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## Soil Carbon Sequestration in Agriculture: How much could it cost to measure soil carbon in Montana?

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This MontGuide outlines some of the factors that affect the costs of measuring soil carbon and presents the results from a study that examines the costs of measuring soil carbon in six regions of Montana.

There is growing concern that human activities, such as burning fossil fuels, are increasing atmospheric concentrations of carbon dioxide (CO<sub>2</sub>) and other gases thought to contribute to global warming. Collectively, these gases are referred to as greenhouse gases. Plants have the ability to remove CO<sub>2</sub> from the atmosphere and sequester (store) it as carbon in the soil. For this reason, studies have shown that U.S. cropland soils have the ability to compensate for up to nine percent of U.S. emissions of greenhouse gases by sequestering carbon in agricultural soils. Carbon is sequestered in the soil when a producer changes from their existing cropping system or management practices to systems or practices that store carbon at a faster rate.

Although the government has not adopted national regulations for com-

panies to reduce their net emissions of greenhouse gases such as CO<sub>2</sub>, many are doing so voluntarily. Companies can reduce the amount of greenhouse gases they contribute to the atmosphere by reducing emissions at their factories and plants.

In some cases, agricultural producers have sold the additional carbon sequestered in croplands (in the form of carbon “credits”) to industrial emitters to help counterbalance their emissions. To be competitive selling carbon, the agricultural sector must supply carbon at prices that are competitive with those charged by other sectors, such as forestry. A previous study in Montana suggests that Montana dry-land grain producers can supply carbon for a competitive price. However, when purchasers pay for agricultural carbon, they want to verify that the carbon has been stored in the soil and that the producer has completed the terms of the contract.

One important issue with soil carbon is that it cannot be observed or easily measured in the same way that point-source industrial emissions or above ground biomass in forests can be measured. For example, the rate of

carbon accumulation in agricultural soils cannot be estimated through visual inspection. Before agricultural producers can participate in the emerging market for tradeable credits, they must be able to verify that the amount of carbon in the soil has increased and can be maintained over a specified period.

The cost of measuring the accumulation of soil carbon will increase the overall cost of credits from agricultural producers and, therefore, will affect the competitiveness of agricultural soil carbon.

### Contract design

The type of contract that the producer enters into will affect the amount of money spent on measuring soil carbon. For example, contracts can be designed that pay producers for changing production practices to those thought to sequester additional carbon, regardless of the additional amount of carbon sequestered. Other contracts tie payments to the actual amount of carbon that is sequestered. For both contract types, many costs are similar, but the need to measure carbon quantity is unique to contracts that pay



Consortium for Agricultural Soils Mitigation of Greenhouse Gases

This MontGuide is one in a series exploring

the potential of agricultural sequestration of carbon. Soil carbon sequestration can be used to reduce the level of greenhouse gases in the atmosphere. Montana State University - Bozeman in collaboration with nine institutions will provide the data and analysis needed to explore the potential of this new market for agricultural producers. More information and accompanying publications can be found at [www.casmgs.montana.edu](http://www.casmgs.montana.edu).

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producers for the amount of additional carbon sequestered. The majority of carbon trades to date have used the type of contract that requires verification of carbon quantity sequestered.

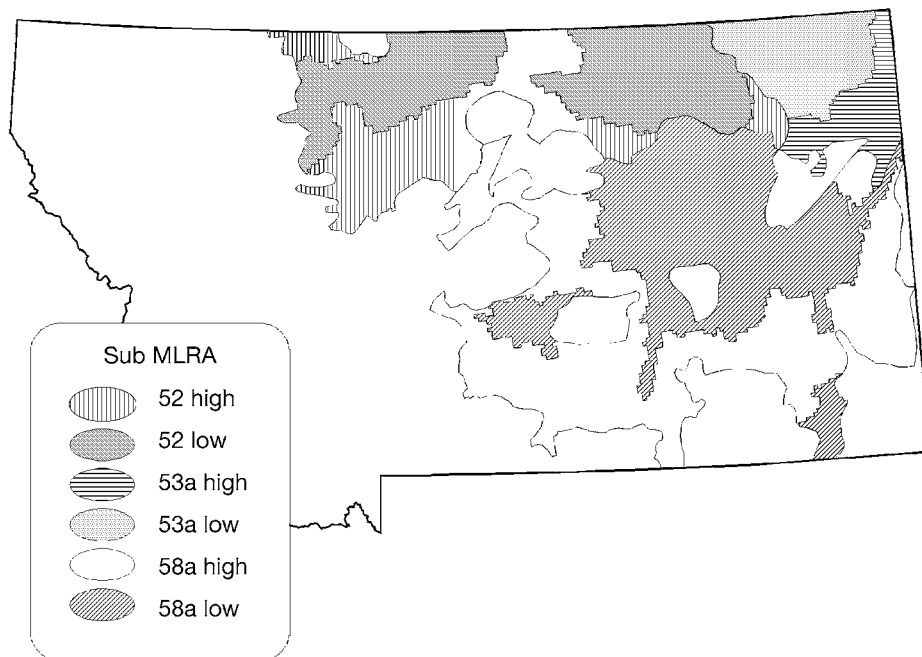
### Estimation of measurement costs

The amount of money spent purchasing carbon is quantified by the cost of carbon plus any incidental costs, such as measurement costs. Although there are several ways to measure soil carbon, the most common is to take soil samples from the field and test them for carbon content in the laboratory. The cost of measuring soil carbon depends partially on the number of soil samples required, the cost per sample and the number of times that soil is sampled over the length of the contract. In Montana, an estimated cost for taking each sample is approximately \$16.37.

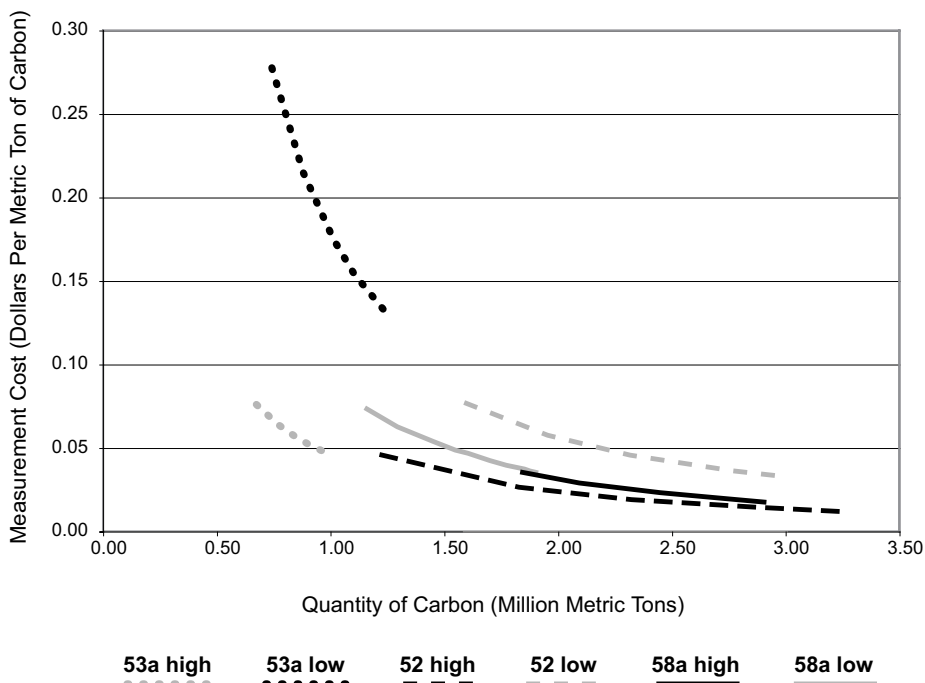
In the Montana study previously mentioned, the costs of measuring soil carbon are estimated for six agroecozones (Fig. 1). Agroecozones are based on Major Land Resource Areas (MLRA) defined by the Soil Conservation Service of the USDA on the basis of soil characteristics, climate, water resources and land use. In the study, carbon prices range between \$10 and \$50 in \$10 increments, and producers enter into contracts that last for 20 years. During that time, soil carbon is measured four times.

Increases in the cost per sample, number of samples or number of times sampling occurs over the contract will raise the cost of measuring soil carbon. For purposes in the study, we subdivided the agroecozones into high and low sub-MRLAs, using rainfall quantities. The growing conditions within each agroecozone are relatively consistent, but the growing conditions between agroecozones differ. We expect that the costs of measuring soil carbon will differ in each area because growing conditions affect producers' ability to sequester carbon.

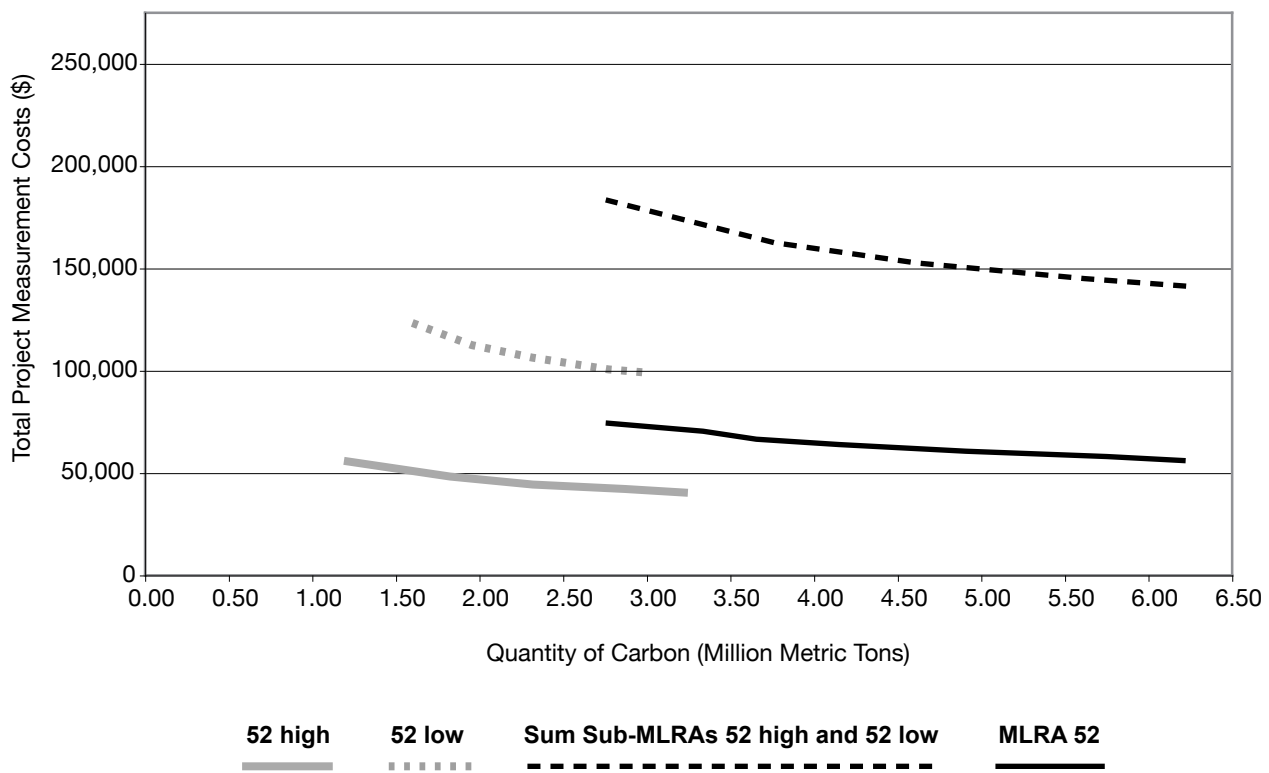
Figure 2 shows the estimated cost of measuring a metric ton of carbon in each of the six agroecozones. In each area, the measurement cost per metric ton declines as the quantity of carbon supplied increases. This suggests that



**Figure 1. Agroecozones as represented by Sub-MRLA (Major Land Resource Areas) in Montana**



**Figure 2. Measurement cost per metric ton carbon and total carbon sequestered**



**Figure 3. Relationship between Region Size and Total Measurement Cost**

it is more efficient to sell large quantities of carbon at one time because the measurement costs per metric ton will be a smaller percentage of overall costs. Figure 2 also shows that measurement costs are different in each area. It is most expensive to measure carbon credits sequestered in the soil in sub-MLRA 53a low, and least expensive in sub-MLRA 52 high.

As mentioned before, different costs will be associated with measuring carbon in each agroecozone, because their growing conditions and economic factors differ. These factors influence both quantity of carbon that can be sequestered and the cost of sequestering the carbon. In general, we expect that measurement costs will be higher in a single area where the ability to sequester soil carbon is highly variable than in an agroecozone that has a uniform ability to sequester carbon, because in variable areas more samples will be needed.

The size of the region will also affect measurement costs. We expect that measuring carbon over a larger region will reduce the costs of measur-

ing. Figure 3 shows this effect for one study area in Montana (Note: this figure shows total measurement costs, not measurement cost per metric ton of carbon). The total cost of measuring sub-MLRA 52 high and 52 low individually is approximately twice as high as when the areas are combined and measured as if they were a single area (MLRA 52). This is because fewer samples are required to measure carbon over a single large area than two smaller areas. When fewer samples are needed the cost of measurement is reduced. This result suggests that it is more efficient to engage in large contracts to supply carbon, because measurement costs will be a smaller part of overall costs.

### Implications for Montana

Companies can buy carbon from the forestry sector and other sources, all of which compete with agriculture to produce carbon. In order for Montana agricultural producers to be competitive, it is important to keep measurement costs as small as possible, while giving buyers assurance of the quantity of carbon

produced. Estimates by Mooney and others in 2003 suggest that measurement costs on Montana areas studied account for less than 10 percent of the total contract expenditure.

The costs of measuring soil carbon will vary between regions, depending on their underlying economic and biophysical conditions. If a region has highly variable carbon sequestration potential, measurement costs will increase. The number of credits being measured also affects costs. In general, areas that can sequester large quantities of carbon have lower per-ton measurement costs. Measurement costs across the six agroecozones in Montana are comparatively small, and are likely to keep Montana producers competitive at selling carbon.

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