



# **KNOW YOUR FERTILIZER RIGHTS**

## **THE 4R NUTRIENT STEWARDSHIP CONCEPT**

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With acknowledgments to Bill Herz, TFI; Jerry Lemunyon, USDA-NRCS;  
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IPNI Workgroup on BMPs and NUE

# IPNI MISSION

“to develop and promote scientific information about the responsible management of plant nutrition for the benefit of the human family.”



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# SUSTAINABILITY ISSUES RELATED TO FERTILIZER USE

- Food and nutrition security
- Employment
- Soil fertility
- Cadmium in soil
- Eutrophication
- Non-renewable resources
- Greenhouse gas emissions
- Stratospheric ozone depletion ( $\text{N}_2\text{O}$ )
- Air quality: ammonia, smog
- Water quality: nitrate, algae
- Public perception



# SUSTAINABILITY GOALS

## Environmental

- Sustain or improve soil quality
- Maintain nutrient levels within natural ecosystems
- Preserve wildlife habitat



## 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



## Economic

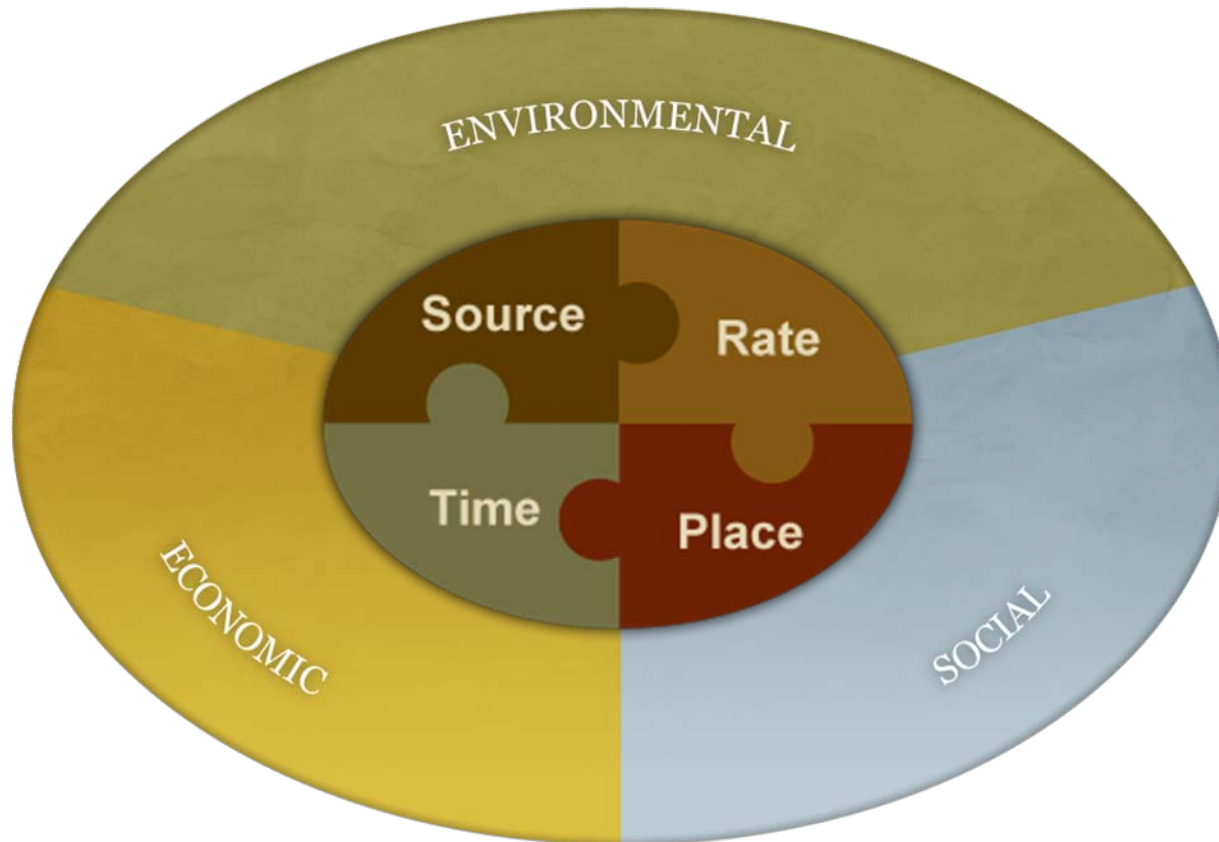
- Produce revenue to sustain farm operations
- Preserve quality of life
- Make the most of dollars spent on fertilizer





# 4R NUTRIENT STEWARDSHIP

- Right Source, Right Rate, Right Time & Right Place
  - Linking practices to science for sustainability performance





# WHO DECIDES WHAT'S RIGHT?

- “a team of farmers, researchers, natural resource managers, extension staff and agribusiness professionals.” - ???
- Input from ALL stakeholders on PERFORMANCE:
  - Indicators
  - Benchmarks
  - Targets
- Farmer (land manager) selects the PRACTICE
  - Dynamic site-specific decision on source, rate, time and place
  - Decision support for highest probability of performance



## Fertilizer BMPs —

# Best Management for Fertilizers on Northeastern Dairy Farms

By Tom W. Bruulsema and Quirine Ketterings

In the past 10 years, many dairy farms in the humid temperate zone of northeastern North America have implemented best management practices (BMPs) for manure and fertilizer to address concerns about nutrient buildup in soils and nutrient losses that can impact water and air quality. This Introductory Guide focuses on fertilizer BMPs: applying the right source at the right rate, at the right time, and in the right place.

On dairy farms, large amounts of nutrients can be removed from the field in the harvest of forages. Nutrients are returned with manure and/or fertilizer applications, and for legumes, also through N fixation. If the amount of nutrients applied exceeds crop nutrient removal, the difference will either be lost to the environment or accumulate in the soil. In the humid temperate zone of northeastern North America, carryover of inorganic N from one year to the next ranges from small to sporadic and risk of harm to the environment increases when surplus inorganic N remains in the soil at the end of the growing season. Surplus P and K most often contribute to an increase in soil test levels.

While dairy farming is associated with increases in soil test P levels over time, not all farm fields test above the agronomic optimum. The proportion of soils deficient in P in northeastern North America ranges from 10 to 20% in Delaware and Pennsylvania to about 50% in Quebec, New York, and Virginia (Ketterings et al., 2005a; PPI, 2006). Soil testing allows a farmer to determine if nutrient additions are needed and is therefore among the most important BMPs for fertilizer management.

Losses of N entail risks to groundwater quality and may also contribute to water quality issues in estuaries where fresh water meets salt water. Losses of P may result in eutrophication of fresh waters, leading to algal blooms and impaired water quality in local water sources.

Fertilizer management influences greenhouse gas emissions as well. Nitrogen fertilizer manufacture emits carbon dioxide, and adding N to soils can increase emissions of nitrous oxide. On the other hand,



Large amounts of nutrients cycle on dairy farms.

appropriate N fertilizer use boosts crop absorption of carbon dioxide, and influences soil carbon storage. Applying the right source of nutrient with the right rate, timing and placement is currently the best that can be done to assure the minimum net emission per unit of crop production (Snyder et al., 2007).

For reliable fertilizer management recommendations, extensive research needs to be conducted for multiple years, on local soils, under local management, and under local weather conditions. This type of research is usually done at universities and research institutions. For state-specific fertilizer application rates, we refer to the local land grant university. However, common principles apply for dairy farms across northeastern North America. In the following pages we describe general BMPs that ensure the right source is applied at the right rate, at the right time and in the right place. "Right" is defined as contributing to the cropping system's productivity, profitability, and sustainability while minimizing any harmful impact on the surrounding environment (IPNI, 2008).

**Abbreviations and notes for this article:** N = nitrogen; P = phosphorus; K = potassium; C = carbon.

This publication is one of a series prepared by cooperators with the staff of the International Plant Nutrition Institute (IPNI). It is part of a project in cooperation with the Foundation for Agronomic Research (FAR) toward fulfilling the goals of a 3-year Conservation Innovation Grant (CIG 68-34-75-5-166) from the USDA-Natural Resources Conservation Service to identify fertilizer best management practices (BMPs). The intent of this publication is to help develop the BMP definition process in such a way that environmental objectives are met without sacrificing current or future production or profit potential and in full consideration of the newer technologies relevant to fertilizer use. The concept of applying the right fertilizer at the "right rate, right time, and right place" is a guiding theme in this series. For additional information, visit the websites: [www.farmresearch.com/CIG](http://www.farmresearch.com/CIG) and [www.ipni.net](http://www.ipni.net). Item # 30-3220

Fertilizer Best Management Practices  
funded by USDA NRCS Conservation Innovation Grant



## Fertilizer Best Management Practices

### Appendix 1. Best Management for Fertilizers on Northeastern Dairy Farms

Practice	Best	Making Progress
<b>RIGHT SOURCE</b>		
1. Credit nutrients from manure and composts	Analyze for total and available nutrients	Occasional or partial analysis
2. Credit N from previous crops	Adjust N rates based on research data for credits from previous crops, particularly legume hay or sod	Reduce corn N rates when following alfalfa
3. Choose a fertilizer nutrient source to suit the crop, soil, and placement	Source chosen to suit application method, blend compatibility, crop needs and sensitivities, and price	Compare anhydrous ammonia, urea, urea-ammonium nitrate, ammonium sulfate, and ammonium nitrate for price
4. Assess use of enhanced-efficiency N sources	Use controlled-release N or inhibitors to match N release to crop N needs where split application is impractical	Partial use of controlled-release sources or inhibitors
<b>RIGHT RATE</b>		
5. Measure soil nutrient supply	Soil analysis for pH, P, K, and other nutrients every 2 to 3 years	Most soils analyzed within past 5 years
6. Maintain soil pH	Lime applied in fall whenever required	Lime applied occasionally
7. Calculate nutrient removal and balance	Calculated from measured yield and nutrient content	Based on estimated yields and nutrient content
8. Determine crop yield potential and nutrient demand	Measured yields from at least 5 past years	Measured yields from at least 5 past years
9. Estimate most economic rates at current prices	Use a calculator based on regional crop response data	Use a generalized calculator based on price ratios
10. End-of-season evaluation for appropriate N rates	Use late season cornstalk nitrate test or soil nitrate test	Monitored occasionally
<b>RIGHT TIME</b>		
11. Assess split application to match crop nutrient uptake	Split applications used whenever practical	Partial use of split applications
12. Crop scouting and plant analysis	Done regularly and systematically for each field	Occasionally done to diagnose problem areas
13. Manage cover crop for optimum nutrient-release timing	Cover crop killed at optimum time for yield of following crop	Cover crop killed in fall
14. Assess optimum timing to suit tillage system	Fertilizer applications with conservation tillage or planting	Fertilizers applied before conservation tillage or planting
<b>RIGHT PLACE</b>		
15. Calibrate equipment for accurate metering and placement	Maintain and test application equipment annually	Equipment well maintained
16. Assess possibilities for with-seed and band placement	Banded or with-seed starter use based on soil test	Banding or with-seed starter for some crops
17. Management zones for variable rate application	Management zones based on multiple-year yield data	Zones delineated by expected productivity
18. Apply soil survey information	Detailed soil survey maps available and in use for each field	Soil survey maps used for some fields
19. Use risk indices to protect water quality	Use Nitrate Leaching Index and Phosphorus Index	Maintain unfertilized buffer of set width from watercourses
20. Incorporate or inject volatile sources	Manure injected; urea banded or soil-incorporated	Manure incorporated within one day after application



# WHAT DOES THE 4R STRATEGY OFFER?

- Source, rate, time and place “right” for goals of sustainable production.
- Checklist for proper fertilization practices and opportunities to improve
- Balance of effort among the 4 “rights”
- Fertilizer industry: delivery and distribution role
- Clear simple public communication.





## 4Rs – INDEPENDENT OR CONNECTED?

- Completely interconnected
- None can be right when one is wrong
- More than one right combination? – possible
- Example for corn:
  - Controlled-release N – pre-plant incorporated
  - Soluble N source – split application, banded and injected
- Linked to crop management



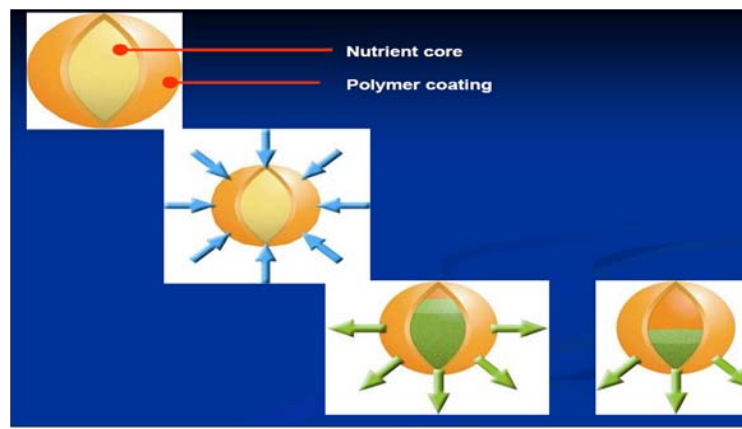
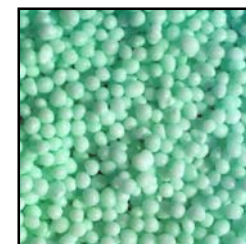
# SCIENTIFIC PRINCIPLES

- General
  - Physics, chemistry, biology
  - Soil fertility and plant nutrition
  - Fundamental processes
  - System performance
- Specific
  - source, rate, time and place



# SCIENTIFIC PRINCIPLES: RIGHT SOURCE

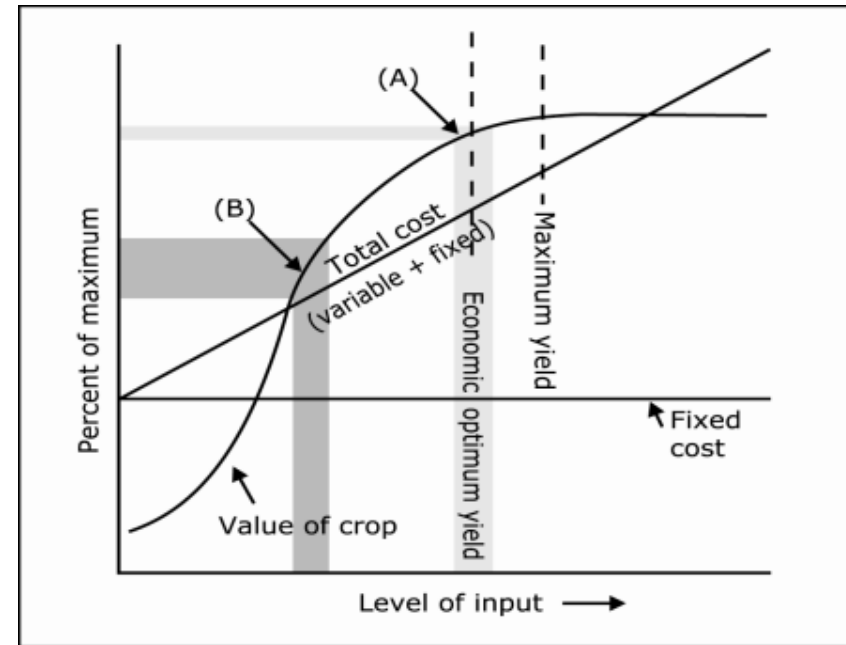
- Ensure a balanced supply of essential nutrients.
- Supply plant-available forms.
- Suit soil physical and chemical properties.
- Recognize:
  - synergisms among nutrient elements and sources;
  - blend compatibility;
  - associated nutritive or non-nutritive elements.





# SCIENTIFIC PRINCIPLES: RIGHT RATE

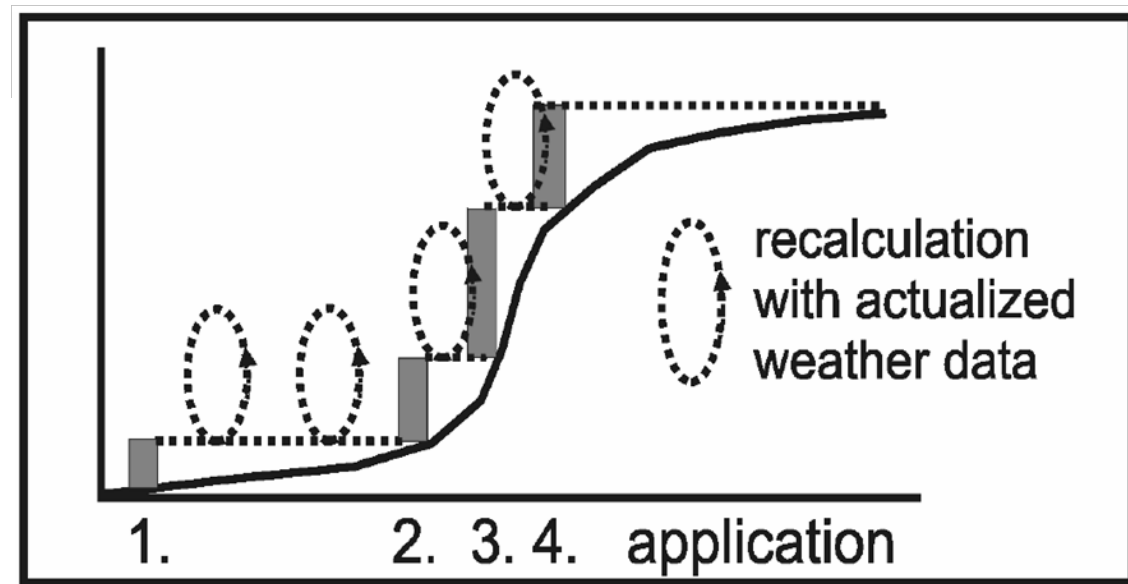
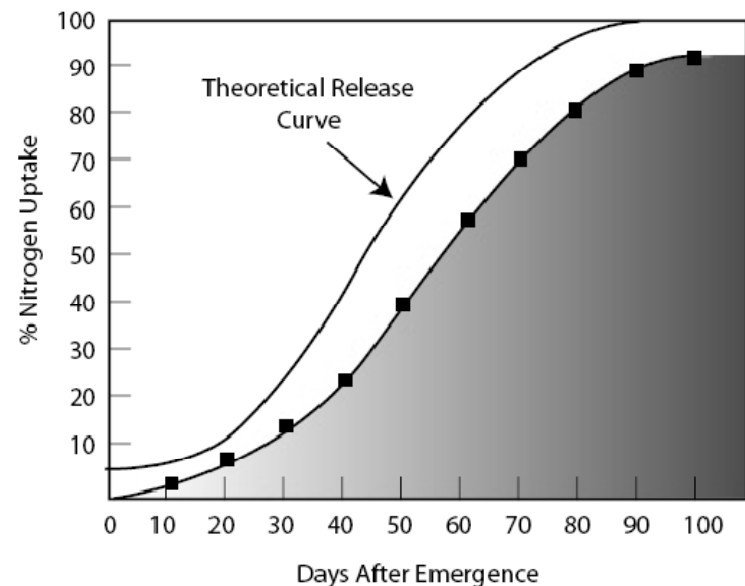
- Assess:
  - Soil nutrient supply;
  - All available nutrient sources;
  - Plant demand.
- Predict fertilizer use efficiency.





## SCIENTIFIC PRINCIPLES: RIGHT TIME

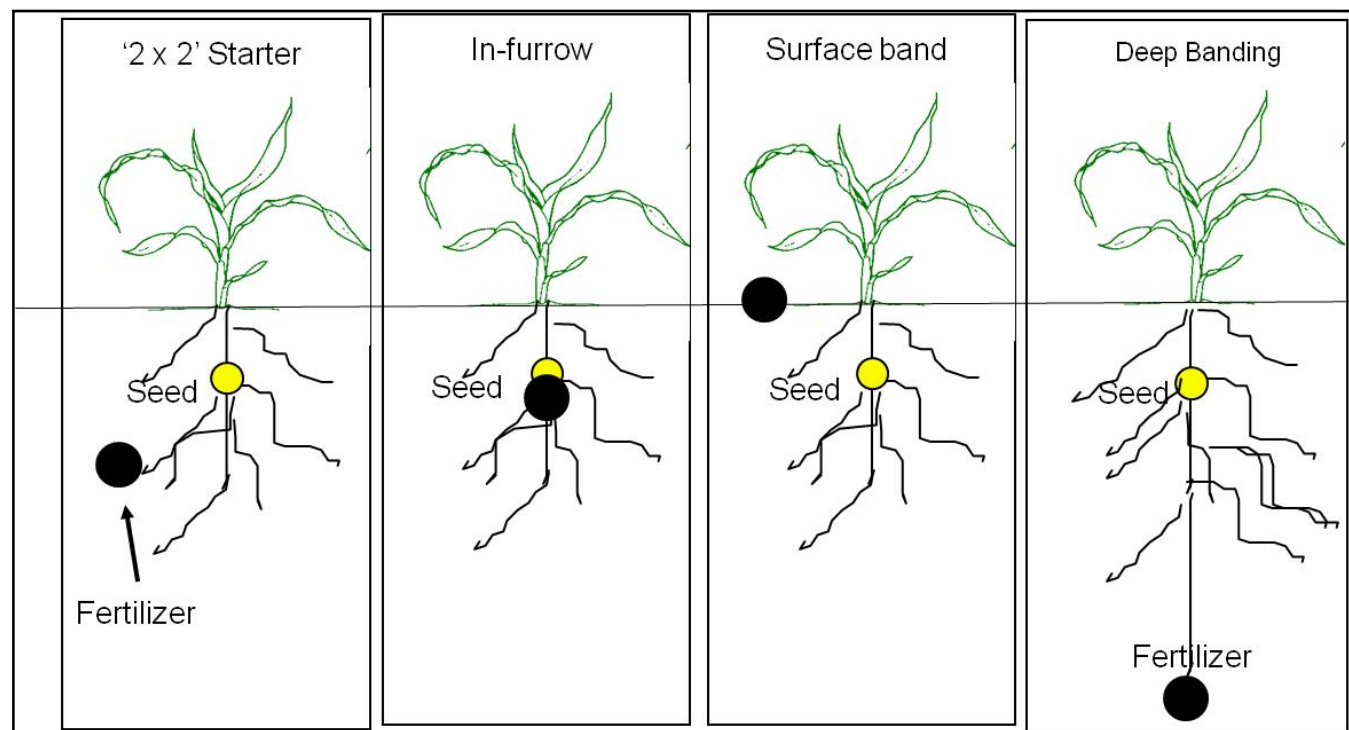
- Match timing of crop uptake.
- Assess dynamics of soil nutrient supply.
- Recognize timing of weather factors influencing nutrient loss.
- Evaluate logistics of field operations.





# SCIENTIFIC PRINCIPLES: RIGHT PLACE

- Recognize root-soil dynamics.
- Manage spatial variability.
- Limit potential off-field transport of nutrients.







# PERFORMANCE

- Outcome of implementing practice
- Fertilizer performance expressed through crop or plant production system
- Includes yield, quality, profit and more
- Long-term soil fertility and productivity
- Nutrient losses to water & air
- Not all measurable – may need indexes and models



# PERFORMANCE ASSESSMENT

- Measures and indicators
- Principles validated by research
- Practices evaluated by stakeholder-selected indicators



# PERFORMANCE:

## MEASURES AND INDICATORS FOR FERTILIZER MANAGEMENT

- Adoption
- Biodiversity
- Ecosystem Services
- Energy Use Efficiency
- Farm Income
- Labor Use Efficiency
- Net Profit
- Nutrient Budget
- Nutrient Loss
- Nutrient Use Efficiency
- Quality
- Return on Investment
- Soil Erosion
- Soil Productivity
- Yield
- Yield Stability
- Water & Air Quality
- Water Use Efficiency
- Working conditions

***STAKEHOLDER INPUT REQUIRED!***

# BMP DEVELOPMENT & ADOPTION

## Policy Level

Regulatory, Infrastructural

## Regional Level

Applied  
agronomic  
scientists

## Farm Level

Producers, crop  
advisers, dealers

**DECISION SUPPORT** based  
on scientific principles

## OUTPUT

Recommendation of **right source,  
rate, time, and place** (BMPs)

## DECISION

Accept, revise, or reject

## ACTION

Change in **practice**

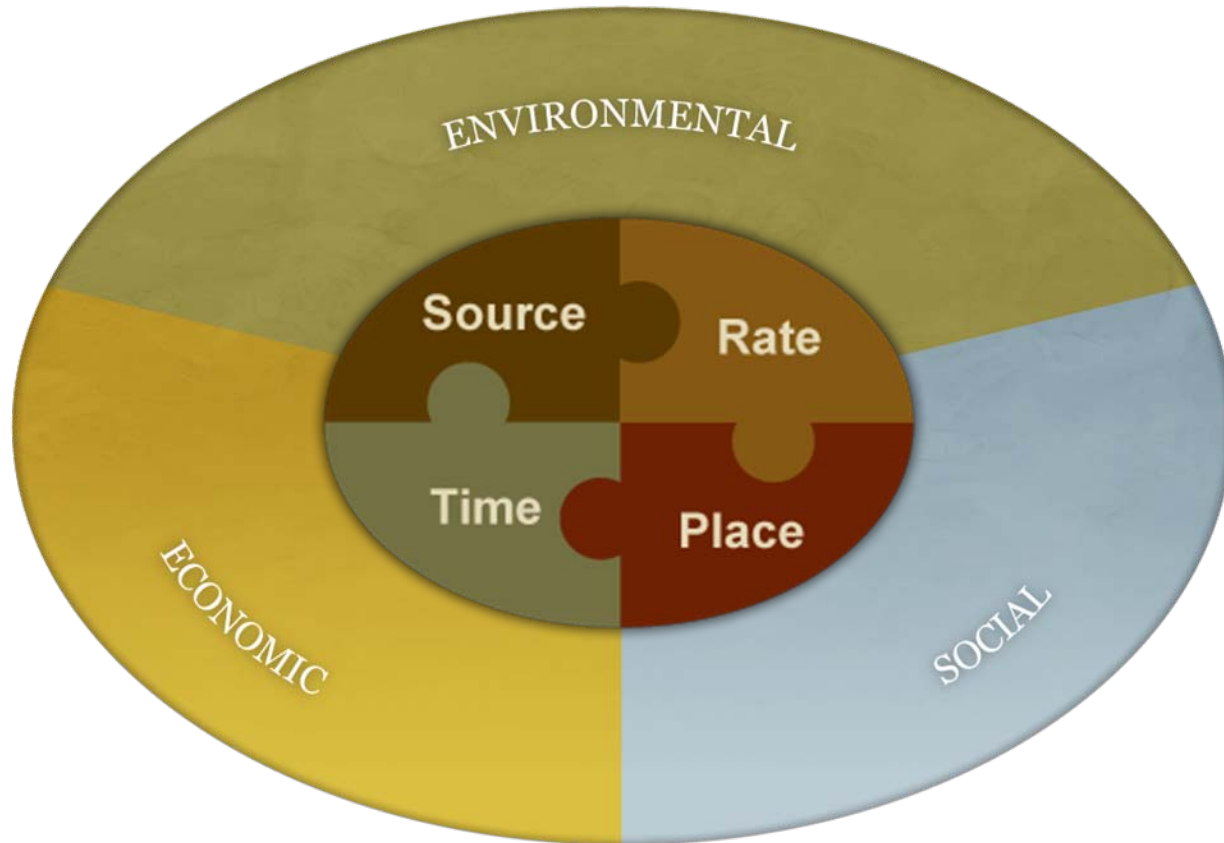
## EVALUATION of OUTCOME

Cropping System  
Sustainability Performance

## LOCAL SITE FACTORS

- Climate
- Policies
- Land tenure
- Technologies
- Financing
- Prices
- Logistics
- Management
- Weather
- Soil
- Crop demand
- Potential losses
- Ecosystem vulnerability

# COMMENTS & DISCUSSION

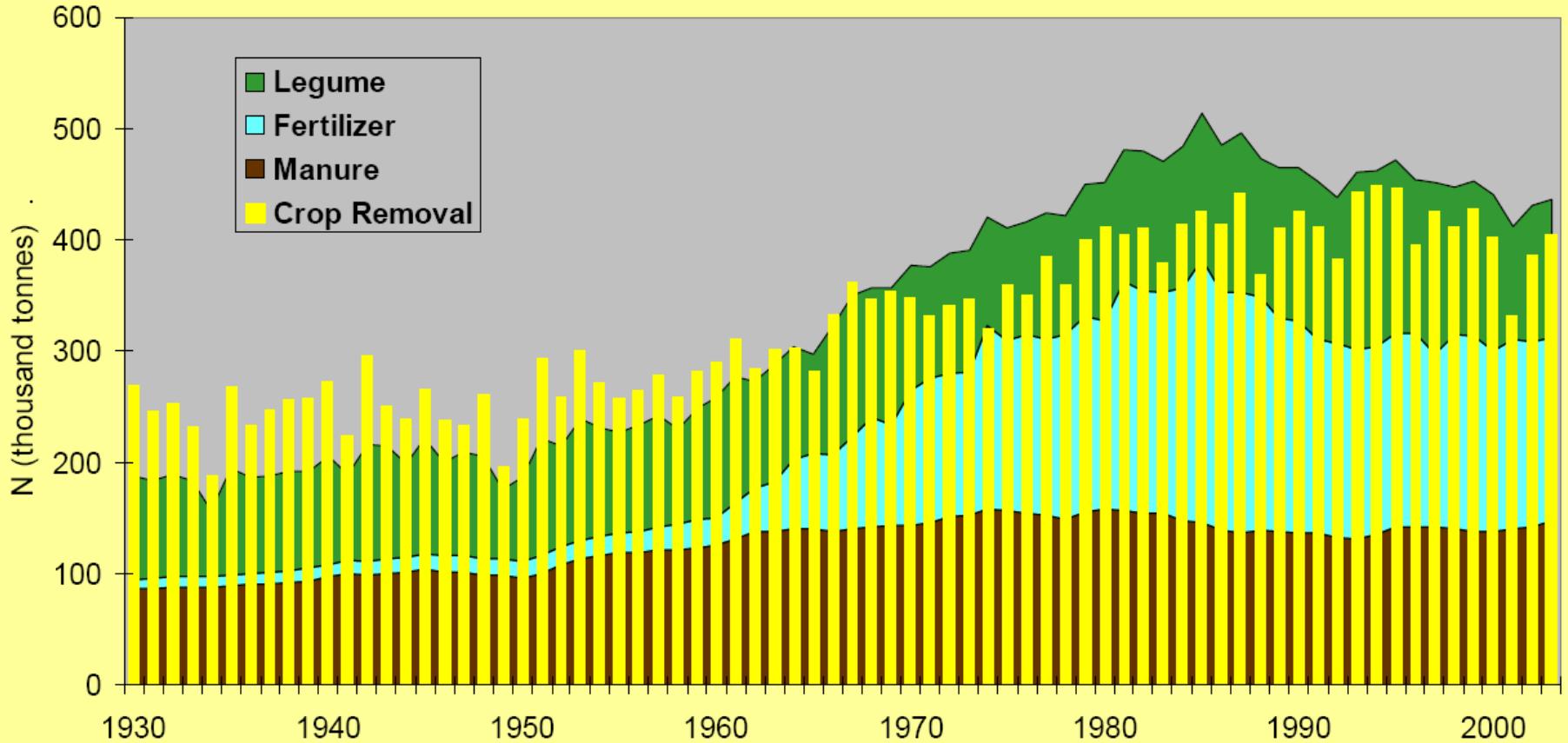


# PERFORMANCE INDICATOR EXAMPLES





# Ontario Crop Nitrogen Balance



**Figure 1.** Estimate of historical crop nitrogen balance for Ontario agriculture, 1930-2003.

Based on total N in manure as-excreted.  
Losses are significant.

# Phosphorus Balance Trends on Agricultural Soils of the Lake Erie Drainage Basin

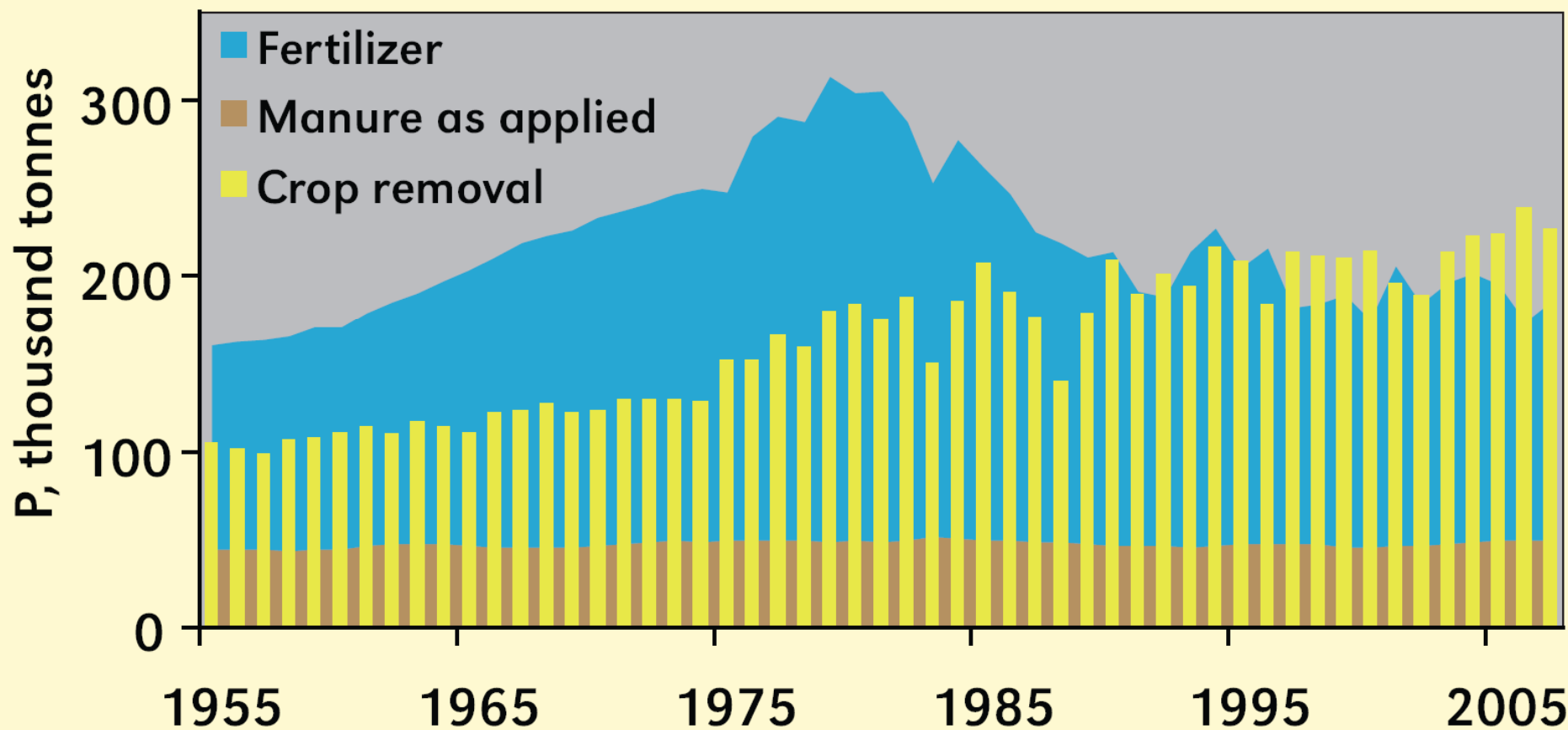
By Laura Bast, Robert Mullen, Ivan O'Halloran, Darryl Warncke, and Tom Bruulsema



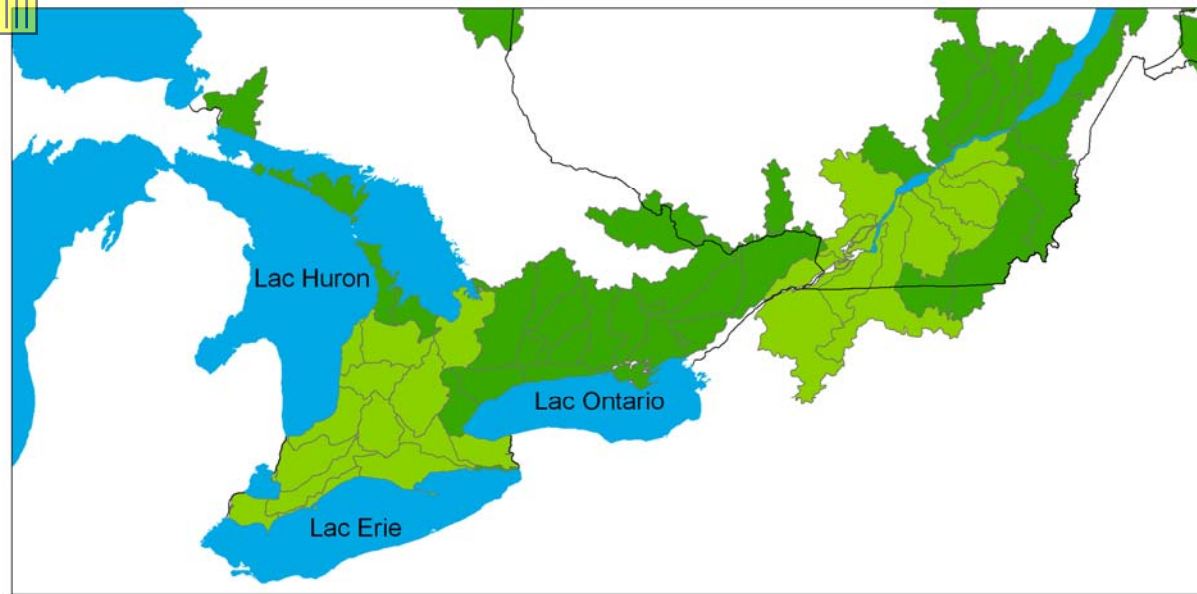


# OHIO – MICHIGAN – ONTARIO

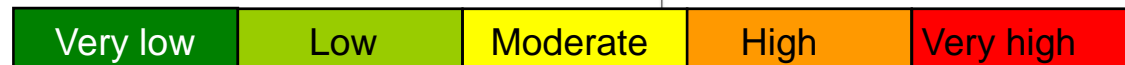
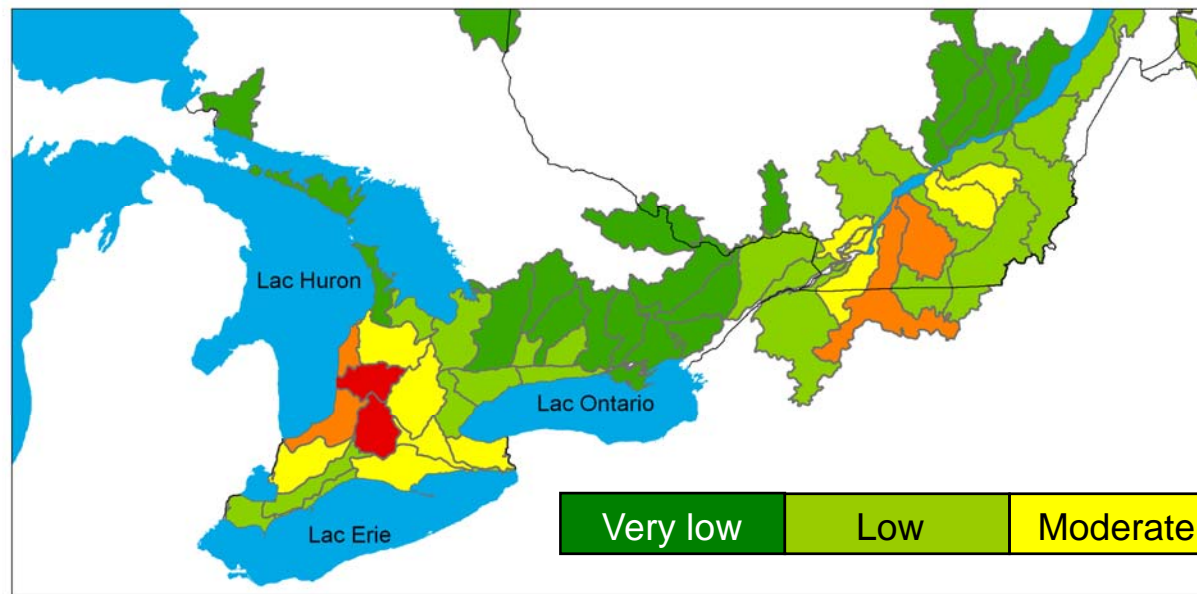
## Crop P Balance - A



Based on available P in recoverable manure.



# Indicator of Risk of Water Contamination by Phosphorus (IROWC-P)



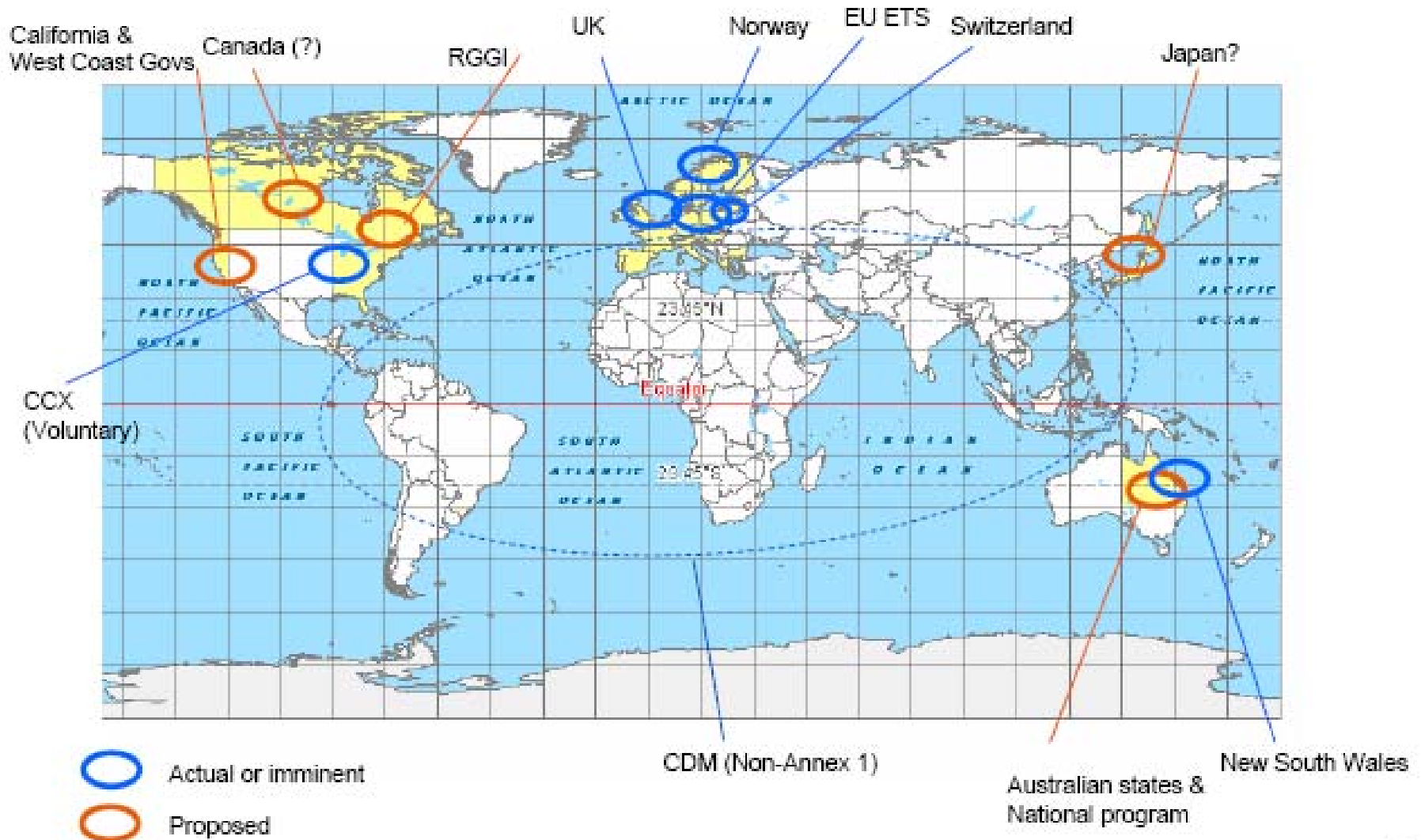
Change in the IROWC\_P of watersheds from 1981 to 2006.  
*E. Van Bochove, AAFC, 2008*

# CREDIT TRADING OPPORTUNITIES

- Greenhouse Gas offsets
- Nitrous Oxide Emission Reduction Protocol
- Water Quality Trading

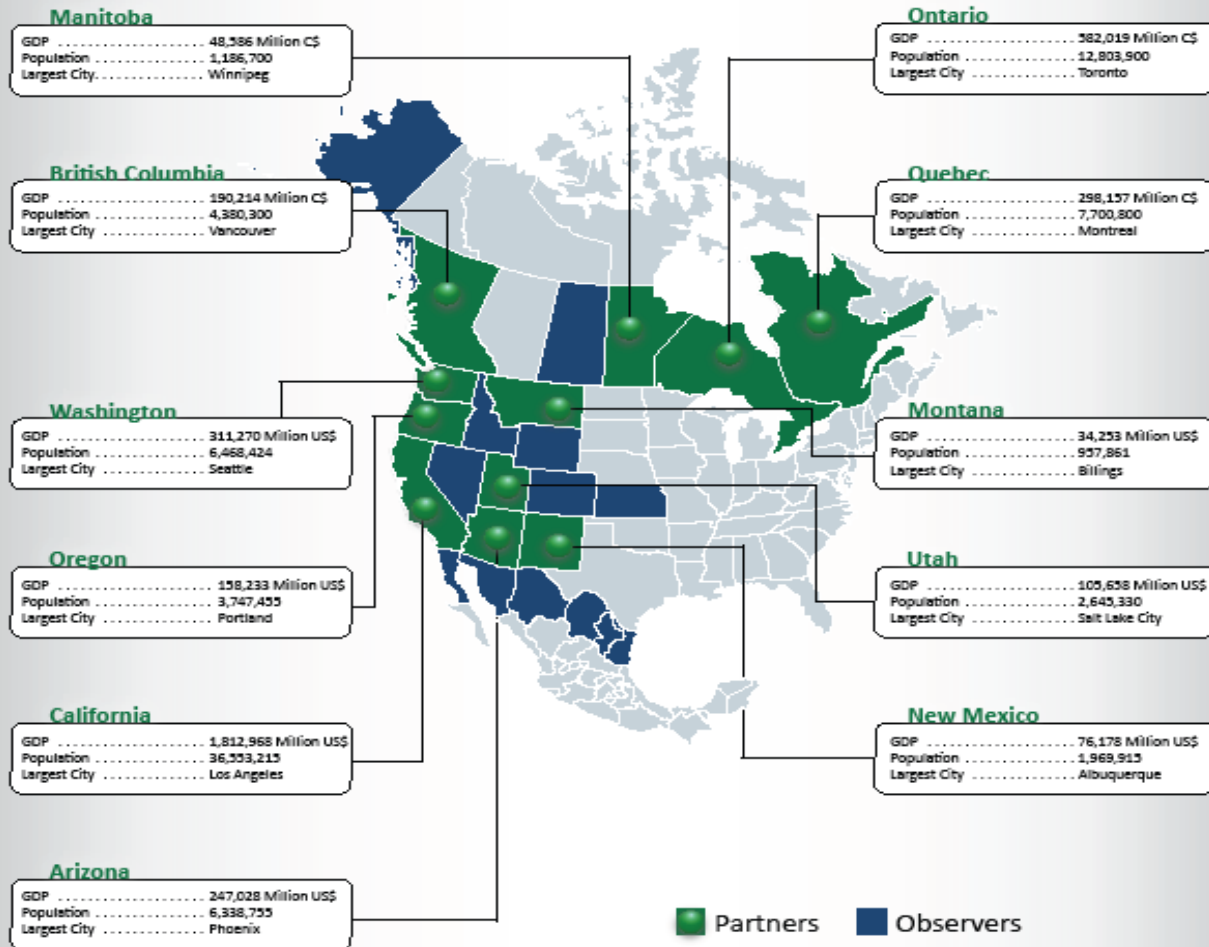


# The Evolving Global Carbon Market





# Western Climate Initiative



## WCI OBSERVERS

**CANADA**  
Saskatchewan

### UNITED STATES

Alaska  
Colorado  
Idaho  
Kansas  
Nevada  
Wyoming

### MEXICO

Baja California  
Chihuahua  
Coahuila  
Nuevo Leon  
Sonora  
Tamaulipas

Don McCabe,  
Ontario Federation of  
Agriculture,  
Soil Conservation  
Council of Canada

All figures for 2007

Source for US data: US Census Bureau and US Bureau of Economic Analysis

Source for Canadian data: Statistics Canada



## SUMMARY – YOUR FERTILIZER RIGHTS

- Crop managers select practices to apply the right source at the right rate at the right time in the right place, based on decision support provided by:
  - Crop advisers, extension, agronomists, research scientists
  - On-farm, station and laboratory research
- to work toward improvements in sustainability using performance indicators selected by stakeholders including:
  - Customers, Residents & Consumers
  - Advisers, Agronomists and Resource Managers
  - Producers
  - i.e., all stakeholders to crop production systems

**COMMENTS WELCOME**

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