Practical Guidelines, Integrated Metrics, and Statistical Methods for Quantifying Carbon Sequestration in Rangeland and Agricultural Soils

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Background/Objectives. Carbon accrual in rangeland and agricultural soils presents an enormous potential for the capture and sequestration of atmospheric carbon. Studies from the USDA and USEPA have found that, under improved land management methods, soil restoration, and land conversion, the estimated 900 million acres of cropland and grazing land in the United States, along with forest land, could capture in excess of 288 million additional tonnes of CO_2 per year – sufficient to offset approximately 16% of annual CO_2 emissions related to the transportation sector. However, to support reliable certification of soil carbon storage credits, cost-effective methods are needed to measure, within a necessary degree of statistical confidence, the accumulation of below-ground carbon. While protocols for soil carbon storage have been developed in several countries, relatively few soil carbon projects have been initiated worldwide due to the high cost of the soil sampling and testing necessary to achieve reliable estimates of carbon accrual. To address this problem, practical guidelines have been developed, which have been incorporated into a new soil carbon sequestration protocol – called the BCarbon Standard – that accommodates the use of innovative testing methods, soil carbon accrual models, improved statistical methodologies, and an interim crediting process to facilitate economical project development and execution.

Approach/Activities. Sampling and analysis to measure changes in below-ground carbon content over time pose a classic "signal and noise" problem. The high degree of variability in the natural carbon content of the soil (the "noise") can make it difficult to distinguish the small increase in carbon content (the "signal") that is achieved over the project period. For this reason, a number of measures (such as soil health, vegetation, and land management practices) can be integrated to quantify the net increase in the below-ground carbon mass with adequate reliability. Based on a comprehensive review of the metrics currently used for soil carbon sequestration projects, this paper presents practical guidelines for sampling and analysis of soils, the use of modeling or other methods to conservatively estimate carbon accrual rates over time, the use of indirect parameters to monitor the progress of the carbon accrual effort, and statistical analyses of beginning and ending laboratory measurements to obtain a reliable estimate of net below-ground carbon gain for the purpose of generating carbon storage credits.

Results/Lessons Learned. Several major projects are presently underway in the US and abroad applying the BCarbon Standard to quantify the mass of carbon stored below ground over time as a result of improved grazing and agricultural land management practices. These projects demonstrate that, as a supplement to traditional soil sampling and testing, the use of soil models, indirect indicators of carbon accrual, and improved statistical methods can facilitate more cost-effective design and implementation of soil carbon sequestration projects. In addition, this work highlights the need for research into data fusion methods to integrate laboratory techniques with emerging in-field technologies to reduce overall uncertainty in the measurement of soil carbon content, as well as the use of remote sensing products and field sensors to better estimate the rate of soil carbon accrual across the landscape.