



## **Measuring, Monitoring, and Verifying Soil Carbon Stocks and Changes in Soil Carbon Stocks for Carbon Markets**

Soil carbon (C) sequestration is a scientifically recognized method of reducing atmospheric carbon dioxide (CO<sub>2</sub>) to help combat global climate change. Because of the multiple co-benefits of soil C, it is referred to as “charismatic C.” Soil C (organic matter) content is an indicator of soil health, fertility, and ecological functioning. Farmers have tested soils for soil organic matter and C content for many decades as a measure of soil health and to determine fertilizer needs. Numerous scientifically sound methods exist to measure soil C,<sup>1</sup> and a suite of robust, cost-effective technologies are in development. Cost-effective, accurate, rapid means of measuring, monitoring and verifying changes in soil C can prepare the agricultural sector to participate in C markets through the sale of “charismatic C” credits.

### ***Protocols needed for Agricultural Participation in C Markets***

A standardized, science-based protocol to measure, monitor, and verify soil carbon content and changes in content is necessary for emerging C markets. A standardized protocol, based on scientifically sound soil sampling techniques, modeling, and remote sensing technologies will establish minimal parameters to verify increases in soil C, providing necessary certainty for C markets. Practice-based estimates of awarding C credits are highly economical, but may not guarantee the level of confidence, per ton of C sequestered, that standardized science-based protocols can ensure.

CASMGS has a proven record of scientific research and results showing the impacts of various management practices on soil C, and on soil C measurement methodologies. CASMG is uniquely qualified to develop a protocol and to update it as policies, technologies, and C markets warrant.

### ***A Nationwide Soil C Network (NSCN)***

Agriculture has great potential to help reduce atmospheric CO<sub>2</sub> concentration through soil carbon sequestration, which also benefits soil quality and sustainability, and is a low-cost, win-win, greenhouse gas mitigation option. However, C markets will require accurate estimates, with low uncertainty, of C sequestration rates. To provide this, a national network of on-farm soil measurements is needed to complement existing models and experimental data. There is currently no soil measurement inventory for agricultural soils, whereas a forest measurement network has existed for many years. CASMG proposes the design and development of a nationwide soil C sampling network based on the USDA National Resources Inventory (NRI). The NSCN will link existing models and point data on soil C, and corroborate and link the data to allow scaling up (i.e. from farm or field levels up to regional or national levels) and scaling down (i.e., from national or regional levels down to farm or field levels). This will allow national inventory data to be linked and corroborated against actual point data at the field and farm level. The NSCN will speed development of accurate, economical soil C measurement methodologies and aid in updates to standardized protocols.

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<sup>1</sup> IPCC Special Report: Land Use, Land-use Change and Forestry, World Meteorological Organization and United Nations Environmental Program, 2000.



## **CASMGS FACTS: Measuring, Monitoring and Verifying Soil C Stocks**

CASMGS' members have developed, tested and maintain the world's and the country's premier tools for measuring, monitoring, and verifying soil C and changes in soil C stocks; methodologies for state- and county-level assessments of soil C stocks; and tools for C markets. These include:

### **Soil Carbon Models and Tools**

- ***CENTURY model*** – The **CENTURY** model is a general model of plant-soil nutrient cycling used to simulate carbon and nutrient dynamics for grasslands, agricultural lands, forests and savannas. The **CENTURY** model is used by the U.S. and other countries to estimate soil C stocks for the annual U.S. Inventory of GHG Emissions and Sinks.
- ***COMET-VR*** – the Voluntary Reporting of Greenhouse Gases-Carbon Management Evaluation Tool (**COMET-VR**) is a decision support tool for agricultural producers, land managers, soil scientists and other agricultural interests. **COMET-VR** provides online software to allow users to calculate in real time the annual carbon flux associated with management practices used. Estimates can be used to construct a soil carbon inventory for the DOE 1605(b) program.
- ***EPIC model*** -- The Environmental Policy Integrated Climate (EPIC) Model is a soil/crop model composed of several simulation components for weather, hydrology, nutrient cycling, pesticide fate, tillage, crop growth, soil erosion, crop and soil management and economics.

### **“Classical” Soil C Measurement Technology**

- The “gold standard” for soil C measurement involves taking “core” samples of soil from the test site, and processing it in a laboratory with either wet or dry combustion to measure total C.

### **Some Cutting-Edge Technologies for C Measurement and Monitoring**

- ***Inelastic Neutron Scattering (INS)***: rapid, non-invasive/non-destructive, portable or stationary platform; works at local and large field scales; can operate in scanning mode. Based on gamma-ray spectroscopy from neutrons directed into soil, causing elastic collisions and scattering of neutrons.
- ***Laser-induced breakdown spectroscopy (LIBS)***: rapid, “person-portable”, field-deployable, high-resolution technology, uses a 1-mm spot laser beam focused on a pressed soil sample, which emits a spectrum with soil C data.
- ***Mid Infra-Red Spectroscopy (MIDR)***: rapid, portable, with scanning capabilities; can be used in the field. Irradiates soil samples with mid-infrared radiation and collects the reflected radiation.
- ***Near-infrared Spectroscopy (NIR)***: an in-situ technique, beams near-infrared light into soil, where it is absorbed by molecular vibrations which are recorded and measured. The instrument can be affixed on tillage equipment.
- ***Pyrolytic Molecular Beam Mass Spectroscopy (py-MBMS)***: a rapid, transportable (not suitable for field use) technology, can detect and differentiate between new and old C; complimentary to other measurement technologies.