Carbon Sequestered in Bison Ranges of South Dakota

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Abstract

The re-introduction of bison to the Northern Plains offers a unique opportunity to investigate carbon sequestration potential in South Dakota soils. This study investigated bison rangeland soils as a carbon sink and developed a dollar value based on current market reports. Soil organic carbon was determined (for the 0-20 cm depth, from four sites, in three slope positions) by subtracting inorganic values from total carbon. Tonnes/ha of organic carbon were converted to tonnes/ha of carbon dioxide. Dollar values were obtained from the Chicago Climate exchange ($4.00) published on August 30, 2006. The value using this method ranged from 245 to 773 $/ha, depending on site and slope position. At one site, carbon values for tilled fields nearby were subtracted from the total accumulated C and a partial value was determined. Values ranged from 140 - 275 $/ha. Currently ranchers can be compensated only for carbon increases due to management changes and are not able to sell carbon sequestered in existing rangeland soils. Conversion of rangeland to cropland often leads to relatively rapid and significant depletion of soil organic carbon. Maintenance of soil organic carbon in current rangeland is in many ways preferable to the cycle of range to crop to range conversions that may be encouraged by current market and policy forces. Policy makers might consider at least partial financial support for managers willing to maintain rangelands that have considerable carbon storage from past carbon sequestration.

Introduction

Overlooked in carbon policy is the contribution of range soils to carbon sequestration. Eynard et al. (2005) found that greater concentrations of organic carbon in the wind erodible size fraction suggests a high potential for loss of organic carbon through erosion and tillage. Grasslands compared to tillage treatments in their study had the highest amounts of stored organic carbon and the minimal potential for erosion loss. Thus these lands represent a significant storage capacity as well as a potential to contribute to CO_2 release if eroded or tilled.

This research project determined the amount of organic carbon in the soils of buffalo rangelands in South Dakota and converted it to dollar values on current market exchange. These values were used to compare two scenarios for carbon crediting policy development for lands maintained as range and managed to minimize erosion losses.

Objectives

1. Determine carbon concentrations in bison range soils in western South Dakota.
2. Determine economic value scenarios for the carbon credits available from bison rangeland.
3. Explore implications for policy development.

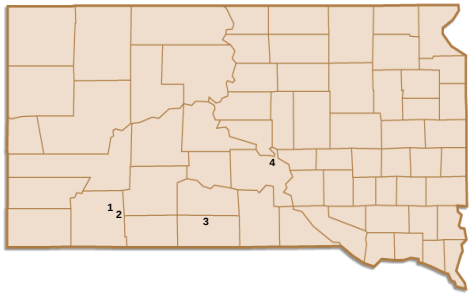
Methods

Four research sites in South Dakota were selected. At each site, 30 X 30m plots in upland, lowland, and mid-slope locations were established with three replications. At the mid-slope location, an exclosure was built in order to compare grazed and non-grazed range.

Soil samples were collected in the spring of 2005. In each plot, four sub-samples were collected at 0-20cm depth and pooled. Total soil carbon was determined by the Combustion Method on the Vario MAX CN analyzer. Inorganic carbon was determined by the Modified Pressure Calcimeter Method and was subtracted from the total carbon value to obtain organic carbon. A soil bulk density of 1.35 g per cubic centimeter was used to convert organic carbon concentration in the top 20 cm of soil to tonnes per hectare of organic carbon. The organic carbon was converted to tonnes per hectare of CO_2 and the August 30, 2006 price ($4.00) from the Chicago Climate Exchange was used to estimate dollar values for carbon stored in the bison range soils.

Two scenarios were compared for C policy development. The first scenario used the value of total stored carbon in the upper profile. This amount could be explored as a one-time payment for a permanent easement similar to the Wetland Reserve Program. The second scenario subtracted typical tilled-land concentrations, measured at a nearby site (34 tonne ha^{-1}), for organic carbon from the total stored carbon in the rangeland and the dollar value was based on the difference between the two. This smaller value might be used as a limited-term payment to prevent range-land managers from tilling their soils for a period of time and to encourage management to limit erosion, as in the Conservation Reserve Program.

Research Sites in South Dakota



Site Description

SITE 1 was located within a 700 ha range unit that had been stocked with approximately 50 bison since April of 2002. The plots were on an Oglala-Canyon soil association. The predominant Canyon Series is shallow, steep, friable, light colored, medium textured and calcareous. These soils are on ridges (18-40%) and on rough, broken side slopes of stream valleys. The research plots were located predominantly on east-facing slopes. Soil texture was fine to medium.

SITE 2 was located within a 1000 ha range unit that had been stocked with approximately 40 bison since December of 2000. The plots were on an Oglala-Canyon soil association. The predominant Canyon Series is shallow, steep, friable, light colored, medium textured and calcareous. These soils are on ridges (18-40%) and on rough, broken side slopes of stream valleys. The research plots were located predominantly on northeast-facing slopes. Soil texture was medium for all slope positions.

SITE 3 was located within one of the range units rotated with approximately 300 bison. The plots were on an Anselmo-Tassel-Dunday soil association. The predominant Anselmo Series is deep, with 5-9% slopes and is well drained. The soils are formed in wind-deposited sandy material that is friable when moist. The research plots were located predominantly on east-facing slopes. Toe-slope textures were coarser than those in mid- and shoulder positions.

SITE 4 was located within a 530 ha range unit that has been stocked with approximately 80 bison since 1995. The plots were on a Sansarc-Opal soil association formed in clayey shale residuum. The predominant series are moderately deep, well drained and steep. These clay soils are on 6-15% slopes and have gray shale within 1 m of the surface. Research plots were located predominately on east slopes. Soil texture was fine for all slope positions.

Table 1. Soil organic carbon and carbon exchange values from bison range, as affected by slope position and grazing.

Site 1

Slope position (grazing*)	Organic Carbon		Full Value**
	%	tonne ha^{-1}	$ ha^{-1} ($ ac^{-1})
Shoulder (g)	1.6	33	479 (194)
Mid (g)	1.4	28	404 (164)
Mid (ug)	1.3	26	381 (154)
Toe (g)	1.8	37	540 (219)
Pr>F	0.3564	0.3564	
LSD P>.05	0.74	15.0	

Site 3

Slope position (grazing*)	Organic Carbon		Value**
	%	tonne ha^{-1}	$ ha^{-1} ($ ac^{-1})
Shoulder (g)	1.6	33	479 (194)
Mid (g)	1.9	38	553 (224)
Mid (ug)	1.5	30	445 (180)
Toe (g)	0.8	17	245 (99)
Pr>F	0.0192	0.0192	
LSD P>.05	0.56	11.4	

Site 2

Slope position (grazing*)	Organic Carbon		Value**
	%	tonne ha^{-1}	$ ha^{-1} ($ ac^{-1})
Shoulder (g)	1.3	26	381 (154)
Mid (g)	1.2	25	363 (147)
Mid (ug)	1.1	23	332 (134)
Toe (g)	1.6	32	466 (189)
Pr>F	0.3649	0.3649	
LSD P>.05	0.59	12.0	

Site 4

Slope position (grazing*)	Organic Carbon		Value**	Partial Value**▲
	%	tonne ha^{-1}	$ ha^{-1} ($ ac^{-1})	$ ha^{-1} ($ ac^{-1})
Shoulder (g)	2.2	44	653 (264)	155 (63)
Mid (g)	2.2	45	666 (269)	168 (68)
Mid (ug)	2.1	43	638 (258)	139 (56)
Toe (g)	2.6	53	773 (313)	275 (111)
Pr>F	0.1339	0.1339		
LSD P>.05	0.43	8.7		

*(g)=grazed, (ug)=ungrazed

**value based on 8/30/06 Chicago Climate Exchange market prices

▲Partial value was calculated using difference between total accumulated carbon in rangeland and value for tilled land in the same area.

Results and Discussion

The statistical analysis showed that there was a significant difference in percent organic carbon due to location. Site 4 averaged 2.3% compared to 1.5, 1.3, and 1.4 for sites 1, 2, and 3 respectively. There was a significant interaction between site and slope position. No difference between grazed and ungrazed areas was found. At sites 1, 2, and 4 there were no significant differences in the percent organic carbon due to slope position. At Site 3, there was a sandy draw and the %C was 0.8 compared to 1.9 on the mid-slope, grazed.

In scenario one, using the total accumulated carbon in the top 20 cm as a base for calculating value, $ ha^{-1} ranged from a low of $245 at site 3 to a high of $773 at site 4. In scenario two, at site 4, subtracting a value for tilled land, the high value dropped to $275.

In conclusion, our data suggest that offering payment for retaining grasslands to sequester carbon could offer a sizable incentive for ranchers in western SD. The dollar values differed by location and in some cases by slope position (or soil type). Implementing a program to offer incentives would require the development of a system to estimate C sequestered, perhaps by laboratory measurement and correlation to soil series or order or perhaps by geographic location. It would also be necessary to decide whether ranchers should be paid for all of the C accumulated, or for some partial value. In our scenario we used a value for tilled soils at a nearby location. It is unlikely that policy or the C market would credit total accumulated C, but a partial credit to maintain existing rangeland should be considered.

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