Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Special session on **Agriculture and Air Pollution**
organized for WGSR by the Task Force on Reactive Nitrogen and the Secretariat

Approaches to Reducing Ammonia Emissions in Canada

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Canada

Sub-title:

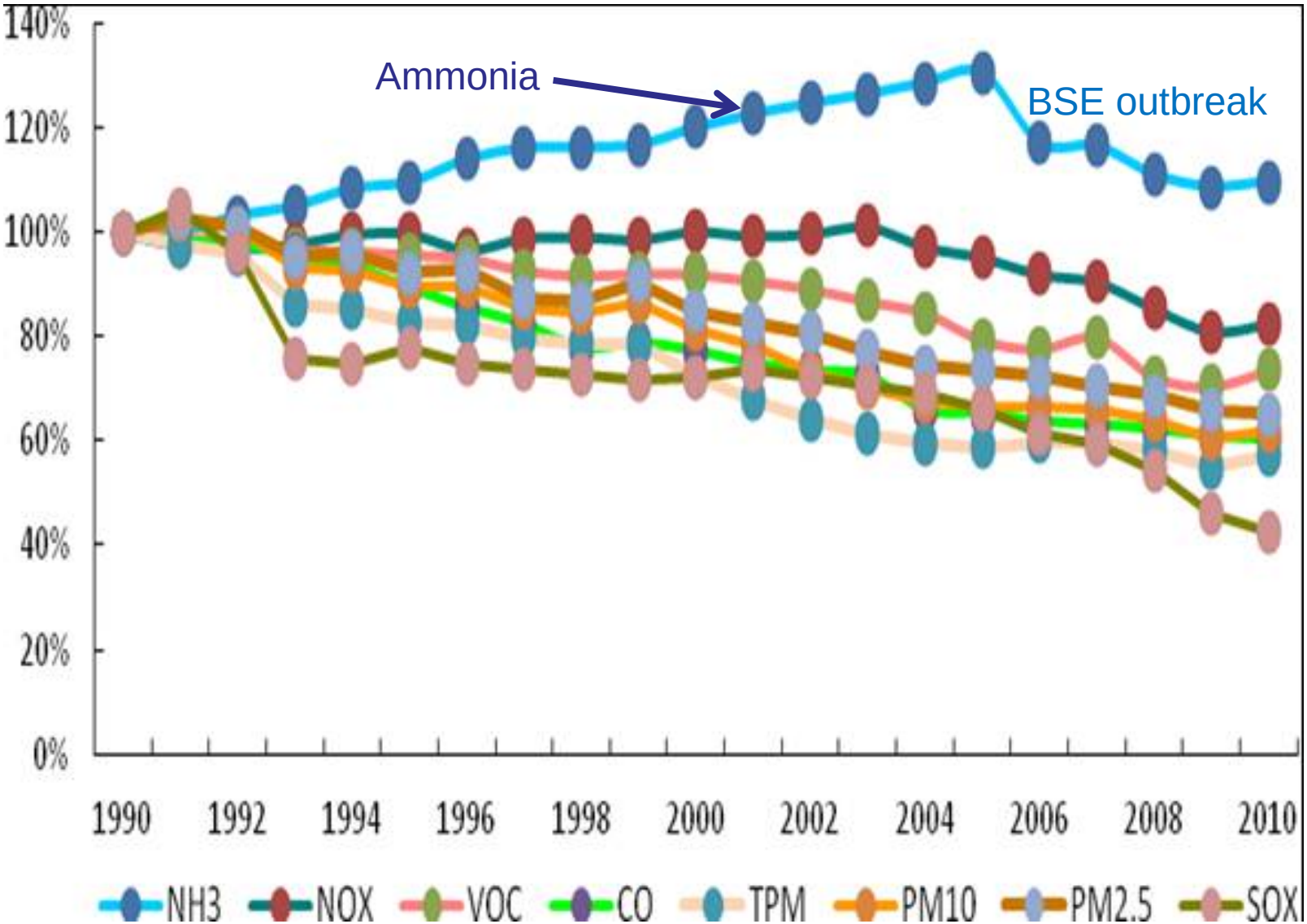
Mitigating ammonia in the absence of government policies: the Canadian experience

Why are there no agricultural policies for ammonia abatement in Canada?

1. Farm practices are under provincial jurisdiction; difficult to have national regulations.
2. Ammonia has lower profile than nitrate in ground water, phosphorous in surface water, or GHG emissions
3. Overlooked synergies:

   e.g. ammonia is main N loss pathway from farms so need abatement to improve N efficiency, and as N is the main energy input on many farms, abatement will reduce energy conumption.

Trend in emissions of air pollutants in Canada



Ammonia emissions in Canada- domestic food consumption and export

Commodity	Per consumed protein (kg/kg)	Due to food consumption (Gg/year)	Due to exports (Gg/year)
Cereal products	0.026	4.8	33
Dairy products	0.21	36	0.45
Eggs	0.15	4.3	0.45
Pulses and nuts	0.004	<0.19	na
Beef	1.3	115	78
Pork	0.43	28	49
Poultry	0.18	14	2
Vegetables	0.1	<4.5	na[1]
Fruits, sugars, oils, fish, beverages		<0.2	na[1]
Totals		**202**	**163**

(Adapted from Sheppard & Bittman, 2015)

Ammonia emissions in Canada- sectors and regions

Prov.	Poultry	Beef	Dairy	Swine	Fertilizer	Provincial Share of National Emissions
	%					%
BC	18.8	45.6	21.3	4.2	10.0	3.6
AB	1.8	70.0	4.4	7.9	20.0	27.3
SK	1.0	51.1	1.5	7.2	39.4	21.4
MB	3.2	44.0	4.2	22.0	26.0	11.4
ON	9.0	32.9	20.7	23.2	15.9	18.6
QC	7.4	18.5	27.7	35.4	12.9	14.8
NB	14.8	27.0	25.9	16.7	16.7	0.6
NS	19.7	30.0	27.4	14.8	8.4	0.7
PE	2.0	32.3	21.7	22.3	22.3	0.7
NF	16.9	11.2	61.5	2.3	7.7	0.1
Total	4.8	45.5	11.1	16.1	22.3	100
			Total National Emissions (tonnes NH3 /yr)			440000

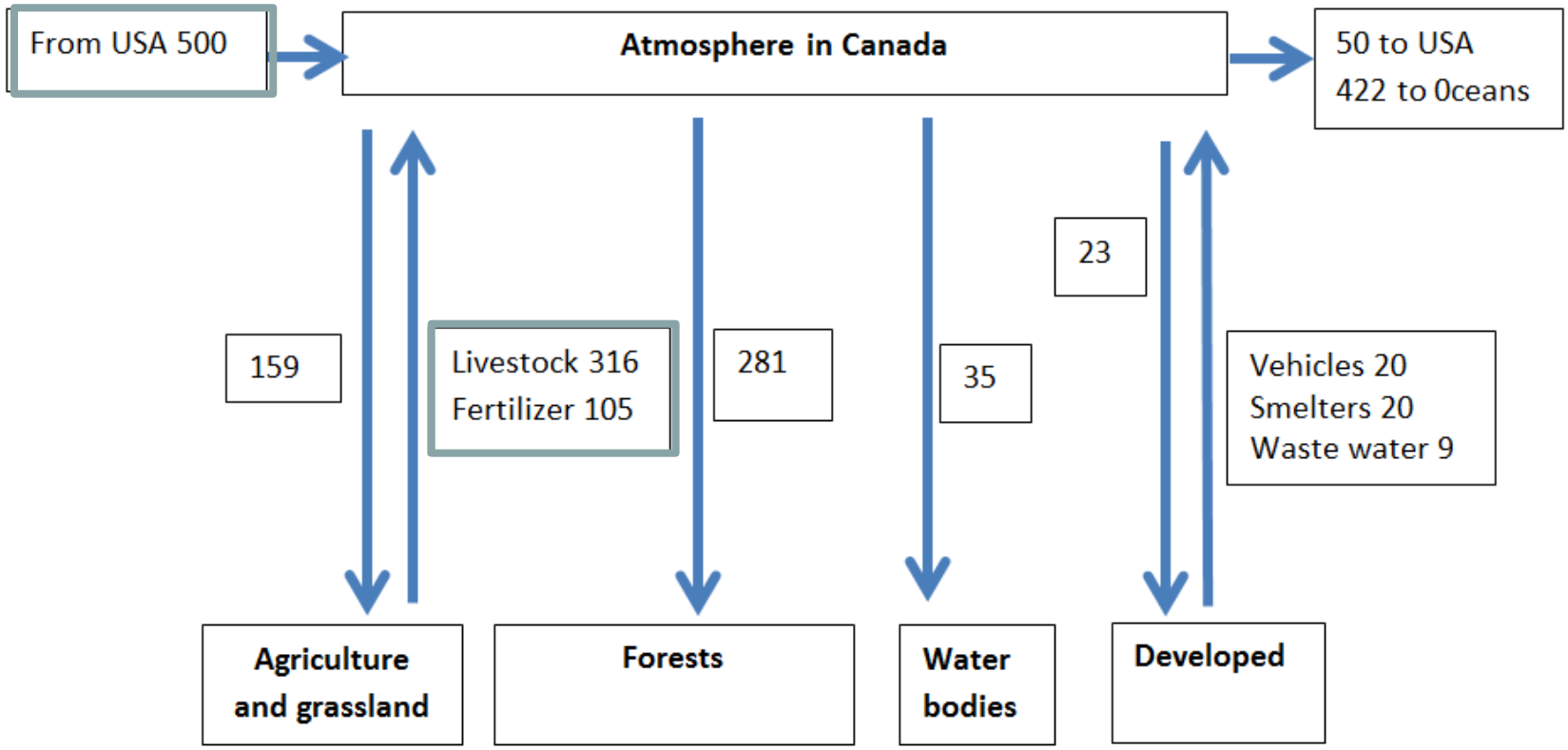
Ammonia emissions in Canada- sectors and farm activities

(kt N/yr)

Estimates	Beef	Pigs	Dairy	Poultry	Total
Total excretion	423.0	130.0	91.8	35.3	680.1
Lost as NH_3 from pasture	**19.6**	**0.0**	**1.8**	**0.0**	**21.4**
Retained on pasture	193.0	0.0	17.2	0.0	210.2
Lost as NH_3 from confinement housing	**90.1**	**37.8**	**15.4**	**9.4**	**152.7**
Transferred to storage as slurry	9.6	87.7	40.3	3.1	140.7
Transferred to storage as solid	111.0	4.3	17.1	22.8	155.2
Lost as NH_3 from storage	**11.3**	**5.2**	**5.8**	**1.2**	**23.5**
Transferred to land as slurry	9.4	83.5	39.0	3.0	134.9
Transferred to land as solid	99.7	3.2	12.6	21.8	137.3
Lost as NH_3 after land spreading	**48.6**	**26.4**	**24.4**	**10.8**	**110.2**
Retained on land after spreading	60.5	60.3	27.2	13.9	161.9
Lost as NH_3 from all production sources	**170.0**	**69.5**	**47.5**	**21.3**	**308.3**
Proportion of N emitted as NH_3 (%)	**40.2**	**53.5**	**51.7**	**60.3**	**45.3**
Commercial fertilizer					**100**
Total agricultural NH_3					**408**

Adapted from Sheppard & Bittman, 2013

Transport into Canada



Clair et al. 2014

Some examples of current farm practices that reduce ammonia emissions in Canada

Practices that reduce ammonia emissions in Canada

1. Use of legumes and pulses in crop rotations to improve income, yield and soil for next crop

Nationally, N fixation > commercial N fertilizer

Practices that reduce ammonia emissions in Canada

2. Side-banding (injection) of urea-based fertilizers to improve fertilizer efficiency and reduce application costs has very low emissions (~5%)

Almost universal for spring grains in western Canada, but cannot be used for winter cereals, forages or with high N rates.

Fertilizer application practices (%) for different N forms in Eastern and Western Canada

	Nitrogen Fertilizers			
Method of application	Urea	UAN	Anhydrous NH_3	Other
Eastern Canada				
Broadcast	16	12	0	14
Incorporated or partially injected	60	49	0	43
Fully injected	25	39	100	43
Western Canada				
Broadcast	6	7	0	21
Incorporated or partially injected	13	26	0	50
Fully injected	82	68	100	30

from Sheppard &Bittman, 2011

Practices that reduce ammonia emissions in Canada

3. Low emission application of pig slurry to reduce odour and phosphorous runoff- especially western Canada

Not widely adopted by dairy because: hard to do on on forages, smaller farms, and there are fewer complaints against smaller dairy farms.

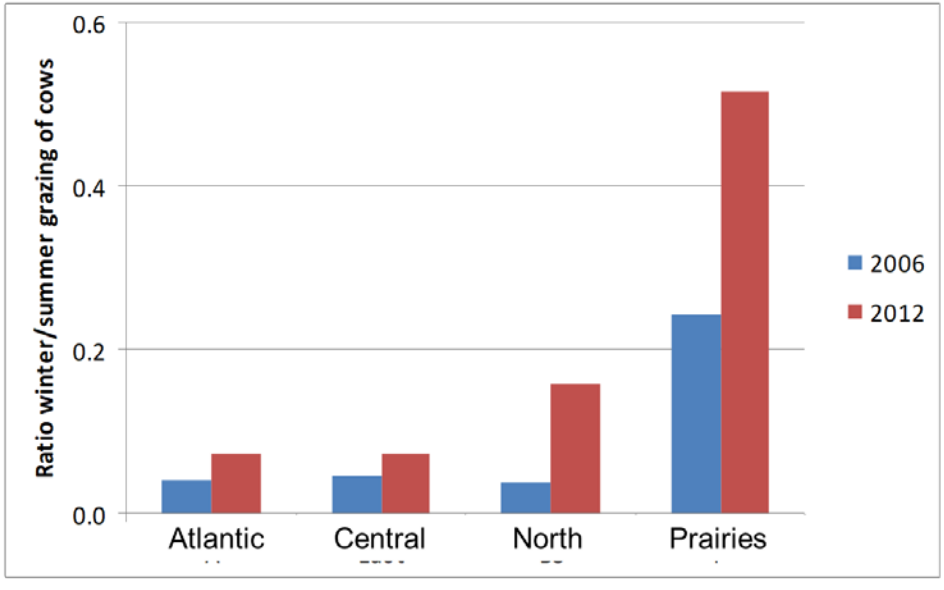
Farms (%) applying slurry manure by broadcasting, and low emission methods including surface banding shallow injection and deep injection

	Atlantic	On/ QC	Boreal	Prairie	Pacific	Canada
Dairy						
broadcast	**82**	**82**	**83**	**70**	**85**	**80**
surface bands	10	6	8	2	1	**5**
shallow injection	2	5	4	12	3	**6**
deep injection	0	3	0.0	14	0	**4**
Swine						
broadcast	76	65	56	**45**		**59**
surface bands	16	10	13	**4**		**9**
shallow injection	2	12	9	**16**		**12**
deep injection	1	9	17	**31**		**16**

Practices that reduce ammonia emissions in Canada

4. Grazing widely used on beef cow-calf operations to reduce operating cost; reduces emissions from housing, storage and manure spreading.

Note: increasing use of winter grazing



Practices that reduce ammonia emissions in Canada

5. Coincidental abatement

- Cold weather and surface crusts reduce emissions from liquid manure especially form dairies

Other ‘Ammonia Abatement Measures’ in Canada

Direct

- **Multiple phase feeding for pigs and chickens target protein intake (cost saving)**
- **Increasing milk yield per cow reduces excretion rate (feed cost saving)**

Indirect

- **Increasing farm sizes-increased use of slurry and greater use of manure contractors.**
- **Precision agriculture reduces N inputs and losses**
- **Large, fast equipment enables timely field operations**
- **Use of urease inhibitors (limited agricultural uses yet)**

Potential for additional low cost ammonia abatement in Canada- targets for policies?

Other low-cost BMPs could increase this to a saving of 96 kt NH_3 $year^{-1}$ or 26% of present emissions (costs less certain but assumed low)

Based on Sheppard, S.C. and Bittman, S., 2013. *Agr. Ecosys. Envir. 171*,90-102.

Practices that reduce ammonia

Countertrends

- More reduced tillage (less opportunity for incorporation)
- Reduced grazing on dairy farms
- More loose housing on dairy farms: greater emitting surface and les targeted feeding
- Shorter cow lifespan hence more replacements must be maintained
- Possibly more overfeeding of protein (we are testing this hypothesis)

Strategic mitigation policy (harm reduction)- can it work?

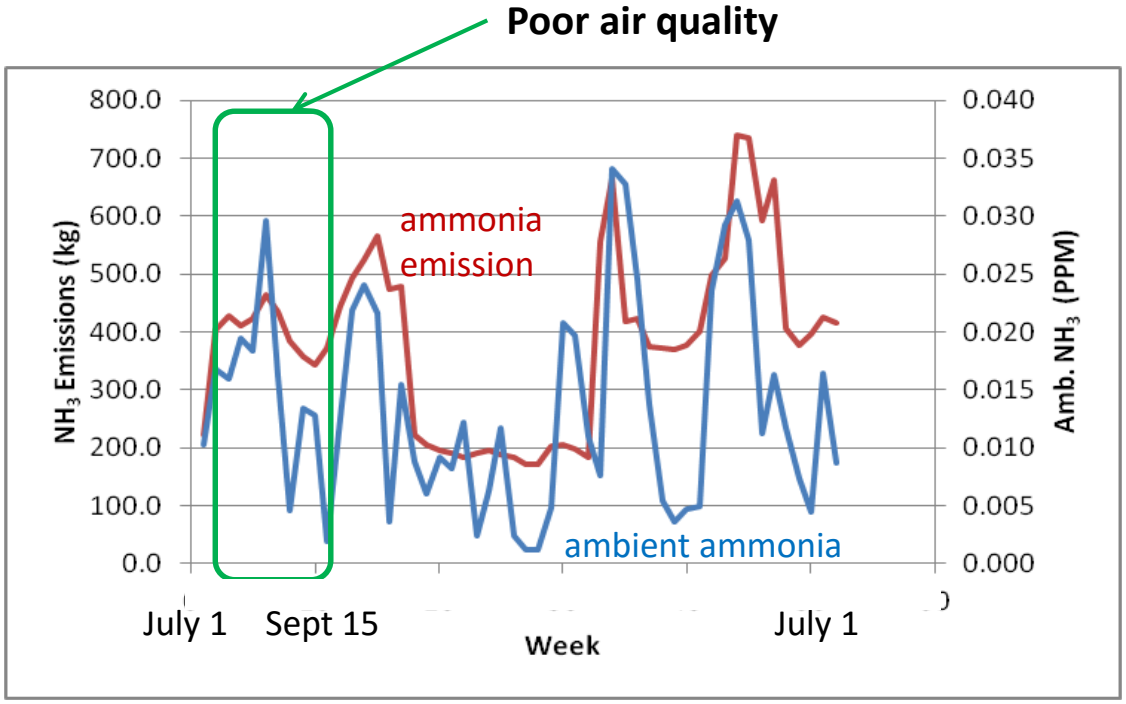
Ammonia: seasonal effects on air quality near Vancouver Canada

Winter

Late summer

Gray haze due to fine particles made of ammonia for agriculture and nitrate form vehicles ---
reduces visibility and hurts tourism

Strategic ammonia policy to mitigate poor air quality - can it work?



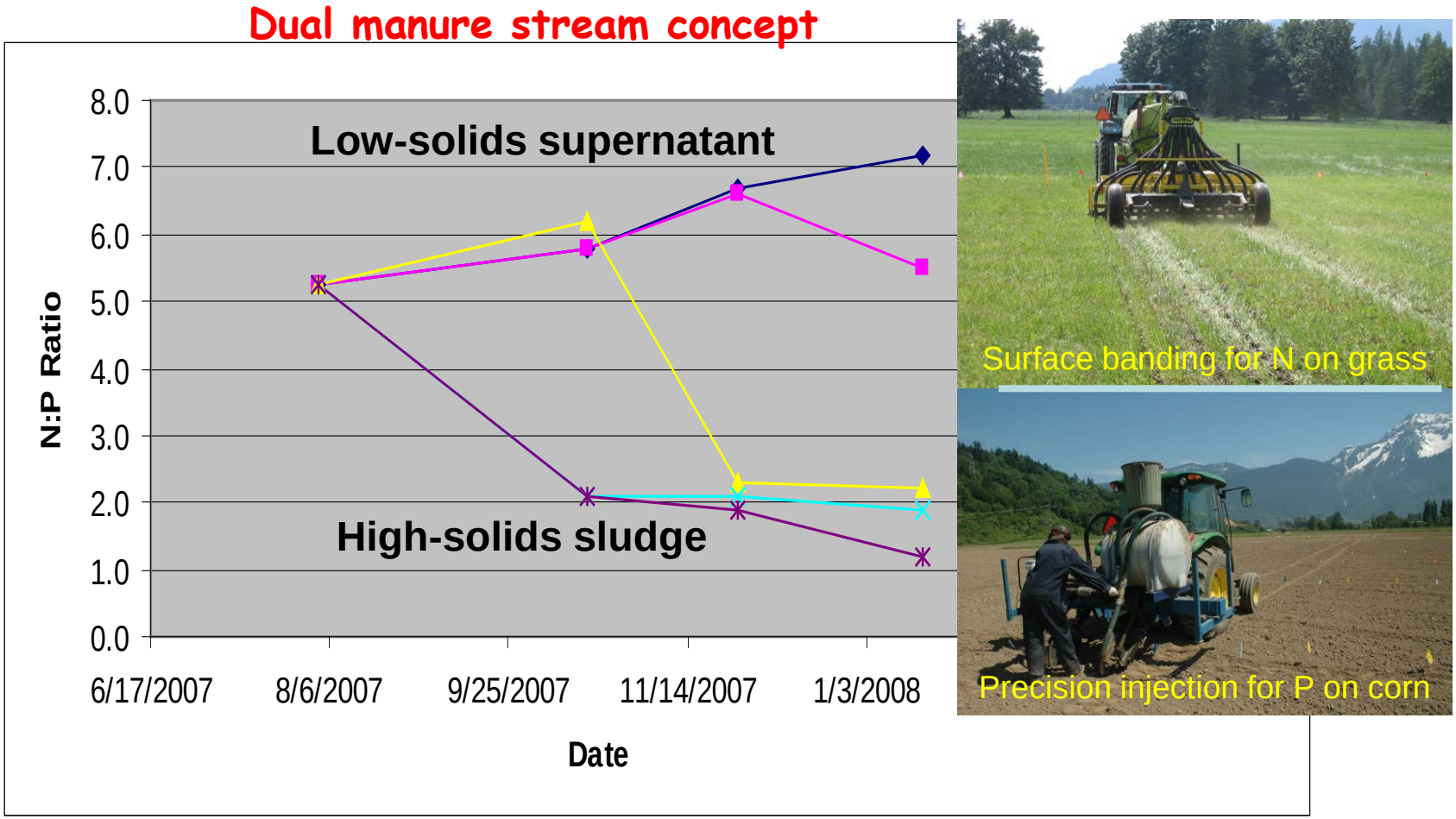
Ammonia emissions (red) and ambient atmospheric concentrations (blue) over 12 month period

Based on Bittman, S. et al. 2015. Atmospheric Env. (in press)

Abatement opportunities using integration

Manure separation for balancing nutrients: achieves for dual ammonia abatement:

- Liquid fraction banded (for N) on grass – low emission due to rapid infiltration
- Sludge fraction (for P) corn by precision closed injection



Cross media

Ammonia mitigation may cause pollution swapping (leaching and N_2O)

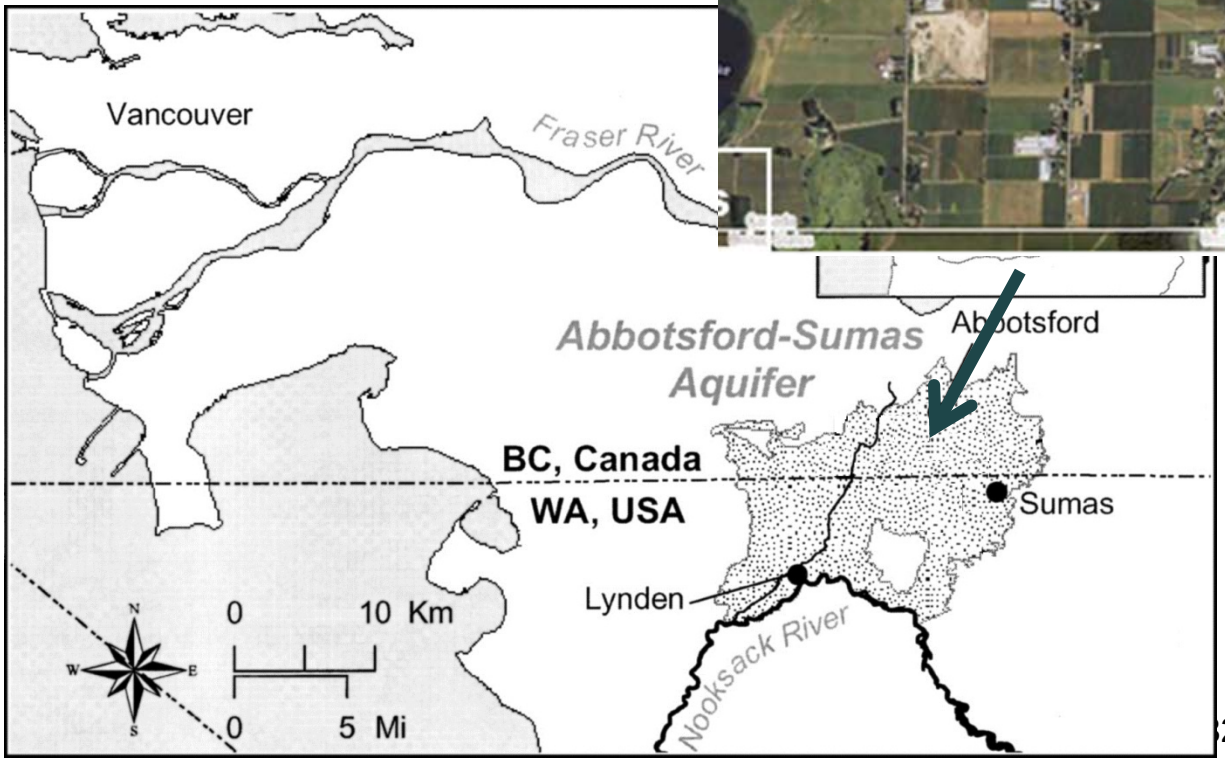
e.g.
Manure injection

Conclusion:

- The drive to efficiency often helps with mitigation (eg precision feeding and fertilizing)
- Emission reduction may piggy-back on more dominant issues (injection of pig manure)
- It is important to understand the emission inventory (eg in Canada emissions from storage are low)
- There are impediments (need large reductions to effect change) but equally there are opportunities to target impact
- Need for multipurpose technology with low uptake threshold such as low emission applicators that can be home built

Thank you

Abbotsford Sumas Aquifer



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Legumes are important source of N in extensive pastureland

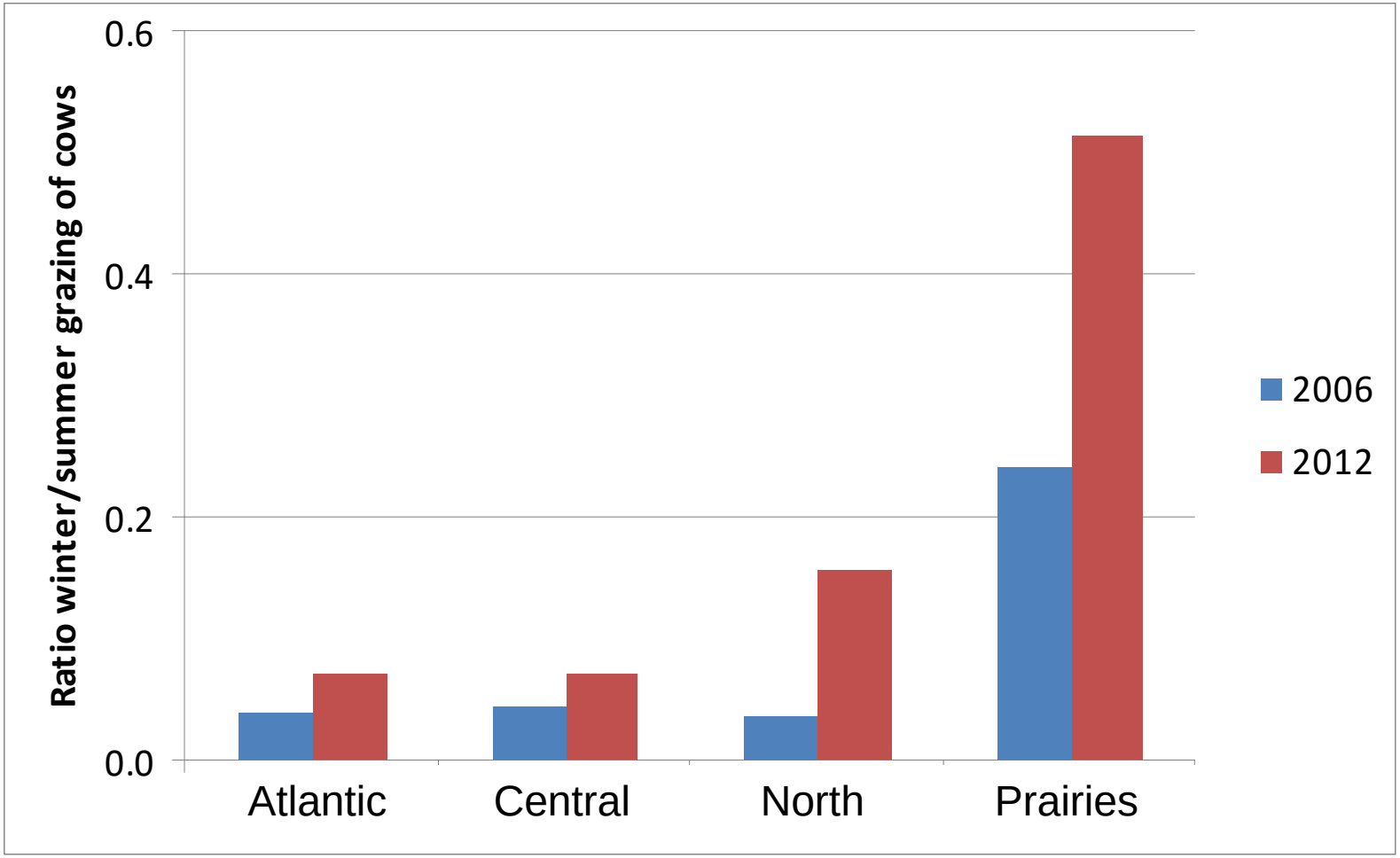
20-yr old stand of *Medicago falcata* variety 'Yellowhead'

Seed production field for 'Yellowhead'

Search for persistent alfalfa for western pastures

Winter grazing of beef cows/calves in Canada

Increase in winter grazing by (pregnant) beef cows from 2006 to 2012



Potential low cost reductions
(new measures-current measures)

Current practice	New practices	Stage-specific reduction (%)	Reduction after all stages within each sector (%)	National cost per year
Current practices	Only BMPs with known low abatement costs: slurry storage and slurry spreading. change in layer housing	---	5	$13M or $0.80 per kg NH_3
Current practices	All BMPs listed with assumed low costs	---	26	Unknown

Practices that reduce ammonia

Increasing dairy farm sizes leads to increased use of liquid manure with more available abatement measures

Size (quartile)	Beef	Dairy	Pigs	Layer
1	13 (1000)	85 (195)	99 (3,300)	34 (70,000)
2	2.6 (200)	77 (94)	99 (2,200	31 (26,000)
3	3.9 (80)	72 (65)	98 (1600)	43 (13.000)
4	4.2 (30)	64 (40)	88 (940)	61 (7,600)