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Soil Enrichment Protocol v2.0 Update

Technical Task Force Meeting #2

September 3, 2024

Housekeeping

- Please keep yourselves muted unless / until you would like to speak
- Please use the raise your hand function when answering a question
- All other attendees/observers are in listen-only mode
- Observers are free to submit questions in the question box
 - **All attendees will be able to see questions submitted to the Q&A section, as well as comment on questions / up-vote questions**
- **For workgroup members submitting comments and questions via chat: Please change your message settings to send comments to Everyone**
- The slides and a recording of the presentation will be posted online

AGENDA



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- **Overview of Sections 3.1 – 3.2**
 - Declaring Practice Categories & Project Domain (15 min)
- **Section 3.3: Gather Data to Validate Model Performance & Uncertainty**
 - Requirement 1: Generalized Dataset Attributes (15 min)
 - Requirement 2: Specific Dataset Requirements to Validate Model (15 min)
 - Specific Rules for Practice Categories (15 min)
- **Section 3.4: Assessment of Bias for Each PC/CFG/ES Combination**
 - Allowed deviations - PC x CFG x ES combinations (45 mins)
- **Next Steps (15 mins)**



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OVERVIEW OF SECTIONS 3.1 (DECLARE PRACTICE CATEGORIES) & 3.2 (DEFINE THE PROJECT DOMAIN)

Section 3.1 Declare Practice Categories (PC)

Table 3.1. Practice Categories and their Associated Practice Effects Requiring Biogeochemical Performance Evaluation

Practice Category Requiring Evaluation	Domain of Practice Effects
Inorganic nitrogen fertilizer application (InN)	Magnitude, form, timing, or method for nitrogen fertilizer applied, with form encompassing inorganic N fertilizers, and method encompassing surface, subsurface, or irrigation-based application
Organic amendments application (OrN)	Magnitude, form, timing, method or variation in C:N ratio for organic amendments applied. Forms include and are not limited to biochar, mulch, compost, and manure, and methods encompass surface, subsurface, or irrigation-based application
Water management/irrigation (Water)	Magnitude, timing, source or method of irrigation water applied
Soil disturbance and/or residue management (TR)	Soil disturbance including tillage and compaction, and residue management encompassing soil exposure after harvest and physical incorporation of green manure
Cropping practices, planting and harvesting (e.g., crop rotations, cover crops) (Crop)	Variety of crops grown, increasing crop rooting depth, may include cover crops and soil preparations such as changing soil pH through liming
Grazing practices	Any of the following: presence/absence of grazing, stocking density, forage type or quality, species of grazers, mixed or single species herds, loading weight, grazing time, and rest/recovery periods

- Each practice within the project must be included within a Practice Category (PC)
- Demonstrates the domain of practice effects and the categories requiring evaluation.
- Projects encouraged to evaluate a range of practice effects in each PC domain
- If project has practices not included in Table 3.1, guidance must be sought from Reserve

Section 3.2 Define the Project Domain

- Evaluation of each PC begins with defining the project domain in terms of its biophysical attributes
 - **Crop Functional Groups (CFG)**
 - **Land Resource Regions (LRR)**
 - **Soils**
 - Clay content
 - NRCS soil texture classes
- Project developer must declare the unique CFGs, LRRs, and soils associated with each declared PC

3.2.1 Declare Project Crop Functional Groups (CFG)

- **CFGs share unique combinations of the following attributes:**
 - N fixation (Y/N)
 - Annual/perennial (A/P)
 - Photosynthetic pathway (C3/C4/CAM)
 - Growth form (tree/shrub/herbaceous)
 - Flooded/not flooded
- **For consistency, these CFGs have been labeled as:**
 - C4A (C4 Annuals – e.g. Corn)
 - C3A (C3 Annual herbaceous – e.g. Wheat)
 - C3AN (C3 Annual N-fixing herbaceous – e.g. Soy)
 - C3AS (C3 Annual shrub – e.g. Cotton)
 - C3AF (C3 Annual herbaceous flooded – e.g. Rice)
 - C3P (C3 Perennial – e.g. Timothy)
 - C3PN (C3 Perennial N-fixing – e.g. Alfalfa)
 - C4P (C4 Perennial – e.g. Switchgrass)

3.2.2 Declare Project Land Resource Regions (LRR)

- The full list of LRRs associated with each PC must be declared
- LRRs represent distinct combinations of climate, land resource use, and geographic features in the U.S., as defined by the USDA
 - Highest level of hierarchal segmentation of land areas in the U.S.
 - 20 LRRs in the conterminous U.S.
- IPCC climate zones must also be declared for each practice category following the climate zone definitions in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories to support use of international studies in model validation.

Land Resource Region (LRR)	
Abv	Description
A	Northwestern Forest, Forage, and Specialty Crop Region
B	Northwestern Wheat and Range Region
C	California Subtropical Fruit, Truck, and Specialty Crop Region
D	Western Range and Irrigated Region
E	Rocky Mountain Range and Forest Region
F	Northern Great Plains Spring Wheat Region
G	Western Great Plains Range and Irrigated Region
H	Central Great Plains Winter Wheat and Range Region
I	Southwest Plateaus and Plains Range and Cotton Region
J	Southwestern Prairies Cotton and Forage Region
K	Northern Lake States Forest and Forage Region
L	Lake State Fruit, Truck Crop, and Dairy Region
M	Central Feed Grains and Livestock Region
N	East and Central Farming and Forest Region
O	Mississippi Delta Cotton and Feed Grains Region
P	South Atlantic and Gulf Slope Cash Crops, Forest, and Livestock Region
R	Northeastern Forage and Forest Region
S	Northern Atlantic Slope Diversified Farming Region
T	Atlantic and Gulf Coast Lowland Forest and Crop Region
U	Florida Subtropical Fruit, Truck Crop, and Range Region

3.2.3 Declare Project Soils

- Soil characteristics must be declared for each PC
 - NRCS Soil texture class (20 classes)
 - % Clay content associated with each class
- Soil texture class abbreviations:

Soil Texture Classes			
Abv	Description	Abv	Description
S	Sand	SCL	Sandy Clay Loam
LS	Loamy Sand	CL	Clay Loam
SL	Sandy Loam	SiCL	Silty Clay Loam
L	Loam	SC	Sandy Clay
SiL	Silt Loam	SiC	Silty Clay
Si	Silt	C	Clay



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SECTION 3.3 DATA TO VALIDATE MODEL PERFORMANCE AND UNCERTAINTY

3.3 Gather Data to Validate Model Performance and Uncertainty

- **Requirement 1: Generalized Dataset Attributes**
 - List of guidelines datasets must adhere to for use in model validation
- **Requirement 2: Specific Dataset Requirements to Validate Model**
 - Set based on geographic extent of a project (LRRs) and soil attributes
- **Special Rules for Practice Categories**
 - List of special cases where grouping of certain CFGs may occur for a specific PC

Requirement 1: Generalized Dataset Attributes

- Datasets must adhere to the following guidelines:
 - Measured datasets must be drawn from peer-reviewed and published experimental datasets with measurements of the emissions source(s) of interest (SOC stock change and/or N₂O and CH₄ change, as applicable), ideally using control plots to test the practice category.
 - **Allowable timeline for using datasets in the process of publication? Must datasets be published before including in model validation?**
 - All validation dataset sources must be reported. The same measurement dataset sources can be used for validating multiple practice categories, when appropriate. Datasets may be used from studies outside of the US. However, the associated IPCC climate zone where these datasets were collected should correspond to the declared IPCC climate zones of the project.
 - **Same requirement for number of declared climate zones? (If 3 or more declared climate zones in project, validation data must cover at least 3 of these declared climate zones).**

Requirement 1: Generalized Dataset Attributes

- Datasets must adhere to the following guidelines (cont.):
 - In the case of SOC stocks, repeat measurements of SOC stock change must be able to capture multi-year changes, as practice effects on SOC may combine short and long-term changes in soil biogeochemical processes. Measurements from paired fields leveraging space-for-time analysis methods that approximate multi-year changes may also be used for SOC validation. **Newer methods for SOC stock monitoring are becoming available that can observe changes with greater precision at shorter time intervals. These methods will be acceptable if there is peer-reviewed support or independent expert support approved by the Reserve for their use in SOC monitoring and if the methods demonstrate accurate measurement of multi-year impacts on SOC stock changes.** Measured datasets of SOC stock change may be made at any depth, but the model must also predict SOC stock change at the corresponding depth. Thus, a fully compiled dataset for validating model performance and uncertainty may contain different depths for SOC stock change measurements as long as the model is predicting SOC stock change at each corresponding depth.
 - **Is eddy covariance flux tower data that's used for SOC stock estimation in the short term to supplement direct SOC measurement an appropriate measurement for model validation?**
 - **Additional parameters/conditions needed for when eddy covariance flux data is used for SOC?**

Requirement 2: Specific Dataset Requirements to Validate Model

- Requirements for validating model performance and uncertainty for a PC/CFG/ES combination are set based on the **geographic extent of a project (i.e., the number of declared LRRs)**, as well as the **soil attributes encountered within the project** (i.e., the declared soil textural classes and clay contents).
- **Logic used to determine the number of declared LRRs required for each PC/CFG/ES combination:**
 - 1 project LRR → Validation dataset must contain that LRR
 - 2 project LRRs → Validation dataset must contain both of those 2 LRRs
 - 3 or more LRRs → Validation dataset must include at least 3 of those LRRs
 - **Does the same logic apply for IPCC climate zones? Currently allowing any combination of LRR & IPCC to reach 3 unique regions requirement.**
- Soil attributes: At least three declared soil textural classes in the validation dataset, and the range in clay contents must span at least 15 percentage points.
- **If the available data fail to meet one of these minimums but exceeds the others in a way that supports a demonstrable test of generalized model performance, a case may be made for a valid exception to Requirement 2. This should be addressed explicitly in the Validation Report and will need to be approved by the Registry and by the external reviewer.**

Requirement 2: Specific Dataset Requirements to Validate Model

- Is the LRR requirement too strict by combination of PC/CFG/ES?
- Deviations allowed for cases where there's insufficient data to cover the required number of LRRs by PC/CFG/ES combination:
 - Allowed validation across the whole domain (all PC and CFG included in validation data) by ES instead of each PC/CFG/ES combination to reach required number of LRRs
 - Assumes that project will be applied across a wide range of sites
 - Add requirements for project domain to apply generalized MVRs that have grouped validation domains to ensure a project isn't heavily weighted in one PCxCFG that had weak representation in validation dataset?

3.3.1 Special Rules for Practice Categories

- If grazing practices have been validated on pasture, and a CFG has been validated for either the Cropping or Soil Disturbance practice categories, the model can be considered validated for grazing on residue for that CFG. **For grazing practices, pasture can be defined as any perennial grass or legume. C3 and C4 grasses do not need to be validated separately for pasture grazing.**
 - More clarity needed on this? How to compare pasture in validation datasets vs. project?
- **Other potential allowable special rules?**
 - Allowances for grouping perennials that are often studied in mixtures, assuming both N-fixing and non-N fixing species are represented?
 - Additional stipulation for % of project area that includes perennials?



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SECTION 3.4 ASSESSMENT OF BIAS FOR EACH PC/CFG/ES COMBINATION

- For each PC/CFG/ES being validated, the model must be shown to be unbiased in estimating the change in SOC, N₂O, or CH₄ pools for the project domain defined in Section 3.2, using measured data that meet the requirements of Section 3.3.
- This is done using the calculation of bias, a simplified version of average relative error calculated between measured data and model predictions.
- Bias indicates the average tendency of the modeled estimates to be larger or smaller than their observed counterparts
- Model bias should be calculated for each study and a mean bias should be computed as the unweighted mean of all biases from individual studies. The mean bias should be less than or equal to an estimate of pooled measurement uncertainty (PMU).

Examples

Model Review Form	
Soil Enrichment Protocol V1.1	
Model Name & Version	DayCent-CR v1.1.0
Model Developer	IndigoAg
SEP Model Requirements and Guidance Version	Version 1.1a
Model Reviewer(s)	Dr. Ankur Desai, University of Wisconsin-Madison
Project-Specific (Type 1) or Generalized Validation (Type 2)?	Project-specific (Type 1)
Model Review Report Submittal Date	13-Mar-2024

Validated Parameters by Emission Source

SOC									
LRR (list all as applicable)	PC (list individually)	Crop Functional Groups							
		C4A	C3A	C3AN	C3AS	C3AF	C3P	C3PN	C4P
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, R, S, T, U	Crop	✓	✓	✓	✓				✓
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, R, S, T, U	TR	✓		✓	✓				
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, R, S, T, U	InN	✓	✓	✓					✓
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, R, S, T, U	OrN	✓	✓	✓	✓				
Valid soil texture classes:		S, LS, SL, L, SiL, Si, SCL, CL, SiCL, SC, SiC, C							

N2O									
LRR (list all as applicable)	PC (list individually)	Crop Functional Groups							
		C4A	C3A	C3AN	C3AS	C3AF	C3P	C3PN	C4P
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, R, S, T, U	Crop	✓	✓	✓					✓
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, R, S, T, U	TR	✓	✓	✓					
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, R, S, T, U	InN	✓	✓	✓					
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, R, S, T, U	OrN	✓	✓						
Valid soil texture classes:		S, LS, SL, L, SiL, Si, SCL, CL, SiCL, SC, SiC, C							

CH4									
LRR (list all as applicable)	PC (list individually)	Crop Functional Groups							
		C4A	C3A	C3AN	C3AS	C3AF	C3P	C3PN	C4P
Valid soil texture classes:									

Model Review Form	
Soil Enrichment Protocol V1.1	
Model Name & Version	DNDC v11.0
Model Developer	ReGrow
SEP Model Requirements and Guidance Version	Version 1.1a
Model Reviewer(s)	Dr. Brian McConkey (Viresco Solutions)
Project-Specific (Type 1) or Generalized Validation (Type 2)?	Generalized (Type 2)
Model Review Report Submittal Date	1-Sep-2023 & 18-Dec-2023 addendum

Validated Parameters by Emission Source

SOC									
LRR (list all as applicable)	PC (list individually)	Crop Functional Groups							
		C4A	C3A	C3AN	C3AS	C3AF	C3P	C3PN	C4P
C, E, F, G, H, K, L, M, N, O, P	Crop	✓	✓	✓	✓	✓			
C, E, F, G, H, K, L, M, N, O, P	InN	✓	✓	✓	✓	✓			
C, E, F, G, H, K, L, M, N, O, P	TR	✓	✓	✓	✓				
C, E, F, G, H, K, L, M, N, O, P	OrN	✓	✓	✓	✓				
C, E, F, G, H, K, L, M, N, O, P	Water	✓	✓	✓	✓	✓			
T	Crop					✓			
T	InN					✓			
T	Water					✓			
Valid soil texture classes:		CL, SiCL, SCL, L, SiL, SL							

N2O									
LRR (list all as applicable)	PC (list individually)	Crop Functional Groups							
		C4A	C3A	C3AN	C3AS	C3AF	C3P	C3PN	C4P
C, E, F, G, H, K, L, M, N, O, P	Crop	✓	✓	✓	✓	✓			
C, E, F, G, H, K, L, M, N, O, P	InN	✓	✓	✓	✓	✓			
C, E, F, G, H, K, L, M, N, O, P	TR	✓	✓	✓	✓				
C, E, F, G, H, K, L, M, N, O, P	OrN	✓	✓	✓	✓				
C, E, F, G, H, K, L, M, N, O, P	Water	✓	✓	✓	✓	✓			
T	Crop					✓			
T	InN					✓			
T	Water					✓			
Valid soil texture classes:		C, CL, SiCL, SCL, L, SiL, SL, LS							

CH4									
LRR (list all as applicable)	PC (list individually)	Crop Functional Groups							
		C4A	C3A	C3AN	C3AS	C3AF	C3P	C3PN	C4P
C, E, F, G, H, K, L, M, N, O, P, T	Crop					✓			
C, E, F, G, H, K, L, M, N, O, P, T	InN					✓			
C, E, F, G, H, K, L, M, N, O, P, T	Water					✓			
C, E, F, G, H, K, L, M, N, O, P, T	OrN					✓			
C, E, F, G, H, K, L, M, N, O, P, T	TR								
Valid soil texture classes:		C, SiC, CL, SiCL, L, SiL							

Project Specific Domains

- There are 3 options for model Validation Reports:
 - Project-specific, that includes demonstration of model validation for a specific project's domain and combinations of crop functional groups, practices categories, and emissions sources;
 - Generalized to demonstrate overall performance of a given model, i.e., demonstrating where model performance is valid **over a range of possible project domains and crop functional group/practices category combinations**; OR
 - Project-specific and referencing an existing model Validation Report (type 1 or 2).
- Additional review for project specific domain? What does that look like?



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NEXT STEPS / TOPICS FOR DISCUSSION



Future Topics for Discussion

- **Soil stratification guidance – next meeting?**
- **Soil sampling/analysis methods – next meeting?**
- Cumulative Accounting
- Accounting for SOC re-measurement
- Others?

Next Steps

- Email us with any feedback on topics discussed today
- Reach out any time to discuss protocol topics or process
- All meeting materials related to the SEP update will be posted here:
<https://www.climateactionreserve.org/how/protocols/ncs/soil-enrichment/dev/>
- ***Next Workgroup Meeting TBD – Sept/Oct 2024 (Doodle Poll)***

Key contacts

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THANK YOU!