PRIMARY PARTICULATE MATTER EMISSIONS FROM CANADIAN AGRICULTURE

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Overview of Emissions Inventory

- An indicator was developed to assess primary particulate matter (PM) emissions over a 25-year period (1981-2006).

- It is part of the Agri-Environmental Indicator Report series reporting on the environmental sustainability of Canadian agriculture.

- 3 classes of PM were investigated
  - TSP – total suspended particulate \( \leq 100\mu m \)
  - \( PM_{10} \) – inhalable particulate \( \leq 10 \mu m \)
  - \( PM_{2.5} \) – ultra fine particulate \( \leq 2.5 \mu m \)
Primary emissions were sub-divided into 10 predominant agricultural activities:

- Wind Erosion
- Land Preparation and Management
- Crop production (pollen etc.)
- Chemical Application
- Biogenic VOC Emission
- Chemical Emission
- Ammonia Emission
- Heterogeneous Chemistry Formation of PM
- Residue Burning
- Harvest
- Animal Cremation
- Animal Feeding operations
- Fertilizer and Manure
Agriculture in Canada

- Total population 33.3 million people
  China: 1353 million people
- Landmass 9.1 million km²
  China: 9.3 million km²
- Farmland 0.68 million km² (7.4% total area)
  China: 5.53 million km² (59.3%)
- Provides 1 in 8 jobs and accounts for 8% of Canada’s GDP (1501 bUS$)
  China GDP: 4327 bUS$
- Produces enough food to feed Canadian population four times over
- 4th largest exporter of agriculture and agri-food products (38.8 bUS$)
- Accounts for ~20% of the total world exports of wheat and wheat flour (10 year average)
- Agricultural machinery 163/100 km²
  China: 147/100 km²

Ref: FAO and World Bank

<table>
<thead>
<tr>
<th>2007 Production (Mt)</th>
<th>Canada</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>11 648 700</td>
<td>152 418 870</td>
</tr>
<tr>
<td>Other cereals/rice</td>
<td>15 680 200</td>
<td>187 397 460</td>
</tr>
<tr>
<td>Potato</td>
<td>4 999 424</td>
<td>64 837 389</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>9 601 100</td>
<td>10 572 571</td>
</tr>
<tr>
<td>Soybean</td>
<td>2 695 700</td>
<td>12 725 147</td>
</tr>
<tr>
<td>Wheat</td>
<td>20 054 000</td>
<td>109 298 296</td>
</tr>
</tbody>
</table>
Canadian Agricultural Landscape

- Comprised of 7 ecozones
  - Represent differing:
    - Landscapes
    - Climates
    - Soil Types

- Majority of Canadian agriculture is in 2 ecozones:
  - Mixedwood Plains
  - Prairies

- Affects:
  - Land management practices
  - Production
Scale of Measurements

Hierarchy
- Ecozone
  - Ecoprosence
    - Ecoregion
      - EcoDistrict → Soil Landscape (SL) Polygon

- Emission estimates are scaled to the SL polygon level

source: NLWIS, 2008
Methodology

- Based on activity and emission factor approach

\[ ER_{i,j} = AP_{i,j} \times EF_i \]

where:
- \( ER_{i,j} \) is the emission rate at SL polygon \( j \) for activity \( i \)
- \( AP_j \) is the activity for intensity at polygon \( j \)
- \( EF_i \) is the emission factor for activity \( i \)
## Emission Factors

<table>
<thead>
<tr>
<th>Activity</th>
<th>Emission Factor Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Erosion</td>
<td>WEQ Model (Woodruff &amp; Siddoway, 1965); California Air Resources Board (CARB), 1997</td>
</tr>
<tr>
<td>Harvest</td>
<td>CARB, 2003</td>
</tr>
<tr>
<td>Land Preparation</td>
<td>US EPA, 1985</td>
</tr>
<tr>
<td>Animal Feeding Operations</td>
<td>Van Heyst, 2005; Roumeliotis &amp; Van Heyst, 2006; Takai et al, 1998; Seedrof, 2004; expert opinion</td>
</tr>
<tr>
<td>Fertilizer Application</td>
<td>Greater Vancouver Regional District Emissions Inventory, 2003</td>
</tr>
<tr>
<td>Crop Residue Burning</td>
<td>US EPA, AP-42; Jenkins, 1996</td>
</tr>
<tr>
<td>Animal Cremation</td>
<td>AEA Technology, 2002; Van Heyst, 2005; expert opinion</td>
</tr>
<tr>
<td>Grain Handling</td>
<td>U.S. EPA AP-42, 2003; Canada Grain Trade Commission; expert opinion</td>
</tr>
<tr>
<td>Chemical Application</td>
<td>ASAE, 2004; Teske et al, 2000</td>
</tr>
<tr>
<td>Pollen</td>
<td>Aylor, 2005</td>
</tr>
</tbody>
</table>
- 652.6 kt PM$_{10}$ & 158.1 kt PM$_{2.5}$ from agricultural operations
- Emissions are greatest in Prairies, where greatest proportion of agricultural activities take place
A decrease in PM emissions between 1981 and 2006 in all provinces with the exception of Quebec
By Agricultural Activity

- Primary PM emissions predominantly from field based activities
  - Wind Erosion
  - Land Preparation
  - Crop Harvest

- Crop residue burning larger in PM$_{2.5}$ emissions
Reductions by Activity

- All activities exhibited some reduction nationally between 1981 and 2006

- Most noted in wind erosion and land preparation sectors due to changes in tillage practices and crop residue management
Emission Factor Validity

- Currently emission factors are extracted from the literature (US-EPA AP-42, scientific studies, and emission models)
- However, there are not enough information available on EFs
- A series of experiments was initiated to quantify EFs associated with crop harvest and land tillage under Eastern Canadian conditions

Verification Activities

- Verification of emission factors for harvest, land preparation
- Monitoring of experimental fields near Ottawa
- Use of dispersion models and tracer experiments to verify and generate emission factors for each activity
- Calculating level of uncertainty for each emissions category
Field Emissions Verification Campaigns

Corn harvesting, 2006, 2008, Ottawa

Spring tillage, 2008 Ottawa
Next Steps

- Currently entering 3rd generation of Agri-Environmental Indicator Series (2nd for PM)
  - Improve and validate emission factors
  - Utilize an updated process-based wind erosion model – WEPS
  - Determine uncertainty
  - Determine PM emissions on a seasonal basis

- Identify linkages and common framework with other air quality indicators:
  - Ammonia Emissions
  - Greenhouse Gases Emissions
  - Odours

- Evaluate the impact of BMPs on air quality
Leapfrogging* opportunities in agriculture for air quality improvement

- All the management practices that reduced soil erosion and restored soil organic matter, were beneficial for reducing PM emissions
  - Install/maintain wind breaks
  - Reduce summerfallow
  - Increase cover crop area
  - No till or reduced tillage, where appropriate
  - Avoid residue burning

- Building a common database of experimental PM emission results for management practices (e.g., tillage, harvest) using different machinery, for various soil texture, and environmental conditions (soil moisture, relative humidity, wind speed, air temperature, etc.) should speed-up the definition of beneficial management practices (BMPs)

- Evaluate the impact of agricultural BMPs on air quality considering PM, ammonia and GHG emissions, all together

*Leapfrogging is a theory of development in which developing countries may accelerate development by skipping inferior, less efficient, more expensive or more polluting technologies and industries and move directly to more advanced ones.

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Thank you!

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