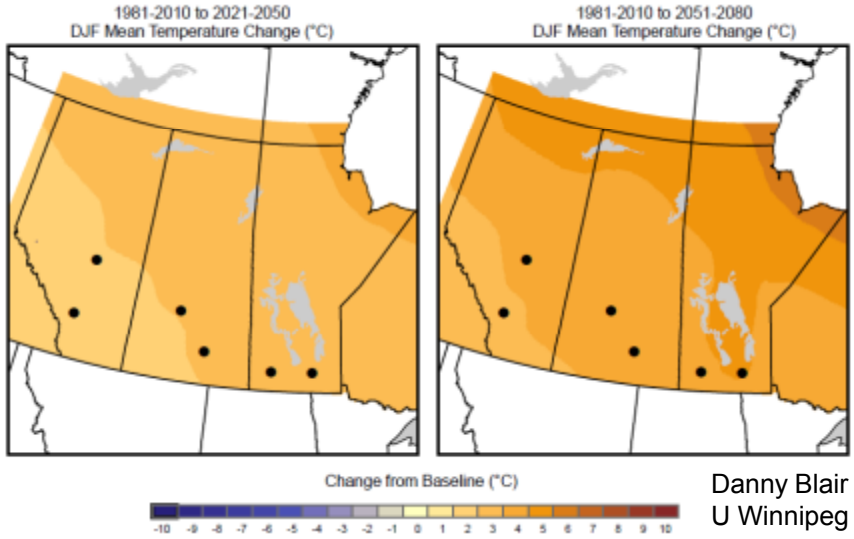
Warning
Some Things You Won't Like

http://myfunnypics.org

N_2O, GHG and Climate Change
Why Care?

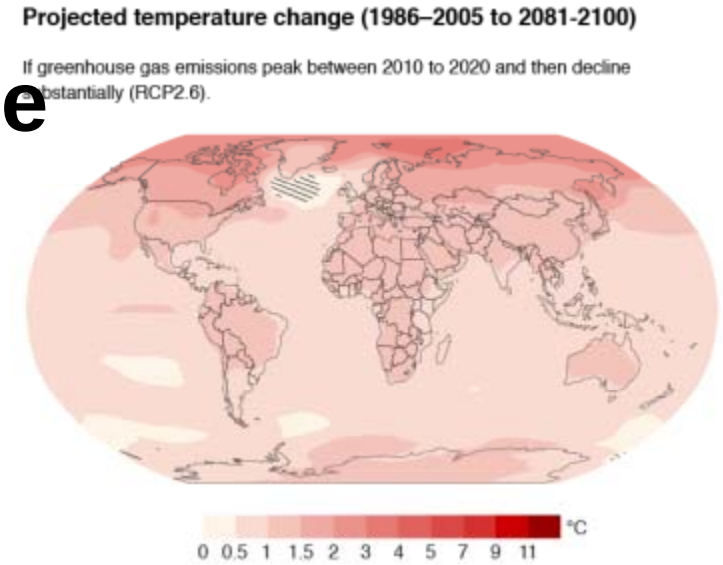


IPCC 2014



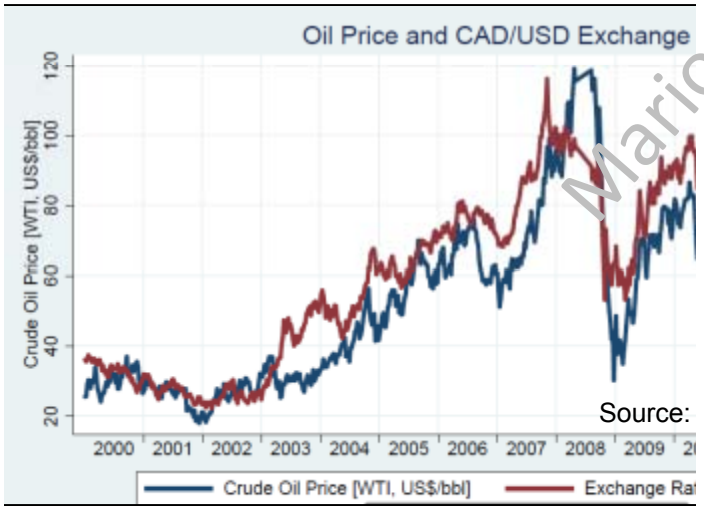
Increase in Mean Winter Temperature For Manitoba

Danny Blair
U Winnipeg

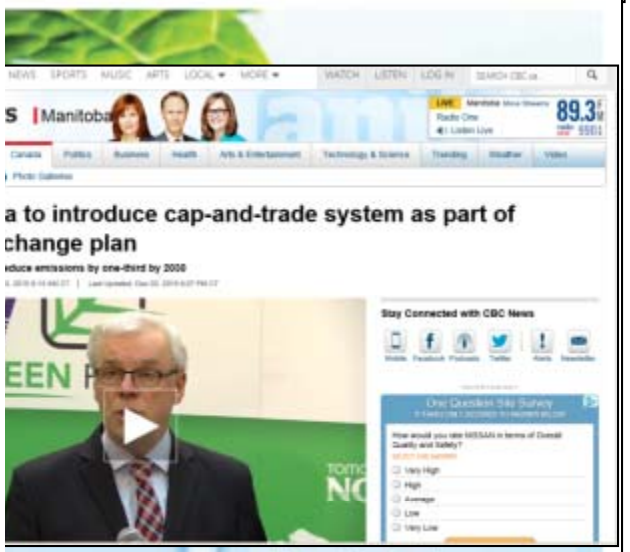


IPCC 2014

Tide Has Turned

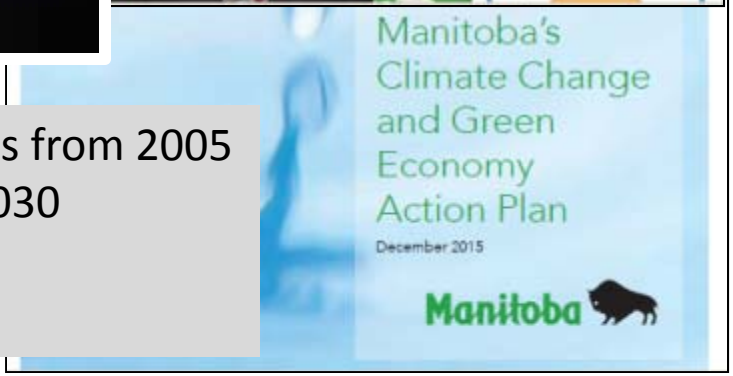


Source:



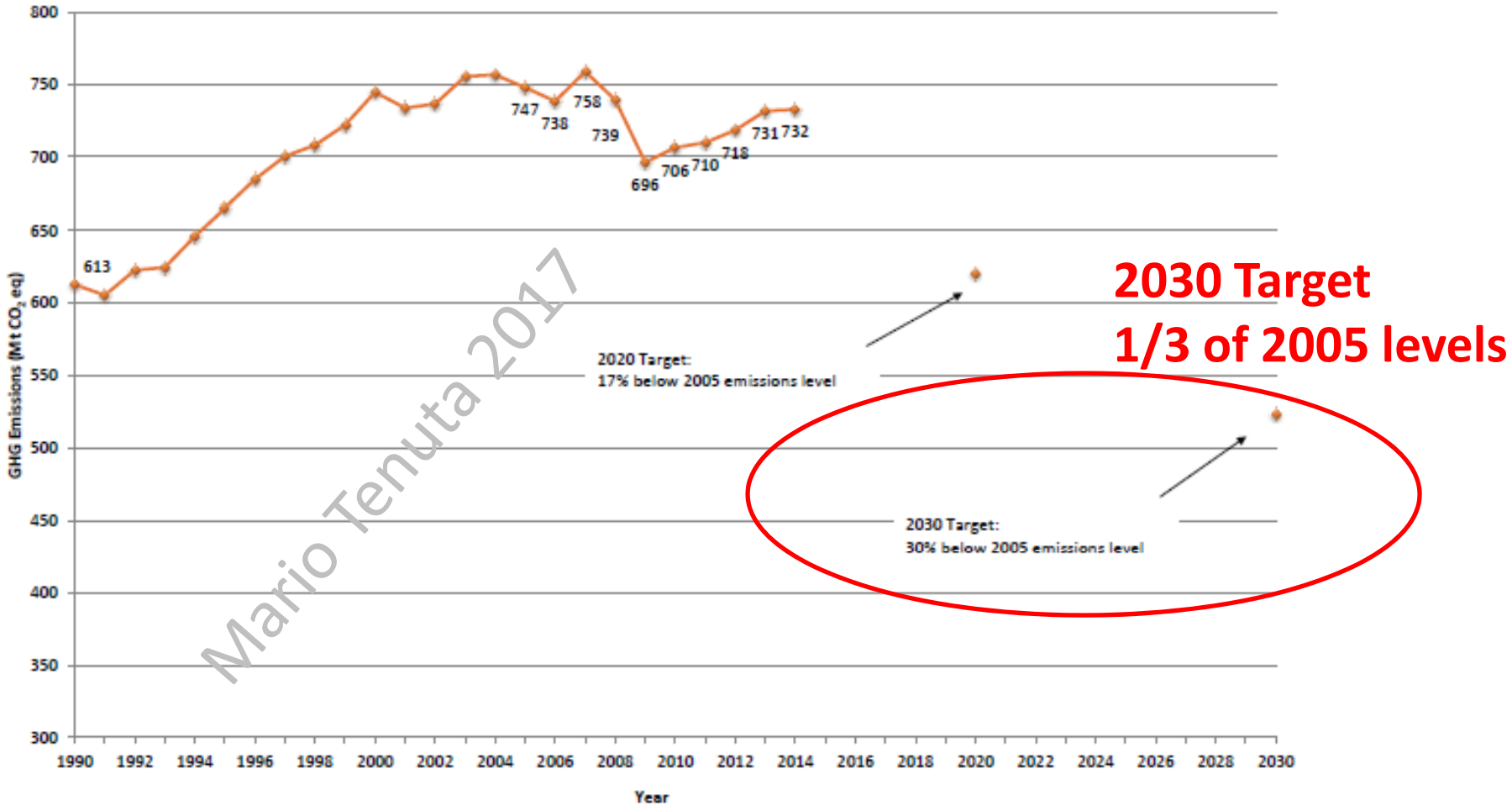
MB will reduce emissions from 2005

- o 1/3 from 2005 by 2030
- o ½ by 2050
- o Neutral by 2080



Short-term Emission Reduction Target

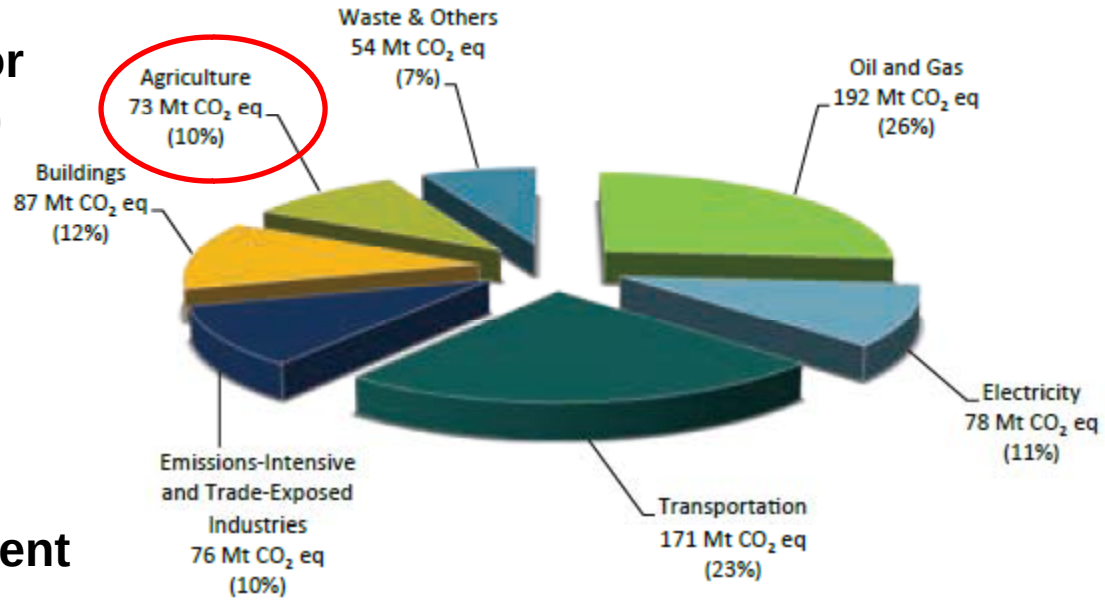
Figure S–3 Canadian GHG Emissions Trend (1990–2014), 2020 Target, 2030 Target



Environment Canada, 2014

Figure S–8 Canada's Emissions Breakdown by Economic Sector (2014)

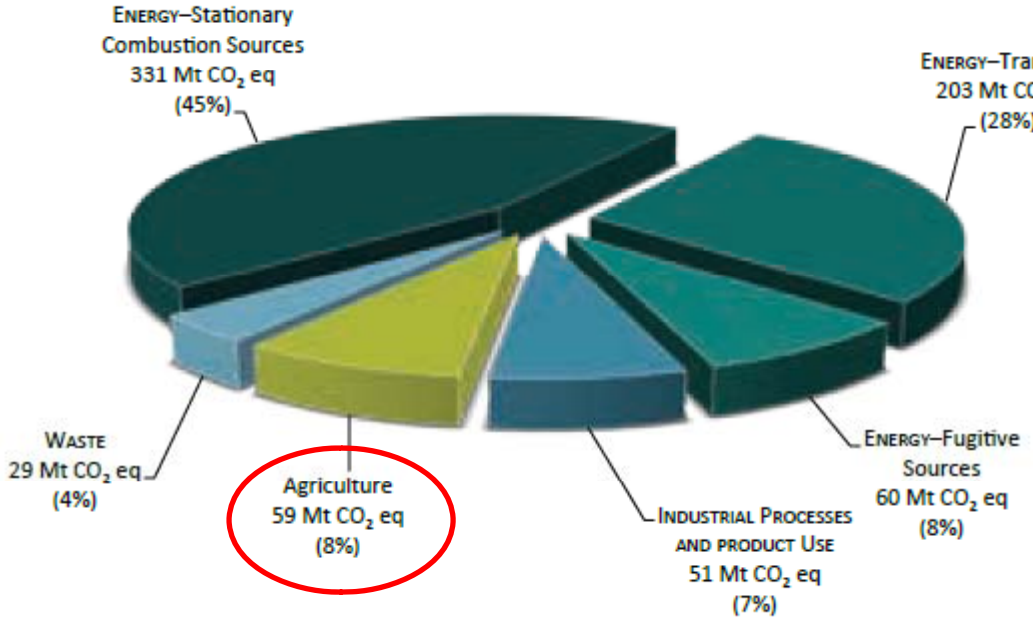
Emission by Economic Sector (includes CO_2 in Agriculture)



Total: 732 Mt CO_2 eq

tals may not add up due to rounding.

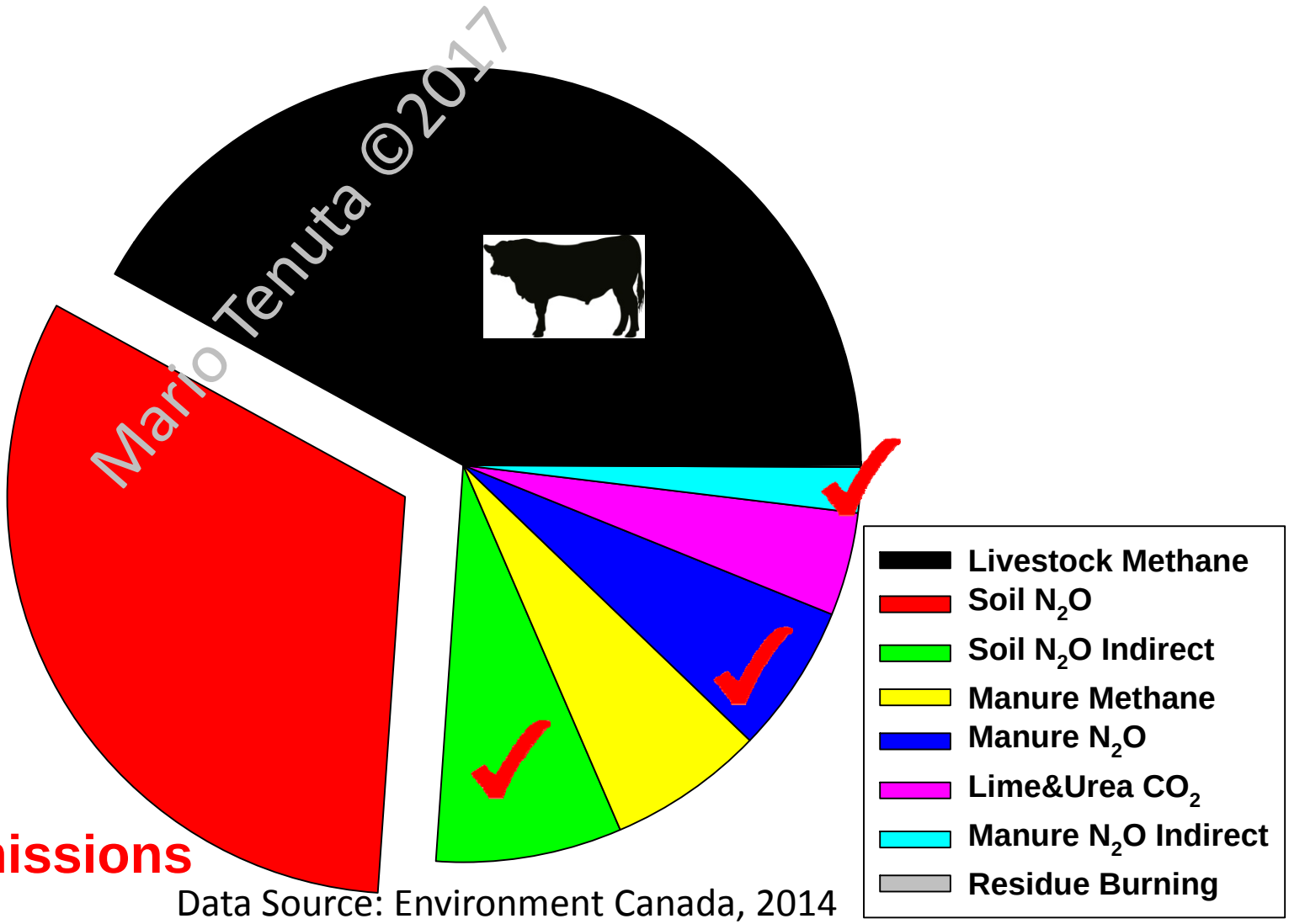
Emission by International Agreement Groupings



Environment Canada, 2014

Figure S–1 Canada's Emissions Breakdown by IPCC Sector (2014)*

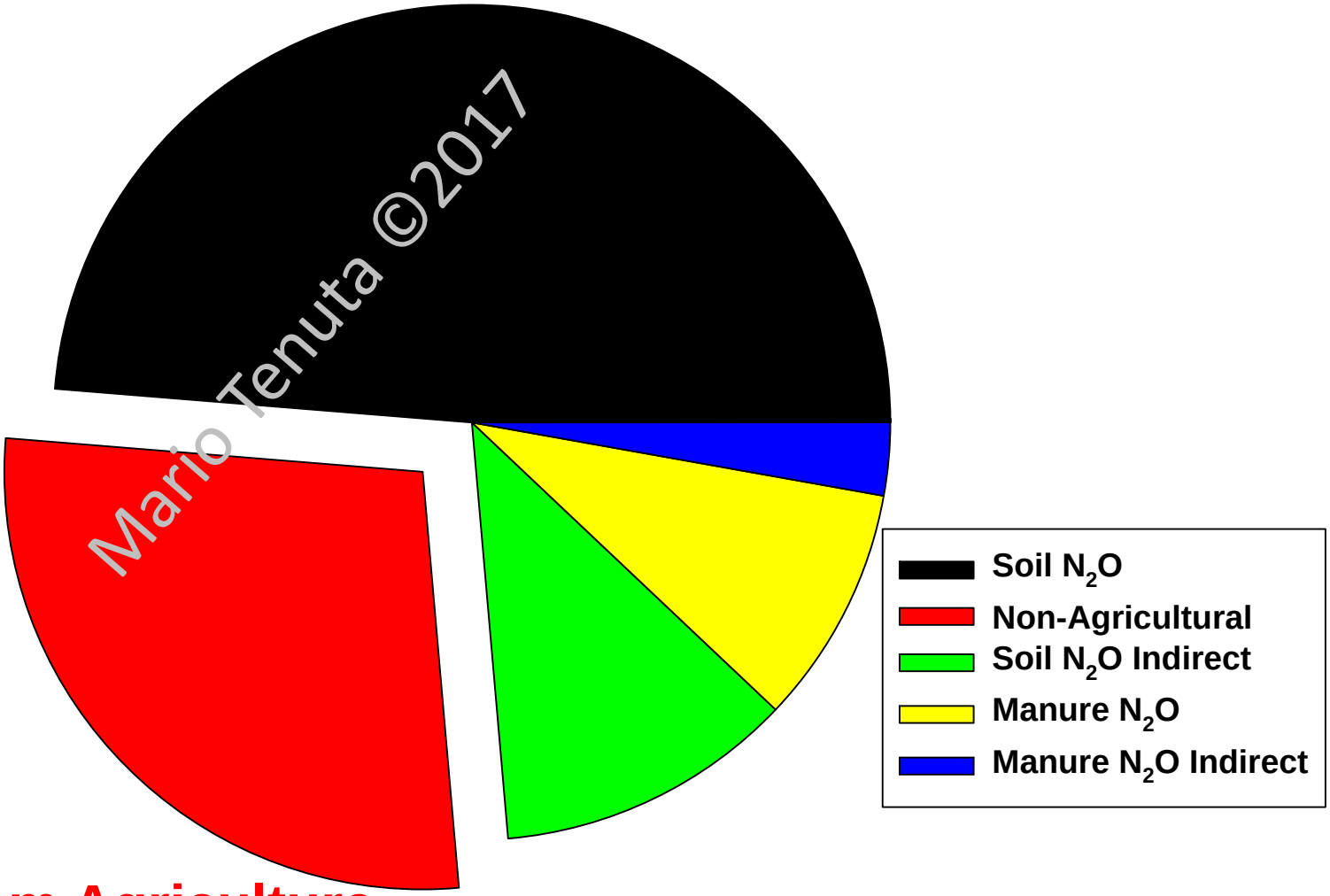
GHG Sources From Agriculture



Soil N_2O Direct Emissions

Data Source: Environment Canada, 2014

N_2O Sources In Canada

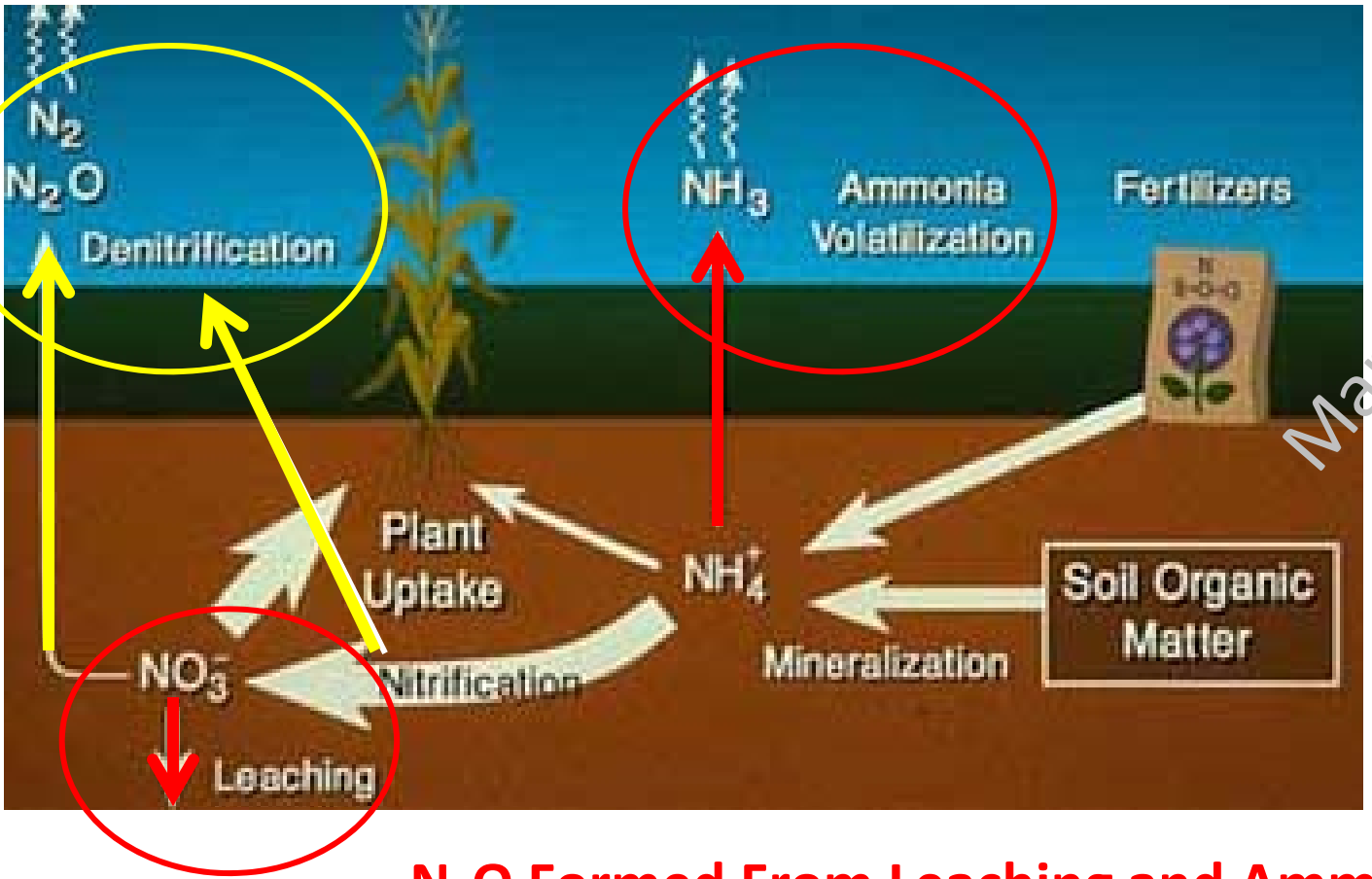


N_2O
Not From Agriculture

Data Source: Environment Canada, 2014

Where Does N_2O From Agriculture Come From?

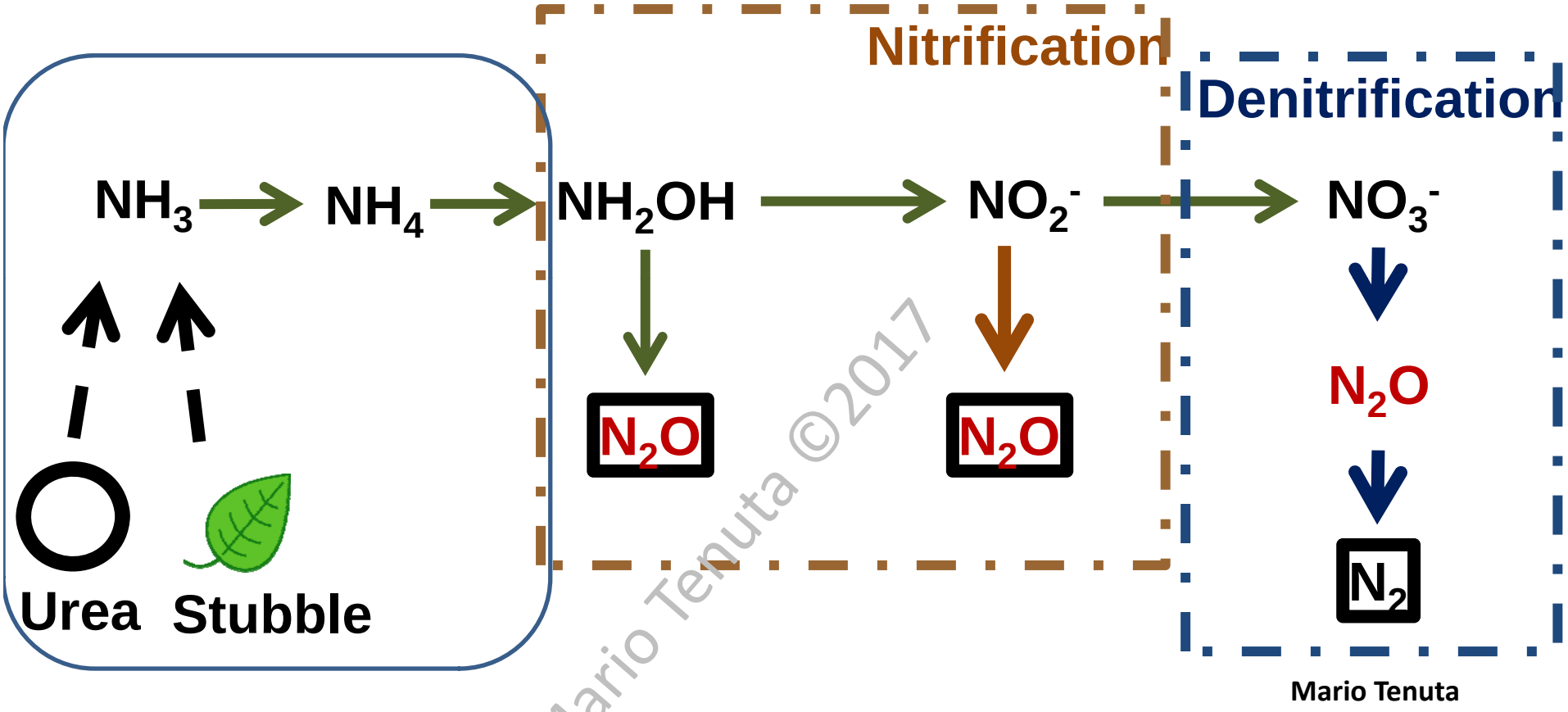
N_2O Directly Emitted



N_2O Formed From Leaching and Ammonia (Indirect)

Environment Canada, 2014

Direct Sources of N_2O From Soils



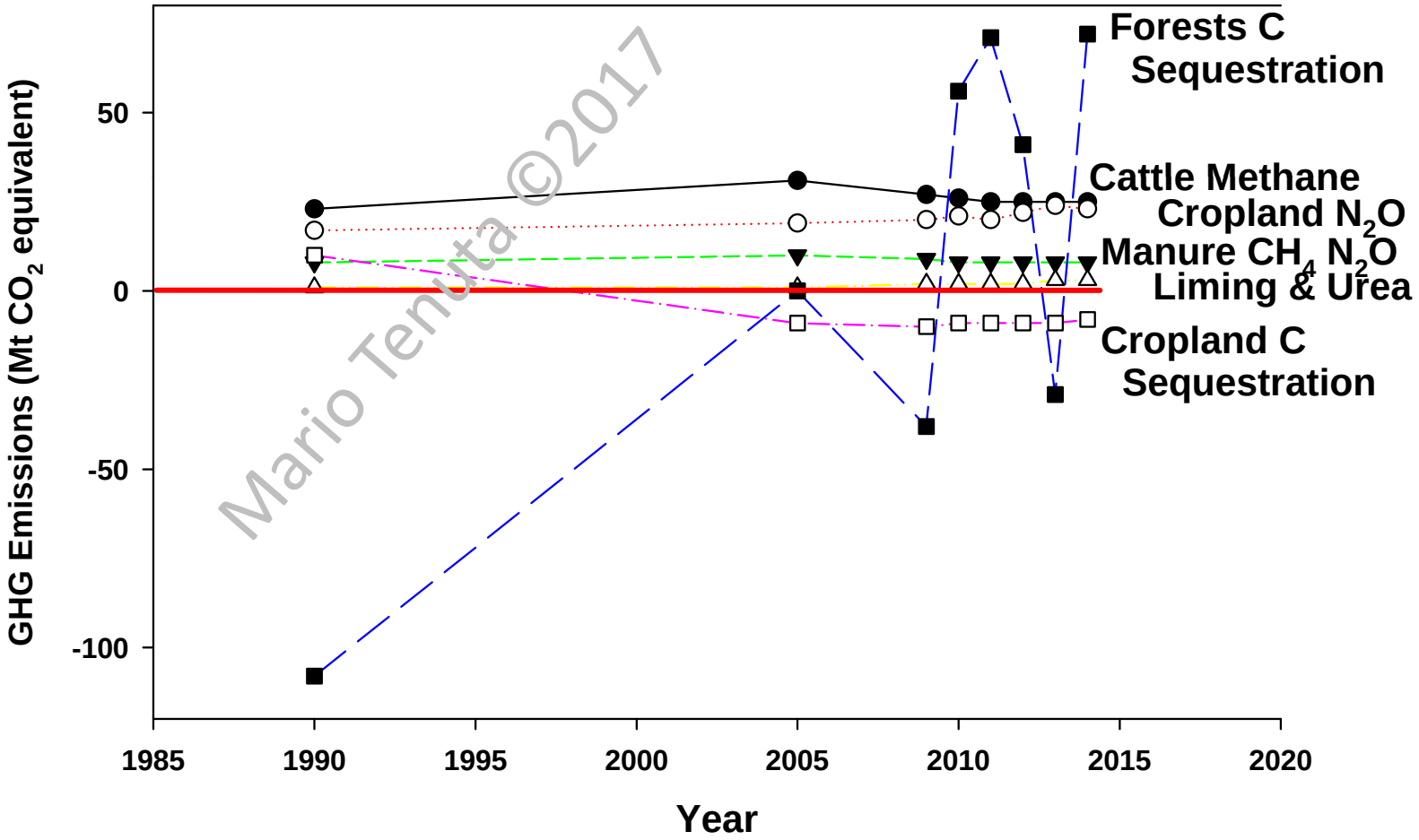
Production of Nitrate in Soil From N Additions Major Source of N_2O

But, but, but….denitrification is important from N fertilizer loss

Where is the CO_2 with Agriculture?

- Diesel, gasoline and natural gas put in other sectors, not agriculture
- CO_2 taken up in grain and biomass harvested eventually decomposes back to CO_2
- CO_2 taken up in residues eventually decomposes to CO_2 or replenishes CO_2 decomposed from soil organic matter
- C sequestration to soil organic matter is in near balance since 2005

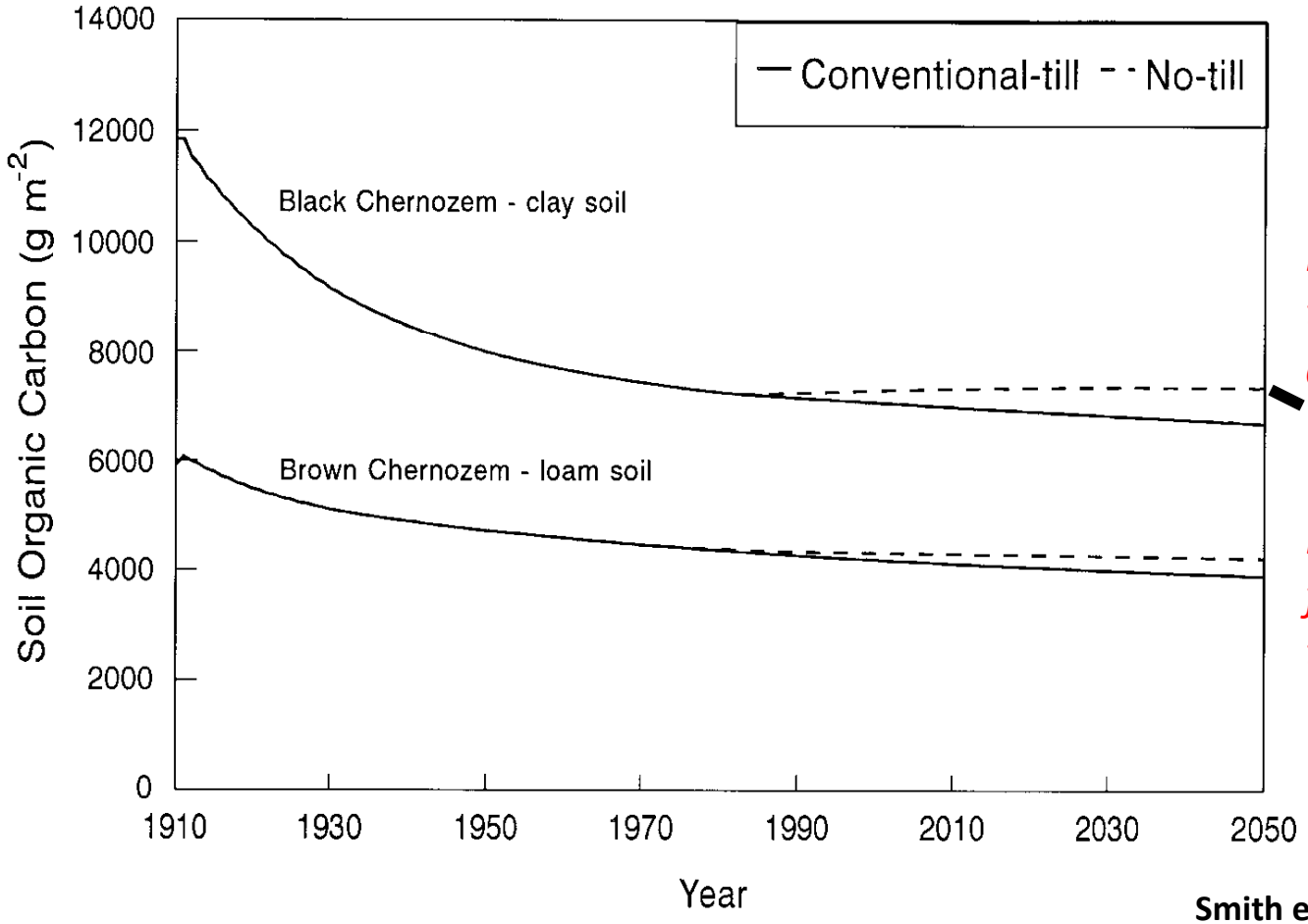
Why No CO_2 Sinks (Sequestration) for Agriculture?



Data Source: Environment Canada 2014

Soil C Loss from Prairie Soils

We've lost a heck a lot of soil organic matter
No-till doesn't gain it back



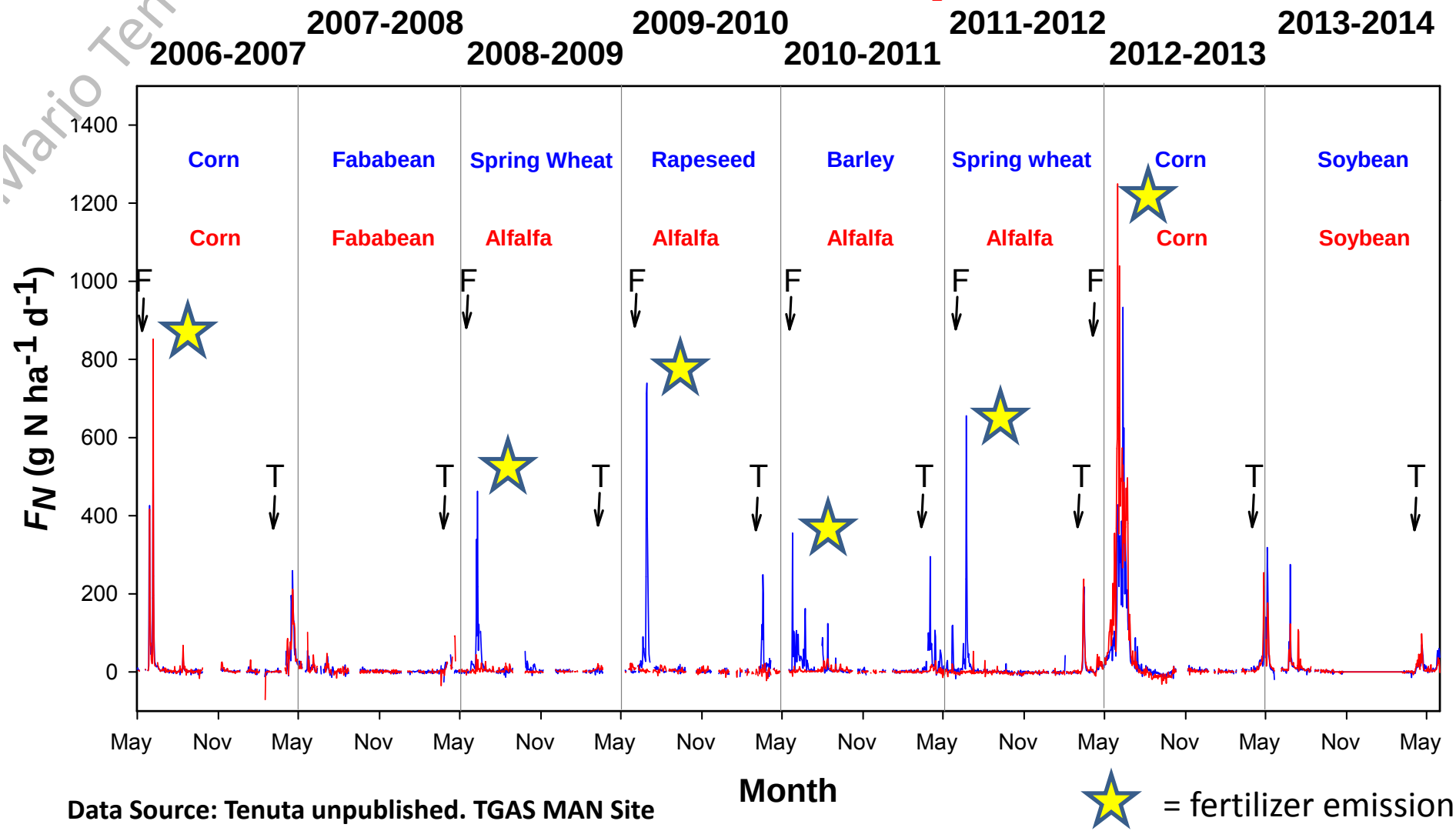
If you go out of no-till the C gained is very quickly lost

Losing happens always faster than gaining

Smith et al. 1997. CJSS

N_2O Always Emitted Shortly After Spring N Fertilizer Application

N fixing crops emit little N_2O



Data Source: Tenuta unpublished. TGAS MAN Site

= fertilizer emission

Carbon Costing- Anhydrous Ammonia Use

Analysis done by Mario Tenuta

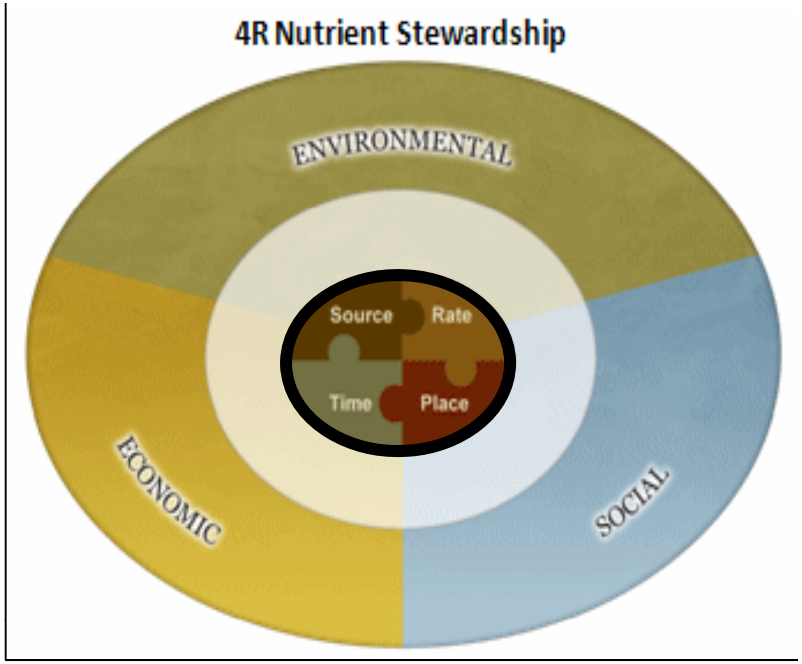
	$/t CO2 C cost	$ /t N NH3	$ /t NH3 NH3	kg N2O-N/kgN EF%	100 kg N/ha rate	User tax $ tax/ha	Manufacture Tax $ tax/100 kgN/ha	Total C tax $/ha	Fert Cost no tax $/ha
Taxes ½ Fertilizer Cost	10	975.61	800	2	100	9.43	2.05	11.48	97.56
	20	975.61	800	2	100	18.86	4.10	22.95	97.56
	30	975.61	800	2	100	28.29	6.15	34.43	97.56
	40	975.61	800	2	100	37.71	8.20	45.91	97.56
	50	975.61	800	2	100	47.14	10.24	57.39	97.56
Taxes > Fertilizer Cost	60	975.61	800	2	100	56.57	12.29	68.86	97.56
	70	975.61	800	2	100	66.00	14.34	80.34	97.56
	80	975.61	800	2	100	75.43	16.39	91.82	97.56
	90	975.61	800	2	100	84.86	18.44	103.30	97.56
	100	975.61	800	2	100	94.29	20.49	114.77	97.56

Forget about Tax on Fertilizer Production – Be concerned about tax on adding N fertilizer to soil!

C tax needs to be over $150/t to have significant affect on total GHG emissions

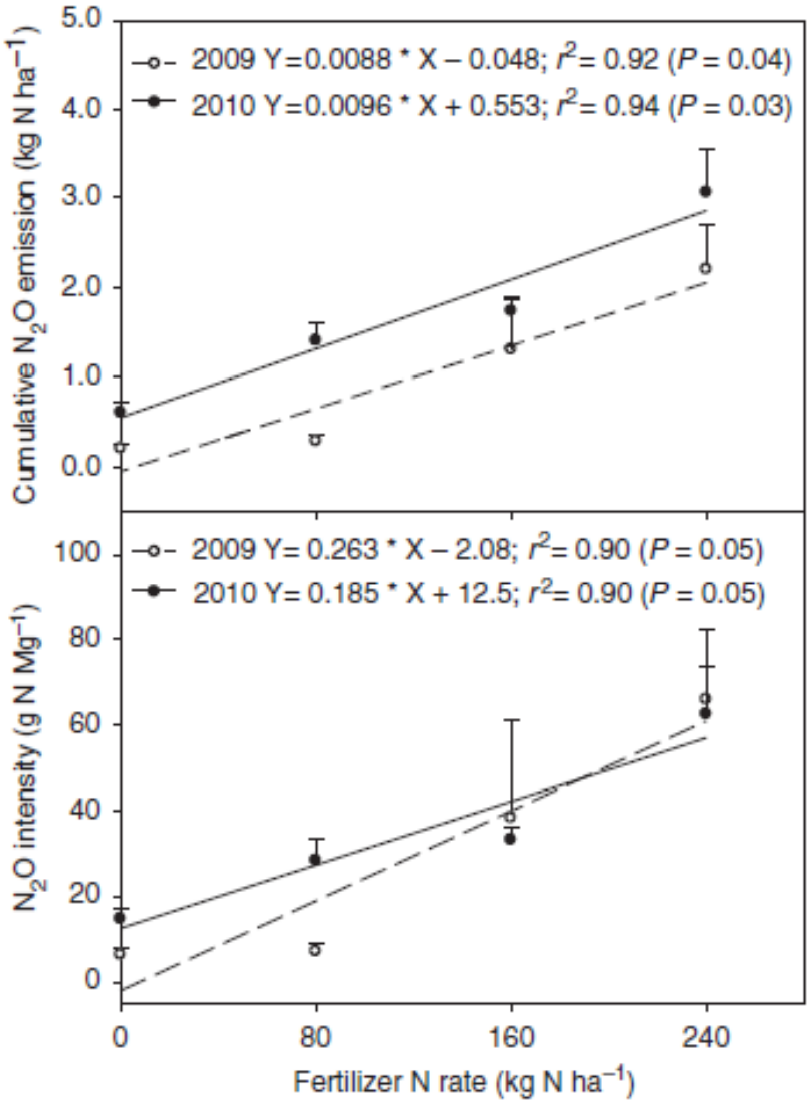
Message: We need to avoid a N use tax by showing change in practices reduces emissions

Is There New Hope?
4R Nutrient Stewardship



- Best use of crop nutrient additions
- Improve/maintain yields
- Improve profitability
- Limit losses
- Have co-benefits (water and air quality, GHG)
- Understandable and easy to follow
- Auditable, provide credits, use $incentive programs
- Applies “agronomic sense” of past, present and future advances
- Is this the voluntary system to implement to avoid the Taxman?

N_2O Emissions Increase with Rate



Gao et al. 2013 Can J Soil Sci

Potato at Carberry

Various Crops TGAS

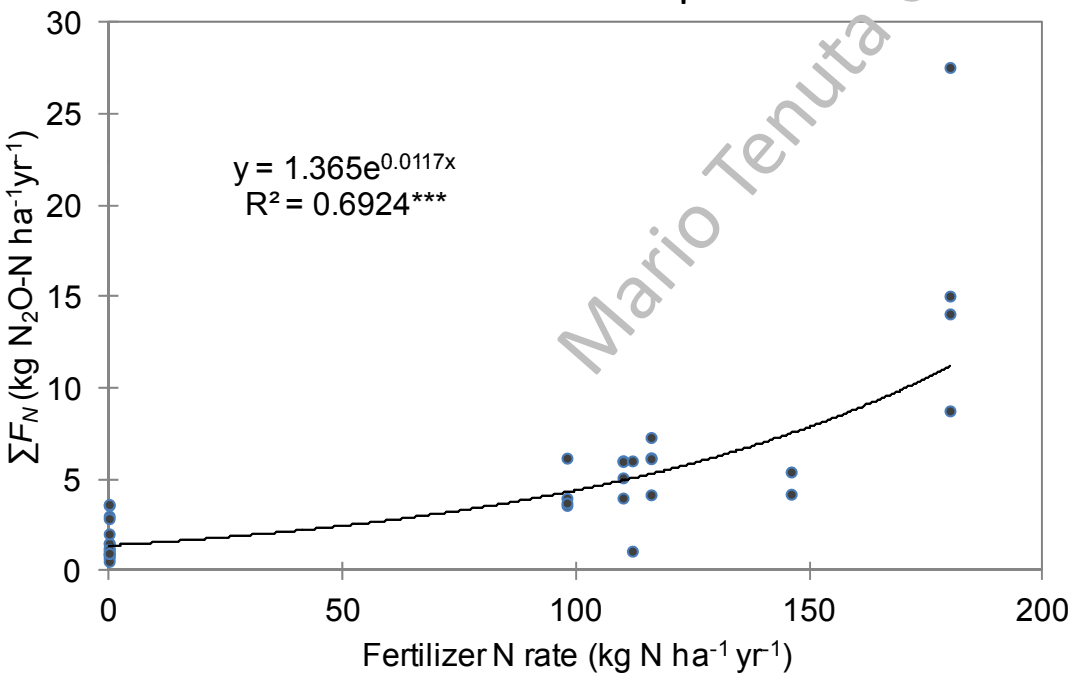
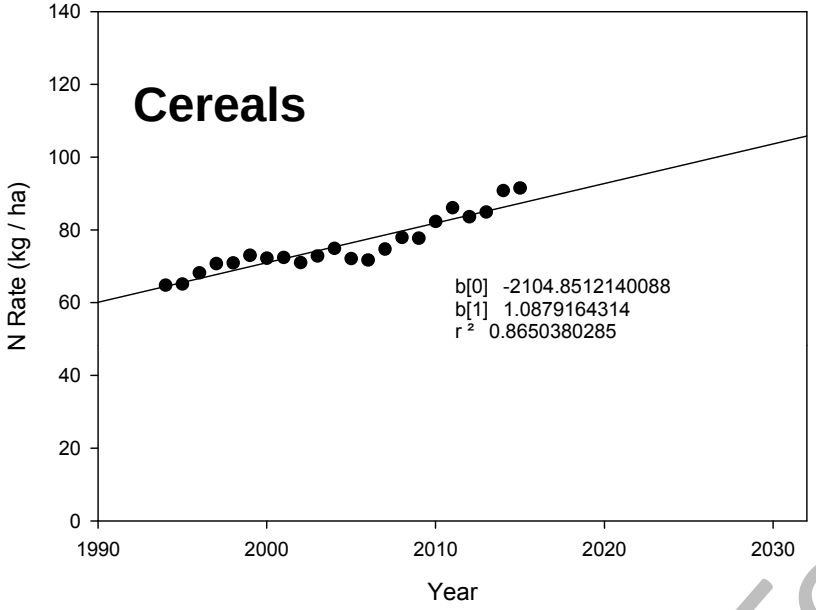
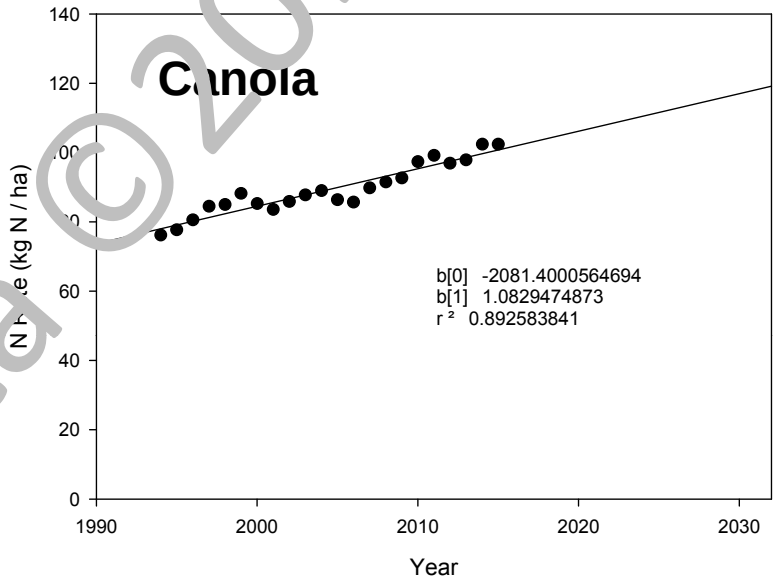


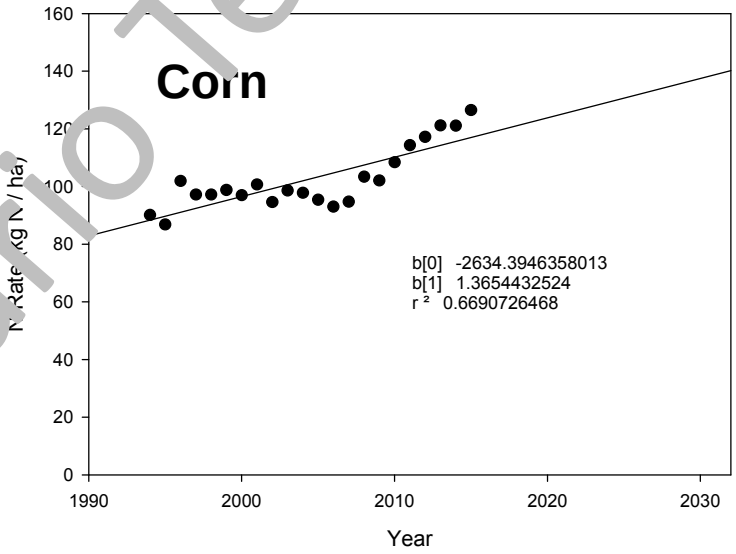
Fig. 4. Relationship between fertilizer N input and annual cumulative N_2O emissions ($\sum F_N$) at the TGAS station over crop years 2006-2014. *** indicates significance of model fit at $P<0.001$.

Tenuta et al. 2016 in prep

Problem: N Rates Keep Increasing



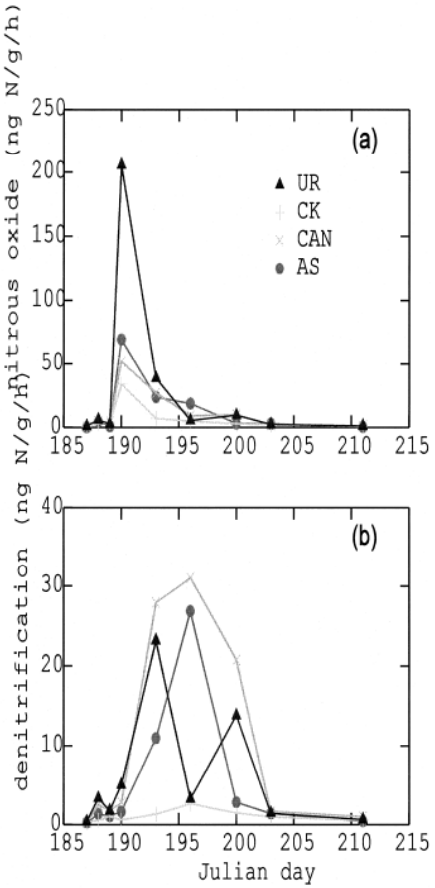




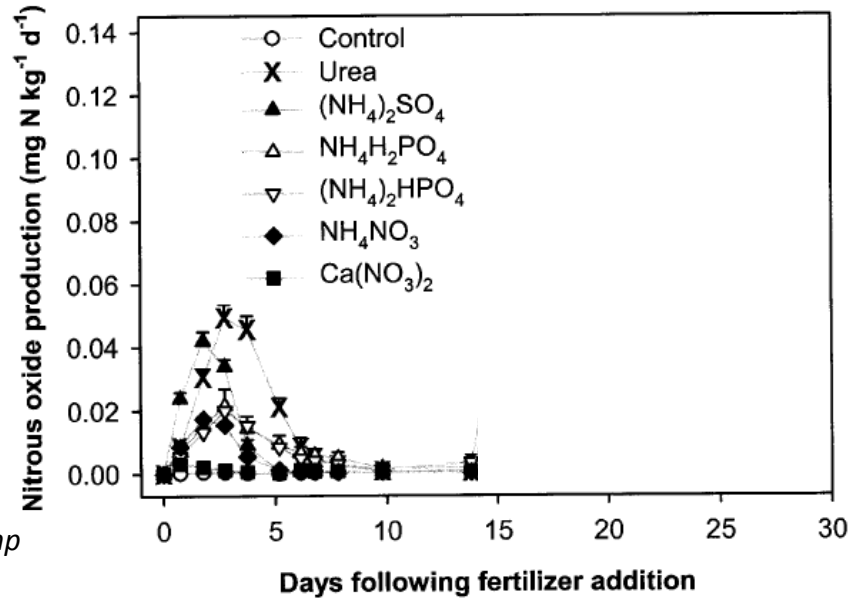
Data from MB
Crop Insurance

Fertilizer Source Effects

- AA > Urea > Ammonium > Nitrate
- Ammonia/urea/ammonium sources lead to N_2O
- Nitrification reason for most emissions



Bergstrom et al. 2001
Comm Soil Scie Pla Anal



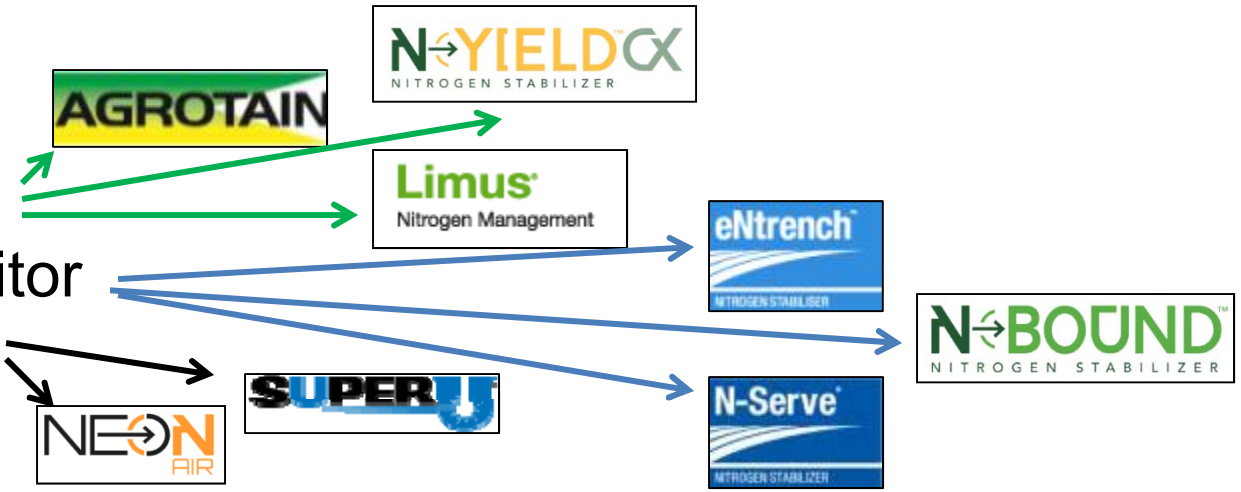
Tenuta and Beauchamp
2003 Can J Soil Sci

Figure 2. Temporal pattern of (a) N_2O production and (b) denitrification rate of soil cores for four fertilizer treatments: unfertilized check (CK), $(NH_4)_2SO_4$ (AS), $Ca(NO_3)_2$ (CAN), and (UR) at 100 kg N/ha (means of six measurements per sampling date).

Fig. 7. Nitrous oxide production with various N fertilizers added to microcosms in laboratory experiment B. Mea dard error) are shown.

Enhanced Efficiency N Fertilizers

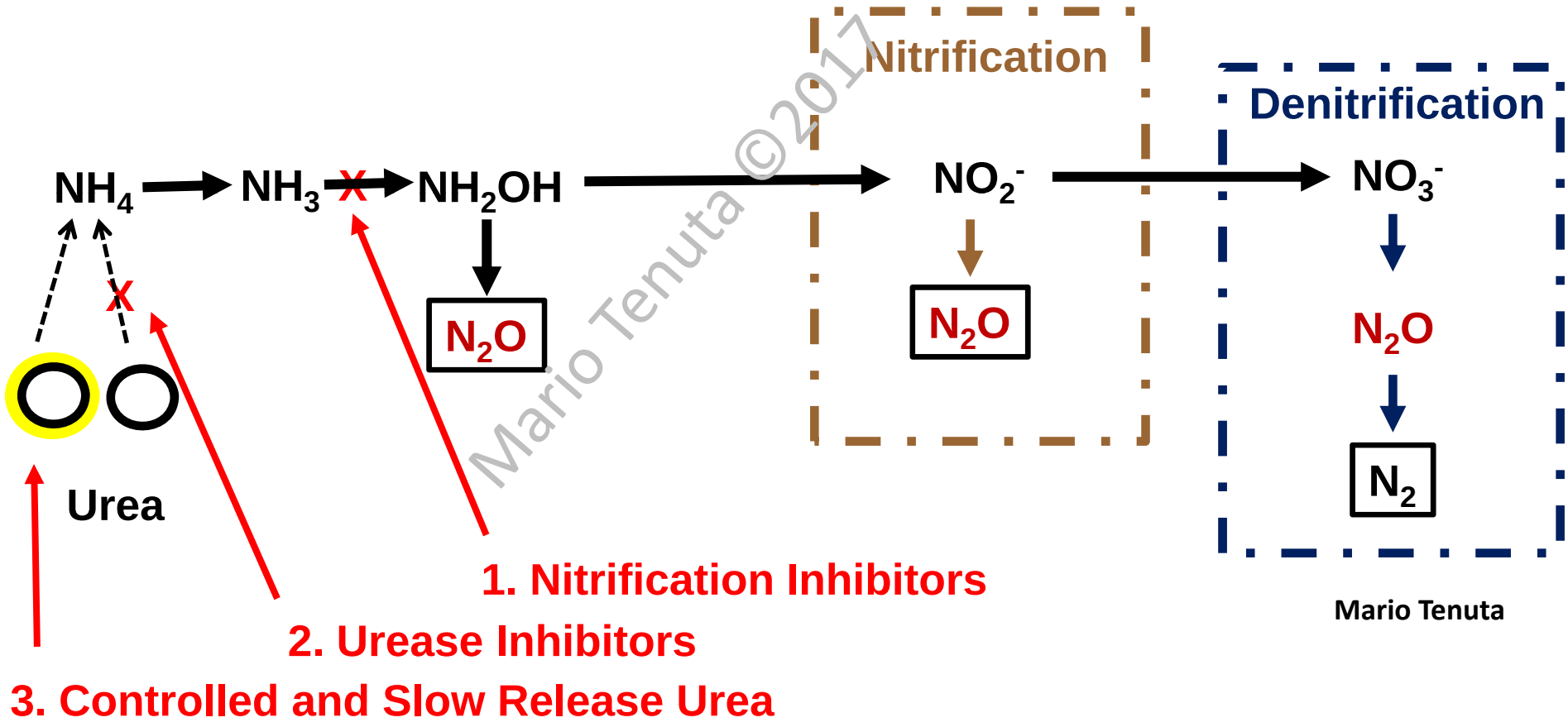
- **Stabilized N**
  - Urease inhibitor
  - Nitrification inhibitor
  - Double inhibitor



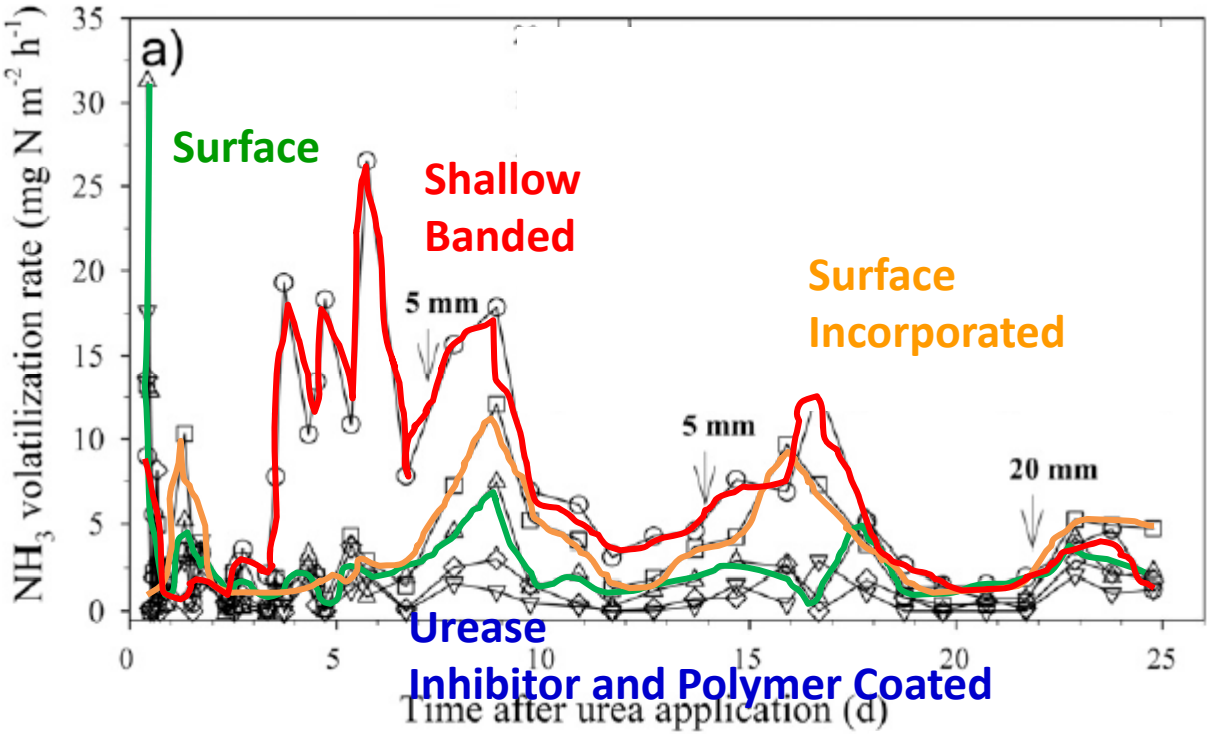
- **Controlled Release**
  - Polymer Coated Urea

- **Slow Release**
  - Sulfur-coated Urea, Methylene Urea, Isobuylidene Diurea, Urea Formaldehyde, Urea Triazone

How Do Enhanced Efficiency Fertilizers Lower N_2O Emissions?



Ammonia Loss Study Near Quebec City



Silty clay loam (27% clay)
125 lbs N/acre
20” band spacing
5 cm depth hand trenched band

Table 3. Cumulative losses of NH_3–N following land application of urea at different moments during the experiment.

Urea application method or type	Cumulative NH_3 losses				
	Day 1	Day 2	Day 5	Day 10	Day 25
	mg NH_3–N m^{-2}				
Broadcast	54	120	194	563b‡	1331b
Broadcast/Incorporated	40	165	245	921b	2250b
Banded/Incorporated	23	68	553	2102a	3768a
NBPT†	40	45	88	290c	669c
Polymer-Coated	31	88	159	225c	508c
Treatment *P* value	NS	NS	NS	> 0.001	> 0.001

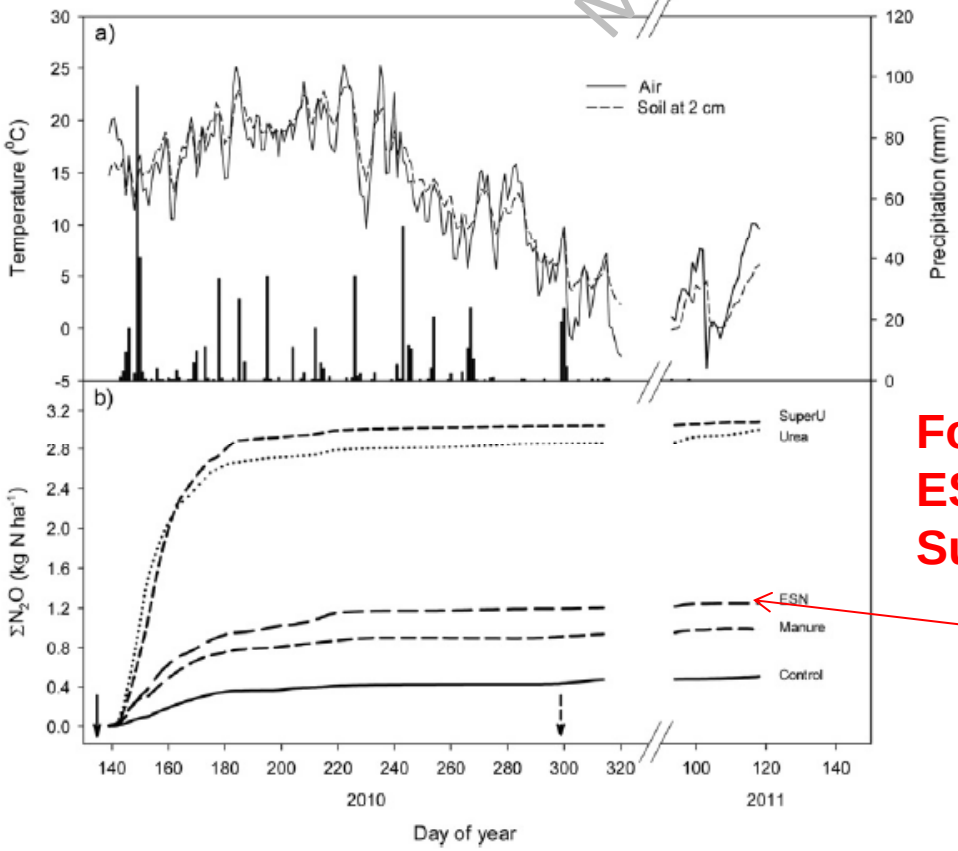
† Urea treated with urease inhibitor *N*-(*n*-butyl) thiophosphoric triamide.

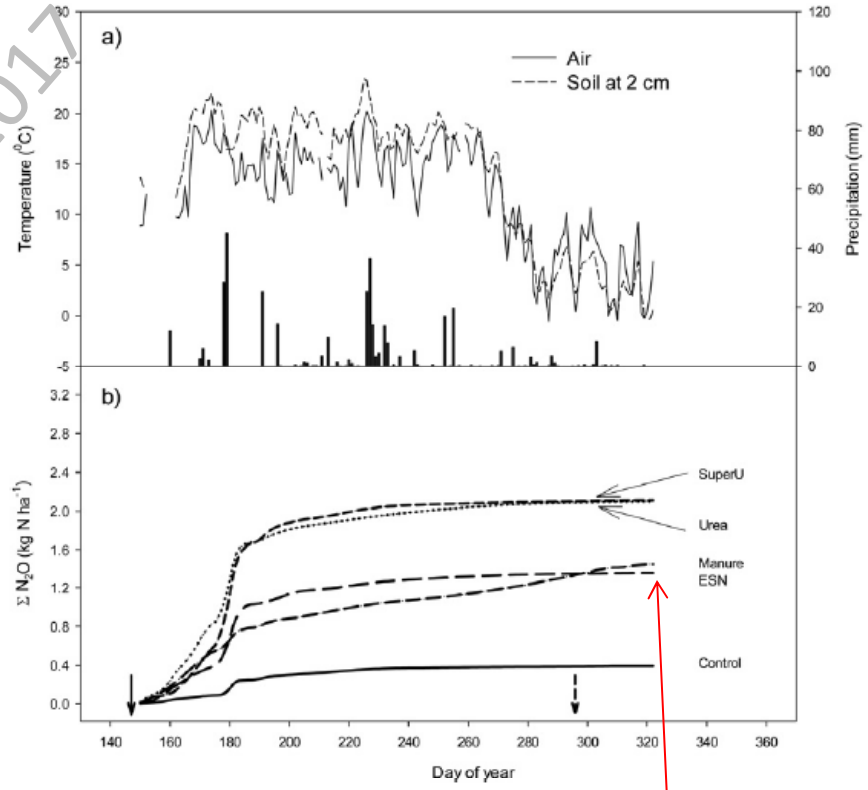
‡ Values in the same column with same letter are not significantly different ($P < 0.05$).

Rochette et al. JEQ 2009

Enhanced Efficiency Fertilizers Can Reduce N_2O Emissions

Asegodom et al. 2013

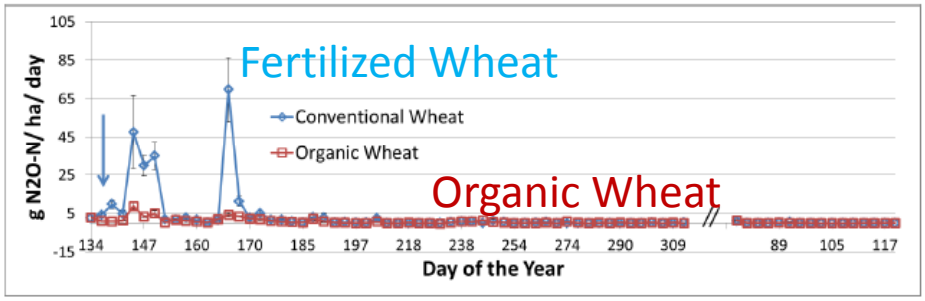


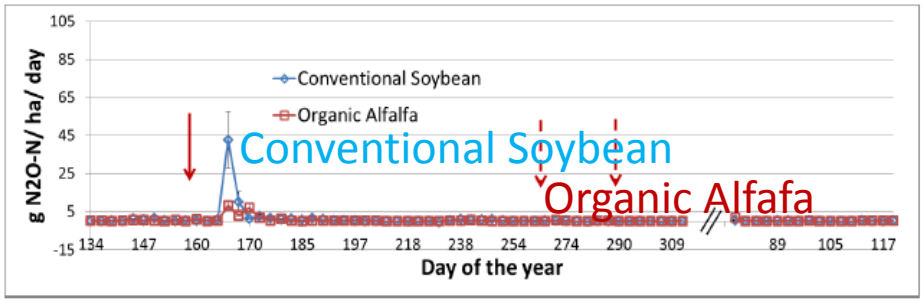


For broadcast incorporated N-ESN lower N_2O emissions than urea or SuperU

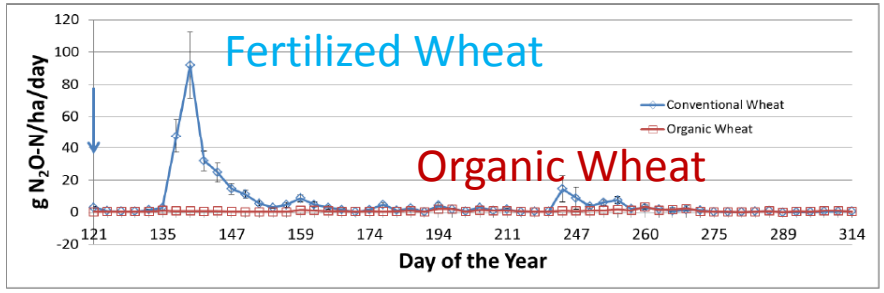
Soybean and Alfalfa Emit Little N_2O

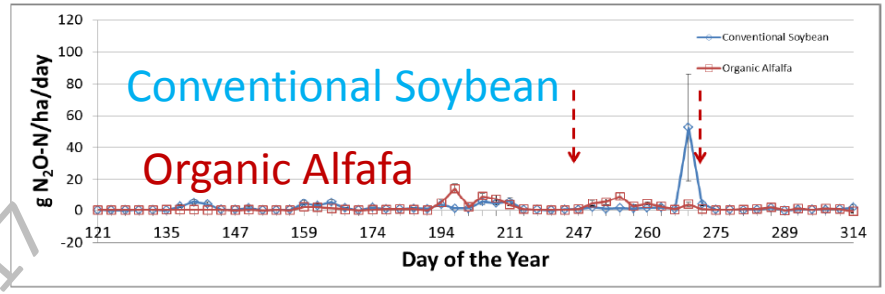
2014





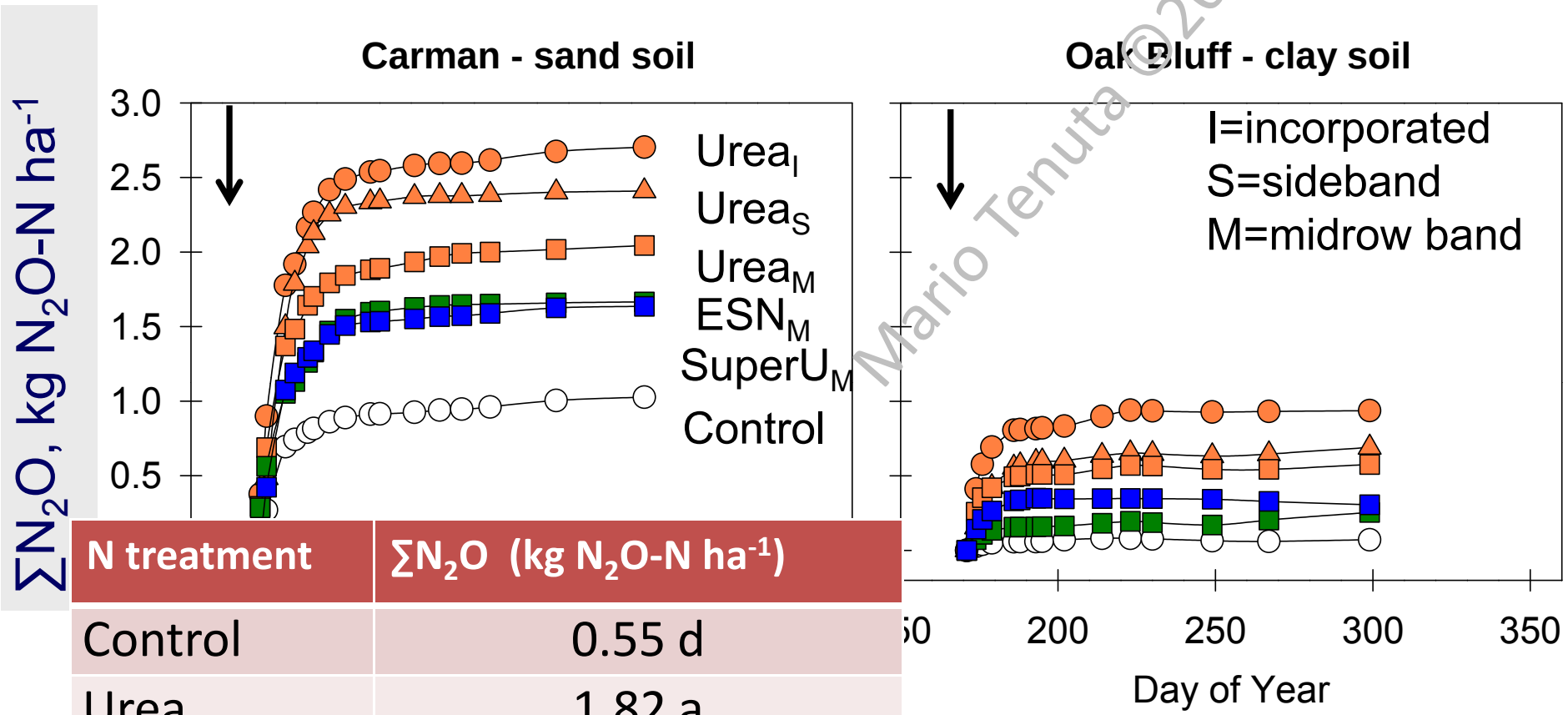
2015





Westphal et al. 2017. Umanitoba MSc Thesis

Fertilizer Placement Effects



N treatment	∑N_2O (kg N_2O-N ha^{-1})
Control	0.55 d
$Urea_I$	1.82 a
$Urea_S$	1.55 a
$Urea_M$	1.31 ab
ESN_M	0.97 c
$SuperU_M$	0.98 c

→ Banding tends to reduce

→ EEF 26% less than urea when banded

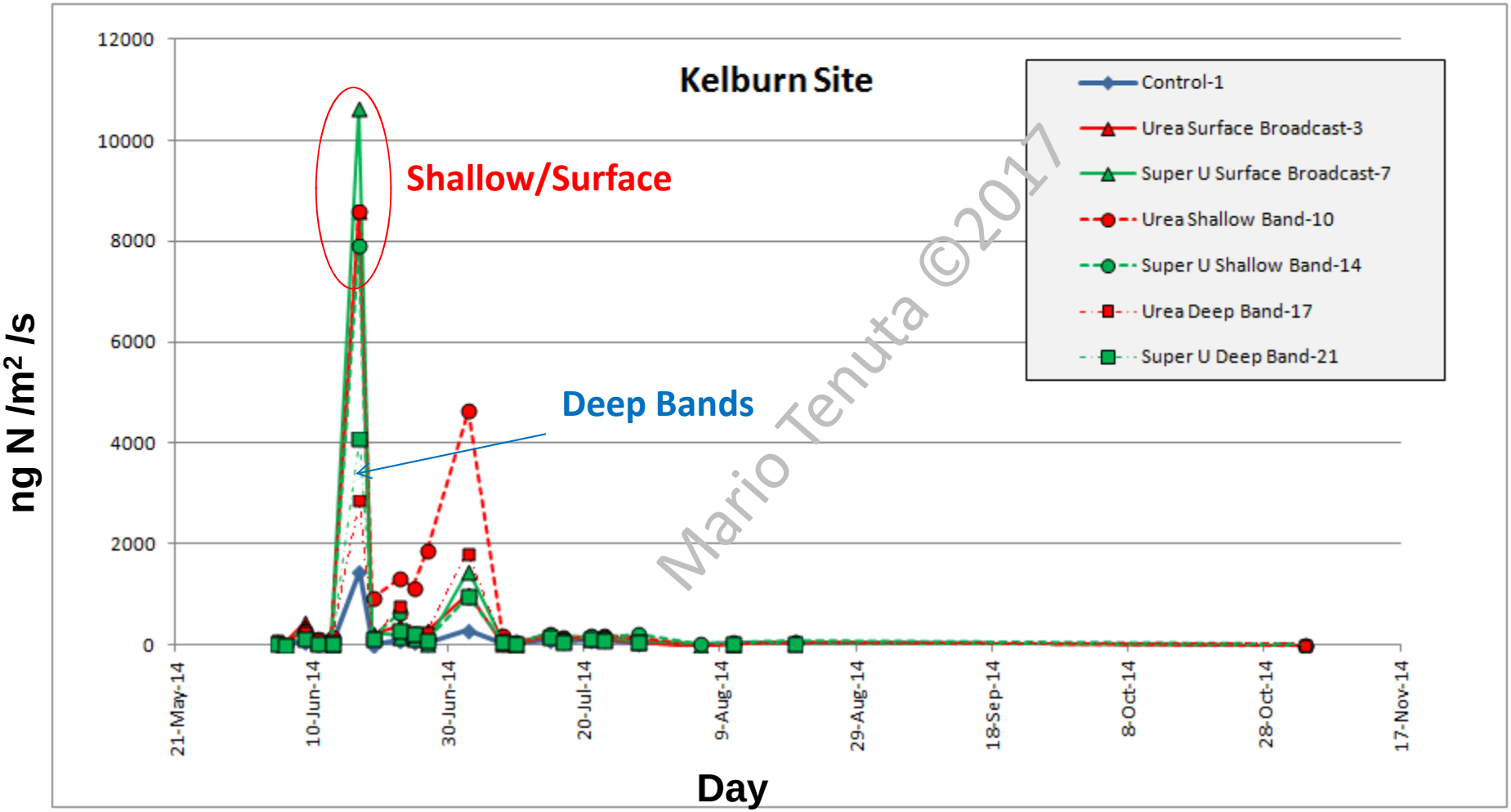
Gao et al. 2014. Agron J

Source and Placement Effects

Deeper band placement reduces N_2O emissions

If shallow banding, use EEF to reduce emissions

Baron et al. b (in prep)



Timing (current MB recommendation)

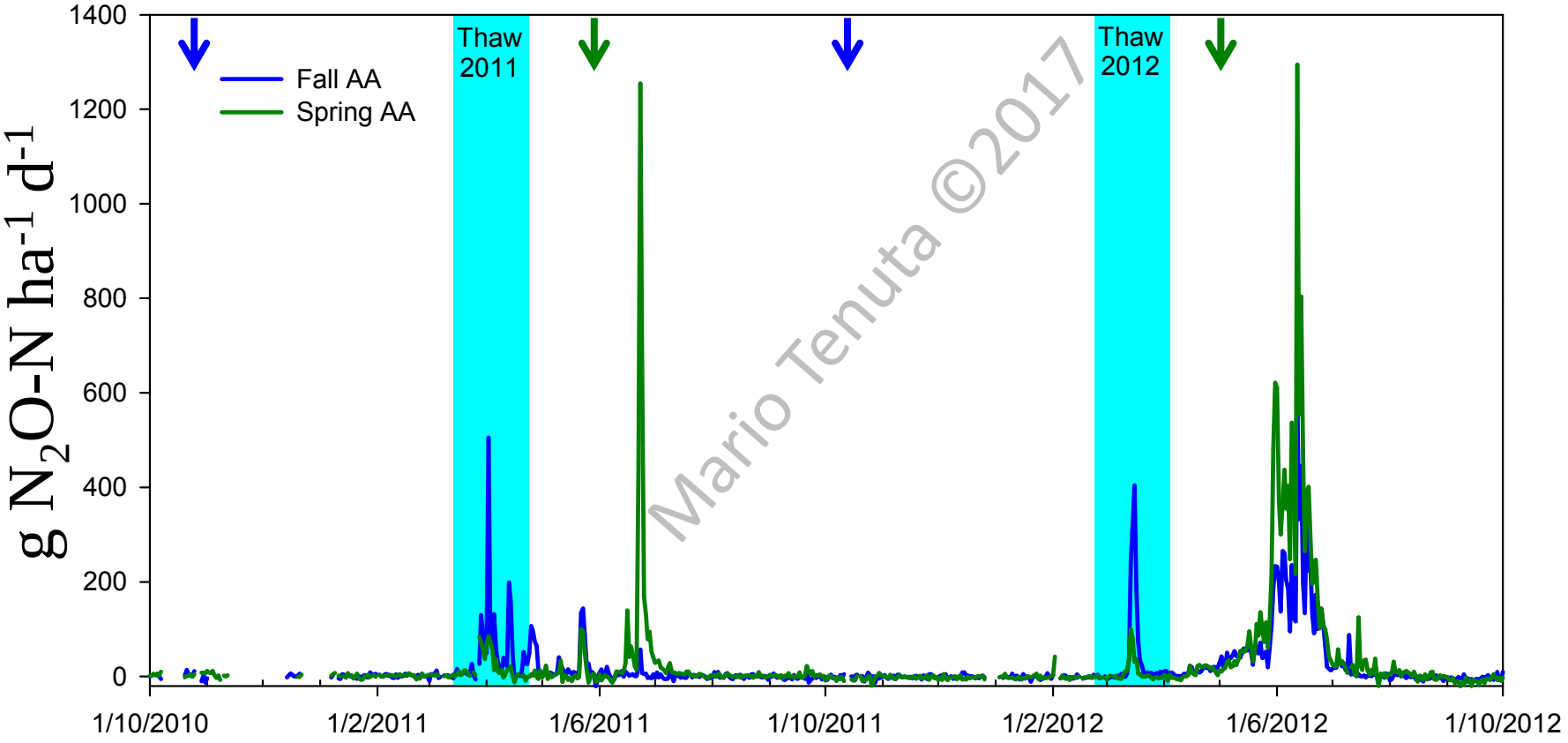
Estimated Average Yield for Application of N Fertilizer in MB

Fall broadcast, incorporated		80% of spring b'cast incorp
Fall banded	100	"
Spring broadcast, incorporated		100% "
Spring banded	120	"

Banded N is 20% better than broadcast N

Spring applied N is 20% better than fall applied N

Apply Anhydrous Late in the Fall



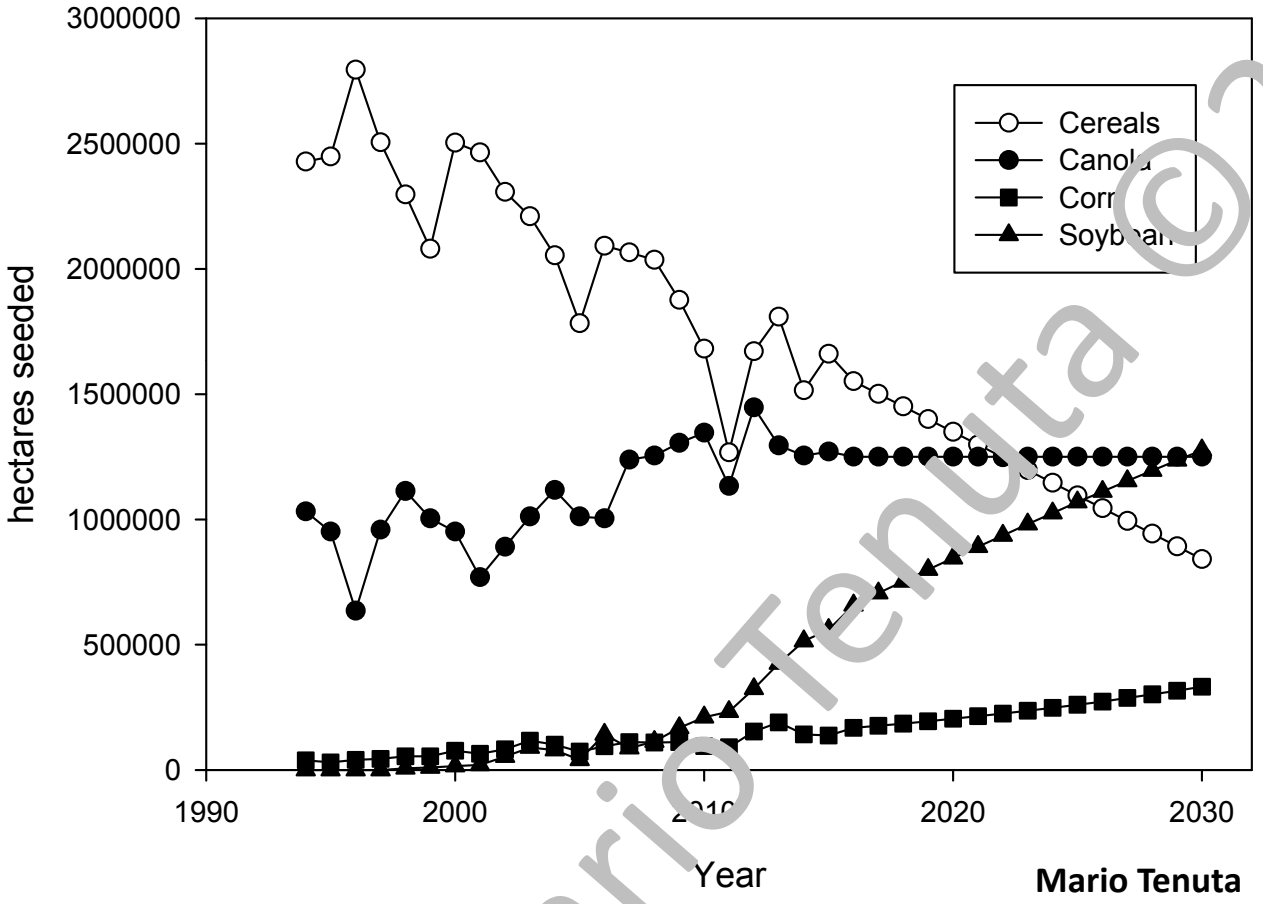
Tenuta et al., J Environ Qual 2015

Date				
Crop	Spring AA		Fall AA	
Year	$\sum F_N$	$\sum F_{N\ winter}$	$\sum F_N$	$\sum F_{N\ winter}$
	kg N ha^{-1}			
2010/11	5.1	1.0	3.2	2.5
2011/12	14.1	0.4	9.4	1.6

Timing Effects Summary

- Don’t apply early fall in wet years
- If going fall, apply very late before freeze-up
- If using urea, use EEF
- Nitrification inhibitors to anhydrous ammonia may help but still uncertain

Manitoba Major Field Crops



Historical data from Statistics Canada

Assumes continued cereal decline

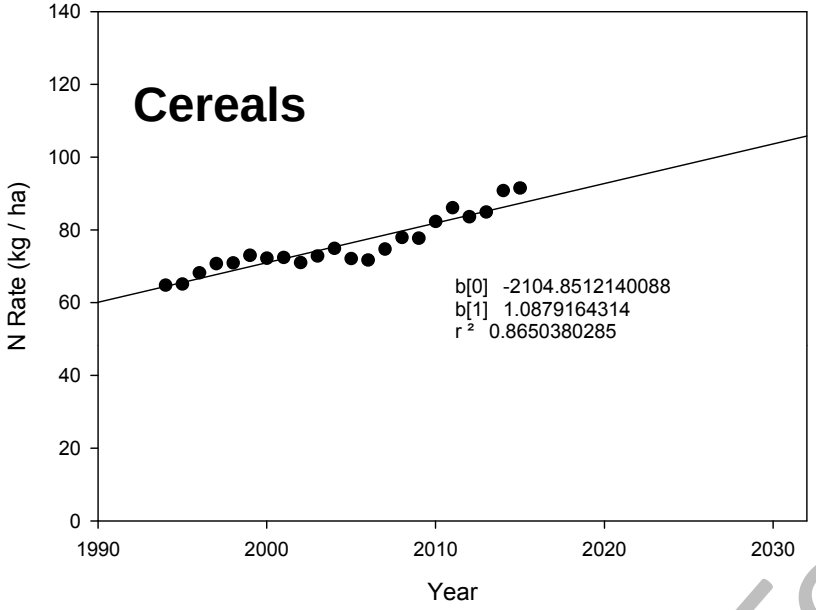
Canola stabilized

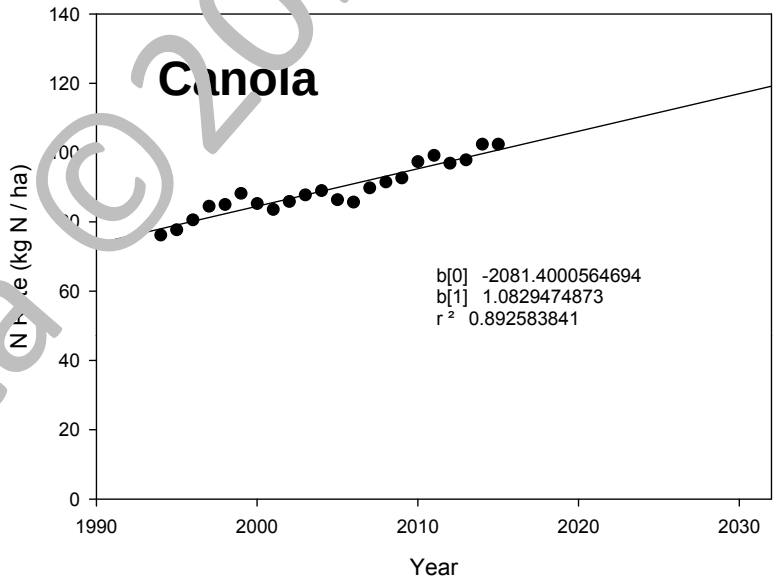
Corn increase a bit more than historical rate increase

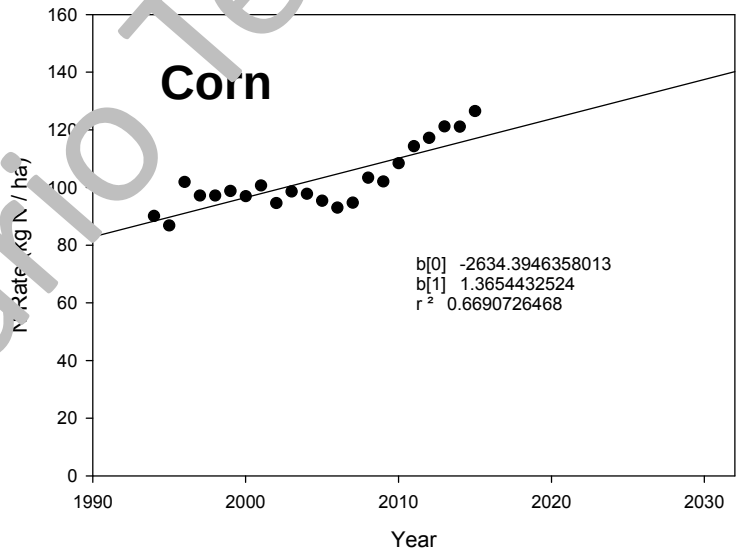
Total cropped area very slight increase

Soybean picks up remaining area of cereal decline

N Rates Keep Increasing

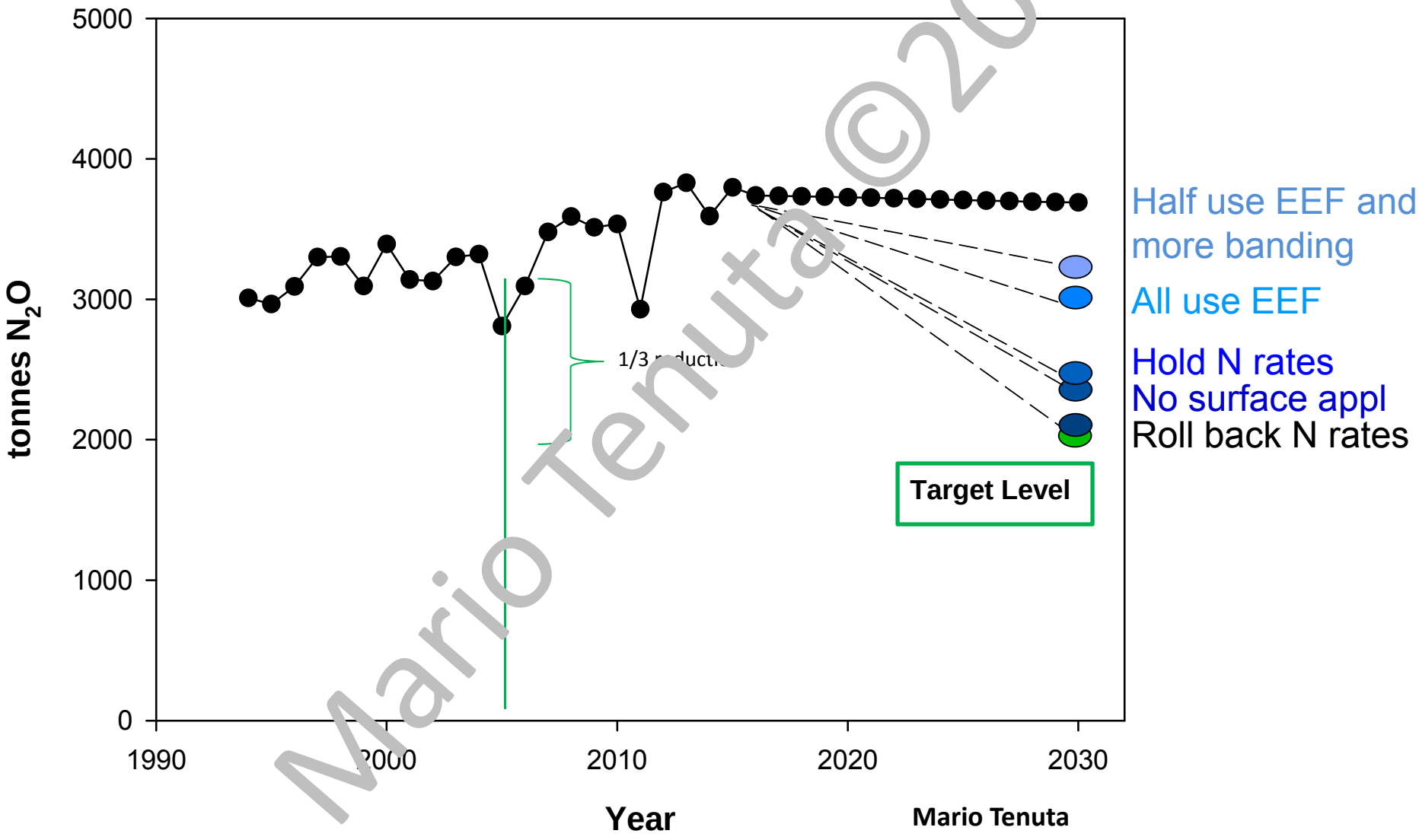






Data from MB
Crop Insurance

Massive Changes in Practices to Reach Reduction Target in MB



What Pisses You Off Most?

- No-till doesn't count much for credits
- Increased yields don't count for credits
- Possibly paying more for fuel
- Possibly paying for N_2O emissions from soil
- Possible restrictions on N Fertilizer use
- Not gonna be easy to reduce N_2O emissions
- University researchers doing GHG research
- That you are not having lunch right now

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Acknowledgements

- IHARF staff for invitation
- IHARF members
- Funding from Provincial and Federal sources
- Funding from Industry (Fertilizer Canada, Agrium, KOCH, BASF, Dow)
- Growers for placing trials on their land
- Many students, technicians and research associates
- Many colleagues (Don Flaten, Brian Amiro, John Heard)

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