Farming the Environment: Spatial Variation and Economic Efficiency in Soil; Developing Policies for Carbon Sequestration and Agriculture

John Antle, Susan Capalbo, and Siân Mooney
Department of Agricultural Economics and Economics
Montana State University

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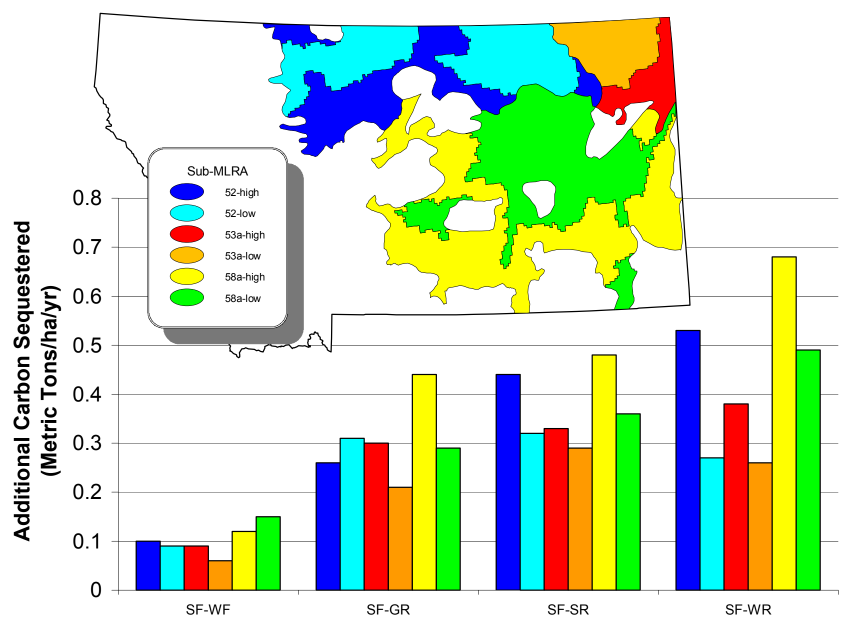
Spatial Variation and Economic Efficiency in Soil; Developing Policies for Carbon Sequestration and Agriculture

John Antle, Susan Capalbo, and Siân Mooney
Department of Agricultural Economics and Economics, Montana State University

Many industrialized counties are looking at ways to reduce their net emissions of greenhouse gases such as carbon dioxide. The Kyoto protocol of the United Nations Framework Convention on Climate Change introduces the idea of a C (carbon) credit trading scheme that would give credit to participating countries for reducing emissions domestically or purchasing them internationally. This potential new market could be beneficial to agricultural producers if they can provide C credits at a cost that is economically competitive with other sources. Recent research suggests that U.S. emissions could be reduced by up to 8 percent through sequestering C in agricultural soils (Lal et al. 1998).

Soil C can be increased by adopting management practices that reduce soil disturbance (and thus C oxidation) and/or increase biomass production. A mix of practices is likely under a market for C reflecting the spatial variability of resource endowments and economic considerations. Figure 1 presents the annual increase in C resulting from a change to cropping systems that increase biomass production in six different agroecozones (called sub-MLRAs) within Montana. C estimates are predicted using the Century ecosystem model (Antle et al. 2001). Figure 1 shows that the quantity of C sequestered varies across space, thus all management practices are not equally suited to each area.

Figure 1. Average annual rate of carbon accumulation for selected crop system changes that increase biomass (Century ecosystem model)



SF-WF Spring wheat fallow to winter wheat fallow
SF-GR Spring wheat fallow to grass
SF-SR Spring wheat fallow to continuous spring wheat
SF-WR Spring wheat fallow to continuous winter wheat

Based on Figure 1, sub-MLRA 58a-high has the greatest technical potential to sequester soil C. Examining only the technical potential ignores a key economic question: what level of incentive or compensation is required to encourage producers to adopt practices that increase soil C?

A producer will participate in a policy or market to sequester additional C if the net returns from production changes plus the market value of C produced exceed the net returns from existing production practices. Figure 2 presents C supply curves for each region reflecting the opportunity cost per metric ton C incurred by producers that switch to a system that sequesters additional soil C.

For example, 3 million metric tons of C can be supplied from sub-MLRA 52-high for approximately $45 per metric ton while the same quantity in sub-MLRA 58a-high could be supplied for approximately $60 per metric ton. Figure 2 demonstrates that the efficiency of soil C sequestration varies spatially and is dependent on both the biophysical rates of C accumulation and the site-specific opportunity costs of changing production practices.

Figure 2. Supply of carbon at payments ranging between $10 to $100 per metric ton

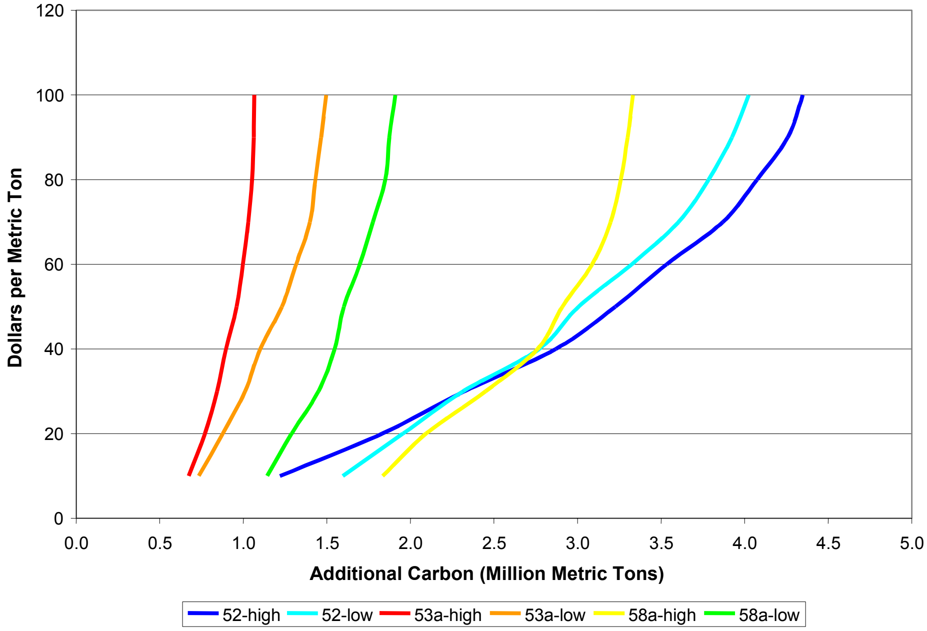


Figure 3 shows that as the price per metric ton of C increases, participation in C sequestration also increases. These shares are simulated using a model for dryland grain production in Montana (Antle et al. 2001). The model reflects both site-specific net returns and the biophysical potential to sequester C. At low payment levels, only producers with the smallest opportunity cost per metric ton C will participate. As payments increase, producers with higher opportunity costs can enter the market increasing the percentage of producers and land area that are engaged in the market and the benefits that accrue to agriculture.

Implications for Agriculture

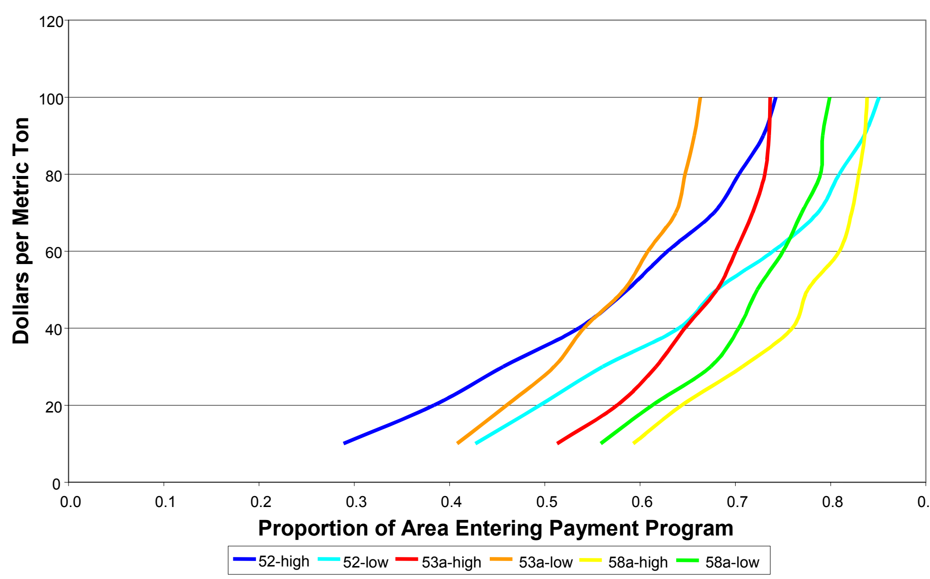
Biophysical and economic conditions that vary by location have two important implications. First, a market for C will be beneficial to regions that have the lowest opportunity costs per metric ton of C sequestered, and as the demand for C increases, there will be more opportunities for more producers to enter the market. Second, C can be sequestered in agricultural soils of the Northern Great Plains at a cost competitive with other sources. Related work by Stavins (1999) and IPCC (2000) show that forest practices can sequester C at costs that range from $3 per metric ton to over $100 per metric ton. These figures suggest that C sequestration could provide new economic opportunities for U.S. agricultural producers.

For More Information

Antle, J.M., S.M. Capalbo, S. Mooney, and K.H. Paustian. "Spatial heterogeneity, contract design and the efficiency of carbon sequestration policies for agriculture." Draft working paper. Department of Agricultural Economics and Economics, Montana State University, Bozeman, 2001.

Intergovernmental Panel on Climate Change (IPCC). *Land Use, Land–Use Change, and Forestry. A special report of the Intergovernmental Panel on Climate Change*. R.T. Watson, I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo, and D.J. Dokken, eds. Cambridge:

Figure 3. Proportion of eligible land area entering a carbon payment program at payments ranging between $10 to $100 per metric ton



Cambridge University Press, 2000.

Lal, R., L.M. Kimble, R.F. Follett, and C.V. Cole. *The Potential of U.S. Cropland to Sequester C and Mitigate the Greenhouse Effect*. Chelsea, MI: Ann Arbor Press, 1998.

Stavins, R.N. 1999. “The costs of carbon sequestration: A revealed–preference approach.” *Amer. Econ. Rev*. 89(4):994–1009.