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Soil Carbon Regulating Ecosystem Services in the State of South Carolina, USA

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Abstract: Sustainable management of soil carbon (C) at the state level requires valuation of soil C regulating ecosystem services (ES) and disservices (ED). The objective of this study was to assess the value of regulating ES from soil organic carbon (SOC), soil inorganic carbon (SIC), and total soil carbon (TSC) stocks, based on the concept of the avoided social cost of carbon dioxide (CO_2) emissions for the state of South Carolina (SC) in the United States of America (U.S.A.) by soil order, soil depth (0–200 cm), region and county using information from the State Soil Geographic (STATSGO) database. The total estimated monetary mid-point value for TSC in the state of South Carolina was $124.36B (i.e., $124.36 billion U.S. dollars, where B = billion = 10^9), $107.14B for SOC, and $17.22B for SIC. Soil orders with the highest midpoint value for SOC were: Ultisols ($64.35B), Histosols ($11.22B), and Inceptisols ($10.31B). Soil orders with the highest midpoint value for SIC were: Inceptisols ($5.91B), Entisols ($5.53B), and Alfisols ($5.0B). Soil orders with the highest midpoint value for TSC were: Ultisols ($64.35B), Inceptisols ($16.22B), and Entisols ($14.65B). The regions with the highest midpoint SOC values were: Pee Dee ($34.24B), Low Country ($32.17B), and Midlands ($29.24B). The regions with the highest midpoint SIC values were: Low Country ($5.69B), Midlands ($5.55B), and Pee Dee ($4.67B). The regions with the highest midpoint TSC values were: Low Country ($37.86B), Pee Dee ($36.91B), and Midlands ($34.79B). The counties with the highest midpoint SOC values were Colleton ($5.44B), Horry ($5.37B), and Berkeley ($4.12B). The counties with the highest midpoint SIC values were Charleston ($1.46B), Georgetown ($852.81M, where M = million = 10^6), and Horry ($843.18M). The counties with the highest midpoint TSC values were Horry ($6.22B), Colleton ($6.02B), and Georgetown ($4.87B). Administrative areas (e.g., counties, regions) combined with pedodiversity concepts can provide useful information to design cost-efficient policies to manage soil carbon regulating ES at the state level.

Keywords: accounting; carbon emissions, CO_2; climate change; inorganic; organic; pedodiversity

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Citation: Mikhailova, E.A.; Zurqani, H.A.; Post, C.J.; Schlautman, M.A.; Post, G.C.; Lin, L.; Hao, Z. Soil Carbon Regulating Ecosystem Services in the State of South Carolina, USA. *Land* **2021**, *10*, 309. https://doi.org/10.3390/land10030309

Academic Editor: Chiara Piccini

Received: 1 March 2021
Accepted: 15 March 2021
Published: 17 March 2021

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1. Introduction

Economic valuation of soil carbon is vital for achieving the United Nations (UN) Sustainable Development Goals (SDGs), especially SDG 13: "Take urgent action to combat climate change and its impacts on future climate" [1]. The ecosystem services (ES) framework is often used in connection with UN SDGs because it is focused on the economic valuation of benefits (ES) and/or disservices (ED) people obtain from nature [2]. The ES framework includes three general categories of services: provisioning, regulating/maintenance, and cultural supporting services [2]. Although TSC is composed of SOC and SIC, only SOC is currently included in the list of soil properties important for ES [3]. Soil organic carbon is derived from living matter and tends to be concentrated in the topsoil (Table 1). In a well-aerated soil, all of the organic compounds found in plant residue are subject to enzymatic oxidation. This reaction is accompanied by oxygen consumption and CO_2 release [4], which is often associated with ED in the form of realized social costs of carbon dioxide (CO_2) emissions [5]. Soil organic carbon is a fraction of soil organic matter (SOM) of <2 mm particle size fraction (Table 1). Soil databases provide SOM (%) and/or SOC (%) in their reports listed in the tables of soil physical properties. Soil organic matter contributes to numerous soil functions (e.g., nutrient and energy reserve, etc.), which are linked to ecosystem goods and services (e.g., nutrient storage and availability, gas regulation, etc.) [6,7]. The role of SOM in delivering these ecosystem goods and services varies with scales from local (e.g., fertility maintenance) to global (e.g., mitigation of carbon emissions) [6,7]. Soil inorganic carbon, which is found in different types of carbonates (e.g., calcium, magnesium), is also essential in various ES/ED (e.g., provisioning services as a liming material for food production). It is reported as calcium carbonate ($CaCO_3$, %) of <2 mm particle size fraction in the tables of soil chemical properties (Table 1).

Previous research on social costs of SOC and SIC in the U.S.A. was conducted at various scales using both biophysical (e.g., soil orders) and administrative accounts (e.g., states, regions, farm, etc.) [8–10]. These analyses allowed estimation of potential social costs of soil carbon, which is useful for decision-making at the national level using detailed tables and maps of social costs of C showing areas with high soil C content, which can become "soil carbon hotspots" upon disturbance [10]. At the national level, the analysis showed that states have different types of soils with various soil C types (e.g., Maryland is dominated by SOC, state of New Mexico is dominated by SIC) [11], which requires soil- and carbon-specific management strategies. Some states demonstrated more soil variability compared to others.

Table 1. Total soil carbon: soil organic matter (SOM), soil organic carbon (SOC), soil inorganic carbon (SIC), and carbon sequestration pathway (adapted from Mikhailova et al., 2019 [8]).

Total soil carbon, TSC (Biotic + Abiotic) = Soil organic carbon, SOC (Biotic) + Soil inorganic carbon, SIC (Abiotic)		
Biotic		**Abiotic**
Soil organic matter (SOM) of <2 mm particle size fraction	**Soil organic carbon (SOC)**	**Soil inorganic carbon (SIC)**
- Fresh residue, decomposing organic matter, stable organic matter (humus), and living organisms. or - "Continuum of organic material in all stages of transformation and decomposition or stabilization [12]."	- Carbon fraction of soil organic matter of <2 mm particle size fraction.	- Carbon fraction of calcium carbonate ($CaCO_3$) of <2 mm particle size fraction.
Conversion (using Van Bemmelen factor of 0.58 or 1.724): SOM (%) = SOC (%) $\times$ 1.724 or SOC (%) = SOM (%) $\times$ 0.58 [13]		**Conversion**: $CaCO_3$ (%) = SIC (%) $\times$ 100/12 or SIC (%) = $CaCO_3$ (%) $\times$ 0.12
Pathways to increased C sequestration: Additions of organic matter (e.g., compost additions, etc.); land/agricultural management (e.g., no-till operations, land conservation, etc.); afforestation, etc. [6,7].		**Pathways to increased C sequestration**: Additions of Ca^{2+} and Mg^{2+} cations outside the soil (e.g., atmospheric deposition, etc.) [14].

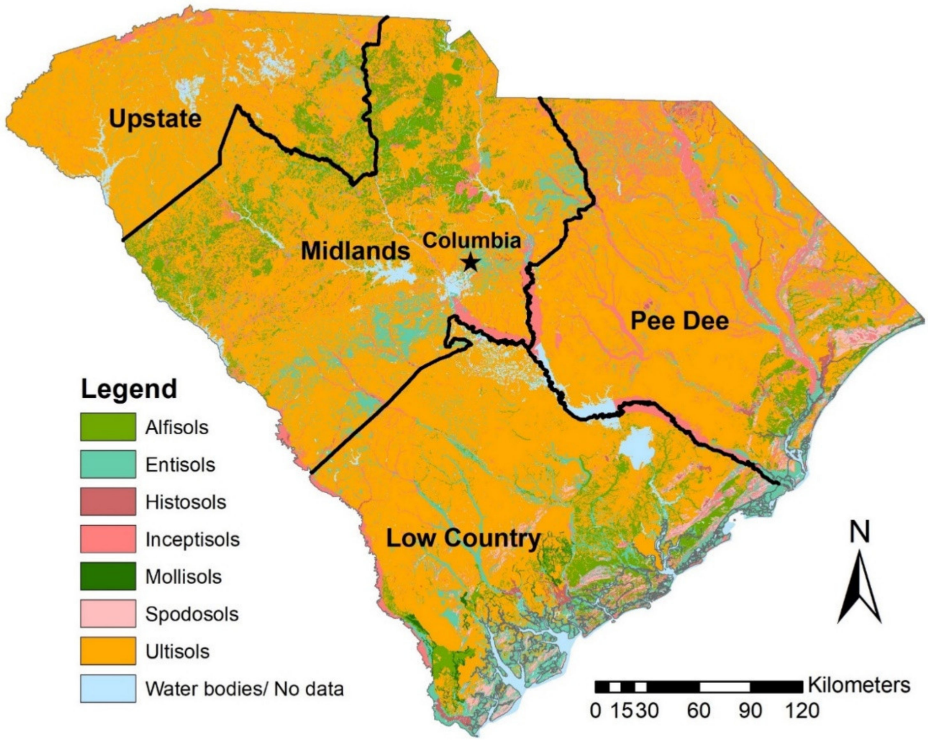


Figure 1. General soil map of South Carolina (U.S.A.) (33.8361° N, 81.1637° W) (adapted from [15]).

The ES framework is increasingly being used to address environmental concerns (e.g., global warming, climate change, etc.), but because of "the difficulty in relating soil properties to ES, soil ES are still not fully considered in the territorial planning decision process" [16]. According to Fossey et al., 2020 [16], soil databases play an essential role in assessing ES/ED in territorial planning. For sustainable soil C management decisions at the state level and its counties, it is critical to determine soil C and the distribution of its social costs within the state overall and by individual counties linked to biophysical units (e.g., soil orders). This type of analysis will allow prioritization of soil C management within the state based on this distribution. The hypothesis of this study is that pedodiversity concepts overlayed with administrative units (Figures 1 and 2) can be used to identify spatial patterns of soil carbon hotspots for sustainable management.

The specific objective of this study was to assess the value of SOC, SIC, and TSC in the state of South Carolina (U.S.A.) based on the social cost of carbon (SC–CO_2) and avoided emissions provided by carbon sequestration, which the U.S. Environmental Protection Agency (EPA) has determined to be \$46 per metric ton of CO_2, which is applicable for the year 2025 based on 2007 U.S. dollars and an average discount rate of 3% [17]. This study provides the monetary values of SOC, SIC, and TSC for soil depth (0–200 cm) across the state and by considering different spatial aggregation levels (i.e., region, county) using State Soil Geographic (STATSGO) database, and information previously reported by Guo et al. (2006) [18].

2. Materials and Methods

The Accounting Framework

This study used both biophysical (science-based, Figure 1) and administrative (boundary-based, Figure 3) accounts to calculate monetary values for SOC, SIC, and TSC (Tables 2 and 3).

Table 2. A conceptual overview of the accounting framework used in this study (adapted from Groshans et al., 2018 [19]).

Biophysical Accounts (Science-Based)	Administrative Accounts (Boundary-Based)	Monetary Account(s)	Benefit(s)	Total Value
Soil extent:	Administrative extent:	Ecosystem good(s) and service(s):	Sector:	Types of value:
Separate constitute stock 1: Soil organic carbon (SOC)				
Separate constitute stock 2: Soil inorganic carbon (SIC)				
Composite (total) stock: Total soil carbon (TSC) = Soil organic carbon (SOC) + Soil inorganic carbon (SIC)				
			Environment:	The social cost of carbon (SC-CO_2) and avoided emissions:
- Soil order	- State - Region - County	- Regulating (e.g., carbon sequestration)	- Carbon sequestration	- $46 per metric ton of CO_2 (2007 U.S. dollars with an average discount rate of 3% [16])

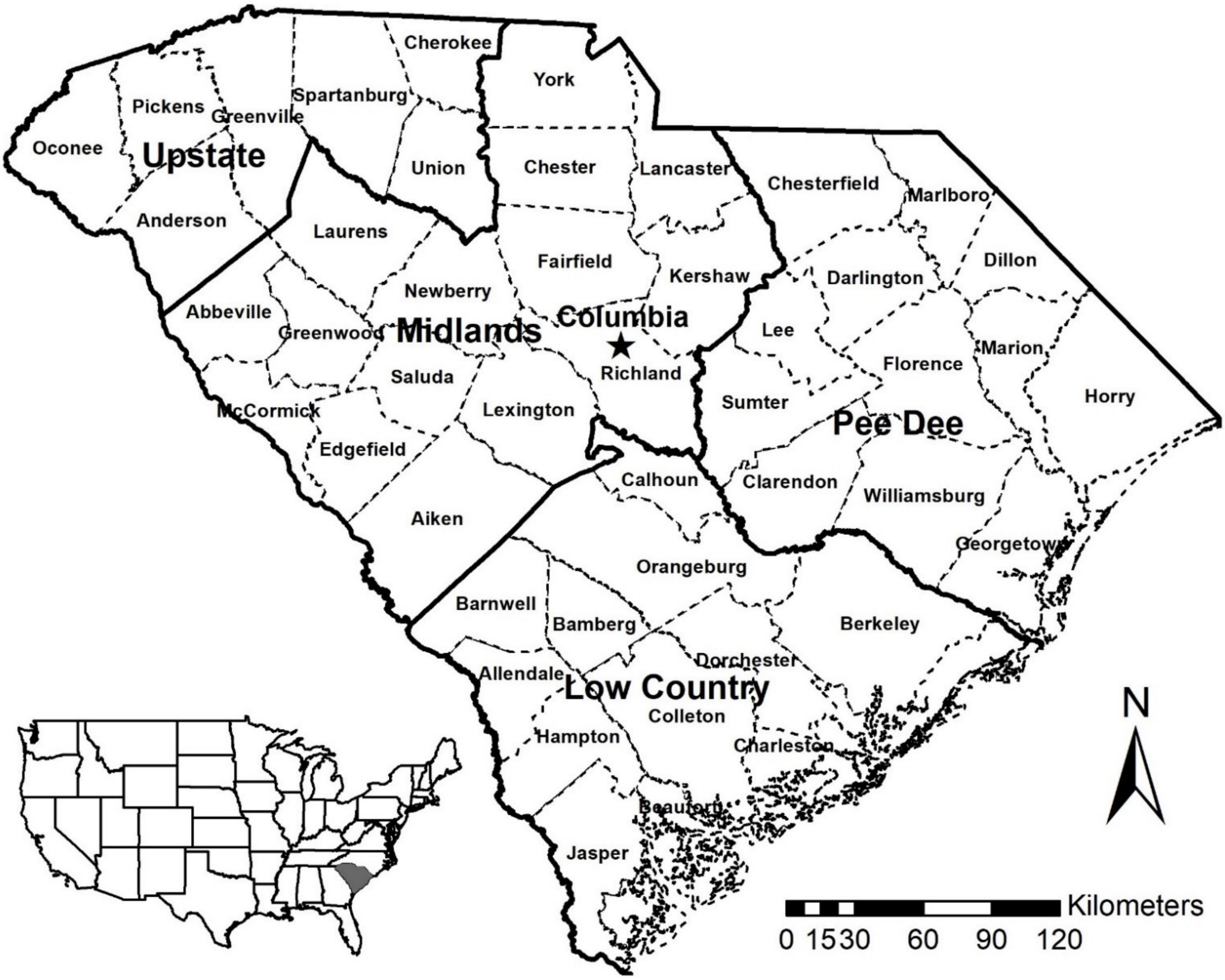


Figure 2. Administrative map of South Carolina (U.S.A.) (33.8361° N, 81.1637° W) with 46 counties and four regions [20].

Table 3. Soil diversity (pedodiversity) by soil order (taxonomic pedodiversity), region, and county in South Carolina (U.S.A.) based on Soil Survey Geographic (SSURGO) Database (2020) [15].

County (Region)	Total Area (km²) (Rank)	Slight <——	Degree of Weathering and Soil Development					——> Strong
		Slightly Weathered			Moderately Weathered		Strongly Weathered	
		Entisols	Inceptisols	Histosols	Alfisols	Mollisols	Spodosols	Ultisols
		Area (km²)						
Anderson	1841 (14)	102	0	0	0	0	0	1739
Cherokee	1012 (44)	118	94	0	100	0	0	700
Greenville	1916 (11)	108	166	0	0	0	0	1642
Oconee	1620 (23)	37	56	0	0	0	0	1527
Pickens	1257 (35)	39	55	0	0	0	0	1163
Spartanburg	1881 (12)	8	161	0	77	0	0	1635
Union	1322 (32)	74	61	0	364	0	0	823
(Upstate)	**10,849 (4)**	**486**	**593**	**0**	**541**	**0**	**0**	**9229**
Abbeville	1269 (34)	52	38	0	401	0	0	778
Aiken	2758 (4)	445	213	11	5	0	0	2084
Chester	1493 (25)	60	82	0	570	6	0	775
Edgefield	1289 (33)	101	56	0	61	0	0	1071
Fairfield	1683 (20)	1	175	0	585	0	0	922
Greenwood	1171 (38)	0	116	0	335	0	0	720
Kershaw	1871 (13)	383	161	20	47	0	0	1260
Lancaster	1409 (30)	53	151	0	62	0	0	1143
Laurens	1837 (15)	125	19	0	351	0	0	1342
Lexington	1756 (17)	454	86	0	36	0	10	1170
Newberry	1621 (22)	70	64	0	278	0	0	1209
Richland	1827 (16)	163	360	8	19	0	0	1277
Saluda	1170 (39)	19	83	0	77	0	0	991
York	1753 (18)	5	134	0	577	0	0	1037
(Midlands)	**22,899 (1)**	**1931**	**1738**	**31**	**3404**	**6**	**10**	**15,779**
Chesterfield	2053 (9)	173	655	0	23	0	0	1202
Clarendon	1566 (24)	39	192	6	0	0	0	1329
Darlington	1442 (28)	36	258	9	0	0	1	1138
Dillon	1040 (42)	91	128	8	0	0	19	794
Florence	2046 (10)	97	224	0	0	0	2	1723
Georgetown	2064 (8)	351	274	57	409	0	115	858
Horry	2888 (1)	252	431	64	287	0	330	1524
Lee	1058 (40)	29	131	0	1	0	0	897
Marion	1241 (36)	107	286	27	0	0	49	772
Marlboro	1230 (37)	75	269	81	17	0	2	786
Sumter	1694 (19)	9	350	0	4	0	2	1329
Williamsburg	2400 (6)	25	209	0	0	0	3	2163
(Pee Dee)	**20,722 (3)**	**1284**	**3407**	**252**	**741**	**0**	**523**	**14,515**
Allendale	1055 (41)	25	101	6	0	0	0	923
Bamberg	1018 (44)	126	1	0	41	0	3	847
Barnwell	1416 (29)	78	138	0	0	0	0	1200
Beaufort	1402 (31)	698	34	6	40	23	210	391
Berkeley	2809 (3)	145	208	23	409	0	137	1887
Calhoun	748 (46)	66	26	0	0	0	0	656
Charleston	2317 (7)	765	332	0	727	0	273	220
Colleton	2677 (5)	280	49	88	140	85	109	1,926
Dorchester	1455 (26)	274	17	1	280	0	30	853
Hampton	1443 (27)	136	87	3	101	0	40	1076
Jasper	1669 (21)	318	58	57	246	116	24	850
McCormick	921 (45)	64	65	0	247	0	0	545
Orangeburg	2844 (2)	73	18	0	25	0	1	2,727
(Low Country)	**21,774 (2)**	**3048**	**1134**	**184**	**2256**	**224**	**827**	**14,101**
Totals	**76,252**	**6749**	**6872**	**475**	**6942**	**230**	**1360**	**53,624**

The present study is based on the SOC [21], SIC [21], TSC estimated values for the SOC, SIC, and TSC storage (in Mg or metric tons) and content (in kg m^{-2}) in the contiguous U.S. from Guo et al. (2006) [18]. A monetary valuation for TSC was calculated using the social cost of carbon (SC-CO_2) of $46 per metric ton of CO_2, which is applicable for 2025 based on 2007 U.S. dollars and an average discount rate of 3% [17]. According to the EPA, the SC-CO_2 is intended to be a comprehensive estimate of climate change damages. Still, it can underestimate the true damages and cost of CO_2 emissions due to the exclusion of various important climate change impacts recognized in the literature [17]. Soil carbon (SC) storage and content numbers were then converted to U.S. dollars and dollars per square meter in Microsoft Excel using the following equations, with a social cost of carbon of $46/Mg CO_2:

$$\$ = (\text{SC Storage, Mg}) \times \frac{44\ \text{Mg CO}_2}{12\ \text{Mg TSC}} \times \frac{\$46}{\text{Mg CO}_2} \quad (1)$$

$$\frac{\$}{\text{m}^2} = \left(\text{SC Content, } \frac{\text{kg}}{\text{m}^2}\right) \times \frac{1\ \text{Mg}}{10^3\ \text{kg}} \times \frac{44\ \text{Mg CO}_2}{12\ \text{Mg TSC}} \times \frac{\$46}{\text{Mg CO}_2} \quad (2)$$

Table 4 presents area-normalized content (kg m^{-2}) and monetary values ($ m^{-2}) of soil carbon, which were used to estimate total soil carbon storage and total soil carbon value by multiplying corresponding content (values) numbers by an area of a particular soil order within a county (region) (Table 3). For example, for the soil order of Entisols, Guo et al. (2006) [18] reported an area-normalized midpoint SOC content number of 8.0 kg·m^{-2} in the upper 2 m (Table 4), which was used to calculate the total SOC storage in soil order by multiplying its area in particular county or region. Then, the reported area-normalized midpoint SOC content number of 8.0 kg·m^{-2} in the upper 2 m (Table 4) was converted to monetary values ($ m^{-2}) of soil organic carbon using a social cost of carbon (SC-CO_2) of $46 per metric ton of CO_2 (2007 U.S. dollars with an average discount rate of 3% [17]), which is $1.35 m^{-2} to calculate the total monetary value of SOC storage.

Table 4. Area-normalized content (kg m^{-2}) and monetary values ($ m^{-2}) of soil organic carbon (SOC), soil inorganic carbon (SIC), total soil carbon (TSC) by soil order based on numbers in the upper 2 m of the soil based on data from Guo et al., 2006 [18] and a social cost of carbon (SC-CO_2) of $46 per metric ton of CO_2 (2007 U.S. dollars with an average discount rate of 3% [17]).

Soil Order	SOC Content	SIC Content	TSC Content	SOC Value	SIC Value	TSC Value
	Minimum–Midpoint–Maximum Values			Midpoint Values		
	(kg m^{-2})	(kg m^{-2})	(kg m^{-2})	($ m^{-2})	($ m^{-2})	($ m^{-2})
Slightly Weathered						
Entisols	1.8–8.0–15.8	1.9–4.8–8.4	3.7–12.8–24.2	1.35	0.82	2.17
Inceptisols	2.8–8.9–17.4	2.5–5.1–8.4	5.3–14.0–25.8	1.50	0.86	2.36
Histosols	63.9–140.1–243.9	0.6–2.4–5.0	64.5–142.5–248.9	23.62	0.41	24.03
Moderately Weathered						
Alfisols	2.3–7.5–14.1	1.3–4.3–8.1	3.6–11.8–22.2	1.27	0.72	1.99
Mollisols	5.9–13.5–22.8	4.9–11.5–19.7	10.8–25.0–42.5	2.28	1.93	4.21
Strongly Weathered						
Spodosols	2.9–12.3–25.5	0.2–0.6–1.1	3.1–12.9–26.6	2.07	0.10	2.17
Ultisols	1.9–7.1–13.9	0.0–0.0–0.0	1.9–7.1–13.9	1.20	0.00	1.20

Note: TSC = SOC + SIC.

3. Results

The total estimated monetary mid-point value for TSC in the state of South Carolina was \$124.36B (i.e., \$124.36 billion U.S. dollars, where B = billion = 10^9), \$107.14B for SOC, and \$17.22B for SIC. The state of South Carolina ranked 31st for TSC, 25th for SOC, and 32nd for SIC. Figure 3 shows the distribution of soil carbon by South Carolina regions.

3.1. Storage and Value of SOC by County, Region, and Soil Order for the State of South Carolina (U.S.A.)

Soil orders with the highest midpoint storage and value for SOC were: Ultisols (\$64.35B), Histosols (\$11.22B), and Inceptisols (\$10.31B) (Tables 5 and 6). The regions with the highest midpoint storage and SOC values were: Pee Dee (\$34.24B), Low Country (\$32.17B), and Midlands (\$29.24B) (Tables 5 and 6). The counties with the highest midpoint SOC storage and values were Colleton (\$5.44B), Horry (\$5.37B), and Berkeley (\$4.12B) (Tables 5 and 6).

3.2. Storage and Value of SIC by County, Region, and Soil Order for the State of South Carolina (U.S.A.)

Soil orders with the highest midpoint storage and value for SIC were: Inceptisols (\$5.91B), Entisols (\$5.53B), and Alfisols (\$5.0B) (Tables 7 and 8). The regions with the highest midpoint SIC storage and values were: Low Country (\$5.69B), Midlands (\$5.55B), and Pee Dee (\$4.67B) (Tables 7 and 8). The counties with the highest midpoint SIC storage and values were Charleston (\$1.46B), Georgetown (\$852.81M), and Horry (\$843.18M) (Tables 7 and 8).

3.3. Storage and Value of TSC (SOC + SIC) by County, Region, and Soil Order for the State of South Carolina (U.S.A.)

Soil orders with the highest midpoint storage and value for TSC were: Ultisols (\$64.35B), Inceptisols (\$16.22B), and Entisols (\$14.65B) (Tables 9 and 10). The regions with the highest midpoint TSC storage and values were: Low Country (\$37.86B), Pee Dee (\$36.91B), and Midlands (\$34.79B) (Tables 9 and 10). The counties with the highest midpoint TSC storage and values were Horry (\$6.22B), Colleton (\$6.02B), and Georgetown (\$4.87B) (Tables 9 and 10).

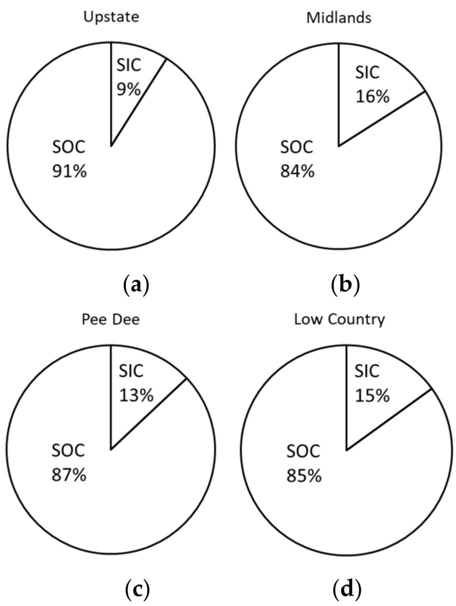


Figure 3. Distribution of soil carbon by region in the state of South Carolina: (**a**) Upstate, (**b**) Midlands, (**c**) Pee Dee, and (**d**) Low Country.

Table 5. Mid-point total soil organic carbon (SOC) storage values by county, region, and soil order for the state of South Carolina (U.S.A.), based on mid-point soil organic carbon (SOC) content numbers in the upper 2 m of the soil based on data from Guo et al., 2006 [18].

County (Region)	Total Storage (kg) (Rank)	Slight <—— Degree of Weathering and Soil Development ——> Strong						
		Slightly Weathered			Moderately Weathered		Strongly Weathered	
		Entisols	Inceptisols	Histosols	Alfisols	Mollisols	Spodosols	Ultisols
		Total Storage (kg)						
Anderson	1.32×10^{10} (19)	8.16×10^{8}	0	0	0	0	0	1.23×10^{10}
Cherokee	7.50×10^{9} (43)	9.44×10^{8}	8.37×10^{8}	0	7.50×10^{8}	0	0	4.97×10^{9}
Greenville	1.40×10^{10} (15)	8.64×10^{8}	1.48×10^{9}	0	0	0	0	1.17×10^{10}
Oconee	1.16×10^{10} (28)	2.96×10^{8}	4.98×10^{8}	0	0	0	0	1.08×10^{10}
Pickens	9.06×10^{9} (37)	3.12×10^{8}	4.90×10^{8}	0	0	0	0	8.26×10^{9}
Spartanburg	1.37×10^{10} (16)	6.40×10^{7}	1.43×10^{9}	0	5.78×10^{8}	0	0	1.16×10^{10}
Union	9.71×10^{9} (34)	5.92×10^{8}	5.43×10^{8}	0	2.73×10^{9}	0	0	5.84×10^{9}
(Upstate)	**7.87×10^{10} (4)**	**3.89×10^{9}**	**5.28×10^{9}**	**0**	**4.06×10^{9}**	**0**	**0**	**6.55×10^{10}**
Abbeville	9.29×10^{9} (36)	4.16×10^{8}	3.38×10^{8}	0	3.01×10^{9}	0	0	5.52×10^{9}
Aiken	2.18×10^{10} (5)	3.56×10^{9}	1.90×10^{9}	1.54×10^{9}	3.75×10^{7}	0	0	1.48×10^{10}
Chester	1.11×10^{10} (30)	4.80×10^{8}	7.30×10^{8}	0	4.28×10^{9}	8.10×10^{7}	0	5.50×10^{9}
Edgefield	9.37×10^{9} (35)	8.08×10^{8}	4.98×10^{8}	0	4.58×10^{8}	0	0	7.60×10^{9}
Fairfield	1.25×10^{10} (24)	8.00×10^{6}	1.56×10^{9}	0	4.39×10^{9}	0	0	6.55×10^{9}
Greenwood	8.66×10^{9} (39)	0	1.03×10^{9}	0	2.51×10^{9}	0	0	5.11×10^{9}
Kershaw	1.66×10^{10} (11)	3.06×10^{9}	1.43×10^{9}	2.80×10^{9}	3.53×10^{8}	0	0	8.95×10^{9}
Lancaster	1.03×10^{10} (33)	4.24×10^{8}	1.34×10^{9}	0	4.65×10^{8}	0	0	8.12×10^{9}
Laurens	1.33×10^{10} (17)	1.00×10^{9}	1.69×10^{8}	0	2.63×10^{9}	0	0	9.53×10^{9}
Lexington	1.31×10^{10} (20)	3.63×10^{9}	7.65×10^{8}	0	2.70×10^{8}	0	1.23×10^{8}	8.31×10^{9}
Newberry	1.18×10^{10} (27)	5.60×10^{8}	5.70×10^{8}	0	2.09×10^{9}	0	0	8.58×10^{9}
Richland	1.48×10^{10} (14)	1.30×10^{9}	3.20×10^{9}	1.12×10^{9}	1.43×10^{8}	0	0	9.07×10^{9}
Saluda	8.50×10^{9} (40)	1.52×10^{8}	7.39×10^{8}	0	5.78×10^{8}	0	0	7.04×10^{9}
York	1.29×10^{10} (21)	4.00×10^{7}	1.19×10^{9}	0	4.33×10^{9}	0	0	7.36×10^{9}
(Midlands)	**1.73×10^{11} (3)**	**1.54×10^{10}**	**1.55×10^{10}**	**4.34×10^{9}**	**2.55×10^{10}**	**8.10×10^{7}**	**1.23×10^{8}**	**1.12×10^{11}**
Chesterfield	1.59×10^{10} (12)	1.38×10^{9}	5.83×10^{9}	0	1.73×10^{8}	0	0	8.53×10^{9}
Clarendon	1.23×10^{10} (25)	3.12×10^{8}	1.71×10^{9}	8.41×10^{8}	0	0	0	9.44×10^{9}
Darlington	1.19×10^{10} (26)	2.88×10^{8}	2.30×10^{9}	1.26×10^{9}	0	0	1.23×10^{7}	8.08×10^{9}
Dillon	8.86×10^{9} (38)	7.28×10^{8}	1.14×10^{9}	1.12×10^{9}	0	0	2.34×10^{8}	5.64×10^{9}
Florence	1.50×10^{10} (13)	7.76×10^{8}	1.99×10^{9}	0	0	0	2.46×10^{7}	1.22×10^{10}
Georgetown	2.38×10^{10} (4)	2.81×10^{9}	2.44×10^{9}	7.99×10^{9}	3.07×10^{9}	0	1.41×10^{9}	6.09×10^{9}
Horry	3.19×10^{10} (2)	2.02×10^{9}	3.84×10^{9}	8.97×10^{9}	2.15×10^{9}	0	4.06×10^{9}	1.08×10^{10}
Lee	7.77×10^{9} (42)	2.32×10^{8}	1.17×10^{9}	0	7.50×10^{6}	0	0	6.37×10^{9}
Marion	1.33×10^{10} (18)	8.56×10^{8}	2.55×10^{9}	3.78×10^{9}	0	0	6.03×10^{8}	5.48×10^{9}
Marlboro	2.01×10^{10} (8)	6.00×10^{8}	2.39×10^{9}	1.13×10^{10}	1.28×10^{8}	0	2.46×10^{7}	5.58×10^{9}
Sumter	1.27×10^{10} (23)	7.20×10^{7}	3.12×10^{9}	0	3.00×10^{7}	0	2.46×10^{7}	9.44×10^{9}
Williamsburg	1.75×10^{10} (10)	2.00×10^{8}	1.86×10^{9}	0	0	0	3.69×10^{7}	1.54×10^{10}
(Pee Dee)	**1.91×10^{11} (1)**	**1.03×10^{10}**	**3.03×10^{10}**	**3.53×10^{10}**	**5.56×10^{9}**	**0**	**6.43×10^{9}**	**1.03×10^{11}**
Allendale	8.49×10^{9} (41)	2.00×10^{8}	8.99×10^{8}	8.41×10^{8}	0	0	0	6.55×10^{9}
Bamberg	7.38×10^{9} (44)	1.01×10^{9}	8.90×10^{6}	0	3.08×10^{8}	0	3.69×10^{7}	6.01×10^{9}
Barnwell	1.04×10^{10} (32)	6.24×10^{8}	1.23×10^{9}	0	0	0	0	8.52×10^{9}
Beaufort	1.27×10^{10} (22)	5.58×10^{9}	3.03×10^{8}	8.41×10^{8}	3.00×10^{8}	3.11×10^{8}	2.58×10^{9}	2.78×10^{9}
Berkeley	2.44×10^{10} (3)	1.16×10^{9}	1.85×10^{9}	3.22×10^{9}	3.07×10^{9}	0	1.69×10^{9}	1.34×10^{10}
Calhoun	5.42×10^{9} (46)	5.28×10^{8}	2.31×10^{8}	0	0	0	0	4.66×10^{9}
Charleston	1.94×10^{10} (9)	6.12×10^{9}	2.95×10^{9}	0	5.45×10^{9}	0	3.36×10^{9}	1.56×10^{9}
Colleton	3.22×10^{10} (1)	2.24×10^{9}	4.36×10^{8}	1.23×10^{10}	1.05×10^{9}	1.15×10^{9}	1.34×10^{9}	1.37×10^{10}
Dorchester	1.10×10^{10} (31)	2.19×10^{9}	1.51×10^{8}	1.40×10^{8}	2.10×10^{9}	0	3.69×10^{8}	6.06×10^{9}
Hampton	1.12×10^{10} (29)	1.09×10^{9}	7.74×10^{8}	4.20×10^{8}	7.58×10^{8}	0	4.92×10^{8}	7.64×10^{9}
Jasper	2.08×10^{10} (6)	2.54×10^{9}	5.16×10^{8}	7.99×10^{9}	1.85×10^{9}	1.57×10^{9}	2.95×10^{8}	6.04×10^{9}
McCormick	6.81×10^{9} (45)	5.12×10^{8}	5.79×10^{8}	0	1.85×10^{9}	0	0	3.87×10^{9}
Orangeburg	2.03×10^{10} (7)	5.84×10^{8}	1.60×10^{8}	0	1.88×10^{8}	0	1.23×10^{7}	1.94×10^{10}
(Low Country)	**1.90×10^{11} (2)**	**2.44×10^{10}**	**1.01×10^{10}**	**2.58×10^{10}**	**1.69×10^{10}**	**3.02×10^{9}**	**1.02×10^{10}**	**1.00×10^{11}**
Totals (kg)	**6.34×10^{11}**	**5.40×10^{10}**	**6.12×10^{10}**	**6.65×10^{10}**	**5.21×10^{10}**	**3.11×10^{9}**	**1.67×10^{10}**	**3.81×10^{11}**

Table 6. The total dollar value of soil organic carbon (SOC) by county, region, and soil order for the state of South Carolina (U.S.A.), based on mid-point soil organic carbon (SOC) numbers for the upper 2 m from Guo et al. 2006 [18] and a social cost of carbon (SC-CO_2) of \$46 per metric ton of CO_2 (2007 U.S. dollars with an average discount rate of 3% [17]).

County (Region)	Total Value (\$) (Rank)	Slight <— Degree of Weathering and Soil Development —> Strong						
		Slightly Weathered			Moderately Weathered		Strongly Weathered	
		Entisols	Inceptisols	Histosols	Alfisols	Mollisols	Spodosols	Ultisols
		Value (\$)						
Anderson	2.22×10^{9} (19)	1.38×10^{8}	0	0	0	0	0	2.09×10^{9}
Cherokee	1.27×10^{9} (43)	1.59×10^{8}	1.41×10^{8}	0	1.27×10^{8}	0	0	8.40×10^{8}
Greenville	2.37×10^{9} (15)	1.46×10^{8}	2.49×10^{8}	0	0	0	0	1.97×10^{9}
Oconee	1.97×10^{9} (28)	5.00×10^{7}	8.40×10^{7}	0	0	0	0	1.83×10^{9}
Pickens	1.53×10^{9} (37)	5.27×10^{7}	8.25×10^{7}	0	0	0	0	1.40×10^{9}
Spartanburg	2.31×10^{9} (16)	1.08×10^{7}	2.42×10^{8}	0	9.78×10^{7}	0	0	1.96×10^{9}
Union	1.64×10^{9} (34)	9.99×10^{7}	9.15×10^{7}	0	4.62×10^{8}	0	0	9.88×10^{8}
(Upstate)	**1.33×10^{10} (4)**	**6.56×10^{8}**	**8.90×10^{8}**	**0**	**6.87×10^{8}**	**0**	**0**	**1.11×10^{10}**
Abbeville	1.57×10^{9} (36)	7.02×10^{7}	5.70×10^{7}	0	5.09×10^{8}	0	0	9.34×10^{8}
Aiken	3.69×10^{9} (5)	6.01×10^{8}	3.20×10^{8}	2.60×10^{8}	6.35×10^{6}	0	0	2.50×10^{9}
Chester	1.87×10^{9} (30)	8.10×10^{7}	1.23×10^{8}	0	7.24×10^{8}	1.37×10^{7}	0	9.30×10^{8}
Edgefield	1.58×10^{9} (35)	1.36×10^{8}	8.40×10^{7}	0	7.75×10^{7}	0	0	1.29×10^{9}
Fairfield	2.11×10^{9} (24)	1.35×10^{6}	2.63×10^{8}	0	7.43×10^{8}	0	0	1.11×10^{9}
Greenwood	1.46×10^{9} (39)	0	1.74×10^{8}	0	4.25×10^{8}	0	0	8.64×10^{8}
Kershaw	2.80×10^{9} (11)	5.17×10^{8}	2.42×10^{8}	4.72×10^{8}	5.97×10^{7}	0	0	1.51×10^{9}
Lancaster	1.75×10^{9} (33)	7.16×10^{7}	2.27×10^{8}	0	7.87×10^{7}	0	0	1.37×10^{9}
Laurens	2.25×10^{9} (17)	1.69×10^{8}	2.85×10^{7}	0	4.46×10^{8}	0	0	1.61×10^{9}
Lexington	2.21×10^{9} (20)	6.13×10^{8}	1.29×10^{8}	0	4.57×10^{7}	0	2.07×10^{7}	1.40×10^{9}
Newberry	1.99×10^{9} (27)	9.45×10^{7}	9.60×10^{7}	0	3.53×10^{8}	0	0	1.45×10^{9}
Richland	2.51×10^{9} (14)	2.20×10^{8}	5.40×10^{8}	1.89×10^{8}	2.41×10^{7}	0	0	1.53×10^{9}
Saluda	1.44×10^{9} (40)	2.57×10^{7}	1.25×10^{8}	0	9.78×10^{7}	0	0	1.19×10^{9}
York	2.18×10^{9} (21)	6.75×10^{6}	2.01×10^{8}	0	7.33×10^{8}	0	0	1.24×10^{9}
(Midlands)	**2.92×10^{10} (3)**	**2.61×10^{9}**	**2.61×10^{9}**	**7.32×10^{8}**	**4.32×10^{9}**	**1.37×10^{7}**	**2.07×10^{7}**	**1.89×10^{10}**
Chesterfield	2.69×10^{9} (12)	2.34×10^{8}	9.83×10^{8}	0	2.92×10^{7}	0	0	1.44×10^{9}
Clarendon	2.08×10^{9} (25)	5.27×10^{7}	2.88×10^{8}	1.42×10^{8}	0	0	0	1.59×10^{9}
Darlington	2.02×10^{9} (26)	4.86×10^{7}	3.87×10^{8}	2.13×10^{8}	0	0	2.07×10^{6}	1.37×10^{9}
Dillon	1.50×10^{9} (38)	1.23×10^{8}	1.92×10^{8}	1.89×10^{8}	0	0	3.93×10^{7}	9.53×10^{8}
Florence	2.54×10^{9} (13)	1.31×10^{8}	3.36×10^{8}	0	0	0	4.14×10^{6}	2.07×10^{9}
Georgetown	4.02×10^{9} (4)	4.74×10^{8}	4.11×10^{8}	1.35×10^{9}	5.19×10^{8}	0	2.38×10^{8}	1.03×10^{9}
Horry	5.37×10^{9} (2)	3.40×10^{8}	6.47×10^{8}	1.51×10^{9}	3.64×10^{8}	0	6.83×10^{8}	1.83×10^{9}
Lee	1.31×10^{9} (42)	3.92×10^{7}	1.97×10^{8}	0	1.27×10^{6}	0	0	1.08×10^{9}
Marion	2.24×10^{9} (18)	1.44×10^{8}	4.29×10^{8}	6.38×10^{8}	0	0	1.01×10^{8}	9.26×10^{8}
Marlboro	3.39×10^{9} (8)	1.01×10^{8}	4.04×10^{8}	1.91×10^{9}	2.16×10^{7}	0	4.14×10^{6}	9.43×10^{8}
Sumter	2.14×10^{9} (23)	1.22×10^{7}	5.25×10^{8}	0	5.08×10^{6}	0	4.14×10^{6}	1.59×10^{9}
Williamsburg	2.95×10^{9} (10)	3.38×10^{7}	3.14×10^{8}	0	0	0	6.21×10^{6}	2.60×10^{9}
(Pee Dee)	**3.22×10^{10} (1)**	**1.73×10^{9}**	**5.11×10^{9}**	**5.95×10^{9}**	**9.41×10^{8}**	**0**	**1.08×10^{9}**	**1.74×10^{10}**
Allendale	1.43×10^{9} (41)	3.38×10^{7}	1.52×10^{8}	1.42×10^{8}	0	0	0	1.11×10^{9}
Bamberg	1.25×10^{9} (44)	1.70×10^{8}	1.50×10^{6}	0	5.21×10^{7}	0	6.21×10^{6}	1.02×10^{9}
Barnwell	1.75×10^{9} (32)	1.05×10^{8}	2.07×10^{8}	0	0	0	0	1.44×10^{9}
Beaufort	2.14×10^{9} (22)	9.42×10^{8}	5.10×10^{7}	1.42×10^{8}	5.08×10^{7}	5.24×10^{7}	4.35×10^{8}	4.69×10^{8}
Berkeley	4.12×10^{9} (3)	1.96×10^{8}	3.12×10^{8}	5.43×10^{8}	5.19×10^{8}	0	2.84×10^{8}	2.26×10^{9}
Calhoun	9.15×10^{8} (46)	8.91×10^{7}	3.90×10^{7}	0	0	0	0	7.87×10^{8}
Charleston	3.28×10^{9} (9)	1.03×10^{9}	4.98×10^{8}	0	9.23×10^{8}	0	5.65×10^{8}	2.64×10^{8}
Colleton	5.44×10^{9} (1)	3.78×10^{8}	7.35×10^{7}	2.08×10^{9}	1.78×10^{8}	1.94×10^{8}	2.26×10^{8}	2.31×10^{9}
Dorchester	1.86×10^{9} (31)	3.70×10^{8}	2.55×10^{7}	2.36×10^{7}	3.56×10^{8}	0	6.21×10^{7}	1.02×10^{9}
Hampton	1.89×10^{9} (29)	1.84×10^{8}	1.31×10^{8}	7.09×10^{7}	1.28×10^{8}	0	8.28×10^{7}	1.29×10^{9}
Jasper	3.51×10^{9} (6)	4.29×10^{8}	8.70×10^{7}	1.35×10^{9}	3.12×10^{8}	2.64×10^{8}	4.97×10^{7}	1.02×10^{9}
McCormick	1.15×10^{9} (45)	8.64×10^{7}	9.75×10^{7}	0	3.14×10^{8}	0	0	6.54×10^{8}
Orangeburg	3.43×10^{9} (7)	9.86×10^{7}	2.70×10^{7}	0	3.18×10^{7}	0	2.07×10^{6}	3.27×10^{9}
(Low Country)	**3.22×10^{10} (2)**	**4.11×10^{9}**	**1.70×10^{9}**	**4.35×10^{9}**	**2.87×10^{9}**	**5.11×10^{8}**	**1.71×10^{9}**	**1.69×10^{10}**
Totals (\$)	**1.07×10^{11}**	**9.11×10^{9}**	**1.03×10^{10}**	**1.12×10^{10}**	**8.82×10^{9}**	**5.24×10^{8}**	**2.82×10^{9}**	**6.43×10^{10}**

Table 7. Mid-point total soil inorganic carbon (SIC) storage by county, region, and soil order for the state of South Carolina (U.S.A.), based on mid-point soil inorganic carbon (SIC) contents in the upper 2 m based on data from Guo et al., 2006 [18].

County (Region)	Total Storage (kg) (Rank)	Slight <—— Degree of Weathering and Soil Development ——> Strong						
		Slightly Weathered			Moderately Weathered		Strongly Weathered	
		Entisols	Inceptisols	Histosols	Alfisols	Mollisols	Spodosols	Ultisols
		Total Storage (kg)						
Anderson	4.90×10^{8} (43)	4.90×10^{8}	0	0	0	0	0	0
Cherokee	1.48×10^{9} (29)	5.66×10^{8}	4.79×10^{8}	0	4.30×10^{8}	0	0	0
Greenville	1.37×10^{9} (30)	5.18×10^{8}	8.47×10^{8}	0	0	0	0	0
Oconee	4.63×10^{8} (45)	1.78×10^{8}	2.86×10^{8}	0	0	0	0	0
Pickens	4.68×10^{8} (44)	1.87×10^{8}	2.81×10^{8}	0	0	0	0	0
Spartanburg	1.19×10^{9} (32)	3.84×10^{7}	8.21×10^{8}	0	3.31×10^{8}	0	0	0
Union	2.23×10^{9} (17)	3.55×10^{8}	3.11×10^{8}	0	1.57×10^{9}	0	0	0
(Upstate)	**7.68×10^{9} (4)**	**2.33×10^{9}**	**3.02×10^{9}**	**0**	**2.33×10^{9}**	**0**	**0**	**0**
Abbeville	2.17×10^{9} (19)	2.50×10^{8}	1.94×10^{8}	0	1.72×10^{9}	0	0	0
Aiken	3.27×10^{9} (10)	2.14×10^{9}	1.09×10^{9}	2.64×10^{7}	2.15×10^{7}	0	0	0
Chester	3.23×10^{9} (11)	2.88×10^{8}	4.18×10^{8}	0	2.45×10^{9}	6.90×10^{7}	0	0
Edgefield	1.03×10^{9} (37)	4.85×10^{8}	2.86×10^{8}	0	2.62×10^{8}	0	0	0
Fairfield	3.41×10^{9} (9)	4.80×10^{6}	8.93×10^{8}	0	2.52×10^{9}	0	0	0
Greenwood	2.03×10^{9} (21)	0	5.92×10^{8}	0	1.44×10^{9}	0	0	0
Kershaw	2.91×10^{9} (13)	1.84×10^{9}	8.21×10^{8}	4.80×10^{7}	2.02×10^{8}	0	0	0
Lancaster	1.29×10^{9} (31)	2.54×10^{8}	7.70×10^{8}	0	2.67×10^{8}	0	0	0
Laurens	2.21×10^{9} (18)	6.00×10^{8}	9.69×10^{7}	0	1.51×10^{9}	0	0	0
Lexington	2.78×10^{9} (14)	2.18×10^{9}	4.39×10^{8}	0	1.55×10^{8}	0	6.00×10^{6}	0
Newberry	1.86×10^{9} (23)	3.36×10^{8}	3.26×10^{8}	0	1.20×10^{9}	0	0	0
Richland	2.72×10^{9} (15)	7.82×10^{8}	1.84×10^{9}	1.92×10^{7}	8.17×10^{7}	0	0	0
Saluda	8.46×10^{8} (38)	9.12×10^{7}	4.23×10^{8}	0	3.31×10^{8}	0	0	0
York	3.19×10^{9} (12)	2.40×10^{7}	6.83×10^{8}	0	2.48×10^{9}	0	0	0
(Midlands)	**3.29×10^{10} (2)**	**9.27×10^{9}**	**8.86×10^{9}**	**7.44×10^{7}**	**1.46×10^{10}**	**6.90×10^{7}**	**6.00×10^{6}**	**0**
Chesterfield	4.27×10^{9} (5)	8.30×10^{8}	3.34×10^{9}	0	9.89×10^{7}	0	0	0
Clarendon	1.18×10^{9} (34)	1.87×10^{8}	9.79×10^{8}	1.44×10^{7}	0	0	0	0
Darlington	1.51×10^{9} (28)	1.73×10^{8}	1.32×10^{9}	2.16×10^{7}	0	0	6.00×10^{5}	0
Dillon	1.12×10^{9} (35)	4.37×10^{8}	6.53×10^{8}	1.92×10^{7}	0	0	1.14×10^{7}	0
Florence	1.61×10^{9} (26)	4.66×10^{8}	1.14×10^{9}	0	0	0	1.20×10^{6}	0
Georgetown	5.05×10^{9} (2)	1.68×10^{9}	1.40×10^{9}	1.37×10^{8}	1.76×10^{9}	0	6.90×10^{7}	0
Horry	4.99×10^{9} (3)	1.21×10^{9}	2.20×10^{9}	1.54×10^{8}	1.23×10^{9}	0	1.98×10^{8}	0
Lee	8.12×10^{8} (39)	1.39×10^{8}	6.68×10^{8}	0	4.30×10^{6}	0	0	0
Marion	2.07×10^{9} (20)	5.14×10^{8}	1.46×10^{9}	6.48×10^{7}	0	0	2.94×10^{7}	0
Marlboro	2.00×10^{9} (22)	3.60×10^{8}	1.37×10^{9}	1.94×10^{8}	7.31×10^{7}	0	1.20×10^{6}	0
Sumter	1.85×10^{9} (24)	4.32×10^{7}	1.79×10^{9}	0	1.72×10^{7}	0	1.20×10^{6}	0
Williamsburg	1.19×10^{9} (33)	1.20×10^{8}	1.07×10^{9}	0	0	0	1.80×10^{6}	0
(Pee Dee)	**2.76×10^{10} (3)**	**6.16×10^{9}**	**1.74×10^{10}**	**6.05×10^{8}**	**3.19×10^{9}**	**0**	**3.14×10^{8}**	**0**
Allendale	6.50×10^{8} (41)	1.20×10^{8}	5.15×10^{8}	1.44×10^{7}	0	0	0	0
Bamberg	7.88×10^{8} (40)	6.05×10^{8}	5.10×10^{6}	0	1.76×10^{8}	0	1.80×10^{6}	0
Barnwell	1.08×10^{9} (36)	3.74×10^{8}	7.04×10^{8}	0	0	0	0	0
Beaufort	4.10×10^{9} (6)	3.35×10^{9}	1.73×10^{8}	1.44×10^{7}	1.72×10^{8}	2.65×10^{8}	1.26×10^{8}	0
Berkeley	3.65×10^{9} (7)	6.96×10^{8}	1.06×10^{9}	5.52×10^{7}	1.76×10^{9}	0	8.22×10^{7}	0
Calhoun	4.49×10^{8} (46)	3.17×10^{8}	1.33×10^{8}	0	0	0	0	0
Charleston	8.66×10^{9} (1)	3.67×10^{9}	1.69×10^{9}	0	3.13×10^{9}	0	1.64×10^{8}	0
Colleton	3.45×10^{9} (8)	1.34×10^{9}	2.50×10^{8}	2.11×10^{8}	6.02×10^{8}	9.78×10^{8}	6.54×10^{7}	0
Dorchester	2.63×10^{9} (16)	1.32×10^{9}	8.67×10^{7}	2.40×10^{6}	1.20×10^{9}	0	1.80×10^{7}	0
Hampton	1.56×10^{9} (27)	6.53×10^{8}	4.44×10^{8}	7.20×10^{6}	4.34×10^{8}	0	2.40×10^{7}	0
Jasper	4.37×10^{9} (4)	1.53×10^{9}	2.96×10^{8}	1.37×10^{8}	1.06×10^{9}	1.33×10^{9}	1.44×10^{7}	0
McCormick	1.70×10^{9} (25)	3.07×10^{8}	3.32×10^{8}	0	1.06×10^{9}	0	0	0
Orangeburg	5.50×10^{8} (42)	3.50×10^{8}	9.18×10^{7}	0	1.08×10^{8}	0	6.00×10^{5}	0
(Low Country)	**3.36×10^{10} (1)**	**1.46×10^{10}**	**5.78×10^{9}**	**4.42×10^{8}**	**9.70×10^{9}**	**2.58×10^{9}**	**4.96×10^{8}**	**0**
Totals (kg)	**1.02×10^{11}**	**3.24×10^{10}**	**3.50×10^{10}**	**1.14×10^{9}**	**2.99×10^{10}**	**2.65×10^{9}**	**8.16×10^{8}**	**0**

Table 8. The total dollar value of soil inorganic carbon (SIC) by county, region, and soil order for the state of South Carolina (U.S.A.), based on mid-point soil inorganic carbon (SIC) numbers for the upper 2 m from Guo et al. 2006 [18] and a social cost of carbon (SC-CO_2) of $46 per metric ton of CO_2 (2007 U.S. dollars with an average discount rate of 3% [17]).

County (Region)	Total Value ($) (Rank)	Slight <—— Degree of Weathering and Soil Development ——> Strong						
		Slightly Weathered			Moderately Weathered		Strongly Weathered	
		Entisols	Inceptisols	Histosols	Alfisols	Mollisols	Spodosols	Ultisols
		Value ($)						
Anderson	8.36×10^{7} (43)	8.36×10^{7}	0	0	0	0	0	0
Cherokee	2.50×10^{8} (29)	9.68×10^{7}	8.08×10^{7}	0	7.20×10^{7}	0	0	0
Greenville	2.31×10^{8} (30)	8.86×10^{7}	1.43×10^{8}	0	0	0	0	0
Oconee	7.85×10^{7} (45)	3.03×10^{7}	4.82×10^{7}	0	0	0	0	0
Pickens	7.93×10^{7} (44)	3.20×10^{7}	4.73×10^{7}	0	0	0	0	0
Spartanburg	2.00×10^{8} (32)	6.56×10^{6}	1.38×10^{8}	0	5.54×10^{7}	0	0	0
Union	3.75×10^{8} (17)	6.07×10^{7}	5.25×10^{7}	0	2.62×10^{8}	0	0	0
(Upstate)	**1.30×10^{9} (4)**	**3.99×10^{8}**	**5.10×10^{8}**	**0**	**3.90×10^{8}**	**0**	**0**	**0**
Abbeville	3.64×10^{8} (19)	4.26×10^{7}	3.27×10^{7}	0	2.89×10^{8}	0	0	0
Aiken	5.56×10^{8} (10)	3.65×10^{8}	1.83×10^{8}	4.51×10^{6}	3.60×10^{6}	0	0	0
Chester	5.42×10^{8} (11)	4.92×10^{7}	7.05×10^{7}	0	4.10×10^{8}	1.16×10^{7}	0	0
Edgefield	1.75×10^{8} (37)	8.28×10^{7}	4.82×10^{7}	0	4.39×10^{7}	0	0	0
Fairfield	5.73×10^{8} (9)	8.20×10^{5}	1.51×10^{8}	0	4.21×10^{8}	0	0	0
Greenwood	3.41×10^{8} (21)	0	9.98×10^{7}	0	2.41×10^{8}	0	0	0
Kershaw	4.95×10^{8} (13)	3.14×10^{8}	1.38×10^{8}	8.20×10^{6}	3.38×10^{7}	0	0	0
Lancaster	2.18×10^{8} (31)	4.35×10^{7}	1.30×10^{8}	0	4.46×10^{7}	0	0	0
Laurens	3.72×10^{8} (18)	1.03×10^{8}	1.63×10^{7}	0	2.53×10^{8}	0	0	0
Lexington	4.73×10^{8} (14)	3.72×10^{8}	7.40×10^{7}	0	2.59×10^{7}	0	1.00×10^{6}	0
Newberry	3.13×10^{8} (23)	5.74×10^{7}	5.50×10^{7}	0	2.00×10^{8}	0	0	0
Richland	4.60×10^{8} (15)	1.34×10^{8}	3.10×10^{8}	3.28×10^{6}	1.37×10^{7}	0	0	0
Saluda	1.42×10^{8} (38)	1.56×10^{7}	7.14×10^{7}	0	5.54×10^{7}	0	0	0
York	5.35×10^{8} (12)	4.10×10^{6}	1.15×10^{8}	0	4.15×10^{8}	0	0	0
(Midlands)	**5.55×10^{9} (2)**	**1.58×10^{9}**	**1.49×10^{9}**	**1.27×10^{7}**	**2.45×10^{9}**	**1.16×10^{7}**	**1.00×10^{6}**	**0**
Chesterfield	7.22×10^{8} (5)	1.42×10^{8}	5.63×10^{8}	0	1.66×10^{7}	0	0	0
Clarendon	2.00×10^{8} (34)	3.20×10^{7}	1.65×10^{8}	2.46×10^{6}	0	0	0	0
Darlington	2.55×10^{8} (28)	2.95×10^{7}	2.22×10^{8}	3.69×10^{6}	0	0	1.00×10^{5}	0
Dillon	1.90×10^{8} (35)	7.46×10^{7}	1.10×10^{8}	3.28×10^{6}	0	0	1.90×10^{6}	0
Florence	2.72×10^{8} (26)	7.95×10^{7}	1.93×10^{8}	0	0	0	2.00×10^{5}	0
Georgetown	8.53×10^{8} (2)	2.88×10^{8}	2.36×10^{8}	2.34×10^{7}	2.94×10^{8}	0	1.15×10^{7}	0
Horry	8.43×10^{8} (3)	2.07×10^{8}	3.71×10^{8}	2.62×10^{7}	2.07×10^{8}	0	3.30×10^{7}	0
Lee	1.37×10^{8} (39)	2.38×10^{7}	1.13×10^{8}	0	7.20×10^{5}	0	0	0
Marion	3.50×10^{8} (20)	8.77×10^{7}	2.46×10^{8}	1.11×10^{7}	0	0	4.90×10^{6}	0
Marlboro	3.38×10^{8} (22)	6.15×10^{7}	2.31×10^{8}	3.32×10^{7}	1.22×10^{7}	0	2.00×10^{5}	0
Sumter	3.11×10^{8} (24)	7.38×10^{6}	3.01×10^{8}	0	2.88×10^{6}	0	2.00×10^{5}	0
Williamsburg	2.01×10^{8} (33)	2.05×10^{7}	1.80×10^{8}	0	0	0	3.00×10^{5}	0
(Pee Dee)	**4.67×10^{9} (3)**	**1.05×10^{9}**	**2.93×10^{9}**	**1.03×10^{8}**	**5.34×10^{8}**	**0**	**5.23×10^{7}**	**0**
Allendale	1.10×10^{8} (41)	2.05×10^{7}	8.69×10^{7}	2.46×10^{6}	0	0	0	0
Bamberg	1.34×10^{8} (40)	1.03×10^{8}	8.60×10^{5}	0	2.95×10^{7}	0	3.00×10^{5}	0
Barnwell	1.83×10^{8} (36)	6.40×10^{7}	1.19×10^{8}	0	0	0	0	0
Beaufort	6.98×10^{8} (6)	5.72×10^{8}	2.92×10^{7}	2.46×10^{6}	2.88×10^{7}	4.44×10^{7}	2.10×10^{7}	0
Berkeley	6.15×10^{8} (7)	1.19×10^{8}	1.79×10^{8}	9.43×10^{6}	2.94×10^{8}	0	1.37×10^{7}	0
Calhoun	7.65×10^{7} (46)	5.41×10^{7}	2.24×10^{7}	0	0	0	0	0
Charleston	1.46×10^{9} (1)	6.27×10^{8}	2.86×10^{8}	0	5.23×10^{8}	0	2.73×10^{7}	0
Colleton	5.84×10^{8} (8)	2.30×10^{8}	4.21×10^{7}	3.61×10^{7}	1.01×10^{8}	1.64×10^{8}	1.09×10^{7}	0
Dorchester	4.44×10^{8} (16)	2.25×10^{8}	1.46×10^{7}	4.10×10^{5}	2.02×10^{8}	0	3.00×10^{6}	0
Hampton	2.64×10^{8} (27)	1.12×10^{8}	7.48×10^{7}	1.23×10^{6}	7.27×10^{7}	0	4.00×10^{6}	0
Jasper	7.37×10^{8} (4)	2.61×10^{8}	4.99×10^{7}	2.34×10^{7}	1.77×10^{8}	2.24×10^{8}	2.40×10^{6}	0
McCormick	2.86×10^{8} (25)	5.25×10^{7}	5.59×10^{7}	0	1.78×10^{8}	0	0	0
Orangeburg	9.34×10^{7} (42)	5.99×10^{7}	1.55×10^{7}	0	1.80×10^{7}	0	1.00×10^{5}	0
(Low Country)	**5.69×10^{9} (1)**	**2.50×10^{9}**	**9.75×10^{8}**	**7.54×10^{7}**	**1.62×10^{9}**	**4.32×10^{8}**	**8.27×10^{7}**	**0**
Totals ($)	**1.72×10^{10}**	**5.53×10^{9}**	**5.91×10^{9}**	**1.95×10^{8}**	**5.00×10^{9}**	**4.44×10^{8}**	**1.36×10^{8}**	**0**

Table 9. Mid-point total soil carbon (TSC) storage by county, region, and soil order for the state of South Carolina (U.S.A.), based on mid-point (TSC) contents in the upper 2 m based on data from Guo et al. 2006 [18].

County (Region)	Total Storage (kg) (Rank)	Slight <— Degree of Weathering and Soil Development —> Strong						
		Slightly Weathered			Moderately Weathered		Strongly Weathered	
		Entisols	Inceptisols	Histosols	Alfisols	Mollisols	Spodosols	Ultisols
		Total Storage (kg)						
Anderson	1.37×10^{10} (26)	1.31×10^{9}	0	0	0	0	0	1.23×10^{10}
Cherokee	8.98×10^{9} (42)	1.51×10^{9}	1.32×10^{9}	0	1.18×10^{9}	0	0	4.97×10^{9}
Greenville	1.54×10^{10} (20)	1.38×10^{9}	2.32×10^{9}	0	0	0	0	1.17×10^{10}
Oconee	1.21×10^{10} (31)	4.74×10^{8}	7.84×10^{8}	0	0	0	0	1.08×10^{10}
Pickens	9.53×10^{9} (39)	4.99×10^{8}	7.70×10^{8}	0	0	0	0	8.26×10^{9}
Spartanburg	1.49×10^{10} (22)	1.02×10^{8}	2.25×10^{9}	0	9.09×10^{8}	0	0	1.16×10^{10}
Union	1.19×10^{10} (32)	9.47×10^{8}	8.54×10^{8}	0	4.30×10^{9}	0	0	5.84×10^{9}
(Upstate)	**8.64×10^{10} (4)**	**6.22×10^{9}**	**8.30×10^{9}**	**0**	**6.38×10^{9}**	**0**	**0**	**6.55×10^{10}**
Abbeville	1.15×10^{10} (34)	6.66×10^{8}	5.32×10^{8}	0	4.73×10^{9}	0	0	5.52×10^{9}
Aiken	2.51×10^{10} (7)	5.70×10^{9}	2.98×10^{9}	1.57×10^{9}	5.90×10^{7}	0	0	1.48×10^{10}
Chester	1.43×10^{10} (24)	7.68×10^{8}	1.15×10^{9}	0	6.73×10^{9}	1.50×10^{8}	0	5.50×10^{9}
Edgefield	1.04×10^{10} (37)	1.29×10^{9}	7.84×10^{8}	0	7.20×10^{8}	0	0	7.60×10^{9}
Fairfield	1.59×10^{10} (17)	1.28×10^{7}	2.45×10^{9}	0	6.90×10^{9}	0	0	6.55×10^{9}
Greenwood	1.07×10^{10} (36)	0	1.62×10^{9}	0	3.95×10^{9}	0	0	5.11×10^{9}
Kershaw	1.95×10^{10} (11)	4.90×10^{9}	2.25×10^{9}	2.85×10^{9}	5.55×10^{8}	0	0	8.95×10^{9}
Lancaster	1.16×10^{10} (33)	6.78×10^{8}	2.11×10^{9}	0	7.32×10^{8}	0	0	8.12×10^{9}
Laurens	1.55×10^{10} (19)	1.60×10^{9}	2.66×10^{8}	0	4.14×10^{9}	0	0	9.53×10^{9}
Lexington	1.59×10^{10} (18)	5.81×10^{9}	1.20×10^{9}	0	4.25×10^{8}	0	1.29×10^{8}	8.31×10^{9}
Newberry	1.37×10^{10} (25)	8.96×10^{8}	8.96×10^{8}	0	3.28×10^{9}	0	0	8.58×10^{9}
Richland	1.76×10^{10} (13)	2.09×10^{9}	5.04×10^{9}	1.14×10^{9}	2.24×10^{8}	0	0	9.07×10^{9}
Saluda	9.35×10^{9} (40)	2.43×10^{8}	1.16×10^{9}	0	9.09×10^{8}	0	0	7.04×10^{9}
York	1.61×10^{10} (16)	6.40×10^{7}	1.88×10^{9}	0	6.81×10^{9}	0	0	7.36×10^{9}
(Midlands)	**2.06×10^{11} (3)**	**2.47×10^{10}**	**2.43×10^{10}**	**4.42×10^{9}**	**4.02×10^{10}**	**1.50×10^{8}**	**1.29×10^{8}**	**1.12×10^{11}**
Chesterfield	2.02×10^{10} (10)	2.21×10^{9}	9.17×10^{9}	0	2.71×10^{8}	0	0	8.53×10^{9}
Clarendon	1.35×10^{10} (28)	4.99×10^{8}	2.69×10^{9}	8.55×10^{8}	0	0	0	9.44×10^{9}
Darlington	1.34×10^{10} (29)	4.61×10^{8}	3.61×10^{9}	1.28×10^{9}	0	0	1.29×10^{7}	8.08×10^{9}
Dillon	9.98×10^{9} (38)	1.16×10^{9}	1.79×10^{9}	1.14×10^{9}	0	0	2.45×10^{8}	5.64×10^{9}
Florence	1.66×10^{10} (15)	1.24×10^{9}	3.14×10^{9}	0	0	0	2.58×10^{7}	1.22×10^{10}
Georgetown	2.89×10^{10} (3)	4.49×10^{9}	3.84×10^{9}	8.12×10^{9}	4.83×10^{9}	0	1.48×10^{9}	6.09×10^{9}
Horry	3.68×10^{10} (1)	3.23×10^{9}	6.03×10^{9}	9.12×10^{9}	3.39×10^{9}	0	4.26×10^{9}	1.08×10^{10}
Lee	8.59×10^{9} (43)	3.71×10^{8}	1.83×10^{9}	0	1.18×10^{7}	0	0	6.37×10^{9}
Marion	1.53×10^{10} (21)	1.37×10^{9}	4.00×10^{9}	3.85×10^{9}	0	0	6.32×10^{8}	5.48×10^{9}
Marlboro	2.21×10^{10} (8)	9.60×10^{8}	3.77×10^{9}	1.15×10^{10}	2.01×10^{8}	0	2.58×10^{7}	5.58×10^{9}
Sumter	1.45×10^{10} (23)	1.15×10^{8}	4.90×10^{9}	0	4.72×10^{7}	0	2.58×10^{7}	9.44×10^{9}
Williamsburg	1.86×10^{10} (12)	3.20×10^{8}	2.93×10^{9}	0	0	0	3.87×10^{7}	1.54×10^{10}
(Pee Dee)	**2.19×10^{11} (2)**	**1.64×10^{10}**	**4.77×10^{10}**	**3.59×10^{10}**	**8.74×10^{9}**	**0**	**6.75×10^{9}**	**1.03×10^{11}**
Allendale	9.14×10^{9} (41)	3.20×10^{8}	1.41×10^{9}	8.55×10^{8}	0	0	0	6.55×10^{9}
Bamberg	8.16×10^{9} (45)	1.61×10^{9}	1.40×10^{7}	0	4.84×10^{8}	0	3.87×10^{7}	6.01×10^{9}
Barnwell	1.15×10^{10} (35)	9.98×10^{8}	1.93×10^{9}	0	0	0	0	8.52×10^{9}
Beaufort	1.68×10^{10} (14)	8.93×10^{9}	4.76×10^{8}	8.55×10^{8}	4.72×10^{8}	5.75×10^{8}	2.71×10^{9}	2.78×10^{9}
Berkeley	2.80×10^{10} (5)	1.86×10^{9}	2.91×10^{9}	3.28×10^{9}	4.83×10^{9}	0	1.77×10^{9}	1.34×10^{10}
Calhoun	5.87×10^{9} (46)	8.45×10^{8}	3.64×10^{8}	0	0	0	0	4.66×10^{9}
Charleston	2.81×10^{10} (4)	9.79×10^{9}	4.65×10^{9}	0	8.58×10^{9}	0	3.52×10^{9}	1.56×10^{9}
Colleton	3.57×10^{10} (2)	3.58×10^{9}	6.86×10^{8}	1.25×10^{10}	1.65×10^{9}	2.13×10^{9}	1.41×10^{9}	1.37×10^{10}
Dorchester	1.36×10^{10} (27)	3.51×10^{9}	2.38×10^{8}	1.43×10^{8}	3.30×10^{9}	0	3.87×10^{8}	6.06×10^{9}
Hampton	1.27×10^{10} (30)	1.74×10^{9}	1.22×10^{9}	4.28×10^{8}	1.19×10^{9}	0	5.16×10^{8}	7.64×10^{9}
Jasper	2.52×10^{10} (6)	4.07×10^{9}	8.12×10^{8}	8.12×10^{9}	2.90×10^{9}	2.90×10^{9}	3.10×10^{8}	6.04×10^{9}
McCormick	8.51×10^{9} (44)	8.19×10^{8}	9.10×10^{8}	0	2.91×10^{9}	0	0	3.87×10^{9}
Orangeburg	2.09×10^{10} (9)	9.34×10^{8}	2.52×10^{8}	0	2.95×10^{8}	0	1.29×10^{7}	1.94×10^{10}
(Low Country)	**2.24×10^{11} (1)**	**3.90×10^{10}**	**1.59×10^{10}**	**2.62×10^{10}**	**2.66×10^{10}**	**5.60×10^{9}**	**1.07×10^{10}**	**1.00×10^{11}**
Totals (kg)	**7.36×10^{11}**	**8.64×10^{10}**	**9.62×10^{10}**	**6.77×10^{10}**	**8.19×10^{10}**	**5.75×10^{9}**	**1.75×10^{10}**	**3.81×10^{11}**

Table 10. Total soil carbon (TSC) values by county, region, and soil order for the state of South Carolina (U.S.A.), based on mid-point total soil carbon (TSC) numbers for the upper 2 m from Guo et al. 2006 [18] and a social cost of carbon (SC-CO_2) of $46 per metric ton of CO_2 (2007 U.S. dollars with an average discount rate of 3% [17]).

County (Region)	Total Value ($) (Rank)	Slight <—— Degree of Weathering and Soil Development ——> Strong						
		Slightly Weathered			Moderately Weathered		Strongly Weathered	
		Entisols	Inceptisols	Histosols	Alfisols	Mollisols	Spodosols	Ultisols
		Value ($)						
Anderson	2.31×10^9 (26)	2.21×10^8	0	0	0	0	0	2.09×10^9
Cherokee	1.52×10^9 (42)	2.56×10^8	2.22×10^8	0	1.99×10^8	0	0	8.40×10^8
Greenville	2.60×10^9 (20)	2.34×10^8	3.92×10^8	0	0	0	0	1.97×10^9
Oconee	2.04×10^9 (31)	8.03×10^7	1.32×10^8	0	0	0	0	1.83×10^9
Pickens	1.61×10^9 (39)	8.46×10^7	1.30×10^8	0	0	0	0	1.40×10^9
Spartanburg	2.51×10^9 (22)	1.74×10^7	3.80×10^8	0	1.53×10^8	0	0	1.96×10^9
Union	2.02×10^9 (32)	1.61×10^8	1.44×10^8	0	7.24×10^8	0	0	9.88×10^8
(Upstate)	**1.46×10^{10} (4)**	**1.05×10^9**	**1.40×10^9**	**0**	**1.08×10^9**	**0**	**0**	**1.11×10^{10}**
Abbeville	1.93×10^9 (34)	1.13×10^8	8.97×10^7	0	7.98×10^8	0	0	9.34×10^8
Aiken	4.24×10^9 (7)	9.66×10^8	5.03×10^8	2.64×10^8	9.95×10^6	0	0	2.50×10^9
Chester	2.41×10^9 (24)	1.30×10^8	1.94×10^8	0	1.13×10^9	2.53×10^7	0	9.30×10^8
Edgefield	1.76×10^9 (37)	2.19×10^8	1.32×10^8	0	1.21×10^8	0	0	1.29×10^9
Fairfield	2.69×10^9 (17)	2.17×10^6	4.13×10^8	0	1.16×10^9	0	0	1.11×10^9
Greenwood	1.80×10^9 (36)	0	2.74×10^8	0	6.67×10^8	0	0	8.64×10^8
Kershaw	3.30×10^9 (11)	8.31×10^8	3.80×10^8	4.81×10^8	9.35×10^7	0	0	1.51×10^9
Lancaster	1.97×10^9 (33)	1.15×10^8	3.56×10^8	0	1.23×10^8	0	0	1.37×10^9
Laurens	2.62×10^9 (19)	2.71×10^8	4.48×10^7	0	6.98×10^8	0	0	1.61×10^9
Lexington	2.69×10^9 (18)	9.85×10^8	2.03×10^8	0	7.16×10^7	0	2.17×10^7	1.40×10^9
Newberry	2.31×10^9 (25)	1.52×10^8	1.51×10^8	0	5.53×10^8	0	0	1.45×10^9
Richland	2.97×10^9 (13)	3.54×10^8	8.50×10^8	1.92×10^8	3.78×10^7	0	0	1.53×10^9
Saluda	1.58×10^9 (40)	4.12×10^7	1.96×10^8	0	1.53×10^8	0	0	1.19×10^9
York	2.72×10^9 (16)	1.09×10^7	3.16×10^8	0	1.15×10^9	0	0	1.24×10^9
(Midlands)	**3.48×10^{10} (3)**	**4.19×10^9**	**4.10×10^9**	**7.45×10^8**	**6.77×10^9**	**2.53×10^7**	**2.17×10^7**	**1.89×10^{10}**
Chesterfield	3.41×10^9 (10)	3.75×10^8	1.55×10^9	0	4.58×10^7	0	0	1.44×10^9
Clarendon	2.28×10^9 (28)	8.46×10^7	4.53×10^8	1.44×10^8	0	0	0	1.59×10^9
Darlington	2.27×10^9 (29)	7.81×10^7	6.09×10^8	2.16×10^8	0	0	2.17×10^6	1.37×10^9
Dillon	1.69×10^9 (38)	1.97×10^8	3.02×10^8	1.92×10^8	0	0	4.12×10^7	9.53×10^8
Florence	2.81×10^9 (15)	2.10×10^8	5.29×10^8	0	0	0	4.34×10^6	2.07×10^9
Georgetown	4.87×10^9 (3)	7.62×10^8	6.47×10^8	1.37×10^9	8.14×10^8	0	2.50×10^8	1.03×10^9
Horry	6.22×10^9 (1)	5.47×10^8	1.02×10^9	1.54×10^9	5.71×10^8	0	7.16×10^8	1.83×10^9
Lee	1.45×10^9 (43)	6.29×10^7	3.09×10^8	0	1.99×10^6	0	0	1.08×10^9
Marion	2.59×10^9 (21)	2.32×10^8	6.75×10^8	6.49×10^8	0	0	1.06×10^8	9.26×10^8
Marlboro	3.73×10^9 (8)	1.63×10^8	6.35×10^8	1.95×10^9	3.38×10^7	0	4.34×10^6	9.43×10^8
Sumter	2.45×10^9 (23)	1.95×10^7	8.26×10^8	0	7.96×10^6	0	4.34×10^6	1.59×10^9
Williamsburg	3.15×10^9 (12)	5.43×10^7	4.93×10^8	0	0	0	6.51×10^6	2.60×10^9
(Pee Dee)	**3.69×10^{10} (2)**	**2.79×10^9**	**8.04×10^9**	**6.06×10^9**	**1.47×10^9**	**0**	**1.13×10^9**	**1.74×10^{10}**
Allendale	1.54×10^9 (41)	5.43×10^7	2.38×10^8	1.44×10^8	0	0	0	1.11×10^9
Bamberg	1.38×10^9 (45)	2.73×10^8	2.36×10^6	0	8.16×10^7	0	6.51×10^6	1.02×10^9
Barnwell	1.93×10^9 (35)	1.69×10^8	3.26×10^8	0	0	0	0	1.44×10^9
Beaufort	2.84×10^9 (14)	1.51×10^9	8.02×10^7	1.44×10^8	7.96×10^7	9.68×10^7	4.56×10^8	4.69×10^8
Berkeley	4.73×10^9 (5)	3.15×10^8	4.91×10^8	5.53×10^8	8.14×10^8	0	2.97×10^8	2.26×10^9
Calhoun	9.92×10^8 (46)	1.43×10^8	6.14×10^7	0	0	0	0	7.87×10^8
Charleston	4.75×10^9 (4)	1.66×10^9	7.84×10^8	0	1.45×10^9	0	5.92×10^8	2.64×10^8
Colleton	6.02×10^9 (2)	6.08×10^8	1.16×10^8	2.11×10^9	2.79×10^8	3.58×10^8	2.37×10^8	2.31×10^9
Dorchester	2.30×10^9 (27)	5.95×10^8	4.01×10^7	2.40×10^7	5.57×10^8	0	6.51×10^7	1.02×10^9
Hampton	2.15×10^9 (30)	2.95×10^8	2.05×10^8	7.21×10^7	2.01×10^8	0	8.68×10^7	1.29×10^9
Jasper	4.25×10^9 (6)	6.90×10^8	1.37×10^8	1.37×10^9	4.90×10^8	4.88×10^8	5.21×10^7	1.02×10^9
McCormick	1.44×10^9 (44)	1.39×10^8	1.53×10^8	0	4.92×10^8	0	0	6.54×10^8
Orangeburg	3.53×10^9 (9)	1.58×10^8	4.25×10^7	0	4.98×10^7	0	2.17×10^6	3.27×10^9
(Low Country)	**3.79×10^{10} (1)**	**6.61×10^9**	**2.68×10^9**	**4.42×10^9**	**4.49×10^9**	**9.43×10^8**	**1.79×10^9**	**1.69×10^{10}**
Totals ($)	**1.24×10^{11}**	**1.46×10^{10}**	**1.62×10^{10}**	**1.14×10^{10}**	**1.38×10^{10}**	**9.68×10^8**	**2.95×10^9**	**6.43×10^{10}**

4. Discussion

Pedodiversity (soil diversity) in South Carolina is a source of various ES goods, services, and disservices (ED). This study demonstrates the value of regulating ES/ED in the state and its regions and counties. According to Mikhailova et al. (2021) [22], taxonomic pedodiversity (e.g., soil order) "provides a general description of the stock, its type, and spatial distribution," which is often rereferred to as a "portfolio" to describe the link between pedodiversity and its stocks. South Carolina soil "portfolio" is composed of seven soil orders: Entisols (9% of the total state area), Inceptisols (9%), Histosols (1%), Alfisols (9%), Mollisols (0%), Spodosols (2%), and Ultisols (70%) (Figure 4, Table 11). Highly weathered Ultisols have the highest proportion of the total area of the state (Figure 4a), which contributes to the highest SOC and TSC storage and their associated social costs of carbon. The contribution of SIC to associated social costs of carbon is small at the state level and primarily associated with Inceptisols, Entisols, and Alfisols.

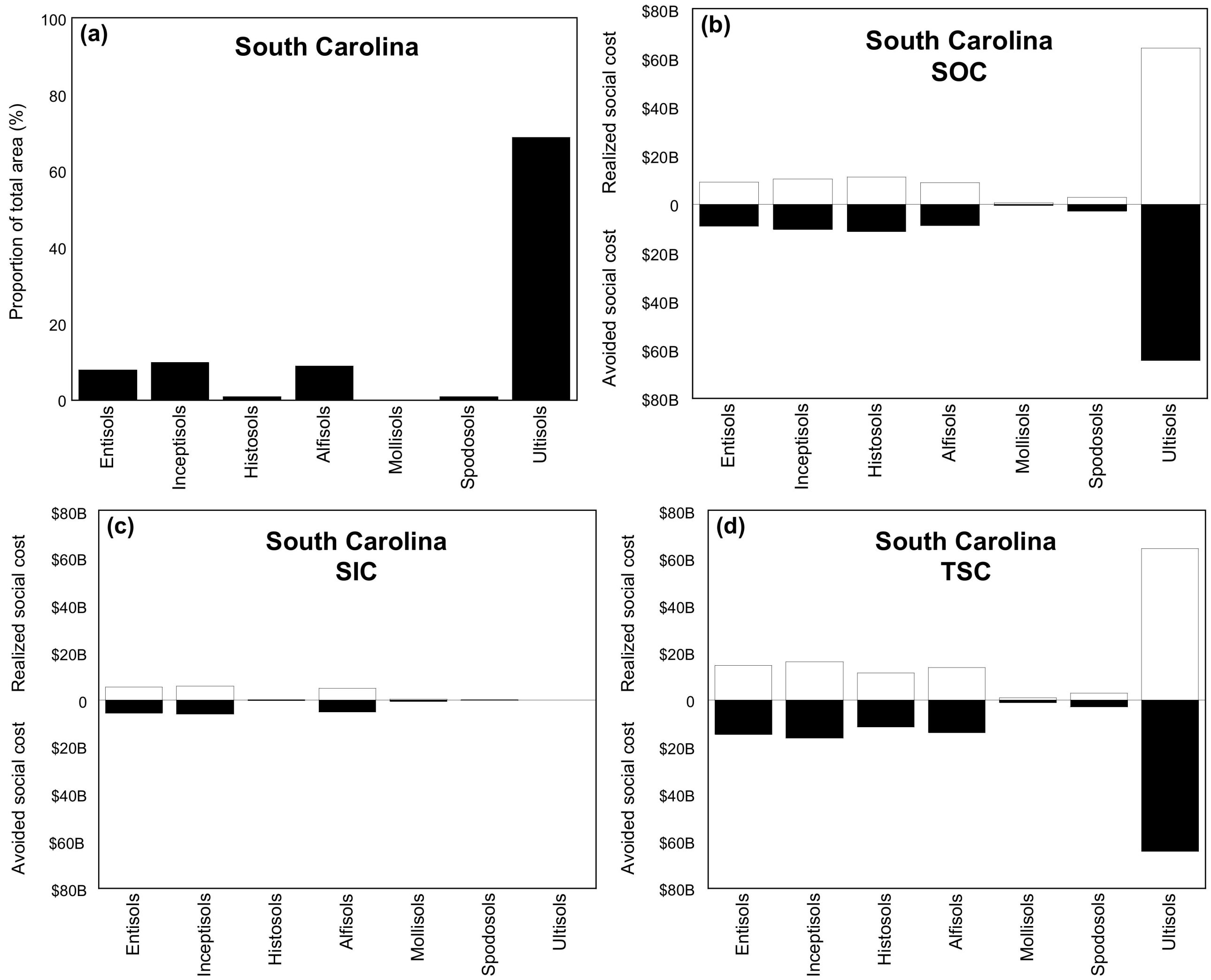


Figure 4. Diagram showing how the "portfolio-effect" and "distribution-effect" of pedodiversity can vary within the state: (**a**) pedodiversity by soil order area; (**b**) value of soil organic carbon (SOC) storage, (**c**) value of soil inorganic carbon (SIC) storage, (**d**) value of total soil carbon (TSC) storage in the upper 2-m depth based on avoided or realized the social cost of CO_2 (SC-CO_2) of $46 (USD) per metric ton of CO_2 [17] by soil order. Note: B = billion = 10^9.

Soil "portfolio" differs within each county, and Figure 5 illustrates this concept using three counties from different regions: Anderson (Upstate), Newberry (Midlands), and Colleton (Low Country).

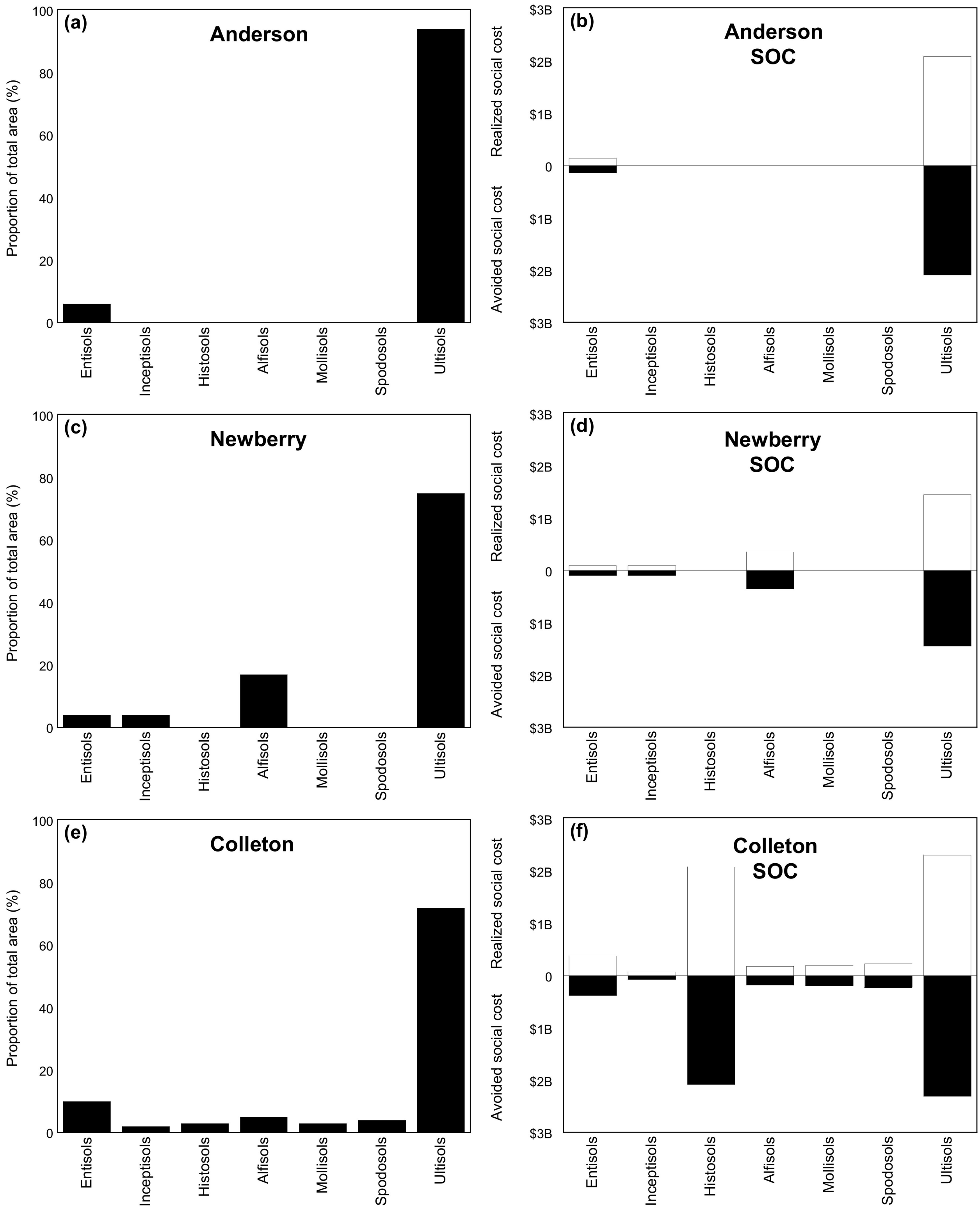
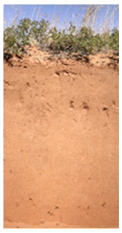
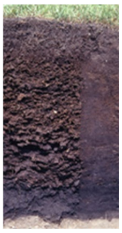
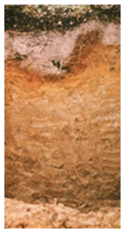
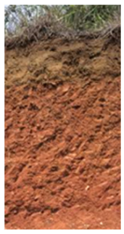


Figure 5. Diagram showing how the "portfolio-effect" and "distribution-effect" of pedodiversity can vary by county: (**a**,**c**,**e**) pedodiversity by soil order area; (**b**,**d**,**f**) value of soil organic carbon (SOC) storage in the upper 2-m depth based on avoided or realized the social cost of CO_2 (SC-CO_2) of $46 (USD) per metric ton of CO_2 [17] by soil order. Note: B = billion = 10^9.

In all three cases, Ultisols occupy the largest proportion of the area in each county. The type of soil order influences the value of SOC storage. In Colleton County, the soil order of Histosols contributes to the social costs of C as much as the Ultisols even though its area is much smaller (Figure 5) because of high SOC content of 142.5 kg m^{-2}. Figures 4 and 5 represent social costs of soil C from different point of views: "avoided" versus "realized" social costs. Soil carbon stored in the soil represents the "avoided social cost" of soil C if not converted to CO_2 and released into the atmosphere. When CO_2 is released into the atmosphere, it becomes the "realized social cost" because of the damages from global warming. In South Carolina, Histosols and Alfisols are particularly sensitive to climate change because of relatively high soil C content, which is most likely to experience higher decomposition rates due to increases in temperature and precipitation. All soils in the state of South Carolina have low recarbonization potential.

Table 11. Distribution of soil carbon regulating ecosystem services in the state of South Carolina (U.S.A.) by soil order (photos courtesy of USDA/NRCS [23]) in the upper 2-m depth based on avoided or realized the social cost of CO_2 (SC-CO_2) of $46 (USD) per metric ton of CO_2 [17].

Soil Regulating Ecosystem Services in the State of South Carolina						
Slight <———— Degree of Weathering and Soil Development ————> Strong						
Slightly Weathered 18%			**Moderately Weathered 9%**		**Strongly Weathered 72%**	
Entisols 9%	**Inceptisols 9%**	**Histosols 1%**	**Alfisols 9%**	**Mollisols 0%**	**Spodosols 2%**	**Ultisols 70%**
						
The social cost of soil organic carbon (SOC) in USD: $107.14B						
$9.11B	$10.30B	$11.20B	$8.82B	$524.00M	$2.82B	$64.30B
9%	10%	10%	8%	0%	3%	60%
The social cost of soil inorganic carbon (SIC) in USD: $17.22B						
$5.53B	$5.91B	$195.00M	$5.00B	$444.00M	$136.00M	$0
32%	34%	1%	29%	3%	1%	0%
The social cost of total soil carbon (TSC) in USD: $124.36B						
$14.60B	$16.20B	$11.40B	$13.80B	$968.00M	$2.95B	$64.30B
12%	13%	9%	11%	1%	2%	52%
Sensitivity to climate change						
Low	Low	High	High	High	Low	Low
Soil organic and inorganic carbon sequestration (recarbonization) potential						
Low	Low	Low	Low	Low	Low	Low

Note: Entisols, Inceptisols, Alfisols, Mollisols, Spodosols, Ultisols are mineral soils. Histosols are mostly organic soils. M = million = 10^6; B = billion = 10^9.

Amelung et al. (2020) [24] proposed linking soil C sequestration to food security using soil- and site-specific potentials and opportunities for soil C sequestration. In this respect, the state of South Carolina faces serious limitations in both soil- (dominated by highly-weathered soil order, Ultisols) and site-specific (high demand for soil C due to rapid urbanization and population growth; rapid changes in coastal areas, etc.) potentials. Soil order Histosols (which often contains organic soils) is located in the coastal areas of the state and can be drained for agriculture and urbanization, leading to high losses of soil C into the atmosphere [24]. Recarbonization of soils in the state of South Carolina may not be economically feasible due to past excessive levels of soil degradation [25], high fertilization and liming costs (including transportation) associated with increasing soil C in mostly highly-weathered and acid soils in the state. It should be noted that the reported soil survey-based C values may be an overestimate of actual soil C measured in the field, but the overall trends for the soil orders should be similar [10]. Soil C should be regularly monitored to quantify soil contributions to ES and its flows [26,27].

5. Conclusions

This study examined the application of soil diversity (pedodiversity) concepts (taxonomic) and its measures to value soil C regulating ES/ED in the state of South Carolina (U.S.A.), its administrative units (regions, counties), and the systems of soil classification (e.g., U.S. Department of Agriculture (USDA) Soil Taxonomy, Soil Survey Geographic (SSURGO) Database) to be considered in territorial planning. Pedodiversity provides a critical context (e.g., "portfolio-effect," "distribution-effect," "evenness-effect," etc.) for analyzing, interpreting, and reporting ES/ED within the ES framework for sustainable management of soil carbon within the state. Taxonomic pedodiversity in South Carolina exhibits high soil diversity (7 soil orders: Entisols, Inceptisols, Histosols, Alfisols, Mollisols, Spodosols, and Ultisols), which is not evenly distributed within the state, regions, and counties. In general, pedodiversity tends to increase from the Upstate to Low Country, where three counties (Beaufort, Colleton, and Jasper) have all seven orders. Similarly, soil carbon storage and its associated social costs tend to increase in a similar geographic direction. Ultisols occupy the highest proportion of the state area (70%) and have the highest SOC storage and related social costs of carbon ($64.30B). The contribution of SIC to associated social costs of carbon is small ($17.22B) at the state level and primarily associated with Inceptisols ($5.91B), Entisols ($5.53B), and Alfisols ($5.00B). In the state of South Carolina, Histosols and Alfisols are particularly sensitive to climate change because of relatively high soil C content, which is most likely experience higher rates of decomposition due to increases in temperature and precipitation. All soils in the state of South Carolina have low recarbonization potential. Administrative areas (e.g., counties, regions) combined with pedodiversity concepts can provide useful information to design cost-efficient policies to manage soil carbon regulating ES at the state level.

Author Contributions: Conceptualization, E.A.M.; methodology, E.A.M., M.A.S. and H.A.Z.; formal analysis, E.A.M.; writing—original draft preparation, E.A.M.; writing—review and editing, E.A.M., C.J.P., G.C.P. and M.A.S.; visualization, H.A.Z., L.L. and Z.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

Acknowledgments: We would like to thank the reviewers for their constructive comments and suggestions.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

ED	Ecosystem disservices
ES	Ecosystem services
EPA	Environmental Protection Agency
SC-CO_2	Social cost of carbon emissions
SDGs	Sustainable Development Goals
SOC	Soil organic carbon
SIC	Soil inorganic carbon
SOM	Soil organic matter
SSURGO	Soil Survey Geographic Database
TSC	Total soil carbon
USDA	United States Department of Agriculture
U.S.A.	United States of America

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