UNIVERSITY of GUELPH
Food, Agricultural and Resource Economics
UNIVERSITY OF SASKATCHEWAN
College of Agriculture and Bioresources
DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS
AGBIO.USASK.CA

Estimates of Negative and Positive Externalities from Agriculture

Tristan Skolrud, Ken Belcher, Patrick Lloyd-Smith, Sarah Prescott, Peter Slade, & Alfons Weersink

Optimizing Land Use for Sustainable Growth:

A CAPI Dialogue

April 24, 2019

Guelph, Ontario

PRELIMINARY RESULTS – DO NOT CITE

Estimates of Negative and Positive Externalities from Agriculture

Tristan Skolrud, Ken Belcher, Patrick Lloyd-Smith, Sarah Prescott, Peter Slade, & Alfons Weersink

Optimizing Land Use for Sustainable Growth:
A CAPI Dialogue
April 24, 2019
Guelph, Ontario

Outline

1. What constitutes an externality?
2. Approach to measuring value of externality
3. Illustration for negative externalities associated with air
4. Summary of other negative externalities
5. Summary of positive externalities
6. Policy implications

Defining externalities

OECD Definition:

Environmental externalities refer to the economic concept of uncompensated environmental effects of production and consumption that affect consumer utility and enterprise cost outside the market mechanism.

As a consequence of negative externalities, private costs of production tend to be lower than its "social" cost. It is the aim of the "polluter/user-pays" principle to prompt households and enterprises to internalize externalities in their plans and budgets.

Negative externalities

Air Pollution

- Greenhouse gases
- Ammonia
- Particulate matter

Water Pollution

- Nitrogen
- Phosphorous
- Coliforms and pathogen contamination

Other

- Soil erosion
- Biodiversity and wildlife

Positive externalities

- Erosion control
- Biodiversity and wildlife habitation
- Landscape aesthetic
- Nutrient recycling

Measuring externalities

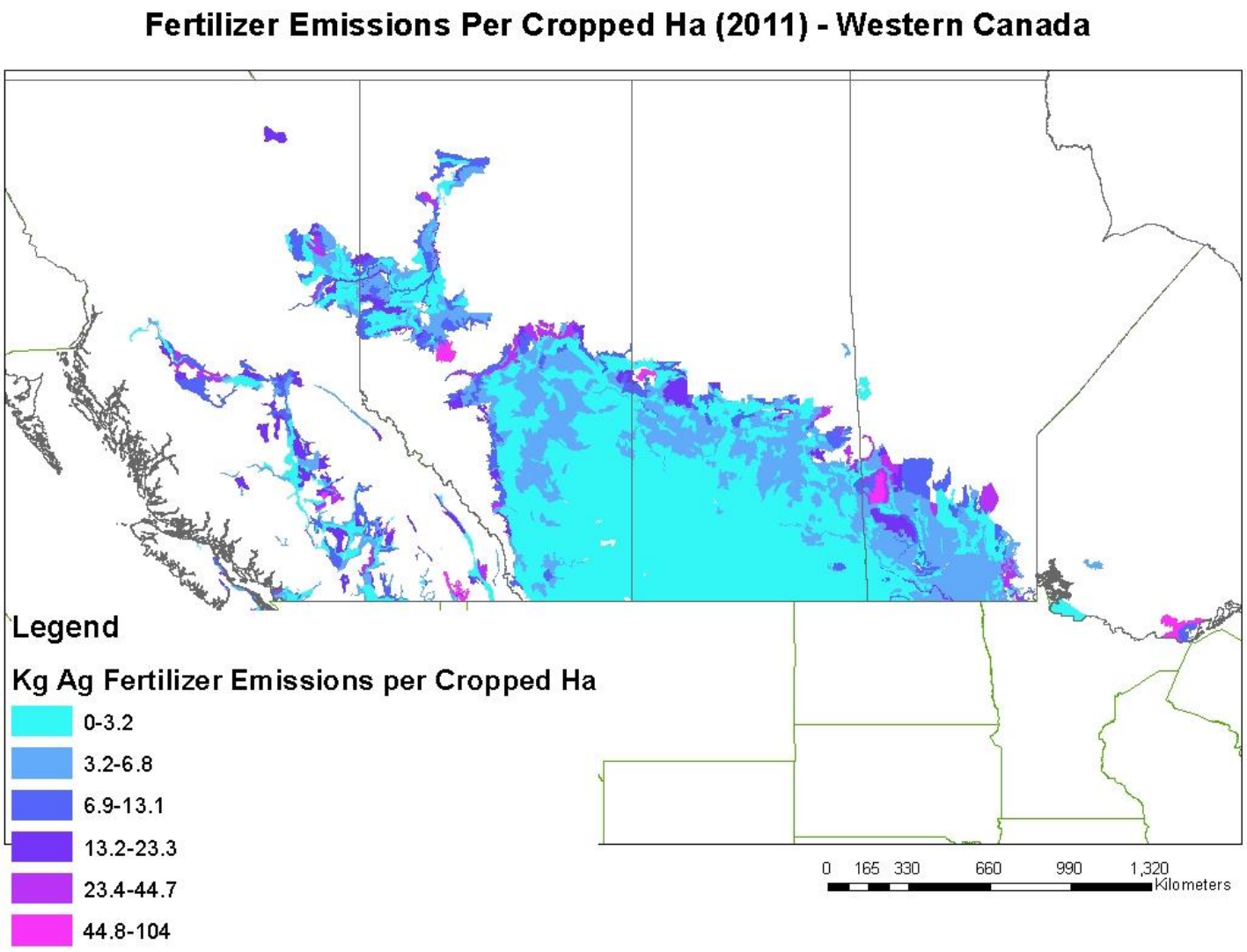
Steps

1. Measure Physical Levels (Emissions)
   - mainly from AAFC's Environmental Indicator report

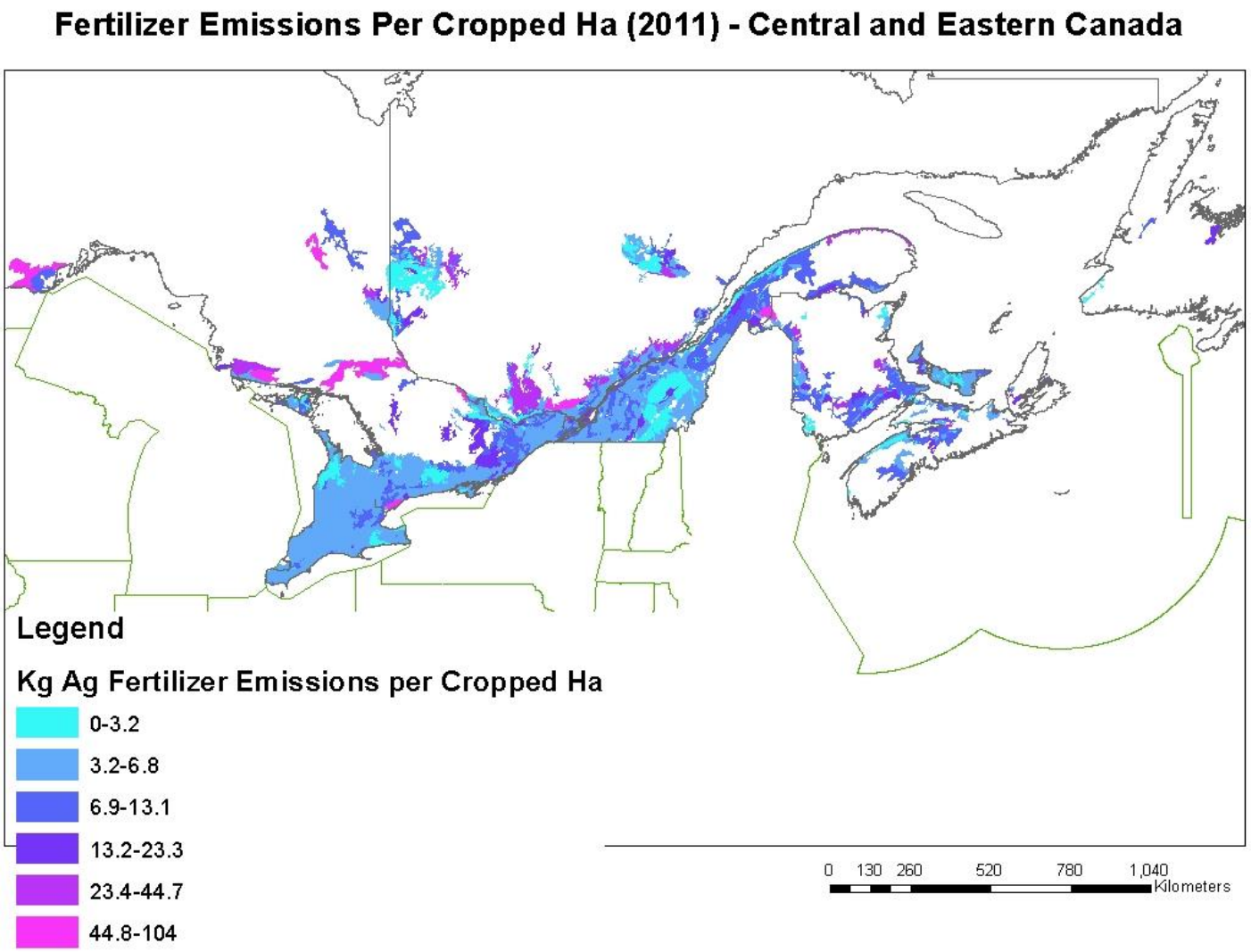
2. Valuation
   - adapted from previous studies

3. Total Measurement
   ($) = Physical Measure * $ /unit

Fertilizer Intensity – A Driver of Externalities



Fertilizer Intensity – A Driver of Externalities



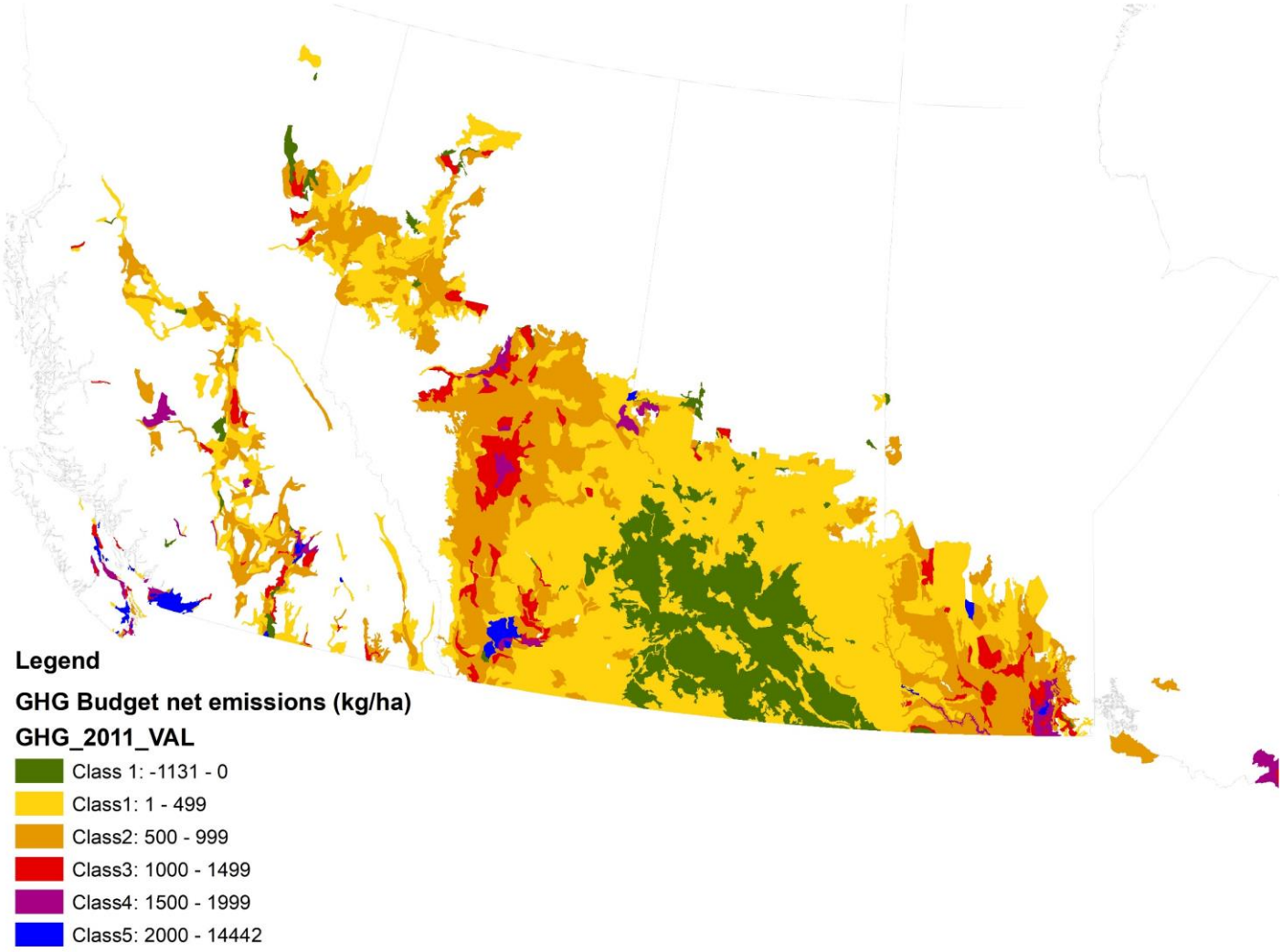
GHG Emissions

Approximately 10% of Canada's GHG emissions are from agriculture (60% livestock and 40% crop production)

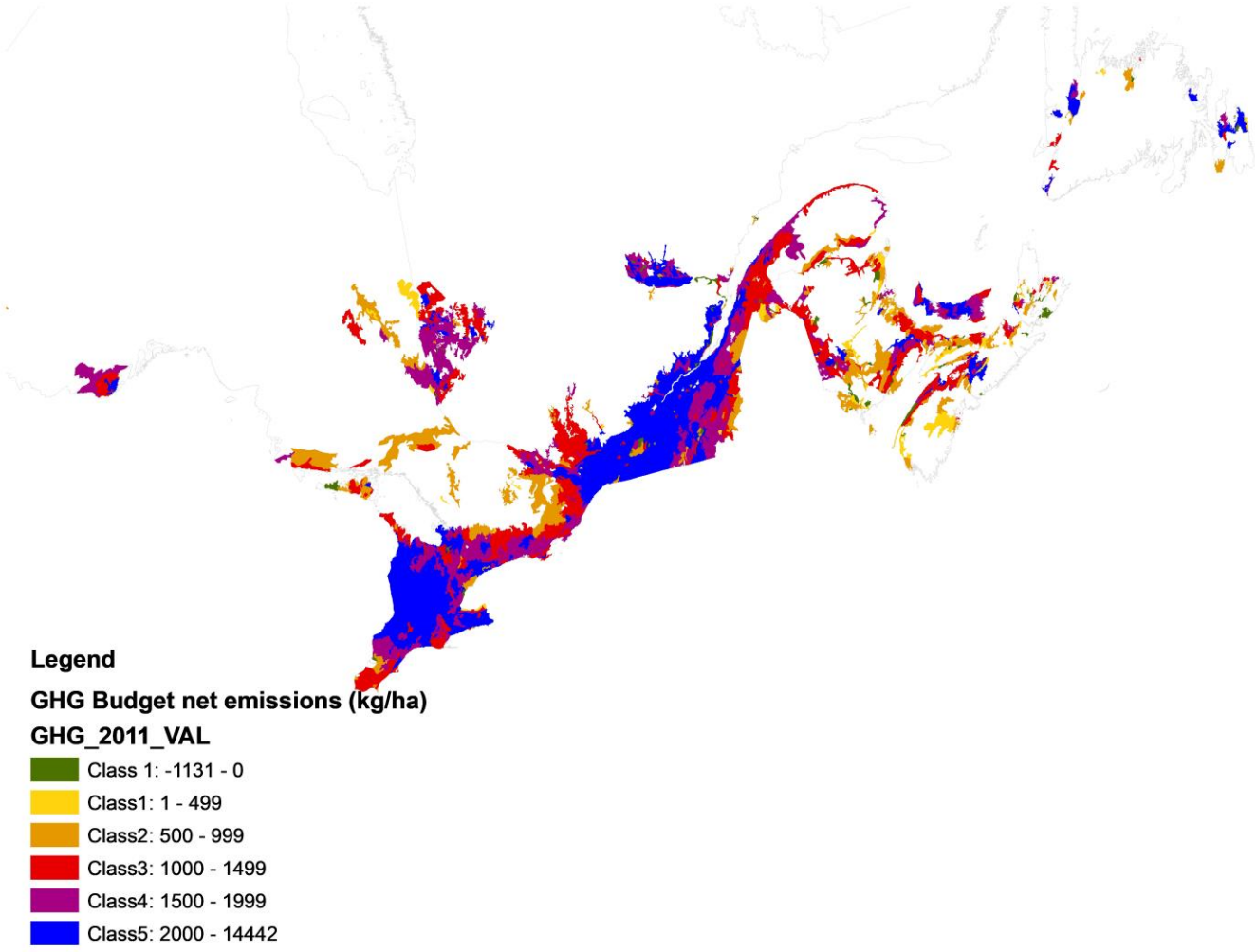
The main gases emitted by agricultural activities are:

- Carbon dioxide (CO_2) released through decomposition of crop residue and soil organic matter;
- Methane (CH_4) is associated with livestock production through enteric fermentation and anaerobic digetion; and
- Nitrous oxide (N_2O)which comes from using fertilizer and manure

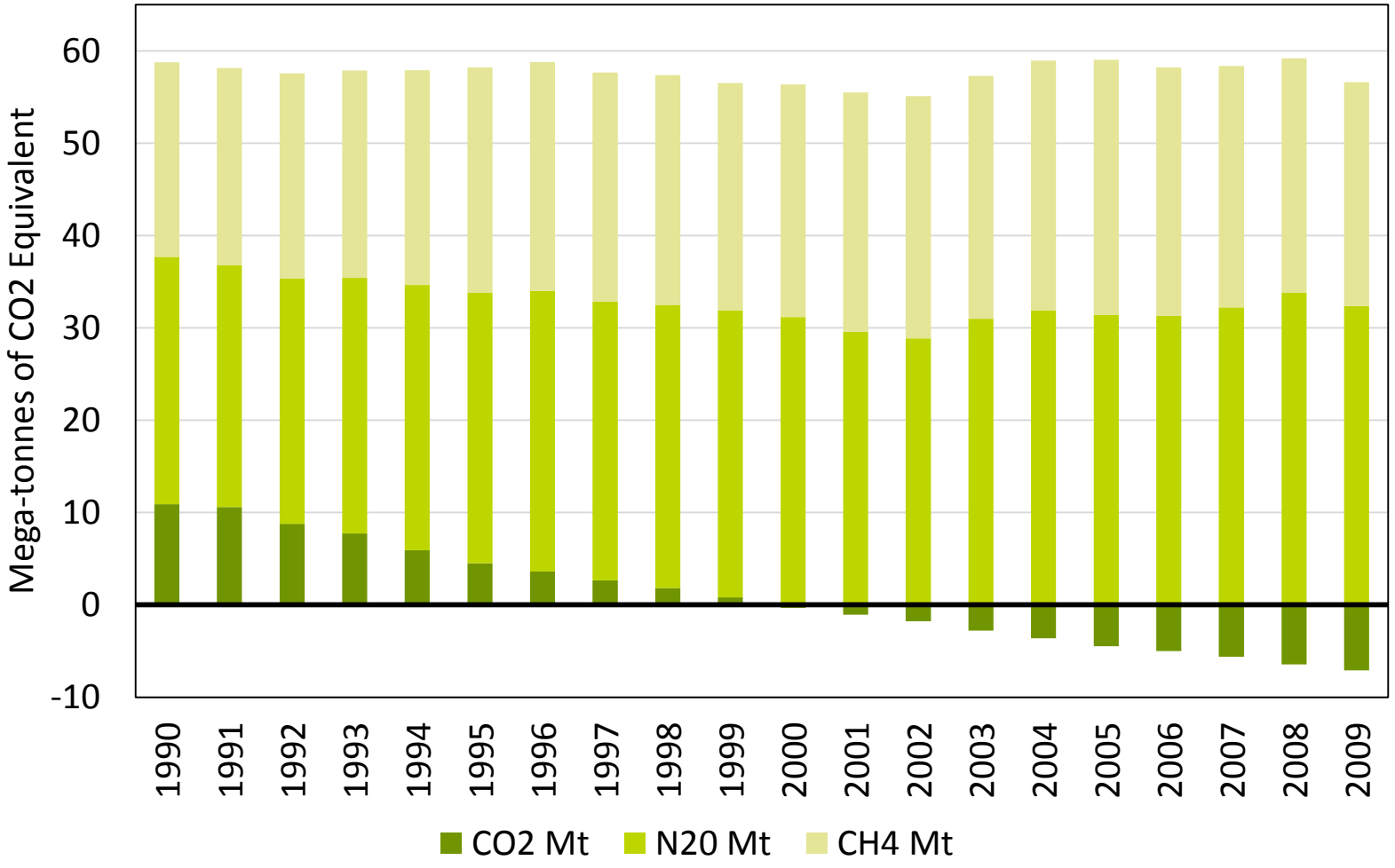
Net agricultural GHG emissions – Western Canada



Net agricultural GHG emissions – Eastern Canada



Canadian On-Farm Net Emissions from Primary Agriculture



GHG valuation

Social Cost of Carbon

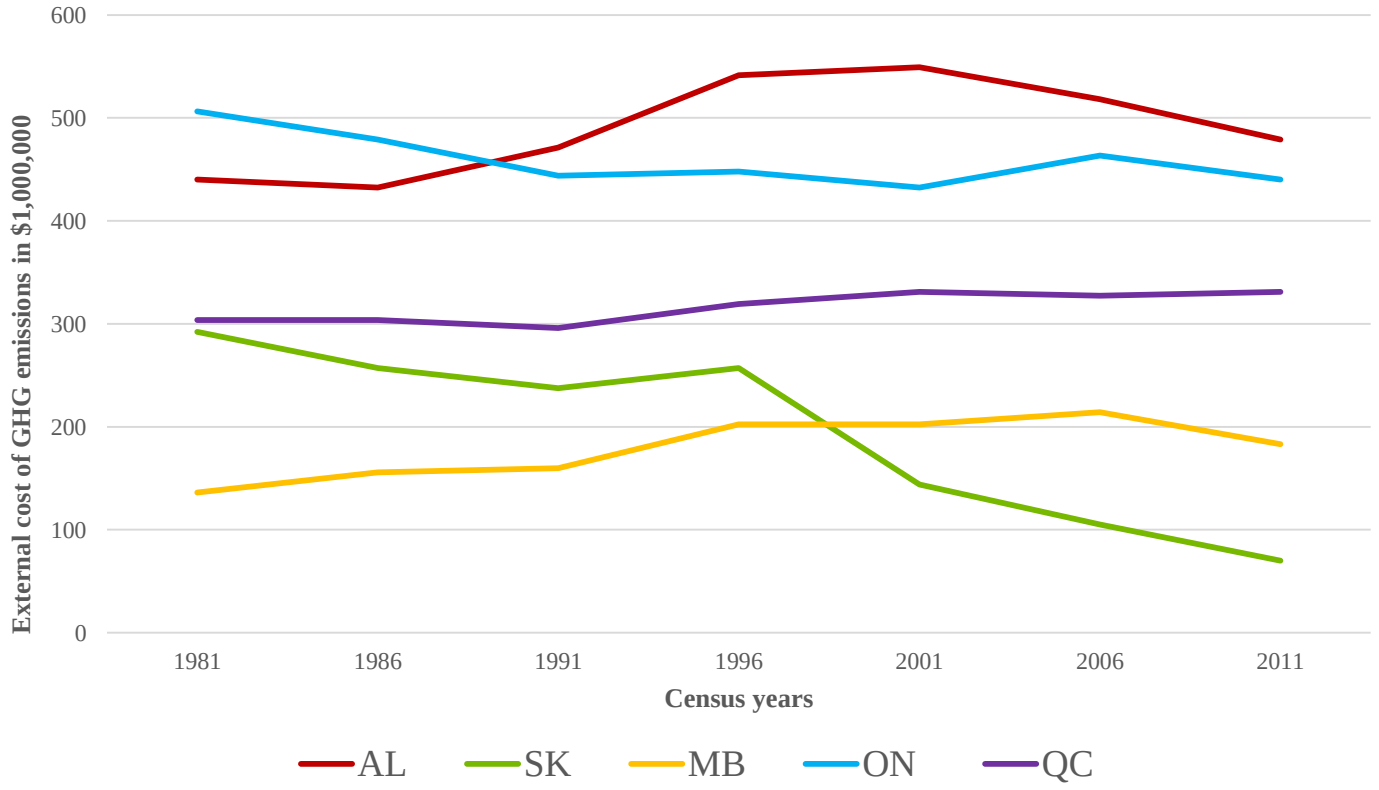
- What is the cost to society from emitting one more unit of CO2-eq?
- Estimate used by Environment and Climate Change Canada:

C$41/tonne

- For example, in SK, total agricultural GHG emissions in 2011 were 1.8 MT, resulting in an externality of **C$73.8 million.**

Cost of GHG Emissions, 1981-2011

10% decline in total value of damages ($1.5 b in 2011)



Particulate Matter

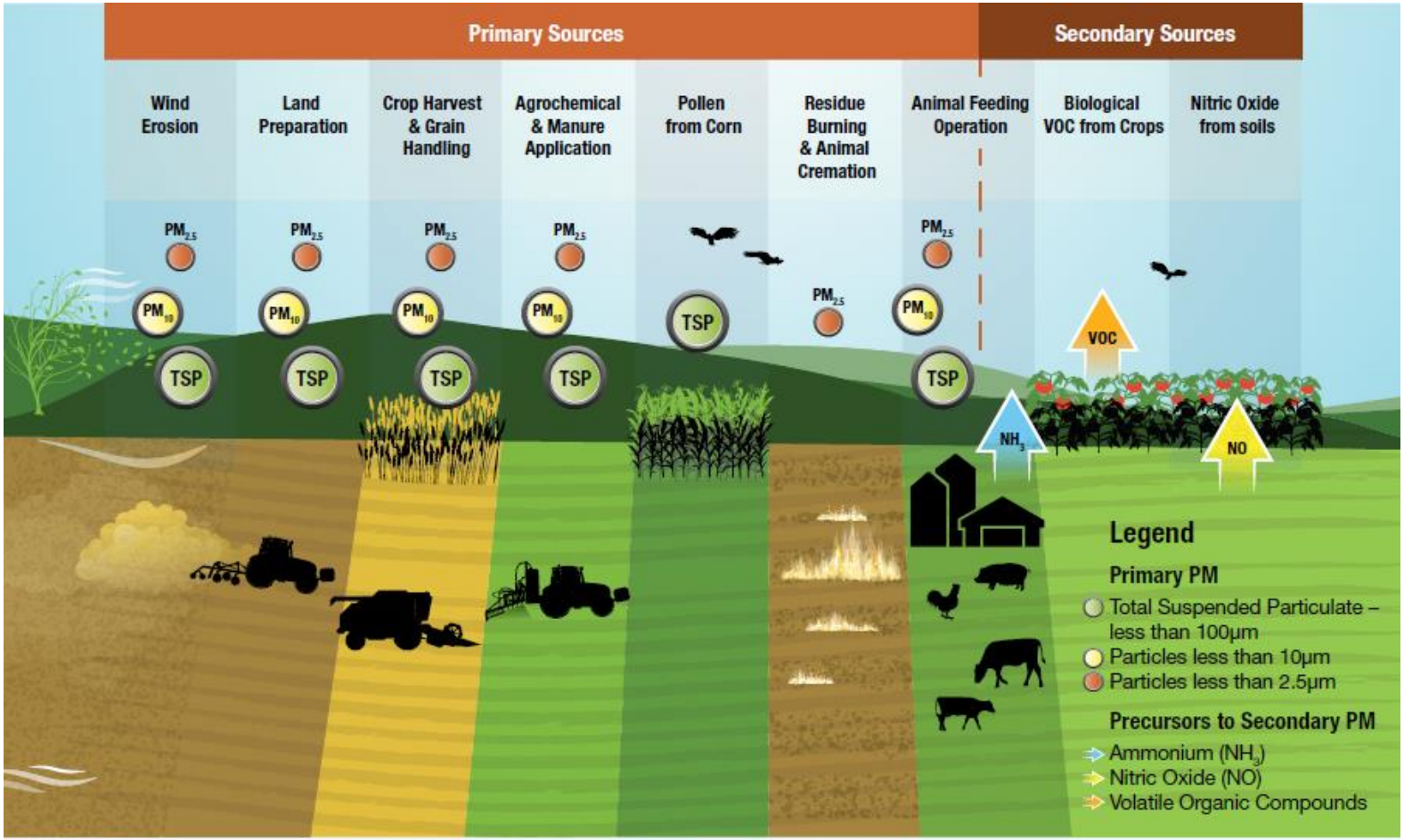
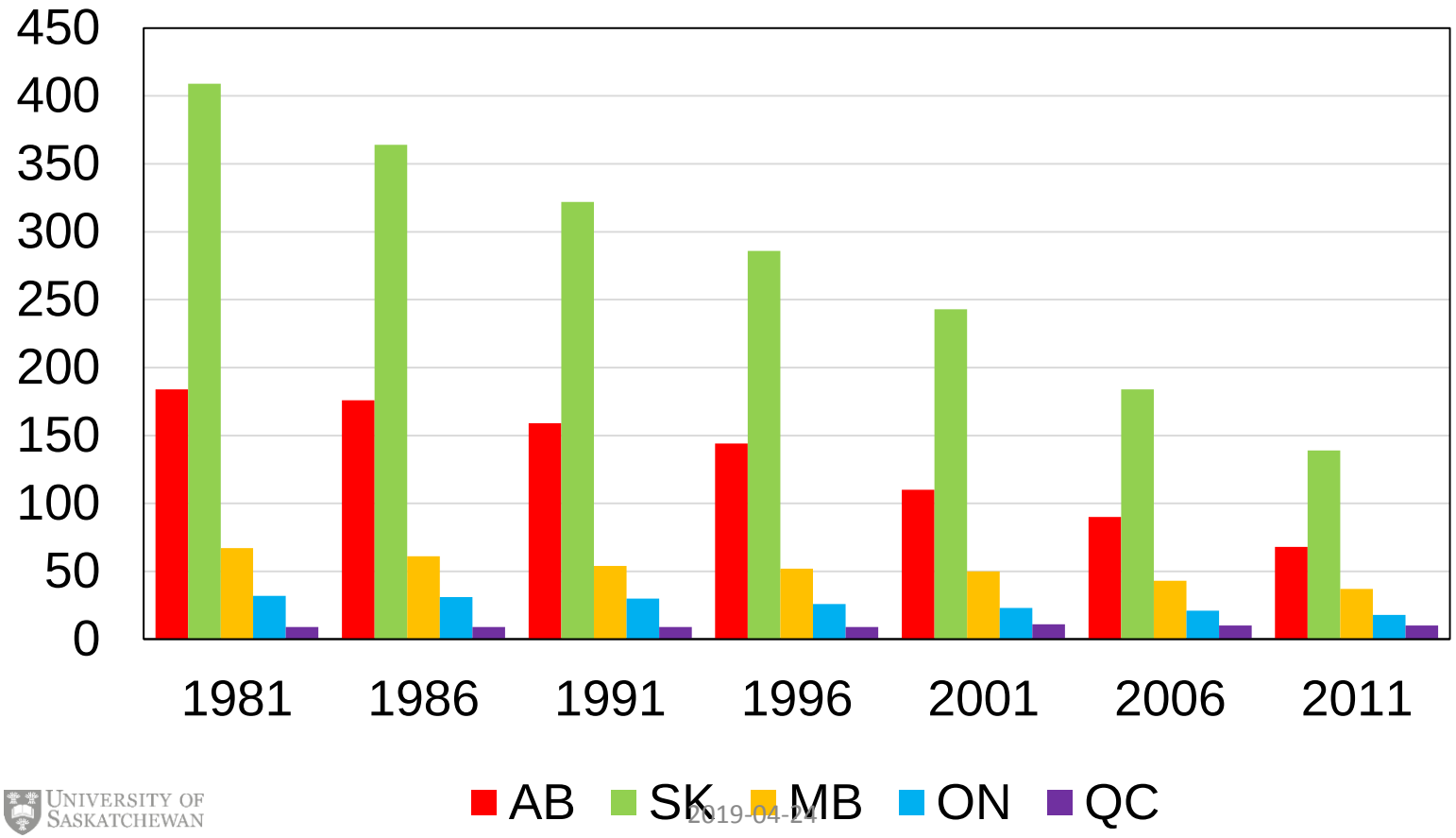


Figure 17–1: Main activities and factors contributing to primary and secondary PM emissions in agriculture

Particulate Matter ($PM_{2.5}$) – Kilo-tonnes per year

Agriculture contributed 5% of all PM emissions in Canada in 2006

Most of this is from land preparation and wind erosion



Particulate Matter - Valuation

Muller and Mendelsohn (2007) estimate the marginal damage of particulate matter emissions from the U.S.

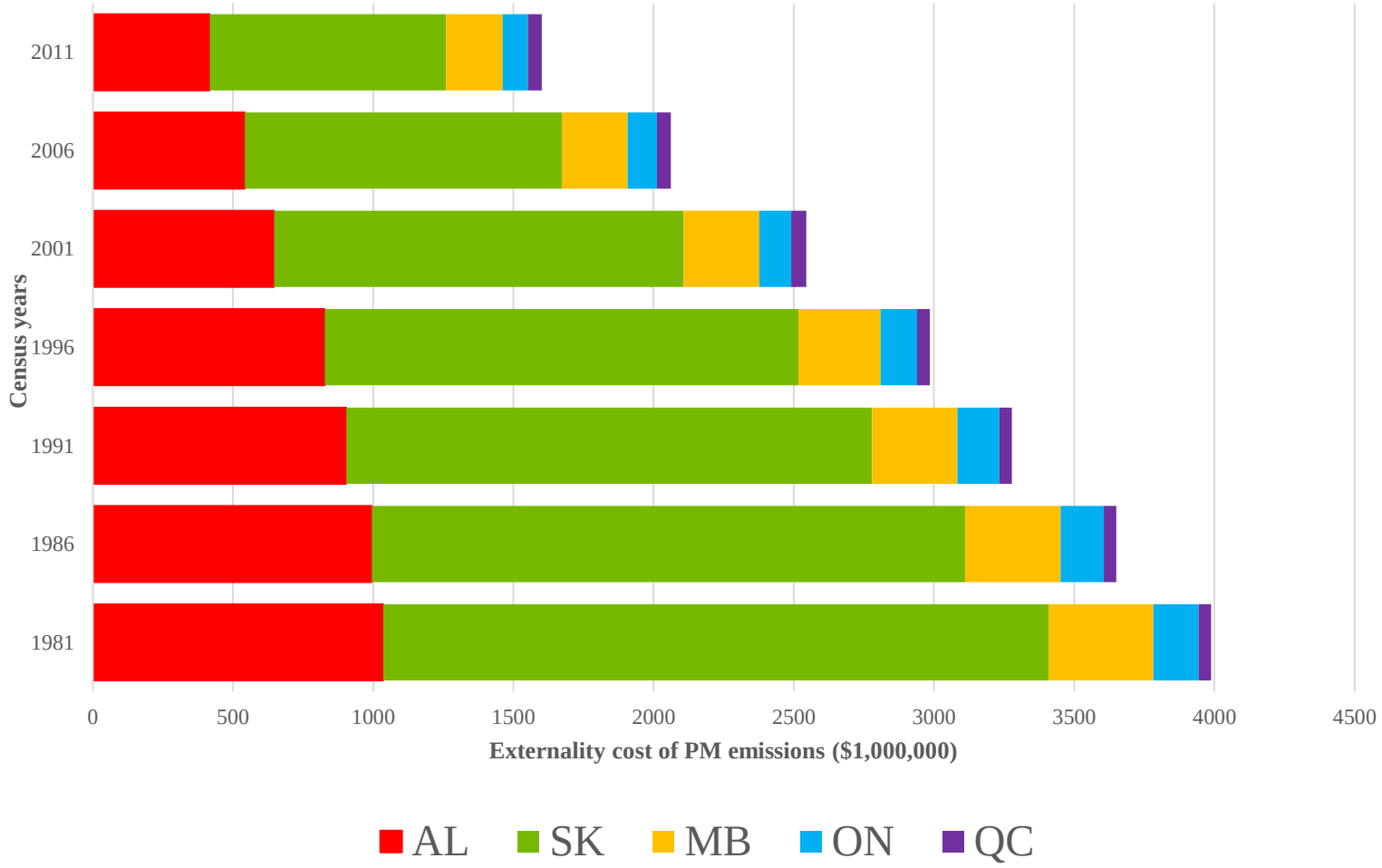
In 2011 Canadian dollars:

- $2,083/tonne (rural areas)
- $6,247/tonne (urban areas)

Why are these figures so large?

- Estimates reflect the reduction in lifespan using the value of a statistical life ($6.2 million USD)
- Statistically significant relationship between particulate matter emissions and adverse human health effects

Particulate Matter – Damage Costs



Ammonia Emissions

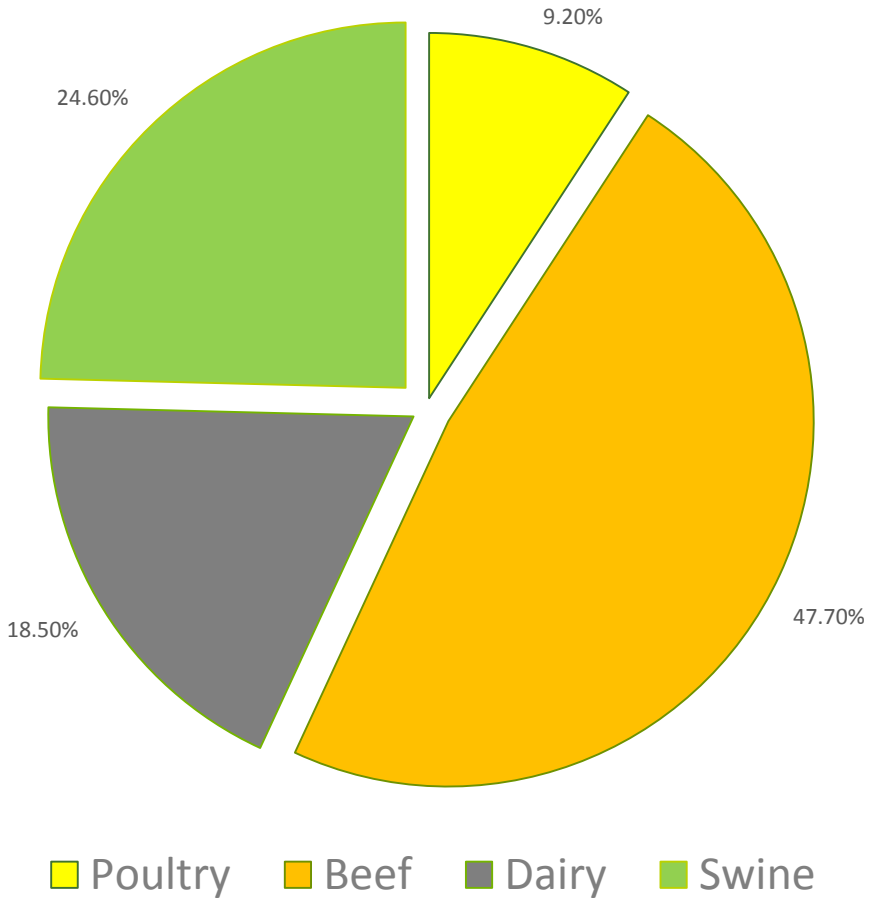
Ammonia gas (NH_3) is released through:

1. the breakdown of excreted urea from cattle and pigs or uric acid from poultry (65%) and

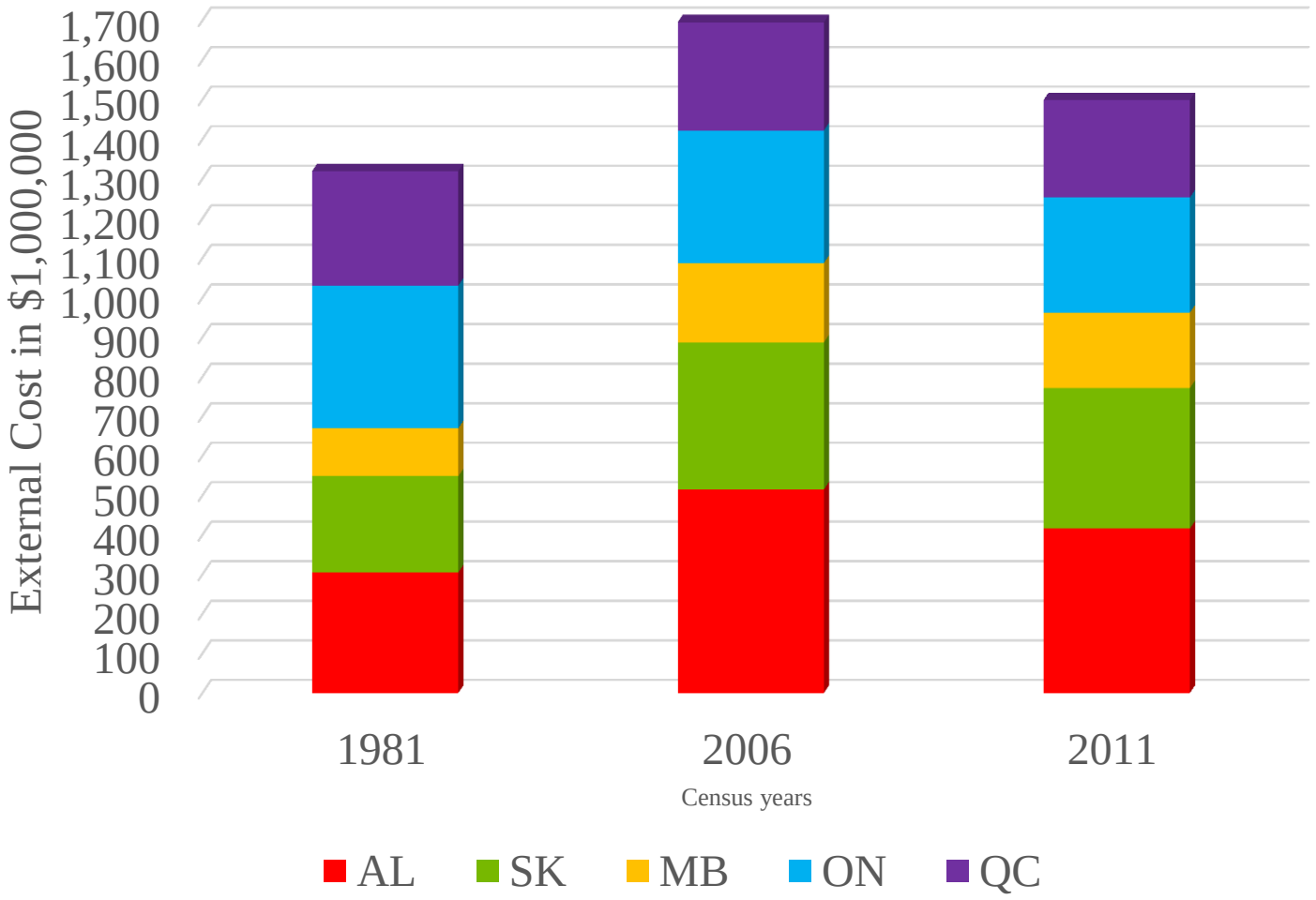
2. N fertilizer containing ammonium or urea (35%)

85% of NH_3 emissions in Canada from agriculture

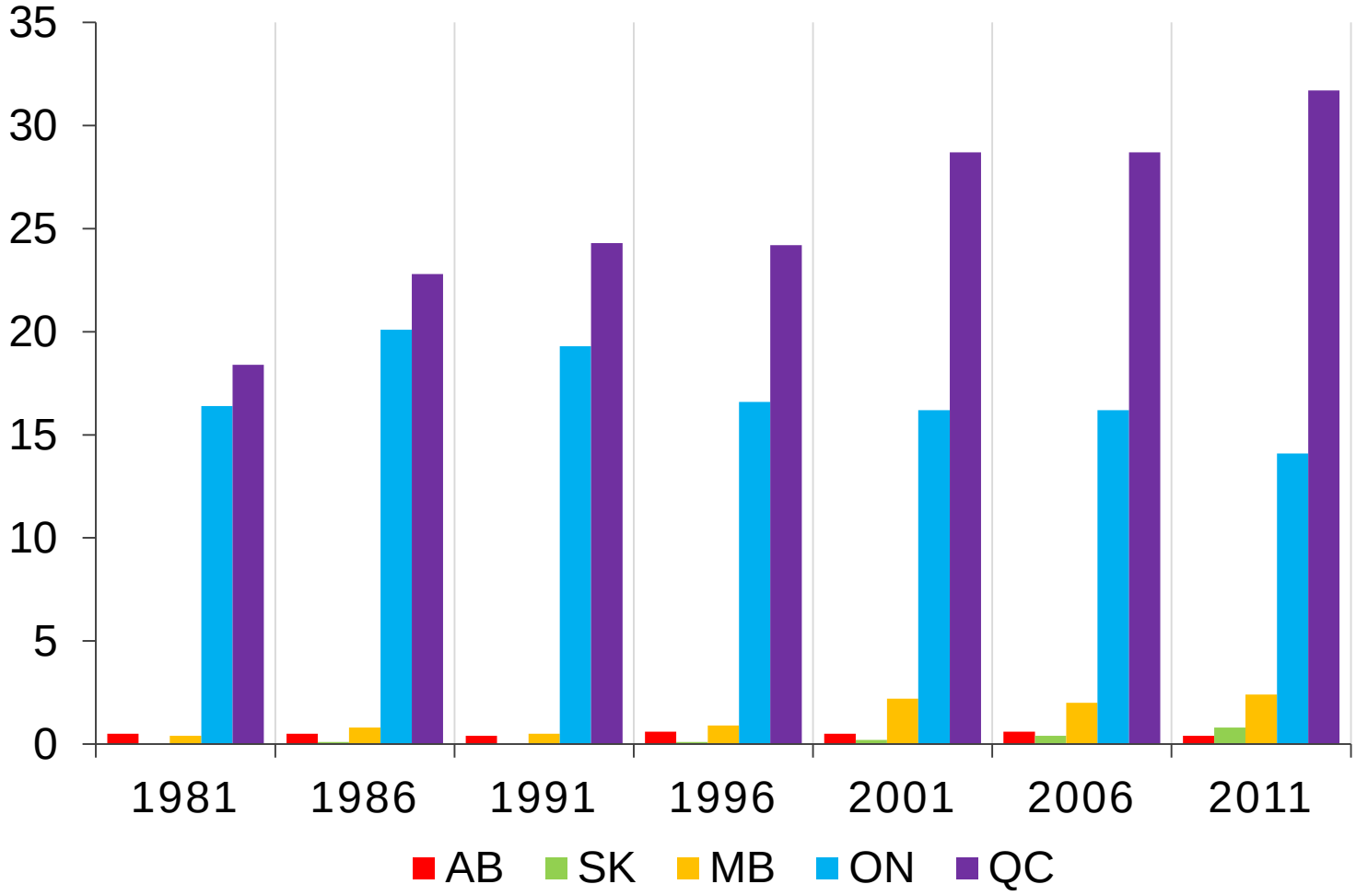
Livestock share of Ammonia Emmisions



Ammonia Emissions- Damage Costs



Kilograms of nitrogen lost per hectare



Water quality

Nitrogen

- Estimates of average N loss per hectare by province
  - Estimate of N leaching into ground and surface water
  - How much does it cost to treat N at a water treatment plant?
    - Between C$3.6/kg and C$8.50/kg

Phosphorous

- WTP study from Larue et al. (2017) suggesting a 10% reduction in phosphorous in Quebec would be worth C$1.20/ha

Pesticides

- WTP from Brethoura and Weersink (2001): C$79.4/household/year

Coliforms

- WTP from Larue et al. (2017) suggesting a 10% reduction in coliform contamination is worth C$0.68/person/year

Soil Erosion

- Externality associated with off-site damages (not to farmer)

Erosion levels

- = Proportion of cropland in each erosion risk level * erosion rate with that risk level * cropland area

- Decline over time due to use of conservation tillage and less summer fallow

Valuation

- $7.68/tonne of eroded soil (Pimmental et al. 1995)

Wildlife and Biodiversity

- Wildlife habitat degraded through intensification of agriculture

Physical Measure

- Wildlife Habitat Capacity on Farmland Indicator from AAFC

Valuation

- WTP from Belcher et al (2015)
  - $52 ($17 consumptive and $35 non-consumptive)- Central
  - $15 ($11 consumptive and $4 non-consumptive)- Prairies

Negative Externalities – Summary

Environmental impact in $ million (% change 1981 to 2011)

Air	Prairies	Central	Total
Ammonia (NH3)	962 (44%)	537 (-17%)	1,499 (14%)
Greenhouse Gas (GHGs)	732 (-16%)	771 (-5%)	1,503 (-10%)
Particulate matter (PM)	1,462 (-61%)	139 (-32%)	1,601 (-60%)
Water			
Nitrogen	188 (337%)	796 (20%)	985 (40%)
Phosphorus	46 (17%)	9 (2%)	55 (14%)
Pesticide	189 (59%)	681 (62%)	869 (61%)
Coliform	40 (5%)	2 (-58%)	42 (-3%)
Other			
Soil Erosion	1,514 (-32%)	535 (-13%)	2,049 (-28%)
Wildlife and biodiversity	47 (1%)	205 (-14%)	253 (-12%)

Positive Externalities – Summary

Environmental impact in $ million (% change 1981 to 2011)

	Prairies	Central	Total
Soil Erosion Control	1,762 (5%)	256 (-30%)	2,017 (-1%)
Wildlife Habitation	4 (-3%)	29 (-15%)	33 (-14%)
Landscape Aesthetics	3,882 (-0%)	624 (-14%)	4,506 (-2%)
Nutrient Recycling	2,518 (5%)	133 (-58%)	2,651 (-3%)
Total	**8,166**	**1,042**	**9,207**

Externalities – Summary

Environmental impact in $ million

	Prairies	Central	Total
Positive Externalities	8,166	1,042	9,207
Negative Externalities	5,180	3,675	8,856
Net Benefits	2,986	-2,633	351

Policy Considerations

- The heterogeneity in the results suggest the need for spatially-specific agri-environmental policy to mitigate negative externalities.
- Because efficient input use results in low emissions, policies that enhance efficiency, both in crop production and livestock, will be crucial in reducing GHG emissions.
- The estimated values could also help to identify policy priorities – which policy is more effective in mitigating negative externalities and increasing positive externalities?
- The role of farm financial conditions (next slide)

Net Market Income by Quintile: Canadian Crop Production