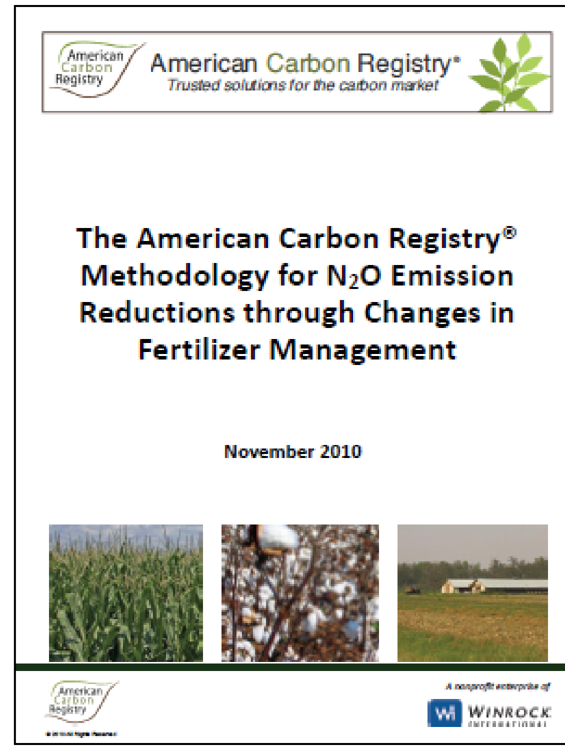
ACR Protocol: N_2O Emission Reductions through Changes in Fertilizer Management

C-AGG Meeting
Sacramento, California
March 29, 2011

At a glance

- Applicable to any modified fertilizer practice
  - Change fertilizer type, timing, placement, rate, use of timed-release fertilizers, nitrification inhibitors, other advanced technologies
- Uses peer-reviewed, highly parameterized DNDC model
- No geographic or crop constraints
- Calculates direct N_2O emissions from fertilizer, and indirect N_2O from leaching and ammonia volatilization, for baseline and project


American Carbon Registry®
Trusted solutions for the carbon market

The American Carbon Registry® Methodology for N_2O Emission Reductions through Changes in Fertilizer Management

November 2010

A nonprofit enterprise of
WINROCK INTERNATIONAL

Objectives

- Scientific rigor for compliance-grade offsets
  - "Tier 3" model, calibrated and validated for project, to capture all the site-specific and seasonal factors affecting N_2O emissions
- Flexibility for farmers
  - They choose practices; even implement multiple changes
  - Focus on what enhances farmer competitiveness and (incidentally) reduces GHG emissions
- Cost-effective, practical to apply and scalable
- "Stackable" with water and air quality benefits

Development process

- Development funded by Packard Foundation
- Two years in development:
  - Simplified methodology with 9 input factors, tested through field trials 2009 in CA (lettuce), IA (corn), AR (cotton)
  - Spatial analysis of N_2O from fertilizer across 31 states (wheat, corn, cotton)
- ACR approval process:
  - Public comments and responses by authors
  - Stakeholder consultation via C/T/M-AGG
  - Scientific peer review by 4 leading nutrient management experts; responses by authors

Project boundary

- Physical: all participating fields
  - Aggregation likely
- Temporal: one year or longer
- GHG boundary:

Sources	Gas	Included / Excluded	Justification / Explanation of choice
Direct and Indirect Nitrous Oxide Emissions Resulting from Fertilizer Application	CO_2	Excluded	Not applicable
	CH_4	Excluded	Not applicable
	N_2O	Included	GHG emitted from fertilizer application
Emissions resulting from Fossil Fuel Combustion	CO_2	Included	GHG emitted from fossil fuel combustion
	CH_4	Included	GHG emitted from fossil fuel combustion
	N_2O	Included	GHG emitted from fossil fuel combustion
Emissions from fertilizer production	CO_2	Included	GHG emitted from production of urea and synthetic fertilizer

Baseline scenario and additionality

- Preliminary screen based on Start Date
- Identify all realistic and credible land use scenarios on project lands in absence of project
  - Continuation of pre-project fertilizer management
  - Project activity without registration as ACR activity
- Demonstate additionality of project scenario via ACR three-prong test
- For both baseline and additionality, must present objective evidence suitable to verifier

DNDC model calibration

- Plant growth impacts soil water, C and N regimes, which determine biogeochemical reactions affecting N_2O emissions
- Calibration parameters:
  - Maximum crop biomass (kg C/ha)
  - Biomass fractions (grain, leaves + stems, roots)
  - Biomass C/N ratio (grain, leaves + stems, roots)
  - Total N demand to reach maximum production (kg N/ha)
  - Thermal degree days (^oC)
  - Water demand (g water/g dry matter)
  - N fixation index (1 for non-legume crops)
- Default values provided in DNDC crop library

Existing DNDC field trials

- Used worldwide for 17 years; 140 peer-reviewed publications
- UC Davis: tomatoes, rice, lettuce, corn, wheat
- Cal State Fresno: corn, cotton
- UC Santa Cruz: broccoli, strawberries
- ARB Research Division: DNDC for N_2O emissions from agriculture statewide, with calibration on: vegetable crops (700,000 acres), fruits and nuts (1.5m acres), field and seed crops (3.2m acres)
- EDF/CA Rice Commission: rice
- North America outside CA: alfalfa, barley, corn, beans, potato, oats, rice, rye soybean, spring & winter wheat

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Key formulas

$$GHG_{BSL\_N_2O,E,j,i} = \left(NL_{DIRECT,j,i} + \left(NL_{VOLAT,j,i} * EF_4\right) + \left(NL_{LEACH,j,i} * EF_5\right)\right) * \frac{44}{28} * GWP_{N_2O}$$

$$BE = GHG_{BSL\_N_2O,E} + GHG_{BSL\_FF,E} + GHG_{BSL,F,E}$$

$$GHG_{BSL\_N_2O,E} = \sum_{t=1}^{t^*}\left(\sum_{i=1}^{M}\left(GHG_{BSL,N_2O,E,i} * A_i\right)\right)$$

$$GHG_{BSL\_FF,E} = \sum_{a}(Fuel_{a,t} \times EF_a)$$

$$GHG_{BSL,F,E} = \sum_{t=1}^{t}\left(\sum_{i=1}^{M}(A_i * AR_{i,f} \; ,*EF_{CO_2 f}) \right)$$

$$ER_{ALM-ACR} = PE - BE$$

$$ER_{ALM-ACR} - \left(ER_{ALM-ACR} * \left(ER_{ALM-ACR\_ERROR} - 10\%\right)\right)$$

$$ERTs = ER_{ALM-ACR,t2} - ER_{ALM-ACR,t1}$$

- No leakage deduction since no shifting of fertilizer use nor yield decrease >5%
- Uncertainty deduction if total uncertainty exceeds 10% of the mean at 90% confidence
- No buffer deduction since reductions irreversible

Aggregator perspective (1)

- Building on existing base of farmers in Midwest and Great Lakes states; testing willingness to move to performance-based, project-specific protocols like ACR
- Aggregation will be key to keeping transaction costs down
- Protocol complexity is not a concern; rather the ability to tell farmers *ex ante* how many credits will accrue to each practice change – i.e. what are the revenues per acre?
  - Need more real-world data and economic analysis to assist farmer decisions
- Farmers may not wait another year
  - Time is now to capture their interest, get capital flowing, create 2011 vintage reductions

Aggregator perspective (2)

- Actively developing projects and recruiting farmers using the protocol
- Greatest strengths of protocol are:
  - *Flexibility* in allowing farmers to choose practices, including implementing multiple practice changes
    - Other protocols choose more prescriptive approach, or limit eligibility to rate reductions; approaches are complementary and will appeal to different landowners
  - *Environmental rigor* using DNDC
  - *Flexibility* in application to any crop – useful for CA
- Uncertainty on CA regulatory approvals raises challenges for investment decisions and off-take agreements

Further information

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Winrock International - American Carbon Registry

- First U.S. private voluntary GHG registry, founded 1996 by Environmental Resources Trust
  - 30 million tons issued to date
- 15 years experience in protocol development, offset issuance, serialization and online transaction reporting
- In-house expertise in forest carbon, REDD+, agriculture and rangelands, international renewable energy, cookstoves, CCS
- Parent non-profit has offices in ~70 countries

Winrock International Institute for Agricultural Development

Nonprofit that works in the U.S. and around the world to empower the disadvantaged, increase economic opportunity, and sustain natural resources

- Build expertise, train leaders
- Apply sound science and economics
- Mobilize markets
- Promote innovation
- Help the disadvantaged

DNDC model inputs

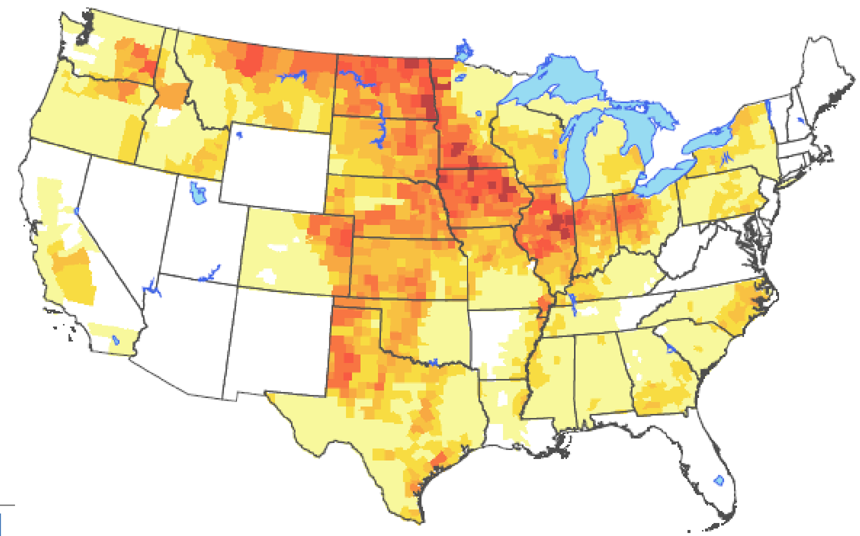
Input Category	Code	Input	Units	Mandatory / Optional	Data Source			
					Project records	*Measured*	*Look-up*	*Default*
Location	***L1***	GPS location of stratum	decimal °	M		X		
Climate	***CI***	Atmospheric background NH_3 concentration	µg N/m³	M				X
	C2	Atmospheric background CO_2 concentration	ppm	M				X
	C3	N concentration in rainfall	mg N/l or ppm	M			X	
	C4	Daily meteorology	multiple	M		X	X	
Soils	***S1***	Land-use type	type	M	X			
	S2	Clay content	0-1	M		X	X	
	S3	Bulk density	g/cm³	M		X	X	
	S4	Soil pH	value	M		X	X	
	S5	SOC at surface soil	kg C/kg	M		X	X	
	S6	Soil texture	type	M		X	X	
	S7	Slope	%	M		X		
	S8	Depth of water retention layer	cm	M		X	X	
	S9	High groundwater table	cm	M		X	X	
	S10	Field capacity	0-1	M		X		X
	S11	Wilting point	0-1	M		X		X
Cropping system	***CR1***	Crop type	type	M	X			
	CR2	Planting date	date	M	X			
	CR3	Harvest date	date	M	X			
	CR4	C/N ratio of the grain	ratio	M		X	X	
	CR5	C/N ratio of the leaf + stem tissue	ratio	M		X	X	
	CR6	C/N ratio of the root tissue	ratio	M		X	X	
	CR7	Fraction of leaves and stem left in field after harvest	0-1	M		X		
	CR8	Maximum yield	kg dry matter/ha	M	X			
Tillage system	***T1***	Number of tillage events	number	M	X			
	T2	Date of tillage events	date	M	X			
	T3	Depth of tillage events	6 depths†	M	X			
N Fertilizer	***F1***	Number of fertilizer applications	number	M	X			
	F2	Date of each fertilizer application	date	M	X			
	F3	Application method	surface / injection	M	X			
	F4	Type of fertilizer	type*	M	X			
	F5	Fertilizer application rate	kg N/ha	M	X			
	F6	Time-release fertilizer	# days for full release	M	X			
	F7	Nitrification inhibitors		M	X			
Organic Fertilizer	***O1***	Number of organic applications per year	number	M	X			
	O2	Date of application	date	M	X			
	O3	Type of organic amendment	type	M	X			
	O4	Application rate	kg C/ha	M	X			
	O5	Amendment C/N ratio	ratio	M				X
Irrigation System	***I1***	Number of irrigation events	number	M	X			
	I2	Date of irrigation	date	M	X			
	I3	Irrigation type	3 types‡	M	X			
	I4	Irrigation application rate	mm	M	X			

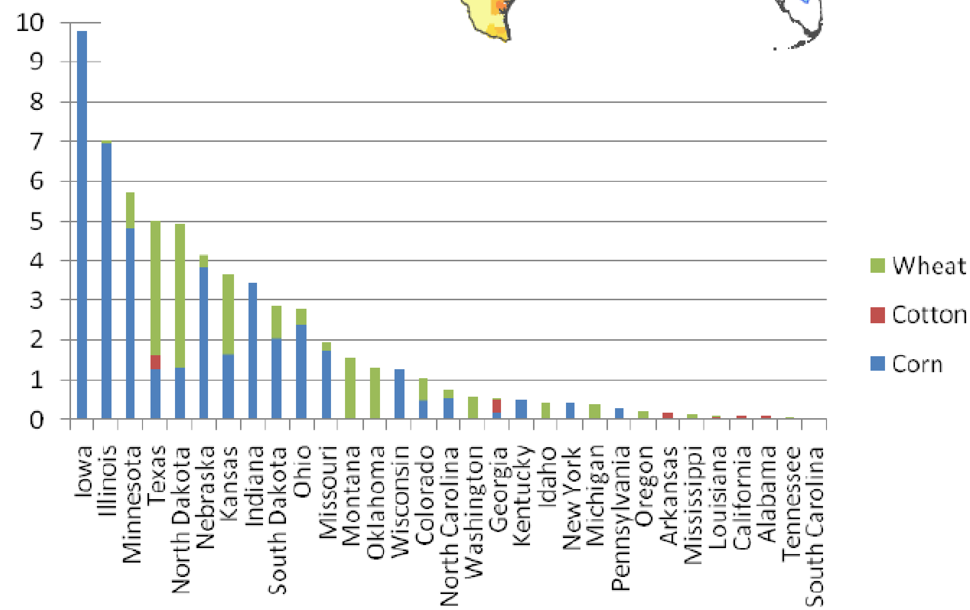
First interim product: development of a simplified methodology, with field testing

- Simplified methodology based on Bouwman *et al* 2002
  - Improve on simple IPCC defaults
  - Methodology required site-specific info on fertilizer type, crop type, soil texture, soil carbon concentration, soil drainage, pH, climate, etc.
  - Test sites in AR (cotton), IA (corn), CA (lettuce) in 2009 season
  - Field data compared to DNDC modeling results
- Results:
  - Improvement on IPCC, far more specific to site
  - Insufficient for seasonal variations
  - In some cases methodology and model results diverge
  - Simplified methodology is powerful for broad regional analyses, but insufficient for rigorous project-level accounting

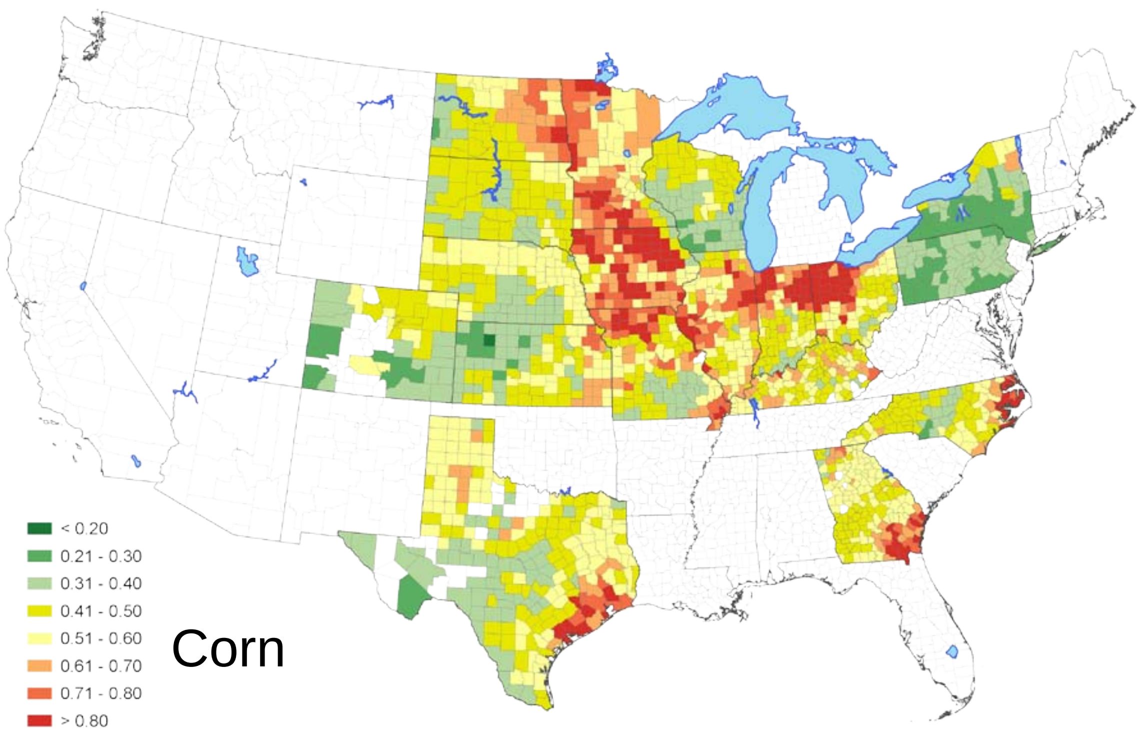
Second interim product: spatial analysis of N_2O emissions in 31 U.S. states

- Analysis of 129m acres wheat, corn and cotton in 31 states
  - 6.2m tonnes of nitrogen applied
  - 3 fertilizer types
- Modified Bouwman model:
  - Fertilizer quantity, type, soil texture and drainage, pH soil carbon concentration used to predict N_2O emissions
- 61m tonnes CO_2e emissions
  - 70% corn, 25% wheat, 5% cotton
- 0.12 - 1.45 $tCO_2e\ ac^{-1}yr^{-1}$

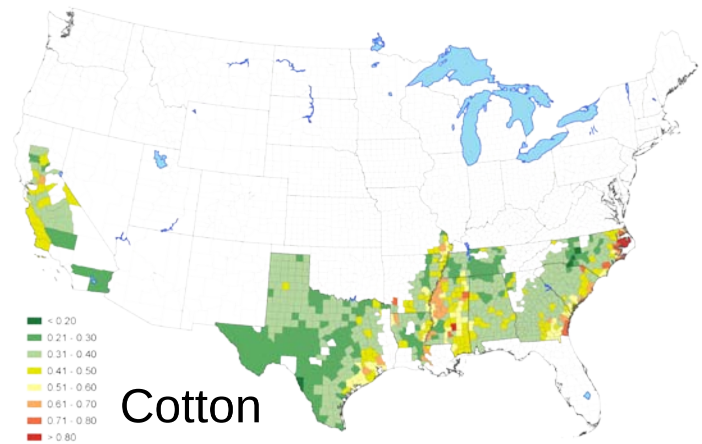


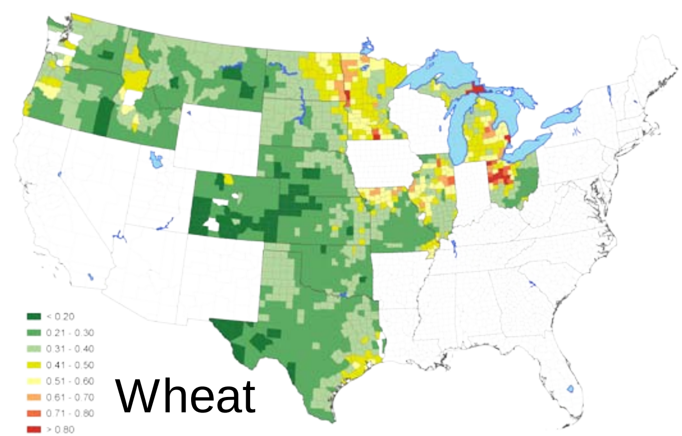


County-level emissions from anhydrous ammonia (tCO_2e/acre-yr)



Corn


Cotton


Wheat