Management of Agricultural Nitrogen Emissions in Alberta: Opportunities and Challenges

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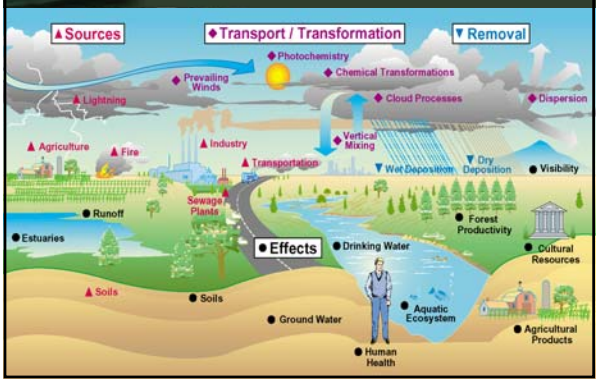
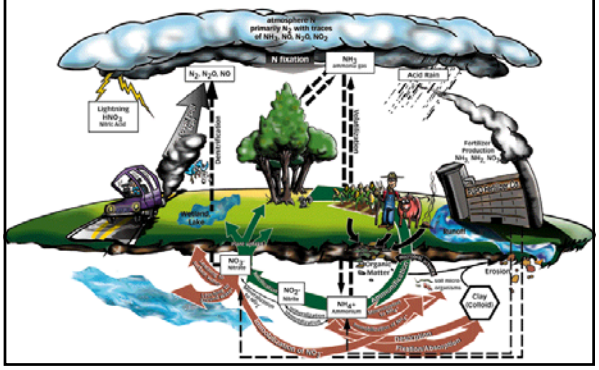
Nitrogen in the Environment



Agriculture Nitrogen Cycle



Agriculture Nitrogen Cycle

Agricultural Nitrogen Sources

Soil: biological, chemical and physical processes; nutrient reservoir

Fertilizer: concentrated inorganic or organic compounds, consistent, high nutrient levels, easy to blend, transport, and apply.

Animal Manure: variable, low nutrient levels, bulky, difficult to adjust nutrient ratios.

Crop Residues: high and low nutrient levels, nutrient immobilization, decomposition.

Biological Fixation: microbial symbiotic and asymbiotic nitrogen fixation

Nitrogen Emissions

Ammonia

- agriculture produces 90% of total ammonia emissions.
  - (Chetner & Sasaki, 2001).
- Fertilizer application – 49,196 tonnes (29%). 27.9%
  - Mineralization of urea fertilizer (84%)
- Livestock productions - 120,717 tonnes (71%). 68.4%
  - Cattle operations (79%)
- Fertilizer Manufacturing 6,597 tonnes 3.7%

Nitrogen Emissions

Nitrous Oxide (N_2O)

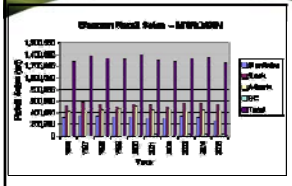
- N_2O 49% of greenhouse gas emissions in agriculture
  - Soil & Fertilizer (42%)
  - Manure Management (7%)
- Fertilizer Manufacturing

Nitrogen Fertilizer Manufacturing

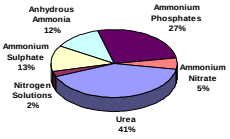
Alberta Advantage

- 5 Fertilizer Manufacturing Plants
- Availability of natural gas

Nitrogen Fertilizer



Alberta N Fertilizer Sales (2004-2005)



Source: Canadian Fertilizer Institute

Total 1.175 M tonnes

Nitrogen Fertilizer

Nitrogen Use Efficiency

- Forms
- Placement methods
- Time of application (fall, spring, midseason)
- Rate of application
- 10% increase in NUE
  - $260M - $350M/yr increased productivity
  - $12-$25/ha/yr production cost reduction

Right Rate, Time & Place

Performance Areas and BMPs

Performance Area	BMP Examples
Right Rate *Apply the right amount of fertilizer*	• Soil Testing • Yield Goal Analysis • Crop Removal Balance • Nutrient Management Plans • Plant Tissue Analysis • Applicator Calibration & Upkeep • Crop Scouting/Assessment • Record Keeping • Variable Rate Technology
Right Time *Apply fertilizer when crops need it*	• Application Timing • Controlled Release Technologies • Inhibitors • Fertilizer Product Choice
Right Place *Apply fertilizer where crops need it*	• Application Method • Incorporation of Fertilizer • Buffer Strips • Conservation Tillage • Cover Cropping • On-Farm Fertilizer Practices

The Sustainability Cycle

This approach is designed to balance the environmental, economic, and social goals of our stakeholders. These goals are connected as part of the sustainability cycle.

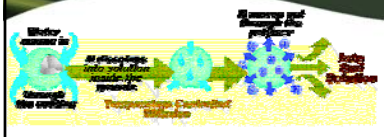
Environmental
- Sustain soil quality
- Avoid the need for additional farmland
- Maintain nutrient levels within natural ecosystems

Economic
- Produce revenue to sustain farm operations
- Enable investment in BMPs
- Preserve quality of life
- Make the most of dollars spent on fertilizer

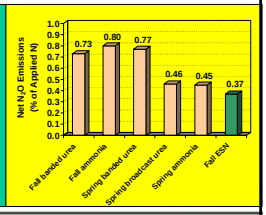
Social
- Produce nutritious, abundant and affordable food
- Support programs for strong and caring communities
- Help meet global food needs
- Provide ongoing employment opportunities in agriculture and related industries

Agrium

Environmentally Smart Nitrogen (ESN)

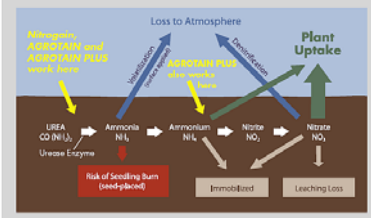


- Improved fertilizer use efficiency
- Reduced number of fertilizer applications
- Reduced toxicity of fertilizer applications
- Consistent nutrient supply & plant growth
- Coated nitrogen is not exposed to losses
  - Reduced nitrate leaching and runoff
  - Reduced greenhouse gas emissions from denitrification and ammonia volatilization



AGROTAIN technology

The Nitrogen Cycle



Nitrogain and AGROTAIN slow the conversion of urea to ammonia which minimizes volatilization (from surface applied urea containing fertilizers) and reduces seedling burn (from seed-placed urea containing fertilizers).

AGROTAIN PLUS has the additional ability of inhibiting the conversion of ammonium to nitrite and nitrate which reduces further losses of nitrogen caused by denitrification and leaching.

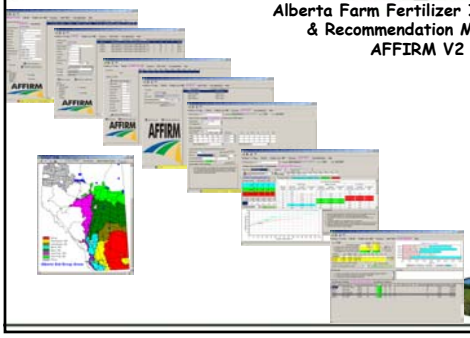
Precision Agriculture

- Global Position System
- Variable rate controllers
- Field mapping
  - yield
  - soil nutrient levels
  - fertilizer prescription
  - landscapes
  - management zones
  - manure?

Decision Support Systems Tools

AFFIRM

Alberta Farm Fertilizer Information & Recommendation Manager
AFFIRM V2

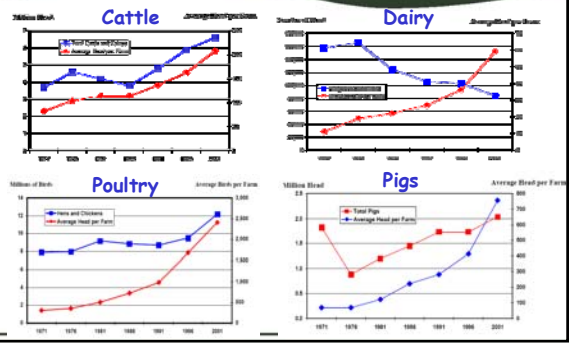


Decision Support Systems Tools

Alberta Farm Fertilizer Information & Recommendation Manager
AFFIRM V2

- fertilizer decisions based on crops, agro-climatic regions, moisture conditions, and production economics (fertilizer costs & crop prices).
- Balanced nutrient economic analysis model.
- Nitrogen mineralization estimates.
- Access to current nutrient management knowledge.
- Laboratory specific soil test calibrations.
- Field & whole farm nutrient optimization.

Alberta Livestock Production

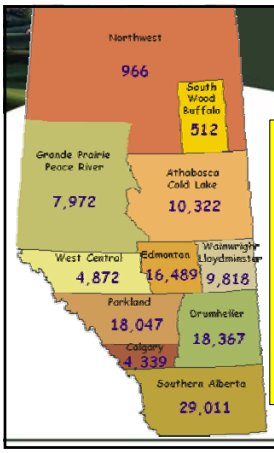


Alberta Livestock Production

Manure Research Findings and Technologies:
From Science to Social Issues

Dr.Atta Atia
Karen Haugen-Kozyra
Dr.Mohamed Amrani
Alberta Agriculture, Food and Rural Development
2004

Livestock Ammonia Emissions

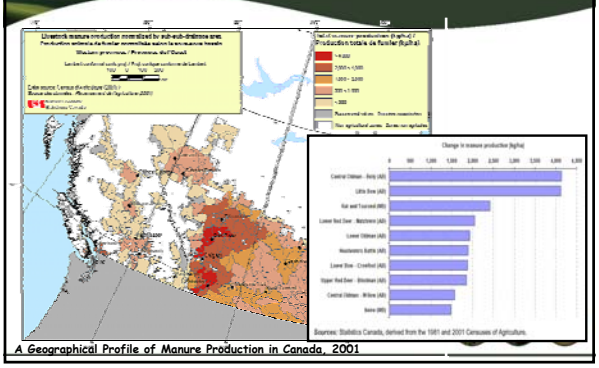


Ammonia Emission Estimates by Airsheds (tonnes/yr)

based on livestock census numbers for 2000 and emission rates specific to livestock type using Asman (1992) emission factors derived from research in the Netherlands

(Chetner & Sasaki, 2001)

Geographical Profile of Manure Production



A Geographical Profile of Manure Production in Canada, 2001

Ammonia Loss from Manure Storage

Measuring Ammonia Emissions from Hog Manure Storage Lagoons and Field Applications (Dzikowski, et.al, 1999)

- 24-40% nitrogen from manure applied to an open field volatilized after 30 hours.
- ammonia losses from 2 lagoons were between 6.6 to 122 kg day^{-1}

Ammonia Emissions Control Strategies

- Suppression Methods
  - Manure storage covers
  - Biocovers
- Inhibition Methods
  - Manure additives
  - Diet manipulation
  - Floor modification
- Capture and Control Methods
  - Biofiltration (?)
  - Oil sprinkling
  - Temperature control
  - Bioscrubbing
  - Ozonation
- Manure Application Methods
  - Injection

Manure Management

Manure Management Principles

- annual planning and proper record keeping.
- application rates based on manure type and nutrient availability, and calculated using annual soil and manure analysis to meet crop nutrient requirements.
- application must account for season, weather conditions and site-specific conditions relating to soil, topography and water.
- application equipment must be calibrated to ensure consistent and appropriate delivery rates of manure.
- manure managed to maximize crop nutrient utilization and does not negatively affect soil, water and air resources.

Agricultural Operations Practices Act (AOPA)

regulations for spreading manure or compost materials for all livestock operations in Alberta.

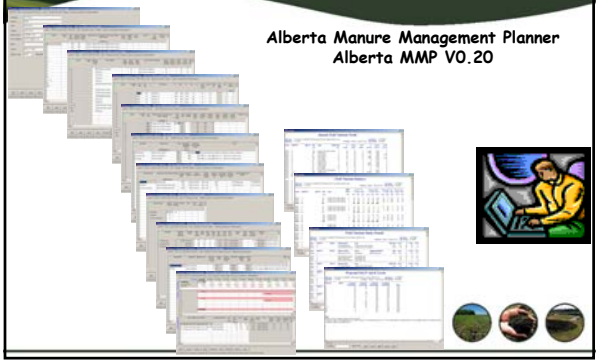
Agricultural Operations Practices Act (AOPA)

Environmental Standards for Nutrient Management

- Surface-applied manure incorporated into soil within 48 hours, unless when applied to forage or direct seeded crops.
- Setback requirements for
  - injected,
  - incorporated and
  - surface-applied not incorporated
- Salt and Nitrate Loading Limitations
- Soil Testing
- Record Keeping

Decision Support Systems Tools

Alberta Manure Management Planner
Alberta MMP V0.20

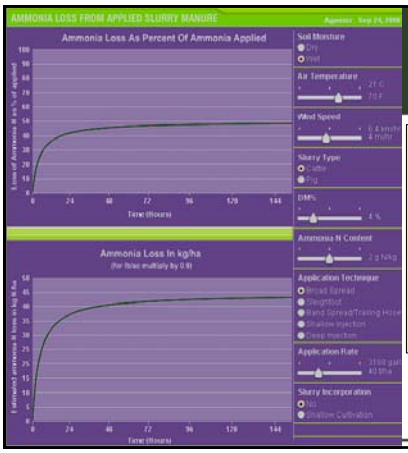


Decision Support Systems Tools

Alberta Manure Management Planner

- Operations' fields, crops, storage, animals, and manure application equipment
- manure allocation (when, where, and how much)
- Process designed to help determine if operation has:
  - Sufficient crop acreage
  - Seasonal land availability
  - Storage capacity
  - Equipment
- N-based or P-based management

Ammonia Loss from Manure



AAFC - BC

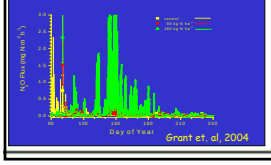
http://www.farmwest.com/

ALFAM model
Ammonia volatilization from field-applied animal manure model (Europe)

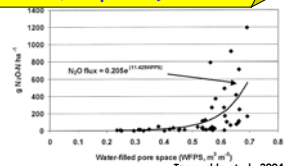
Greenhouse Gas N_2O Emissions

Temporal & Spatial Variation
- N fertilizer application
- Manure application
- Soil nitrogen levels
- Landscape variability
- Modeling (Century, *ecosys*, DNDC, ExpertN)

Response of measured (symbols) and modelled (lines) N_2O emissions to fall banded urea in Westco plots in 2003



Grant et. al, 2004



Izaurralde et.al. 2004

N_2O Emissions

Western Canada N_2O Research on N Fertilizer

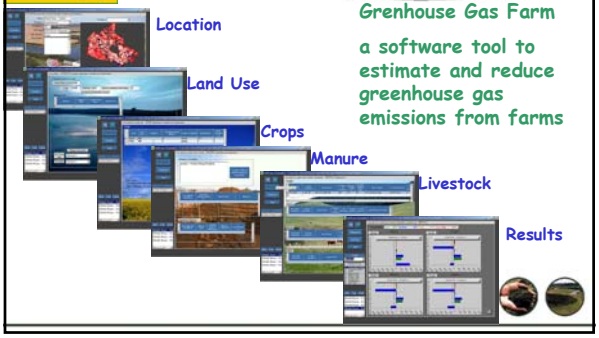
Location	Range	Mean
Saskatchewan	0.1 - 0.4%	0.2%
MB Winnipeg	0.4 - 0.8%	0.5%
MB Brandon	0.1 - 0.4%	0.3%
AB Breton		0.1%
AB Ellerslie*	0.2 - 2.0%	

Source: F. Selles and R. Lemke

1996 IPCC Guidelines for National Greenhouse Gas Inventory:

1.25% of all N added to soils (fertilizer, crop residues, manures, and N fixed by legumes) is lost as N_2O

Decision Support Systems Tools



Grenhouse Gas Farm

a software tool to estimate and reduce greenhouse gas emissions from farms

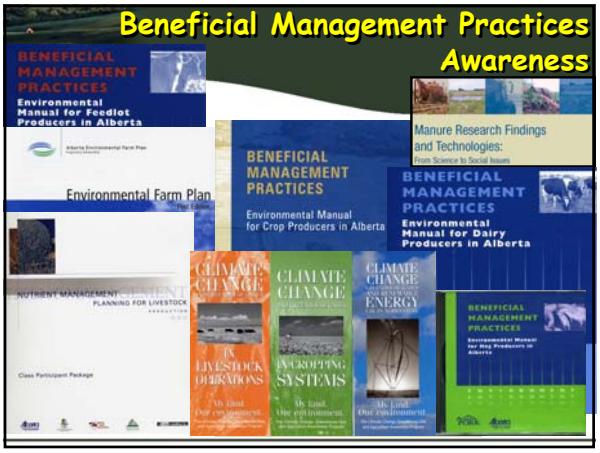
Decision Support Systems Tools

Grenhouse Gas Farm

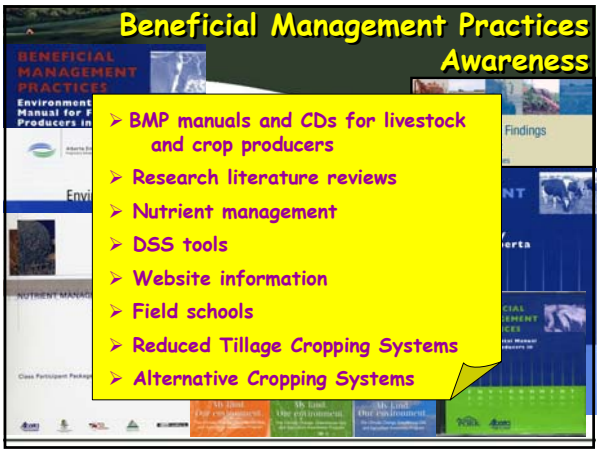
Predict net greenhouse gas emissions on a whole farm basis using interwoven algorithms that relate farm operations to nutrient cycling and greenhouse gas emissions:

- Focal point/repository for research
- Identify areas for needed research
- Improve estimates of greenhouse gas emissions based on systems analysis
- Allow farmers, researchers and decision makers to evaluate proposed mitigation practices.

Beneficial Management Practices Awareness



Beneficial Management Practices Awareness



- BMP manuals and CDs for livestock and crop producers
- Research literature reviews
- Nutrient management
- DSS tools
- Website information
- Field schools
- Reduced Tillage Cropping Systems
- Alternative Cropping Systems

Research & Monitoring Programs

- Air Quality Monitoring
- Water Quality Monitoring
- Soil Quality Monitoring
- Greenhouse Gas Research
- Nitrogen Use Efficiency Research
- Manure Management Technology Research
- Livestock Management Research

Knowledge Gaps & Research Needs

- Nutrient management BMPs.
- Modeling of nutrient cycling in soils.
- Systems approach for nutrient accounting.
- Improved technologies in manure handling, storage and application to land.
- Improved nutrient use efficiency linked to water use efficiency.
- Precision agriculture variable rate nutrient application based on field landscapes (fertilizer & manure).
- Laboratory and field procedures to improve estimation of soil nutrient availability to crops.
- Livestock feeding strategies to reduce nutrient excretion and improve NUE.

Opportunities

Partnerships

- Industry
- Government
- Educational Institutions
- Research Institutions
- Non-Government Organizations

Closing Comments

- Right Rate, Right Place, Right Time, Right Form, Right Method
- Modeling & Inventories: Before we can predict Where and When, need to know How and Why. Validation required.
- Nitrogen losses provides an opportunity to improve our management and to capture N for crop production
- Nitrogen Use Efficiency: Economic & environmental benefits
- Technology – needs & opportunity
- Awareness of environmental stewardship
- Regulations used to help guide management