Grazing Land and Livestock Management GHG Methodology

Stakeholder Consultation Webinar
January 22, 2013
Outline

• Background, methodology structure, and FRAMEWORK module
  – Nicholas Martin, ACR

• Accounting for micro-scale impacts
  – Nancy Harris, Winrock International

• Accounting for small and large-scale impacts on enteric, manure, fertilizer emissions and biotic sequestration
  – Tim Pearson, Winrock International

• Accounting for leakage
  – Lauren Nichols, ACR

• Q&A
Webinar logistics

To ask questions:
  – Type questions into ‘Chat’ box near bottom of your webinar pane
  – ‘Raise Hand’ (in vertical bar at left of your webinar pane) to hold your place in line to ask a question

GLLM methodology is open for public comment through January 31, 2013
  – All public and webinar comments will be addressed and posted with methodology

Webinar will be recorded and posted shortly to www.americancarbonregistry.org
American Carbon Registry

• First U.S. voluntary carbon registry
  – 37.5 MMT CO$_2$e verified carbon reductions since 1996
  – Non-profit organization

• Registry roles:
  – Develop and approve carbon protocols
  – Review and register projects
  – Oversee independent verification
  – Transparently track transactions and retirements
  – Support California compliance market, both as OPR and with new protocols

• 2011: 2.9 million ERTs sold, retired or contracted at average price of $5.51/tCO$_2$e (range $1-14$)
Winrock International Institute for Agricultural Development

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

• 1985 merger of Winrock Int’l Livestock Research & Training Center, International Ag Development Service, and Ag Development Council

• Rockefeller family tradition of agricultural research and extension, yield improvement, global food security

• Seeking ways to connect farmers and ranchers to new markets, enhance competitiveness, maintain/increase yields
Methane and $N_2O$ emissions from U.S. agriculture (MMT CO$_2$e, 2010)

- Agriculture = 428 MMT CO$_2$e or 6.3% of US GHG emissions
- Livestock = 210 MMT CO$_2$e
  - 141 MMT from enteric CH$_4$
  - 70 MMT from manure
  - Mostly beef and dairy cattle
  - Additional $N_2O$ from feed production
Thanks to:

- David & Lucile Packard Foundation
- GLLM Technical Advisory Committee:
  - Shawn Archibeque, Colorado State University
  - Richard Conant, Colorado State University
  - Gustavo Cruz, UC Davis
  - David Diaz, The Climate Trust
  - Alan Franzluebbers, USDA – Agricultural Research Service
  - Stephen De Gryze, Terra Global Capital
  - Karen Haugen Kozyra, Prasino Group / BIGGS project
  - Ermias Kebreab, UC Davis
  - April Leytem, USDA – Agricultural Research Service
  - Arvin Mosier, USDA – Agricultural Research Service (ret’d)
  - Matt Sutton-Vermeulen, Prasino Group / BIGGS Project
  - Juan Tricarico, Dairy Management Institute
Objectives

• Develop a comprehensive methodology to unlock large-scale GHG reductions in the beef and dairy sectors
  – Enteric, manure, fertilizer, fossil fuel emission reductions and enhanced biotic sequestration in soil and plants
  – Flexible modular structure
  – Tiered GHG accounting methods

• Conduct economic and spatial analysis of beef and dairy operations to identify regions and mitigation practices with significant uptake potential

• Field test methodology on dairy and beef operations across U.S.
  – Currently identifying pilot producers and conducting focus groups

• Inform development of regulatory protocols
Modular structure, many eligible practices

- Flexibility to edit and update components without affecting the rest of the methodology
- Facilitates expanding potential accounting and project interventions
- Simplifies project development as users can focus only on applicable modules depending on which sources/pools they will affect and scale of impacts

**Example practices:**
- Rotational and management intensive grazing in beef and dairy
  - Dietary changes, feed additives to suppress enteric CH₄
  - Reduce fertilizer and natural gas emissions embedded in feed
- Change manure management system
  - Tree planting (silvopasture)
  - Fertilize or irrigate pasture
  - Convert cropland to pasture
- Etc.
Methodology structure
**Tiered accounting methods**

- Complexity and data requirements of required accounting method correspond to the scale of impacts expected in a particular SSR.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-XANTE</td>
<td>Ex ante estimate of net reductions directs user to A-MICROSCALE, A-SMALLSCALE, or full accounting module</td>
</tr>
<tr>
<td>A-MICROSCALE</td>
<td>Excel tool – simple emission factors, low data requirements when estimated impacts on a SSR are &lt;5,000 tCO₂e/y</td>
</tr>
<tr>
<td>A-SMALLSCALE</td>
<td>Used in U.S. for biotic, fertilizer and fossil fuel impacts between 5,000 and 60,000 tCO₂e/y. Uses COMET v2.0.</td>
</tr>
<tr>
<td>A-ENTERIC</td>
<td>Used for impacts &gt;5,000 tCO₂e/y</td>
</tr>
<tr>
<td>A-MANURE</td>
<td>Used for impacts &gt;5,000 tCO₂e/y</td>
</tr>
<tr>
<td>A-FERTILIZER</td>
<td>Used in U.S. for impacts &gt;60,000 tCO₂e/y and outside US for impacts &gt;5,000 tCO₂e/y</td>
</tr>
<tr>
<td>A-BIOTIC</td>
<td>Used in U.S. for impacts &gt;60,000 tCO₂e/y and outside US for impacts &gt;5,000 tCO₂e/y</td>
</tr>
<tr>
<td>L-GLLM</td>
<td>Activity-shifting and market effects leakage emissions</td>
</tr>
<tr>
<td>T-RISK</td>
<td>Tool for calculating buffer contribution for biotic seq.</td>
</tr>
</tbody>
</table>

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**American Carbon Registry**
FRAMEWORK-GLLM

- Overall structure and functionality of methodology
- Guidance when other modules are required or optional
- Applicability conditions for the methodology overall
- Defining the project boundary (geographic boundary, temporal boundary, and GHG SSRs included/excluded from accounting)
- Demonstrating additionality
- Formula to calculate ERTs using output parameters of other modules
- Monitoring requirements
- Rules for aggregates and Programs of Activities
Applicability conditions

- Dairy and beef operations
- Project lands managed for grazing/livestock in the project scenario
- GLLM activities on public lands receive credit for biotic sequestration only if responsible agency cedes offset ownership and must make buffer contribution in non-project ERTs
- Projects on leased lands must demonstrate offset title and effective control of SSRs; owner agrees not to change land use for minimum project term
- >3% reduction in yield relative to baseline must use L-GLLM to deduct leakage
- Aggregates and PoAs must follow rules in Annex
Project boundary

- Facilities and lands where livestock are held, fed and grazed, in both the baseline and project scenarios
  - All entities over which Project Proponent has effective control; may span several commercial entities
  - May include analytical units corresponding to animal management rather than land areas
- May not exclude lands/facilities where emissions increase due to project activity
- May include multiple areas, facilities, owners, and start dates
Temporal boundaries

- **Start Date**: discrete date when project management diverges from baseline management, as defined in GHG Project Plan.
  - Multiple start dates for PoA

- **Crediting Period**: timeframe over which baseline is valid and credits generated. May be renewed.
  - 10 years for all impacts except biotic
  - 40 years for biotic sequestration

- **Minimum Project Term**: length of commitment by Project Proponent to monitoring and verification.
  - 40 years for projects claiming credit for biotic sequestration
  - No minimum term for irreversible enteric, manure, fertilizer, fossil fuel reductions
## GHG boundary

<table>
<thead>
<tr>
<th>Sources</th>
<th>Gas</th>
<th>Included/Excluded</th>
<th>Justification / Explanation of choice</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enteric emissions from dairy and beef cattle</strong></td>
<td>CO₂</td>
<td>Excluded</td>
<td>Potential emissions are negligibly small</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>Included</td>
<td>Primary GHG affected by the project activity</td>
</tr>
<tr>
<td></td>
<td>N₂O</td>
<td>Excluded</td>
<td>Potential emissions are negligibly small</td>
</tr>
<tr>
<td><strong>Manure emissions from dairy and beef cattle</strong></td>
<td>CO₂</td>
<td>Included</td>
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</tr>
<tr>
<td></td>
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<td>Primary GHG affected by the project activity</td>
</tr>
<tr>
<td></td>
<td>N₂O</td>
<td>Included</td>
<td>Primary GHG affected by the project activity</td>
</tr>
<tr>
<td><strong>Combustion of fossil fuels</strong></td>
<td>CO₂</td>
<td>Included</td>
<td>Must be included if emissions significantly higher than baseline.</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>Excluded</td>
<td>Potential emissions are negligibly small</td>
</tr>
<tr>
<td></td>
<td>N₂O</td>
<td>Excluded</td>
<td>Potential emissions are negligibly small</td>
</tr>
<tr>
<td><strong>Emissions from land application of organic and synthetic fertilizers</strong></td>
<td>CO₂</td>
<td>Excluded</td>
<td>Potential emissions are negligibly small</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>Excluded</td>
<td>Potential emissions are negligibly small</td>
</tr>
<tr>
<td></td>
<td>N₂O</td>
<td>Included</td>
<td>Primary GHG affected by the project activity</td>
</tr>
<tr>
<td>Carbon pools</td>
<td>Included / Excluded</td>
<td>Justification / Explanation of choice</td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------</td>
<td>-------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Aboveground</td>
<td>Included / Excluded</td>
<td>Must be included if ex ante estimate of baseline C stocks exceed project C stocks. May be included if project exceed baseline and PP wishes to claim credit.</td>
<td></td>
</tr>
<tr>
<td>Belowground</td>
<td>Included / Excluded</td>
<td>Must be included if ex ante estimate of baseline C stocks exceed project C stocks. May be included if project exceed baseline and PP wishes to claim credit.</td>
<td></td>
</tr>
<tr>
<td>Dead wood</td>
<td>Excluded</td>
<td>Changes in the dead wood pool are expected to be negligibly small over the Crediting Period.</td>
<td></td>
</tr>
<tr>
<td>Harvested wood products</td>
<td>Included / Excluded</td>
<td>Must be included if ex ante estimate of baseline C stocks exceed project C stocks. May be included if project exceed baseline and PP wishes to claim credit.</td>
<td></td>
</tr>
<tr>
<td>Litter</td>
<td>Excluded</td>
<td>Changes in the dead wood pool are expected to be negligibly small over the Crediting Period.</td>
<td></td>
</tr>
<tr>
<td>Soil organic carbon</td>
<td>Included / Excluded</td>
<td>Must be included if ex ante estimate of baseline C stocks exceed project C stocks. May be included if project exceed baseline and PP wishes to claim credit.</td>
<td></td>
</tr>
</tbody>
</table>
Additionality

- **Start Date**: if >1 year before submission of GHG Project Plan, provide evidence of GHG mitigation objective
- **Regulatory Surplus**: review applicable regulations and demonstrate project activity is not mandated
- **Performance Standard**: option of a “positive list” of practices at very low baseline adoption rates that are deemed additional
- **Three-Prong Test**: show regulatory surplus, not common practice, and faces at least one implementation barrier, using an ACR-approved additionality tool
Early adopters

- Activities with <5% adoption in industry may use a common practice baseline
  - Assess baseline adoption rate through surveys of available data, or expert opinion
  - Set baseline based on practices of non-adopters
  - No renewal of Crediting Period (10 years) if adoption remains below 5% → early adopters incentive not working

- Activities with >5% adoption must demonstrate project-specific additionality and use a project-specific baseline
  - Set baseline based on own operations
  - May be renewed only until adoption reaches 50%
ERT calculation

\[ ERT_{GLLM_t} = E_{ENT} + E_{MAN} + E_{FERT} + E_{FF} + (S_{BIO} \times (1 - Buffer\%)) - E_{LK} \]

- \(E_{ENT}, E_{MAN}\) etc. come from applicable module (large, small or micro scale)
- \(Buffer\%\) comes from T-RISK tool and is a deduction from biotic sequestration only
- \(E_{LK}\) comes from L-GLLM and includes both activity-shifting leakage (if required) and market leakage
  - Generally a positive number though could be negative
  - “Positive leakage” may only be credited if PP can demonstrate to ACR and VVB that the same reductions may not be claimed by other producers
Monitoring & Verification

- Monitoring period 1-5 years
- Field verification every 5 years; may do desk audits between
- Validation once per Crediting Period
- What to monitor:
  - All parameters listed in relevant accounting module
  - Project boundaries and implementation
  - Field data, collected using SOPs with QA/QC plan
- Stratification recommended
  - Relatively homogenous managed land areas, animal populations
- Conservativeness
Aggregates and PoAs

• Aggregate: multiple Project Participants grouped as one registered project, coordinated by an aggregator. Overall project boundary, single Start Date and Crediting Period.
  – Single GHG Project Plan
  – Reduce transaction costs of project development, validation and verification; reduce uncertainty

• PoA: multiple Cohorts (each an Aggregate) incrementally added to project over time. Overall project baseline, additionality and monitoring methodology. Multiple cohort Start Dates and Crediting Periods.
  – Single GHG Project Plan with initial Cohort (full validation); subsequent Cohort Descriptions (abbreviated validation)
Aggregates and PoAs

• **Aggregate:**
  – Boundaries, baseline, additionality, accounting thresholds, uncertainty requirements applied at Aggregate level

• **PoA:**
  – Clear criteria for addition of Cohorts
  – Clear documentation control for multiple Cohorts and Crediting Periods
  – Procedure to avoid double inclusion
  – No planned exceedance of accounting thresholds with later Cohorts

• **No de-bundling allowed**
  – Splitting project participants from Aggregate, or Cohorts from PoA, to stay below SSR accounting thresholds
Scaled Approach to GHG Accounting

The magnitude of estimated GHG impacts determines the accounting approach.

Need an accounting approach before you know the magnitude of estimated GHG impacts.

**MICRO SCALE**

- $< 5,000 \text{ t CO}_2\text{e}$
- $< 5,000 \text{ t CO}_2\text{e}$

**SMALL SCALE**

- $5,000 \text{ to } 60,000 \text{ t CO}_2\text{e}$
- AND
- Direct Emissions $< 60,000 \text{ t CO}_2\text{e}$

**LARGE SCALE**

- $> 60,000 \text{ t CO}_2\text{e}$
- $> 5,000 \text{ t CO}_2\text{e}$

start here

Need an accounting approach before you know the magnitude of estimated GHG impacts.

**MICRO SCALE**

- $< 5,000 \text{ t CO}_2\text{e}$
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- AND
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**LARGE SCALE**

- $> 60,000 \text{ t CO}_2\text{e}$
- $> 5,000 \text{ t CO}_2\text{e}$

start here
A-MICROSACLE

• Excel spreadsheet-based tool
• Simplified, automated GHG accounting procedures applied
• Provides a preliminary estimate of expected emission reductions from each source category:
  – Biotic Sequestration (S-BIO)
  – Enteric Fermentation (E-ENT)
  – Manure Management (E-MAN)
  – Fertilizer Use (E-FERT)
  – Fossil Fuel Use (E-FF)
• Output is based on data inputs provided by user for baseline and project scenarios
• Results of A-MICROSACLE → T-XANTE
Biotic Sequestration

- Based on IPCC Tier 1 accounting methodology

**A-MICROSCALE**

<table>
<thead>
<tr>
<th>Parameter Name:</th>
<th>s_bio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter Description:</td>
<td>Net microscale biotic sequestration/ emissions (t CO₂e)</td>
</tr>
<tr>
<td>Calculated value:</td>
<td>33,229 t CO₂e yr⁻¹</td>
</tr>
</tbody>
</table>

Instructions: Enter data into the light blue cells for both baseline and project scenarios. Use the unit converter box in the upper right as needed.

- Geographic Region: North America
- Climate Region: Warm Temperate Moist
- Soil Type: Low Activity Clay
- Size of Project Area: 5,000 ha

**Land Cover Type**
- Baseline Data: Long Term Cultivated Crop
- Project Data: Grassland

**Grassland Management**
- Baseline Data: N/A
- Project Data: Improved

**Grassland Inputs**
- Baseline Data: Medium
- Project Data: High

**Cropland Management**
- Baseline Data: Full Tillage
- Project Data: N/A

**Cropland Inputs**
- Baseline Data: Medium
- Project Data: N/A

Are you planting trees in the project area? No
## Enteric Fermentation

### Parameter Name:

### Parameter Description:

### Calculated value:

- **E\_ENT**
  - Net microscale enteric emissions (t CO\(_2\)e)

**0 t CO\(_2\)e yr\(^{-1}\)**

**INSTRUCTIONS:** Enter data into LIGHT BLUE CELLS for both baseline and project scenarios. Change values in gray cells only if you have project specific data, otherwise leave existing default values as they appear in the cell.

### Geographic Region:

- **North America**

### Table: Baseline Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Dairy Cows</th>
<th>Mature females</th>
<th>Mature Males</th>
<th>Calves on forage</th>
<th>Growing heifers/steers</th>
<th>Replacement/growing</th>
<th>Feedlot cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Animals Produced Per Year</td>
<td>1,000</td>
<td>75</td>
<td>300</td>
<td>150</td>
<td>300</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feeding Situation</td>
<td>90</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Average Live-Weight of Animal (kg)</td>
<td>600</td>
<td>500</td>
<td>500</td>
<td>180</td>
<td>255</td>
<td>375</td>
<td>415</td>
</tr>
<tr>
<td>Average Daily Weight Gain (kg day(^{-1}))</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total Annual Milk Production (kg cow(^{-1}) yr(^{-1}))</td>
<td>8,395</td>
<td>1,205</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feed content of milk (%)</td>
<td>4.0</td>
<td>4.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Feeding Regime:** Enter the type and % of each feed in the total annual diet of each animal category. Select feed name from drop down menu.

### Table: Project Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Dairy Cows</th>
<th>Mature females</th>
<th>Mature Males</th>
<th>Calves on forage</th>
<th>Growing heifers/steers</th>
<th>Replacement/growing</th>
<th>Feedlot cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Animals Produced Per Year</td>
<td>1,000</td>
<td>900</td>
<td>40</td>
<td>75</td>
<td>306</td>
<td>156</td>
<td>300</td>
</tr>
<tr>
<td>Feeding Situation</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Average Live-Weight of Animal (kg)</td>
<td>600</td>
<td>500</td>
<td>800</td>
<td>180</td>
<td>255</td>
<td>375</td>
<td>415</td>
</tr>
<tr>
<td>Average Daily Weight Gain (kg day(^{-1}))</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
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<td>1,205</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
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<td>4.0</td>
<td>4.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Manure Management

A-MICROSCALE

<table>
<thead>
<tr>
<th>Parameter Name:</th>
<th>Parameter Description:</th>
<th>Calculated value :</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>E_MAN</strong></td>
<td>Net microscale manure emissions (t CO₂e)</td>
<td><strong>402 t CO₂e yr⁻¹</strong></td>
</tr>
</tbody>
</table>

Instructions: Enter data into light blue cells for both baseline and project scenarios.

Geographic Region: | North America
Average Annual Temperature: | 18 °C

<table>
<thead>
<tr>
<th>Manure Management System</th>
<th>% of manure managed under each system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>Project</td>
</tr>
<tr>
<td>Pasture/Range/Paddock</td>
<td>0</td>
</tr>
<tr>
<td>Daily Spread</td>
<td>0</td>
</tr>
<tr>
<td>Solid Storage</td>
<td>100</td>
</tr>
<tr>
<td>Dry Lot</td>
<td>0</td>
</tr>
<tr>
<td>Liquid/Slurry with crust</td>
<td>0</td>
</tr>
<tr>
<td>Liquid/Slurry without crust</td>
<td>0</td>
</tr>
<tr>
<td>Uncovered anaerobic lagoon</td>
<td>0</td>
</tr>
<tr>
<td>Pit storage &lt;1 month</td>
<td>0</td>
</tr>
<tr>
<td>Pit storage &gt;1 month</td>
<td>0</td>
</tr>
<tr>
<td>Anaerobic digester</td>
<td>0</td>
</tr>
<tr>
<td>Burned for fuel</td>
<td>0</td>
</tr>
<tr>
<td>Deep bedding &lt;1 month, no mixing</td>
<td>0</td>
</tr>
<tr>
<td>Deep bedding &lt;1 month, active mixing</td>
<td>0</td>
</tr>
<tr>
<td>Deep bedding &gt;1 month, no mixing</td>
<td>0</td>
</tr>
<tr>
<td>Deep bedding &gt;1 month, active mixing</td>
<td>0</td>
</tr>
<tr>
<td>Composting - In-Vessel</td>
<td>0</td>
</tr>
<tr>
<td>Composting - static pile</td>
<td>0</td>
</tr>
<tr>
<td>Composting - intensive windrow</td>
<td>0</td>
</tr>
<tr>
<td>Composting - passive windrow</td>
<td>0</td>
</tr>
<tr>
<td>Aerobic treatment</td>
<td>0</td>
</tr>
</tbody>
</table>
## Fertilizer Use

### A - Microscale

**Parameter Name:** E-FERT  
**Parameter Description:** Net microscale fertilizer emissions (t CO\(_2\)e)  
**Calculated value:** -193 t CO\(_2\)e yr\(^{-1}\)

**Instructions:** Enter data into light blue cells for both baseline and project scenarios.

<table>
<thead>
<tr>
<th>Synthetic Fertilizer Application:</th>
<th>Baseline</th>
<th></th>
<th>Project</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Weight Applied (kg yr(^{-1}))</strong></td>
<td>15,000</td>
<td>15,000</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td><strong>%N</strong></td>
<td>82</td>
<td>82</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td><strong>Area of Land Where Fertilizer is Applied (ha)</strong></td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td><strong>Total Weight Applied (kg yr(^{-1}))</strong></td>
<td>0</td>
<td>0</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td><strong>%N</strong></td>
<td>100</td>
<td>100</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td><strong>Area of Land Where Fertilizer is Applied (ha)</strong></td>
<td>0</td>
<td>0</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
</tr>
</tbody>
</table>

**Organic Manure Application:**  
% of managed manure applied to fields:  
Baseline: 100  
Project: 100

---

**UNIT CONVERTER**

\[ \text{pounds} = \text{kilograms (kg)} \]

\[ \text{acres} = \text{hectares (ha)} \]
### Fossil Fuel Use

**A-MICROSCALE**

<table>
<thead>
<tr>
<th>Parameter Name:</th>
<th>E_FF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter Description:</td>
<td>Net microscale fossil fuel emissions (t CO$_2$e)</td>
</tr>
<tr>
<td>Calculated value:</td>
<td><strong>153</strong> t CO$_2$e yr$^{-1}$</td>
</tr>
</tbody>
</table>

**Instructions:** Enter data on annual fuel quantities into the light blue cells.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Project</th>
<th>Fuel Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethane</td>
<td>0</td>
<td>0</td>
<td>Gallons</td>
</tr>
<tr>
<td>Propane</td>
<td>0</td>
<td>0</td>
<td>Gallons</td>
</tr>
<tr>
<td>Butane</td>
<td>0</td>
<td>0</td>
<td>Gallons</td>
</tr>
<tr>
<td>LPG</td>
<td>0</td>
<td>0</td>
<td>Gallons</td>
</tr>
<tr>
<td>Motor Gasoline</td>
<td>20,000</td>
<td>5,000</td>
<td>Gallons</td>
</tr>
<tr>
<td>Aviation Gasoline (avgas)</td>
<td>0</td>
<td>0</td>
<td>Gallons</td>
</tr>
<tr>
<td>Other Kerosene</td>
<td>0</td>
<td>0</td>
<td>Gallons</td>
</tr>
<tr>
<td>Gas/Diesel Oil</td>
<td>10,000</td>
<td>8,000</td>
<td>Gallons</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>0</td>
<td>0</td>
<td>Gallons</td>
</tr>
<tr>
<td>Biogas</td>
<td>0</td>
<td>0</td>
<td>Gallons</td>
</tr>
<tr>
<td>Other Liquid Biofuels</td>
<td>0</td>
<td>0</td>
<td>Gallons</td>
</tr>
</tbody>
</table>

*If necessary, change units using drop-down menus.*
T-XANTE

- Fully automated
- Uses results from A-MICROSCALE to display which modules should be used

Is your project located within the continental United States?  

<table>
<thead>
<tr>
<th>Emission Category</th>
<th>Module Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biotic Sequestration:</td>
<td>A-SMALLSCALE</td>
</tr>
<tr>
<td>Enteric Fermentation:</td>
<td>A-MICROSCALE</td>
</tr>
<tr>
<td>Manure:</td>
<td>A-MANURE</td>
</tr>
<tr>
<td>Fertilizer:</td>
<td>A-MICROSCALE</td>
</tr>
<tr>
<td>Fossil Fuel:</td>
<td>A-MICROSCALE</td>
</tr>
</tbody>
</table>
Navigating Through the Modules

MICRO SCALE
< 5,000 t CO$_2$e
< 5,000 t CO$_2$e

SMALL SCALE
5,000 to 60,000 t CO$_2$e
AND
Direct Emissions < 60,000 t CO$_2$e

LARGE SCALE
> 60,000 t CO$_2$e
> 5,000 t CO$_2$e
Navigating Through the Modules

Applicable for:
- Biotic Sequestration
- Fertilizer emissions
- Fossil fuel emissions

NOT applicable (yet) for:
- Enteric emissions
- Manure Emissions

5,000 to 60,000 t CO$_2$e
AND
Direct Emissions < 60,000 t CO$_2$e
A-SMALLSCALE Data Inputs

• Historic land management
• Planned project land management
• Soil type
• Fertilizer inputs
• Fossil fuels used
Model

• Uses **COMET 2.0**, a “user-friendly, web-based tool that provides estimates of carbon sequestration and net greenhouse gas emissions from soils and biomass for US farms and ranches”

• Uses IPCC Tier 2 methods for estimating emissions

• In the future we will be able to switch to COMET-FARM which will have the capability of also calculating manure emissions and enteric fertilizer emissions
Support Tool for Agriculture, Range & Agroforestry

Step 1. Enter the State and County Information: Select the State and County where the parcel is located.

Select a State: ALABAMA
Select a County: Autauga

Next button

Internet Explorer Version: 9.0
Current Session: 1011366995 Current Run ID: 1
Step 2 (B). This page displays the status of your carbon calculations for the parcels that you have defined.

Click the parcel button to enter the name and size of the parcel. Then CLICK the "NEXT" button to continue with the carbon analysis for the selected parcel.

APPANOOSE County, Iowa Parcel Selection:

Enter the information for PARCEL 1

Name: Parcel 1
Size: 20 Acres
Step 3. Enter the Soil Information: Select the dominant soil texture and hydric status for your parcel.

Select the surface soil texture:

- clay
- clay loam
- loam
- loamy sand
- sand
- sandy clay
- sandy clay loam
- sandy loam
- silt
- silt loam
- silty clay
- silty clay loam

Is this a hydric soil? Select No or Yes:

- No
- Yes

NEXT
3. Current Period:
A. Select a management for the time period from any of the available tabs.
B. Choose a Soil Disturbance or tillage for this parcel.
C. Describe the woody landuse management, if applicable.
Choose A Management System for each Time Period:

- **Historic Period: 1880 to 1970;**
  - Selected System: **LOWLAND CROPLAND (NON-IRRIGATED)**

- **Modern Period: 1970s through Mid 1990s;**
  - Selected System: **CORN 2 YRS-GRASS HAY 4 YRS (NON-IRRIGATED), CRP: None, Tillage: Intensive**

- **Current Period: Late 1990s to 2012;**
  - Selected System: **CORN 2 YRS-GRASS HAY 4 YRS (Non-Irrigated), Tillage: Intensive**

- **Projection Period: 2012 to 2022;**
  - Selected System: **LIGHT USE; ROTATIONAL; UNFERTILIZED GRASS/LEGUME (NON-IRRIGATED), Tillage: Grazing**

---

1. **Projection Period:**
   - A. Select a management for the time period from any of the available tabs.
   - B. Choose a **Soil Disturbance** or tillage for this parcel.
   - C. Describe the woody landuse management, if applicable.

---

**RANGE: PASTURE Managements**

- Grass/Legume Hay/Pasture Mix/Continuous (Non-Irrigated)
- Heavy Use; Seasonal; Fertilized Grasses (Non-Irrigated)
- Heavy Use; Year-Round; Fertilized Grasses (Non-Irrigated)
- Light Use; Rotational; Unfertilized Grass/Legume (Non-Irrigated)
- Moderate Use; Rotational; Unfertilized Grass/Legume (Non-Irrigated)
- Moderate Use; Seasonal; Unfertilized Grass/Legume (Non-Irrigated)

**Sort List By:**

- Irrigation:
  - Non-Irrigated

**Tillage Selection:**

- Grazing
Step 7. Enter the Nutrient Management information for the Current and Projection periods by clicking on the BAR for either the Current or Projection Period: The following table represents the year by year crops in the selected management as it was modeled.

APPANOSE County, Iowa Nutrient Management History for Parcel 1

Current Period: Late 1990s to 2012;
Management: corn 2 yrs - grass hay 4 yrs (Non-Irrigated), Tillage: Intensive Tillage

<table>
<thead>
<tr>
<th>YEAR</th>
<th>CROPS</th>
<th>Fertilizer N lb/acre</th>
<th>Avg. N application lb/acre</th>
<th>Manure N lb/acre</th>
<th>Timing</th>
<th>Nitrification Inhibitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>corn</td>
<td>104</td>
<td>104</td>
<td>0</td>
<td>Spring</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>corn</td>
<td>104</td>
<td>104</td>
<td>0</td>
<td>Spring</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>grass hay</td>
<td>30</td>
<td>30</td>
<td>0</td>
<td>Spring</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>grass hay</td>
<td>30</td>
<td>30</td>
<td>0</td>
<td>Spring</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>grass hay</td>
<td>30</td>
<td>30</td>
<td>0</td>
<td>Spring</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>grass hay</td>
<td>30</td>
<td>30</td>
<td>0</td>
<td>Spring</td>
<td>No</td>
</tr>
</tbody>
</table>

Average yearly nitrogen value: 55 lb/acre

RUN MODEL
### Carbon Stock Changes and N₂O Emissions

<table>
<thead>
<tr>
<th>Source</th>
<th>Baseline Scenario</th>
<th>Projection Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Carbon</td>
<td>Uncertainty</td>
</tr>
<tr>
<td></td>
<td>tons/year</td>
<td>%</td>
</tr>
<tr>
<td>Soil Carbon Change</td>
<td>0.533</td>
<td>19%</td>
</tr>
<tr>
<td>N₂O Flux</td>
<td>46.2</td>
<td>Undetermined %</td>
</tr>
</tbody>
</table>

**Soil Carbon STOCK CHANGE/STORAGE:** A positive value indicates carbon sequestration and a negative value indicates a LOSS of soil carbon.

"Unknown" % indicates that COMET2 is unable to determine an uncertainty value for the management options selected based on the current ground truth information.

"Undetermined" % indicates that all data is not yet available to allow COMET2 to determine an uncertainty value for computed N₂O fluxes.

### Emissions as CO₂ Equivalents

<table>
<thead>
<tr>
<th>Scenario</th>
<th>CO₂ Equivalents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>tons/year</td>
</tr>
<tr>
<td></td>
<td>-1.96</td>
</tr>
<tr>
<td>N₂O Flux</td>
<td>7.16</td>
</tr>
<tr>
<td>TOTAL</td>
<td>5.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projection</th>
<th>CO₂ Equivalents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tons/year</td>
</tr>
<tr>
<td>Net Soil CO₂ Flux</td>
<td>-47.1</td>
</tr>
<tr>
<td>N₂O Flux</td>
<td>8.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>38.5</td>
</tr>
</tbody>
</table>

**Net CO₂ Emissions or Flux:** A positive value indicates an EMISSION or ADDITION of greenhouse gas to the atmosphere and a negative value indicates a REMOVAL of greenhouse gas from the atmosphere.

One Ton of carbon is equivalent to 3.667 Tons of CO₂. To convert CO₂ to C, divide by 3.667.

The N₂O flux is converted into Tons of CO₂ using the conversion constant value of 310 to calculate the GWP.
Navigating Through the Modules

MICRO SCALE

< 5,000 t CO₂e

< 5,000 t CO₂e

SMALL SCALE

5,000 to 60,000 t CO₂e

AND

Direct Emissions < 60,000 t CO₂e

LARGE SCALE

> 60,000 t CO₂e

> 5,000 t CO₂e
Navigating Through the Modules

- A-BIOTIC
- A-ENTERIC
- A-MANURE
- A-FERTILIZER

LARGE SCALE

> 60,000 t CO₂e

> 5,000 t CO₂e
A-BIOTIC Applicability Conditions

• Biotic sequestration **MUST** be included if emissions are significantly higher or sequestration is significantly lower under the project scenario than the baseline

• **Optional** in all other cases

• Where biotic sequestration is included, **A-BIOTIC MUST** be used:
  – In the US:
    • where direct emissions > 60,000 t CO$_2$-e annually; OR
    • Where reductions in emissions > 60,000 t CO$_2$-e annually
  – Internationally:
    • where reductions in emissions > 5,000 t CO$_2$-e annually
A-BIOTIC Data Inputs

- Tillage
  - type
  - depth
  - frequency
- Livestock
  - presence
  - type
  - manure application, production and management
- Grass
  - type
  - productivity
  - management
- CPES
  - trees and shrubs (field measurement)
A-BIOTIC Emissions Calculations

• Divided between:
  – soil carbon and carbon stored in grasses (above and belowground)
  – carbon stored in trees and shrubs (above and belowground)

• Soil carbon and grass storage calculated using a process model

• Tree and shrub carbon derived from field measurement using ACR tool CPES
A-BIOTIC Model

- Examples include Century, DayCent and Roth-C
- Must be studies (e.g. journal articles demonstrating use of model is appropriate in region where it is being applied)
- Model must have potential to determine soil carbon to an identified depth while considering:
  - Crop/grass type and productivity
  - Crop/grass management (including tillage)
  - Livestock presence, type and number
  - Manure applied, produced and management of manure application/production
- Modeling of herbaceous vegetation is an optional capability that must be used where present
- Validation of model required with limited field data sampling at each verification
CPES

• Trees and shrubs
• Stocks derived from field measurement
• Baseline stocks equal to stocks at start of project
Navigating Through the Modules

LARGE SCALE

A-BIOTIC
A-ENTERIC
A-MANURE
A-FERTILIZER

> 60,000 t CO₂e
> 5,000 t CO₂e
A-ENTERIC Applicability Conditions

• Enteric emissions **MUST** be included where with-project emissions are significantly elevated (see T-XANTE)
• **Optional** in all other cases
• **A-ENTERIC MUST** be used:
  – In the US:
    • where direct emissions > 5,000 t CO$_2$-e annually; OR
    • where reductions in emissions > 5,000 t CO$_2$-e annually
  – Internationally:
    • where reductions in emissions > 5,000 t CO$_2$-e annually
A-ENTERIC Data Inputs

- Number of livestock
- Body weight of livestock
- Information about different feed types:
  - Composition of annual diet (% of each feed)
  - Dietary ether extract
  - Gross energy intake
  - Dietary neutral detergent fiber
A-ENTERIC Emissions Calculations

• Divided by livestock sub-category:
  – Lactating cows
  – Dry cows
  – Heifers and steers

• Calculations based on empirical equations developed using animal and feed data collected in open-circuit respiration chambers from 1963 to 1995
Navigating Through the Modules

A-BIOTIC
A-ENTERIC
A-MANURE
A-FERTILIZER

> 60,000 t CO₂e
> 5,000 t CO₂e
A-MANURE Applicability Conditions

• Manure emissions MUST be included where with-project emissions are significantly elevated (see T-XANTE)
• Optional in all other cases
• Where manure emissions are included, A-MANURE MUST be used:
  – In the US:
    • where direct emissions > 5,000 t CO$_2$-e annually; OR
    • Where reductions in emissions > 5,000 t CO$_2$-e annually
  – Internationally:
    • where reductions in emissions > 5,000 t CO$_2$-e annually
A-MANURE Data Inputs

• Type(s) of manure management system(s)
• Quantity of feces produced
• Properties of feces:
  – Volatile solids content
  – Manure pH
• Quantities of manure storage and loss
• Ambient temperatures
A-MANURE Emissions Calculations

- Calculations based on Dairy GEM
- Dynamic baseline
- Emissions dependent on manure system and time of year (ambient temperature)
  - CO₂: methane flaring from enclosed manure storage
  - CH₄: sum of emissions from:
    - Barn floors and open lots
    - Stored manure (covered, uncovered, dry stacks)
    - Manure applied to fields
    - Manure from grazing animals
  - N₂O: sum of emissions from:
    - Barn floors / dry lots
    - Unenclosed storage of manure / stacked dry manure
Navigating Through the Modules

A-BIOTIC
A-ENTERIC
A-MANURE
A-FERTILIZER

LARGE SCALE

> 60,000 t CO₂e

> 5,000 t CO₂e
A-FERTILIZER Applicability Conditions

• Fertilizer emissions **MUST** be included where with-project emissions are significantly elevated (see T-XANTE)
• Optional in all other cases
• Where fertilizer emissions are included, **A-FERTILIZER MUST** be used:
  – In the US:
    • where direct emissions > 60,000 t CO₂-e annually; OR
    • Where reductions in emissions > 60,000 t CO₂-e annually
  – Internationally:
    • where reductions in emissions > 5,000 t CO₂-e annually
Data Inputs

- Atmospheric Factors
- Daily meteorology
- Edaphic factors (e.g., clay content, soil pH)
- Cropping factors (e.g., crop type, planting and harvest dates)
- Tillage factors (e.g., date and depth of tillage)
- Fertilizer application factors (e.g., type and application rate)
- Irrigation factors (e.g., # irrigation events, date)
A-FERTILIZER Model

• No specific model is endorsed (e.g., DNDC, Daycent)
• Must demonstrate that model is appropriate for climate/agroecological zone in which the project is located
• Must quantify both direct and indirect emissions
• Output must be the fertilizer-derived emission at a specific point in time
A-FERTILIZER Emissions Calculations

- Direct N$_2$O emissions
- Indirect N$_2$O emissions
  - Annual nitrate leaching loss
  - Annual ammonia volatilization and nitric oxide emissions
- Emissions from fertilizer production
Leakage

A decrease in sequestration or increase in emissions outside project boundaries as a result of project implementation.

- Activity shifting leakage: caused by shifting of the activities of people within project area
- Market effects leakage: caused by shifts in supply and demand for the product and services affected by the project.
L-GLLM: Accounting for Leakage

• Estimates GHG emissions from both activity shifting and market-effects leakage
• Applicable to all project activities
• Requires estimation and justification of output/yield in baseline case; monitoring of output/yield in project case.
  – Required where project leads to >3% decrease in output
Activity Shifting Leakage

• Accounting for activity shifting leakage emissions is required where:
  – Baseline output exceeds project output by >3% and;
  – Baseline land owner / user purchases new fields, brings new fields into production, increases livestock population outside project boundaries, or is displaced from project area
Activity Shifting Leakage

• Must monitor all livestock operations of baseline land owners/users.
• Production should be reported;
  – where not possible, common practice should be used to determine per unit area / per head emissions and estimates of numbers of head.
• Same methods as in the emissions modules should be used, dependent on magnitude.
  ➢ $E_{AS} =$ summed emissions
Market Effects Leakage

• Accounting for market effects leakage emissions is required where:
  – Baseline output exceeds project output by >3%.

• Accounting method attempts to capture emissions associated with market-mediated response of producers outside project boundary.
  – Employs theory that ME leakage can be quantified using published estimates of price elasticities of supply and demand\(^1\).

Market Effects Leakage Factor

- Module defines the default market-effects leakage factor applicable to any project using this methodology, using derived equation.

\[ LE_{M,t} = \frac{E_S}{E_D - E_S} \]

- \( E_S \) and \( E_D \) for dairy and beef sectors in US have been derived and published; all US based GLLM project activities must use the following values:

<table>
<thead>
<tr>
<th>Sector</th>
<th>( E_S )</th>
<th>( E_D )</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Dairy Sector</td>
<td>0.075</td>
<td>-0.26</td>
</tr>
<tr>
<td>US Beef Cattle Sector</td>
<td>0.91</td>
<td>-0.61</td>
</tr>
</tbody>
</table>

- Projects located outside the US must use verifiable values for \( E_S \) and \( E_D \), based on peer reviewed studies / local market data.
Calculating Market Effects leakage deduction

\[ E_{ME} = \left[ \left( \frac{Y_{P,t} + Y_{AS,t}}{Y_{BSL,t}} \right) - Y_{BSL,t} \right] \times L_{M,t} \times e_{BSL,t} \]

Where:

- \( E_{ME} \) Net greenhouse gas emissions due to market-effects leakage (t CO\(_2\)-e)
- \( Y_{P,t} \) Project output at time t; lbs/kg, gal/l, etc.
- \( Y_{AS,t} \) Output from production shifted to non-project areas at time t; lbs/kg, gal/l, etc.
- \( Y_{BSL,t} \) Baseline projected output at time t; lbs/kg, gal/l, etc.
- \( L_{M,t} \) Market leakage factor at time t from equation 1
- \( e_{BSL,t} \) Baseline emissions per unit output (t CO\(_2\)-e/ lbs/kg, gal/l output)
Total Leakage Deduction

\[ E_{LK} = E_{ME} + E_{AS} \]

*Where:*

- \( E_{LK} \): Net greenhouse gas emissions due to leakage (t CO\textsubscript{2}-e)
- \( E_{ME} \): Net greenhouse gas emissions due to market-effects leakage (t CO\textsubscript{2}-e)
- \( E_{AS} \): Net greenhouse gas emissions due to activity shifting leakage (t CO\textsubscript{2}-e)
<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicholas Martin</td>
<td>ACR</td>
<td><a href="mailto:nmartin@winrock.org">nmartin@winrock.org</a></td>
<td>703.842.9500</td>
</tr>
<tr>
<td>Tim Pearson</td>
<td>Winrock – Ecosystem Services</td>
<td><a href="mailto:tpearson@winrock.org">tpearson@winrock.org</a></td>
<td>703.302.6559</td>
</tr>
<tr>
<td>Lauren Nichols</td>
<td>ACR</td>
<td><a href="mailto:lnichols@winrock.org">lnichols@winrock.org</a></td>
<td>703.203.6250</td>
</tr>
<tr>
<td>Nancy Harris</td>
<td>Winrock – Ecosystem Services</td>
<td><a href="mailto:nharris@winrock.org">nharris@winrock.org</a></td>
<td>703.302.6519</td>
</tr>
</tbody>
</table>
Thank you!