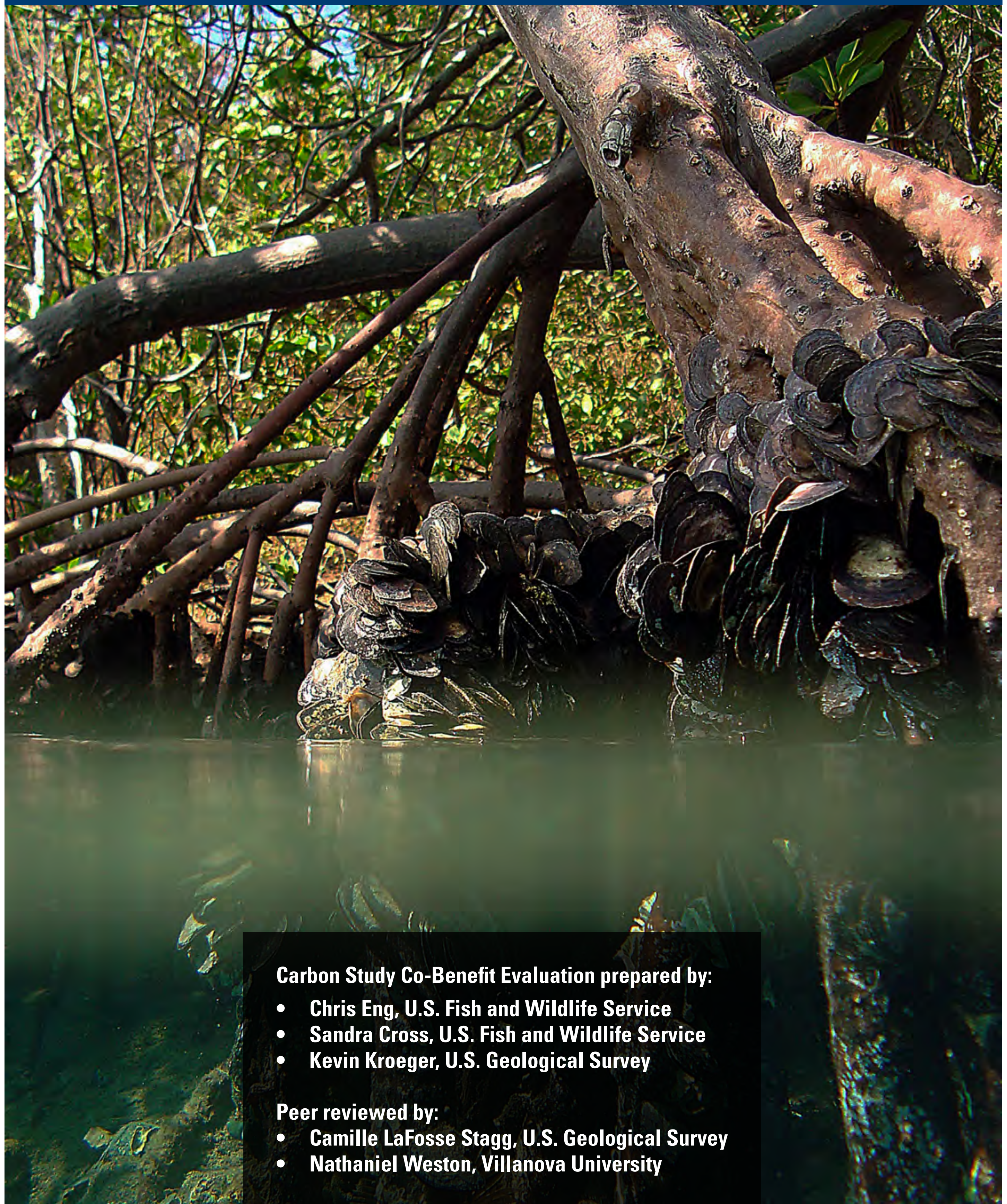
U.S. Fish and Wildlife Service

Coastal Program
Carbon Study
Co-Benefit Evaluation

Carbon Study
Co-Benefit Evaluation



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Carbon Study
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(Opposite Page) Red Mangrove / Caroline Rogers, USGS

A Conservation Leader

that works with communities to voluntarily protect and improve habitats that benefit fish, wildlife, and people. We also develop resources for decision makers, land managers, and restoration practitioners to better manage and deliver habitat conservation. By working together, we sustain the people and wildlife that rely on coastal and marine ecosystems.

Our Mission

is to achieve voluntary habitat conservation by providing technical and financial assistance, in collaboration with partners, for the benefit of federal trust species.

Working with Communities

along our nation's coasts, we conserve habitat on public and private lands to deliver landscape conservation, build resilient coasts and communities, and maintain habitat connectivity and continuity, from headwater streams to the ocean.

Find the Coastal Program online:

Webpage — bit.ly/3T1hptX

YouTube — bit.ly/3SKI7FF

(Opposite Page) Coastal Program Poster Illustration / Virginia Greene

Carbon Study
Coastal Program

The Coastal Program

has worked with numerous partners and communities to:

Implement more than
4,900
habitat projects[1]

Improve more than
209,000
acres of uplands

Improve more than
399,000
acres of wetlands

Protect more than
2.3 million
acres of habitat

1. Program statistics maintained since 1985 by the Coastal Program

Carbon Study
Introduction

Restoring tidal flow to a salt marsh on Humboldt Bay National Wildlife Refuge, California.

Introduction

Carbon dioxide (CO_2) is a gas that occurs naturally in the atmosphere, as part of the carbon cycle (Figure 1). However, CO_2 is also the primary greenhouse gas produced by human activities, including from combustion of fossil fuels (e.g., gasoline, oil, and coal). In 2020, CO_2 accounted for 79 percent of U.S. greenhouse gas emissions from human activities.[2] In 2022, the average atmospheric CO_2 concentration was 50 percent higher than pre-industrial levels – concentrations not seen for millions of years.[3]

An abundance of CO_2 is concerning because it traps heat in Earth's atmosphere and increases the overall temperature of the planet. Warmer temperatures change global weather patterns, which in turn increase the frequency and intensity of natural disasters, such as storms, flooding, and heat waves. Exposure to extreme weather conditions can increase human health and well-being concerns, such as allergies and illnesses, food and water availability, and economic security.

Oceans play an important role in the carbon cycle by removing CO_2 from the atmosphere. Higher concentrations of CO_2 in the atmosphere are causing the ocean to absorb more CO_2, resulting in more acidic oceans - a process known as ocean acidification. Today, oceans are 30 percent more acidic than pre-industrial levels.[4] Ocean acidification negatively affects fish, wildlife, and habitats, such as slowing the growth of coral and impairing shell formation by bivalves and other calcifying species.

These climate change impacts may seem overwhelming; however, people are making a difference by reducing their carbon footprint and conserving natural habitats and functions that sequester and store carbon from the atmosphere. As part of the carbon cycle, trees, grasses, and other plants remove carbon from the atmosphere and store carbon within the plants, roots, and soil. By protecting and restoring natural habitats, we can improve carbon sequestration and long-term storage of carbon.

2. https://epa.gov/ghgemissions/overview-greenhouse-gases
3. https://noaa.gov/news-release/carbon-dioxide-now-more-than-50-higher-than-pre-industrial-levels
4. https://noaa.gov/education/resource-collections/ocean-coasts/ocean-acidification

Carbon Study
Purpose

Purpose

Co-benefits are beneficial outcomes that result from a conservation action that are not the primary purpose for the action. The Coastal Program evaluated the carbon co-benefits delivered by habitat conservation (i.e., improvement and protection) completed between 2010 and 2020. The purpose of the carbon study is to demonstrate the important role that habitat conservation projects have in removing atmospheric carbon dioxide and more broadly mitigating a significant cause of climate change. By evaluating and communicating carbon co-benefits, the conservation community can engage a broader audience, better advocate for conservation, and maximize conservation benefits.

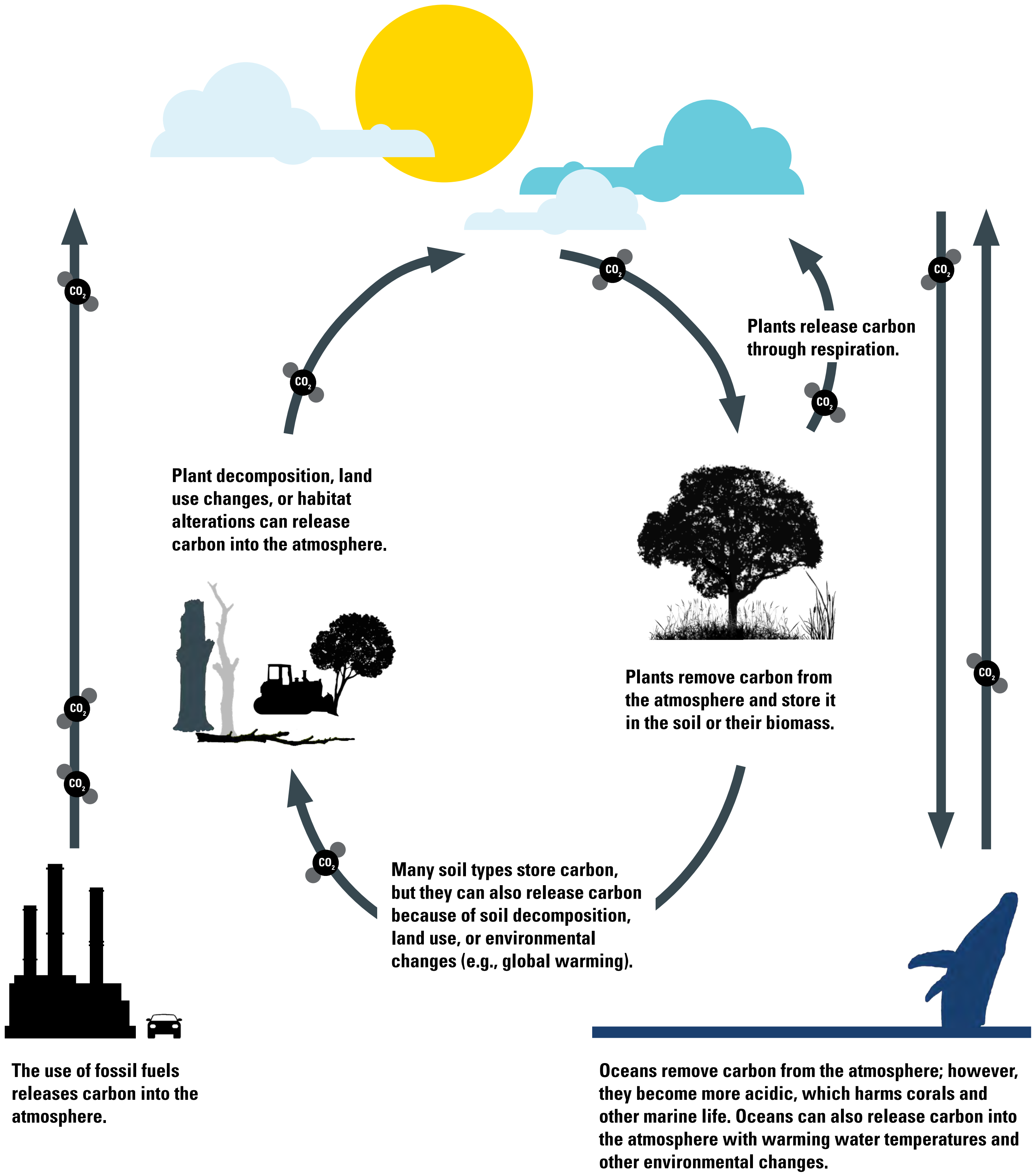
The *Coastal Program Carbon Study – Co-Benefits Evaluation* provides an abbreviated description of our methods, results of the carbon study, and suggestions for data interpretation. A more detailed description of the data, data management decisions, and carbon calculations are provided in the *Coastal Program Carbon Study – Data & Methods*. The reason for preparing separate documents is because the study methods are specific to the Coastal Program; however, the approach can serve as a model for others seeking to evaluate the carbon co-benefits delivered by their conservation projects.

We worked with the U.S. Geological Survey on the evaluation and consulted with other experts regarding a wide range of topics, including carbon sequestration rates and stocks by habitat type and region. A list of our partners and other experts who assisted with the carbon evaluation is provided in Appendix A.

Tidal marsh restoration at White Slough on Humboldt Bay National Wildlife Refuge, California / Conor Shea, USFWS

Carbon Study
Carbon Cycle

Figure 1. Simplified Carbon Cycle



Carbon Study
Methods

Carbon Study

The Coastal Program evaluated the carbon co-benefits delivered by a suite of habitat improvement (e.g., restoration and enhancement) and protection projects completed between 2010 and 2020. Evaluating carbon co-benefits can be a nuanced process, so we established the following study conditions to make a large-scale evaluation possible.

The study:

- Evaluates only carbon dioxide co-benefits – the study does not evaluate other greenhouse gases (e.g., methane and nitrous oxide).
- Estimates annually sequestered carbon for habitat improvement projects.
- Estimates annually sequestered carbon and total carbon stock for habitat protection projects.
- Excludes carbon emissions associated with natural processes and conservation treatments, such as in the case of prescribed fires.
- Avoids comparison of carbon sequestration and storage potentials between impaired habitats and improved habitats, such as comparing carbon sequestration rates of invasive and native plants.
- Assumes annual carbon sequestration rates and stocks are uniform within regions and habitat types.
- Assumes habitats are functioning at a typical carbon storage and/or sequestration capacity.

In this study, annually sequestered carbon is the net amount of CO_2 removed by a habitat type over a period of one year and total carbon stock is the amount of CO_2 stored by a habitat type.

Study Methods

As noted before, the *Coastal Program Carbon Study – Data & Methods* provides a detailed description of the study methods, including decisions to exclude certain ecological classifications and conservation treatments (i.e., actions). In the *Data & Methods* document, we use the term "accomplishment" instead of "project" because it is the term used by our project tracking database (i.e., Habitat Information Tracking System). Below are the abbreviated steps we used to calculate annually sequestered carbon and total carbon stocks.

Carbon Sequestration Rates and Stocks

We conducted a literature review and consulted experts to identify carbon sequestration rates and stocks for each habitat category. Carbon sequestration rate is the rate at which a habitat can remove and store atmospheric CO_2 for a period of time (e.g., annually). Carbon stock is the total amount of carbon stored by a habitat, such as in vegetation and soil.

Once we selected the rates and stocks, we standardized units and established a reasonable scale (e.g., state or region) to apply rates and stocks based on the source and expert opinions (Table 1). The rates and stocks in Table 1 were rounded to the nearest whole number, because a higher level of precision was not necessary for the scope of this study. Full literature citations for the rates and stocks are provided in Appendix B. It may be useful to know that a metric ton (i.e., MT) is equal to a mega gram (i.e., Mg).

Table 1. Carbon Sequestration Rates and Stocks

Habitats	Geography	Carbon Sequestration Rate (MTC/km^2yr)	Carbon Sequestration Stock (MTC/km^2)
Tidal Saltwater Wetlands & Tidal Freshwater, Non-Forested Wetlands [a]	Alaska	301 [b]	62,741 [c]
	California	104	32,000
	Lower Mississippi	272	34,000
	Mid-Atlantic	177	45,000
	New England	151	39,000
	Pacific Northwest	110	37,000
	South Atlantic (Gulf Coast)	124	34,000
	Texas	238	39,000
Tidal Freshwater Forested Wetlands & Forested Wetlands [b]	CONUS	67	19,065
	Alaska	57	49,798
	Puerto Rico	120	20,000
Upland Forests	Alaska	8 [b]	4,800 [c]
Upland Forests [d]	Central States	38	5,770
	Great Plains	8	1,160
	Northeast	55	7,090
	Northern Lake States	40	4,390
	Pacific Northwest (East)	45	4,610
	Pacific Northwest (West)	174	13,000
	Pacific Southwest	58	7,660
	Rocky Mountains (North)	-7	4,020
	Rocky Mountains (South)	-18	2,010
	South Central	90	5,370
	Southeast	96	5,950

Table 1. (continued)

Habitats	Geography	Carbon Sequestration Rate (MTC/km^2yr)	Carbon Sequestration Stock (MTC/km^2)
Grasslands [b]	CONUS	21	2,786
Non-Forested Peatlands [b]	CONUS	135	90,903
	Alaska	57	74,489
	Puerto Rico	375	125,000
Forested Peatlands [b]	CONUS	120	107,782
	Alaska	52	69,602
Non-Tidal, Non-Forested Wetlands [b]	CONUS	102	13,730
	Alaska	57	48,434
	Puerto Rico	119	23,810
Mangroves	Southwest Florida and Gulf of Mexico	98 [e]	31,800 [b]
Shrublands [b]	CONUS	21	2,786
Submerged Aquatic Vegetation [b]	Atlantic Coast	43 [f] (Global)	2,000
	Gulf of Mexico		3,100
	High Latitude Sub-Regions		2,000
	Pacific Coast		1,400
Tundras [b]	Alaska	N/A	729

* CONUS = Contiguous United States

(a) Wang, F., Lu, X., Sanders, C.J., et al. 2019. Tidal wetland resilience to sea level rise increases their carbon sequestration capacity in United States. Nat Commun 10, 5434. (https://doi.org/10.1038/s41467-019-13294-z).

(b) U.S. Global Change Research Program. 2018. Second State of the Carbon Cycle Report (SOCCR 2): A Sustained Assessment Report. [Cavallaro, N., G. Shrestha, R. Birdsey, M. A. Mayes, R. G. Najjar, S. C. Reed, P. Romero-Lankao, and Z. Zhu (Eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 878 pp., doi: 10.7930/SOCCR2.(https://carbon2018.globalchange.gov/).

(c) Zhu, Z., and McGuire, A.D. (Eds). 2016. Baseline and projected future carbon storage and greenhouse-gas fluxes in ecosystems of Alaska. U.S. Geological Survey Professional Paper 1826, 196 p. (http://dx.doi.org/10.3133/pp1826). Data derived from USGS LandCarbon Assessment and National Land Cover Database.

(d) Hoover, C.M., Smith, J.E. 2021. Current aboveground live tree carbon stocks and annual net change in forests of conterminous United States. Carbon Balance Manage 16, 17. (https://doi.org/10.1186/s13021-021-00179-2).

(e) Marchio, D.A.; Savarese, M.; Bovard, B.; Mitsch, W.J. 2016. Carbon Sequestration and Sedimentation in Mangrove Swamps Influenced by Hydrogeomorphic Conditions and Urbanization in Southwest Florida. Forests 2016, 7, 116. (https://doi.org/10.3390/f7060116)

(f) Hiraishi, T., Krug, T., Tanabe, K., Srivastava, et. al (Eds). 2014. IPCC, Switzerland 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (https://www.ipcc.ch/publication/2013-supplement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories-wetlands/).

Calculating Annually Sequestered Carbon (using Carbon Sequestration Rates)

Habitat conservation projects that include notably different habitats may require each habitat to be evaluated separately. The refinement of the habitat delineation will depend on the desired scale of the evaluation and available carbon sequestration data.

1. Determine if the conservation treatment maintains or improves carbon co-benefits.
2. Determine if the habitat(s) provides carbon co-benefits.
3. Determine size of project area or delineate and determine the size of the habitats.
4. Identify carbon sequestration rate(s) for the habitat(s) and project location(s).
5. Calculate annual carbon sequestration:

$$\text{Annually Sequestered Carbon for a Habitat Improvement Project or Habitat Type} \left(\frac{\text{MTC}}{\text{yr}}\right) =$$
$$\text{Carbon Sequestration Rate} \left(\frac{\text{MTC}}{\text{km}^2\text{yr}}\right) \times \text{Project or Habitat Area (km}^2\text{)}$$

Calculating Total Carbon Stock

Habitat protection projects that include notably different habitats may require each habitat to be evaluated separately. The scale of the desired evaluation and degree of available carbon data will impact a study's accuracy. A more refined scale will have more precise habitat areas and carbon data available.

1. Determine if the protected habitat(s) provide carbon co-benefits.
2. Determine size of project area or delineate and determine the size of the habitats.
3. Identify carbon sequestration stock(s) for the habitat(s) and project location(s).
4. Calculate total carbon stock:

$$\text{Total Carbon Stock for a Habitat Protection Project or Habitat Type (MTC)} =$$
$$\text{Carbon Sequestration Stock} \left(\frac{\text{MTC}}{\text{km}^2}\right) \times \text{Project or Habitat Area (km}^2\text{)}$$

Converting Carbon to Carbon Dioxide

We converted annually sequestered carbon and total carbon stock to the equivalent quantity of CO_2, because people often have a better understanding of CO_2, as the primary greenhouse gas emitted from human activities.

1. Identify molar mass of carbon dioxide (44.01 atomic mass unit) and carbon (12.01 atomic mass unit).
2. Determine annually sequestered carbon or total carbon stock.
3. Calculate CO_2 equivalent:

$$\text{Carbon Dioxide (MTC/yr or MTC)} =$$
$$\text{Annually Sequestered Carbon (MTC/km}^2\text{yr) or Total Carbon Stock (MTC/km}^2\text{)} \times \left(\frac{CO_2\text{ Molar Mass (AMU)}}{\text{Carbon Molar Mass (AMU)}}\right)$$

(Opposite Page) Prescribed burn / Senior Airman Jensen Stidham, U.S. Air Force

Converting to Everyday Equivalent

Depending on the audience, it may be useful to convert annually sequestered and total carbon stock into more relatable outcomes. Carbon or CO_2 equivalents can be converted to outcomes that are likely easier for audiences to understand, using the U.S. Environmental Protection Agency's online Greenhouse Gas Equivalencies Calculator (www.bit.ly/3Kso4cD).

When selecting an equivalent, it is useful to have a good understanding of what will resonate with your audience. Examples of everyday equivalents include the number of gas-powered vehicles driven for one year or the number of houses' equivalent CO_2 emissions from one year of electricity use. We further discuss everyday equivalents under the Communicating Carbon Co-Benefits in the Study Discussion.

The carbon study excluded carbon emissions associated with natural processes and conservation treatments.

Study Results

We evaluated annually sequestered carbon and total carbon stock for habitat conservation projects completed between 2010 and 2020. The following tables summarize our carbon co-benefits by protect type, habitat type, and state.

Carbon Co-Benefits by Project Type

Table 2 summarizes annually sequestered carbon and total carbon stock by project type for all eligible Coastal Program habitat improvement and protection projects completed between 2010 and 2020. The table also provides carbon dioxide equivalents.

Table 2. Carbon Co-Benefit by Project Type

Project Type	Annually Sequestered Carbon (MTC/yr)	Carbon Dioxide Equivalent (MTC/yr)	Total Carbon Stock (MTC)	Carbon Dioxide Equivalent (MTC)
Habitat Improvement	26,923	98,665	N/A	N/A
Habitat Protection	28,865	105,782	6,127,644	22,456,463

Note: 1) Habitat improvement and protection annually sequestered carbon totals should be reported separately to avoid double counting of carbon benefits because certain projects are included in both project types.
2) Total carbon stock was not calculated for improvement projects, because we could not determine the existing state of carbon stocks or level of habitat degradation.

Habitat Improvement Carbon Co-Benefits by Habitat

Table 3 summarizes annually sequestered carbon by habitat for all eligible Coastal Program habitat improvement projects completed between 2010 and 2020. The table also provides carbon dioxide equivalents. The total area for habitat improvement accomplishments by habitat category are provided in the *Coastal Program Carbon Study – Data & Methods*.

Table 3. Habitat Improvement Annually Sequestered Carbon by Habitat

Habitat Category	Annually Sequestered Carbon (MTC/yr)	Carbon Dioxide Equivalent (MTC/yr)
Forested Peatlands	13,385	49,053
Forested Wetlands & Tidal Freshwater Forested Wetlands	498	1,826
Grasslands	21	77
Mangroves	121	444
Non-Forested Peatlands	4	14
Non-Tidal, Non-Forested Wetlands	1,671	6,123
Shrublands	230	844
Submerged Aquatic Vegetation	8	28
Tidal Saltwater Wetlands & Tidal Freshwater Non-Forested Wetlands	9,523	34,899
Upland Forests	1,462	5,357

Note: 1) Habitat improvement and protection annually sequestered carbon totals should be reported separately to avoid double counting of carbon benefits because certain projects are included in both project types.
2) Total carbon stock was not calculated for improvement projects, because we could not determine the existing state of carbon stocks or level of habitat degradation.

Carbon Study
Results

Habitat Protection Carbon Benefits by Habitat

Table 4 summarizes annually sequestered carbon and total carbon stock by habitat type for all eligible Coastal Program habitat protection projects completed between 2010 and 2020. The table also provides carbon dioxide equivalents. The total area for habitat protection accomplishments by habitat category are provided in the *Coastal Program Carbon Study – Data & Methods*.

Table 4. Habitat Protection Carbon Co-Benefits by Habitat

Habitat Type	Annually Sequestered Carbon (MTC/yr)	Carbon Dioxide Equivalent (MTC/yr)	Total Carbon Stock (MTC)	Carbon Dioxide Equivalent (MTC)
Forested Peatlands	3	9	3,391	12,428
Forested Wetlands & Tidal Freshwater Forested Wetlands	2,162	7,924	618,355	2,266,136
Grasslands	10	37	1,375	5,038
Non-Forested Peatlands	322	1,182	292,251	1,071,036
Non-Tidal, Non-Forested Wetlands	3,711	13,599	1,599,378	5,861,368
Shrublands	15	54	1,989	7,289
Submerged Aquatic Vegetation	1,533	5,618	109,850	402,576
Tidal Saltwater Wetlands & Tidal Freshwater Non-Forested Wetlands	8,161	29,907	1,930,582	7,075,155
Upland Forests	12,948	47,451	1,570,473	5,755,437

Note: 1) Habitat improvement and protection annually sequestered carbon totals should be reported separately to avoid double counting of carbon benefits because certain projects are included in both project types.

Carbon Co-Benefits by State

Table 5 summarizes annually sequestered carbon by state for all eligible Coastal Program habitat improvement projects completed between 2010 and 2020. The table also provides carbon dioxide equivalents.

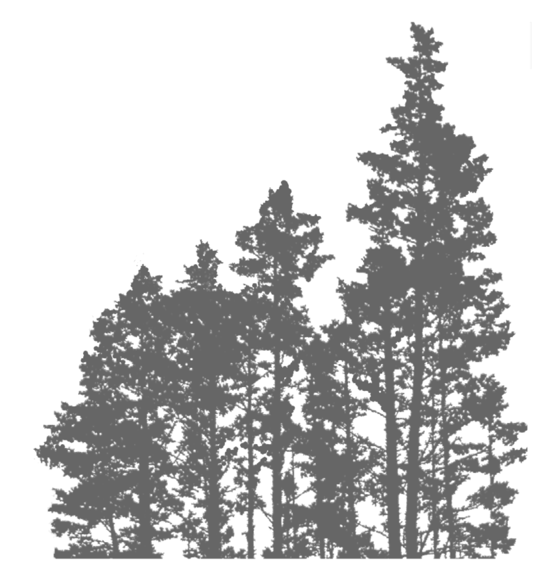
Table 5. Habitat Improvement Carbon Co-Benefits by State

State	Annually Sequestered Carbon (MTC/yr)	Carbon Dioxide Equivalent (MTC/yr)
Alabama	3	9
California	2,360	8,648
Connecticut	18	65
Delaware	206	754
Florida	957	3,506
Georgia	4	15
Indiana	1	4
Louisiana	201	738
Maine	41	151
Maryland	4	14
Massachusetts	23	84
Michigan	119	435
Mississippi	20	73
New Jersey	27	99
New York	1	4
North Carolina	13,279	48,664

Table 5. (continued)

State	Annually Sequestered Carbon (MTC/yr)	Carbon Dioxide Equivalent (MTC/yr)
Oregon	312	1,144
Pennsylvania	2	8
Puerto Rico	651	2,386
Rhode Island	23	84
South Carolina	281	1,031
Texas	6,218	22,789
Virginia	2,326	8,524
Virgin Islands	2	7
Washington	1,689	6,189
Wisconsin	485	1,778

Note: 1) Habitat improvement and protection annually sequestered carbon totals should be reported separately to avoid double counting of carbon benefits because certain projects are included in both project types.
2) Total carbon stock was not calculated for improvement projects, because we could not determine the existing state of carbon stocks or level of habitat degradation.



Results

Table 6 summarizes annually sequestered carbon and total carbon stock by state for all eligible Coastal Program habitat protection projects completed between 2010 and 2020. The table also provides carbon dioxide equivalents.

Table 6. Habitat Protection Carbon Co-Benefits by State

State	Annually Sequestered Carbon (MTC/yr)	Carbon Dioxide Equivalent (MTC/yr)	Total Carbon Stock (MTC)	Carbon Dioxide Equivalent (MTC)
Alaska	2,023	7,414	1,659,452	6,081,525
California	1,771	6,490	234,260	858,510
Delaware	17	62	2,163	7,928
Florida	1,516	5,556	109,296	400,546
Maine	9,330	34,191	1,656,032	6,068,993
Maryland	3,249	11,905	695,168	2,547,637
Massachusetts	316	1,158	81,469	298,565
Oregon	604	2,214	88,445	324,132
South Carolina	4,931	18,070	713,512	2,614,863
Texas	3,843	14,085	593,446	2,174,849
Virginia	81	297	11,774	43,151
Washington	937	3,435	248,721	911,507
Wisconsin	247	906	33,906	124,258

Note: Habitat improvement and protection annually sequestered carbon totals should be reported separately to avoid double counting of carbon benefits because certain projects are included in both project types.

Discussion

Study Discussion

The Coastal Program is a voluntary program that works with local communities to protect and restore natural habitats that are important to fish, wildlife, and people. Building trust and relevancy with communities is fundamental to our approach to conservation and the success of our conservation projects.

Often it is easy for us and other conservation practitioners to talk about the wildlife benefits of our work; however, there are many other benefits that can be derived from habitat conservation projects. Awareness and effective communication of these co-benefits can allow us to better connect with conservation practitioners, decision makers, and local communities.

By evaluating and raising awareness of these benefits, decision makers can make more informed land use decisions and practitioners can more successfully advocate for conservation projects. By highlighting the importance of these benefits, we can engage a broader audience and tell a more comprehensive conservation story. Understanding the value of these benefits can create an incentive for the improvement and protection of natural habitats as well as encourage practitioners to incorporate conservation techniques that maximize these benefits.

In this study, the Coastal Program evaluated carbon co-benefits associated with our habitat conservation (e.g., improvement and protection) projects completed between 2010 and 2020. We chose to focus on carbon because CO_2 is the greenhouse gas predominantly responsible for global temperature change.[5] Furthermore, conservation projects can make important contributions toward mitigating climate change by sequestrating and storing CO_2.

The following discussion presents background study information and considerations when communicating carbon co-benefits.

Study Background

Due the diverse nature of the Coastal Program's conservation portfolio, our projects represent a wide range of conservation treatments (e.g., actions), habitats, and geographies. As noted before, we established study conditions to make it feasible to use a large and diverse dataset that was not designed specifically to evaluate carbon co-benefits. A detailed description of the study methods are provided in the *Coastal Program Carbon Study – Data & Methods*.

We were conservative in the inclusion of certain project types, treatments, habitats, and geographies as to not overstate or misrepresent our carbon co-benefits. We excluded 1,259 improvement and 584 protection projects for a variety of reasons, including projects with highly variable habitats or vegetation condition that would make it difficult to use a uniform carbon sequestration stock and/or rate. We included 550 improvement and 255 protection projects in the carbon study.

5. https://climate.nasa.gov/ask-nasa-climate/3143/steamy-relationships-how-atmospheric-water-vapor-amplifies-earths-greenhouse-effect/

Carbon Study
Discussion

Coastal prairies store most of their sequestered carbon in their roots and surrounding soil.

Communicating Carbon Co-Benefits

An important part of this study is to help conservation practitioners, land managers, and others to effective communicate carbon co-benefits delivered by habitat conservation projects.

The following is a summary of important considerations when presenting the results of this study.

- **For habitat improvement projects, we only calculated annually sequestered carbon. We did not calculate total carbon stock for improvement projects, because we could not determine the existing state of carbon stocks or level of habitat degradation.**
- **For habitat protection projects, we calculated annually sequestered carbon and total carbon stock.**
- **Carbon co-benefits for habitat protection and improvement projects cannot be combined, because certain projects may occur on the same site and can result in double counting of carbon co-benefits.**

We converted certain study results into everyday equivalents and created infographics, on the following pages, as examples of how to make the results more accessible. A description of how to convert study results to everyday equivalents is provided in Converting to Everyday Equivalent. For some of the annually sequestered carbon results, we extended estimates over 50 years to illustrate the long-term benefits provided by these projects.

In our infographics, we use term "annually sequestered carbon" to refer to the amount of CO_2 removed over a period of one year. We also use the term "maintain carbon stock" to refer to the preservation of stored carbon in plants, soil, or other carbon reservoirs.

Oregon Islands National Wildlife Refuge, Oregon / Peter Pearsall, USFWS

Carbon Study
Discussion

Communicating Carbon Co-Benefits by Project Type

The following infographics are examples of how to communicate the carbon co-benefits associated with the improvement and protection projects evaluated in the study (Table 2).

A carbon evaluation of Coastal Program conservation projects completed between 2010 and 2020, estimates that:

- **Selected habitat improvement projects will annually sequester:**

More than **98,000** MT of CO_2

The equivalent CO_2 emissions from **11,102,172** gallons of gasoline consumed

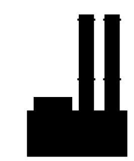
- **Over 50 years, selected habitat improvement projects will sequester:**

More than **4,933,000** MT of CO_2

The equivalent CO_2 emissions from **1,174,122** gas passenger vehicles driven for one year

- **Selected habitat protection projects will annually sequester:**

More than **105,000** MT of CO_2



The equivalent CO_2 emissions from **116,579,871** pounds of coal burned

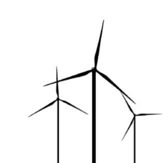
- **Over 50 years, selected habitat protection projects will sequester:**

More than **5,289,000** MT of CO_2

The equivalent CO_2 emissions from the electricity use of **1,043,837** houses for one year

- **Selected habitat protection projects will maintain:**

More than **22,456,000** MT of CO_2



The equivalent greenhouse gas emissions avoided by **5,910** wind turbines running for one year

Carbon Study
Discussion

Communicating Carbon Co-Benefits by Habitat

Tables 3 and 4 provide carbon co-benefits by habitat type for habitat improvement and protection projects, respectively. The results do not reflect habitat carbon sequestration or storage potentials, rather the number and size of projects in those habitats. Refer to carbon sequestration rates and stocks (Table 1) to evaluate habitat sequestration or storage potentials.

Conservation practitioners or land managers seeking to prioritize habitats to conserve based on carbon sequestration potentials should refer to carbon sequestration rates and stocks, such as in Table 1 or similar resource.

The following infographics are examples of how to communicate the carbon co-benefits by the habitat types evaluated in the study.

A carbon evaluation of Coastal Program conservation projects completed between 2010 and 2020, estimates that:

- Selected forest peatland improvement projects will annually sequester:

More than
49,000
MT of CO_2

The equivalent greenhouse gas emissions avoided by
17,032
tons of waste recycled instead of landfilled

- Over 50 years, selected upland forest improvement projects will sequester:

More than
267,000
MT of CO_2

The equivalent CO_2 emissions from
30,139,530
gallons of gasoline consumed

- Selected non-tidal, non-forested wetland protection projects will annually sequester:

More than
13,000
MT of CO_2

The equivalent CO_2 emissions from
897,760,888
smartphones charged

- Selected tidal saltwater and tidal freshwater non-forested wetlands protection projects will maintain:

More than
7,075,000
MT of CO_2

The equivalent CO_2 emissions from the electricity use of
1,396,326
houses for one year

Carbon Study
Discussion

Communicating Carbon Co-Benefits by State

Carbon co-benefits for habitat protection and improvement projects cannot be combined, because certain projects may occur on the same site and can result in double counting of carbon co-benefits. Tables 5 and 6 provide carbon co-benefits by state for habitat improvement and protection projects, respectively. The results reflect the number and size of projects in each states.

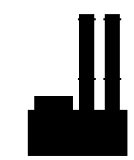
For projects that span multiple states, carbon co-benefits were divided equally among each state. Attributing the carbon co-benefits by state acres was beyond the scope of this study. There were only two projects that span two states, where the carbon results were divided equally between 1) Georgia and South Carolina and 2) North Carolina and Virginia.

The following infographics are examples of how to summarize the carbon co-benefits by state.

A carbon evaluation of Coastal Program conservation projects completed between 2010 and 2020, estimates that:

- Selected habitat improvement projects in North Carolina will annually sequester:

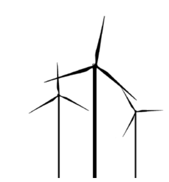
More than
48,000
MT of CO_2



The equivalent CO_2 emissions from
53,631,457
pounds of coal burned

- Over 50 years, selected habitat improvement projects in California will sequester:

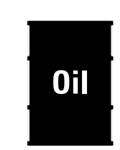
More than
432,000
MT of CO_2



The equivalent greenhouse gas emissions avoided by
114
wind turbines running for one year

- Over 50 years, selected habitat protection projects in Texas will annually sequester:

More than
704,000
MT of CO_2



The equivalent CO_2 emissions from
1,630,488
barrels of oil consumed

- Selected habitat protection projects in Alaska will maintain:

More than
6,081,000
MT of CO_2

The equivalent CO_2 emissions from the electricity use of
1,200,227
houses for one year

Future Carbon Studies

Future Carbon Studies

The following are recommendations for future Coastal Program carbon studies or studies that will use the same methods.

Recommendations

- Review the data conditions described in the *Coastal Program Carbon Study – Data & Methods* to confirm that the conditions continue to be applicable.
- Review new projects for conditions not represented in this study (e.g., new ecological classifications and treatments).
- Review and refine carbon sequestration rates and stock, so they are more representative of the habitat and geography, if applicable to the scope and scale of the study.

Monetary Equivalent

Perhaps one of the most universal equivalents is money, thus converting carbon co-benefits into a dollar amount may be more relatable to certain audiences. The social cost of carbon is an economic estimate of the impacts associated with an additional ton of CO_2 being emitted into the atmosphere. This cost can also represent the value of avoided impacts through emission reductions.[6] This cost incorporates a wide range of climate change impacts, including to agriculture, human health, infrastructure, and biodiversity, among other social sectors and ecosystem services.[7]

Calculating monetary equivalents were beyond the scope of this carbon study. When converting carbon co-benefits into a dollar amount, it will be important to discount the costs and benefits that accrue over different time periods.

6. https://news.climate.columbia.edu/2021/04/01/social-cost-of-carbon/
7. https://epa.gov/environmental-economics/working-paper-social-cost-carbon-made-simple?

Appendix A

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Carbon Sequestration Rates and Stocks from Source Literature

Habitats	Geography	Carbon Sequestration Rate	Carbon Sequestration Stock
Tidal Saltwater Wetlands & Tidal Freshwater Non-Forested Wetlands [a]	Alaska	301 gC/m^2/yr [b1]	62,741 gC/m^2 [c]
	California	103.8 ± 8 gC/m^2/yr	0.032 gC/cm^3
	Lower Mississippi	271.9 ± 18 gC/m^2/yr	0.034 gC/cm^3
	Mid-Atlantic	176.5 ± 14 gC/m^2/yr	0.045 gC/cm^3
	New England	151.3 ± 11 gC/m^2/yr	0.039 gC/cm^3
	Pacific Northwest	110.2 ± 6 gC/m^2/yr	0.037 gC/cm^3
	South Atlantic (Gulf Coast)	123.6 ± 11 gC/m^2/yr	0.034 gC/cm^3
	Texas	237.8 ± 16 gC/m^2/yr	0.039 gC/cm^3
Tidal Freshwater Forested Wetlands & Forested Wetlands [b2]	CONUS*	6.70168E-05 (TgC/yr)/km^2	1.90651E-05 PgC/km^2
	Alaska	5.72681E-05 (TgC/yr)/km^2	4.97983E-05 PgC/km^2
	Puerto Rico	0.00012 (TgC/yr)/km^2	0.00002 PgC/km^2
Upland Forests	Alaska	7.99 g/m^2/yr [c]	4.8 PgC/106km^2 [b3]
Upland Forests [d]	Northeast	0.55 tC/ha/yr	70.9 tC/ha
	Northern Lake States	0.4 tC/ha/yr	43.9 tC/ha
	South Central	0.9 tC/ha/yr	53.7 tC/ha
	Southeast	0.96 tC/ha/yr	59.5 tC/ha
	Central States	0.38 tC/ha/yr	57.7 tC/ha
	Great Plains	0.08 tC/ha/yr	11.6 tC/ha
	Rocky Mountains (North)	-0.07 tC/ha/yr	40.2 tC/ha
	Rocky Mountains (South)	-0.18 tC/ha/yr	20.1 tC/ha
	Pacific Northwest (East)	0.45 tC/ha/yr	46.1 tC/ha
	Pacific Northwest (West)	1.74 tC/ha/yr	130 tC/ha
	Pacific Southwest	0.58 tC/ha/yr	76.6 tC/ha
Grasslands [b4]	CONUS	20.56 Tg/yr/106km^2	2786.12782 Tg/106km^2
Non-Forested Peatlands [b2]	CONUS	0.000135189 (TgC/yr)/km^2	9.09027E-05 PgC/km^2
	Alaska	5.68828E-05 (TgC/yr)/km^2	7.44894E-05 PgC/km^2

Carbon Sequestration Rates and Stocks from Source Literature

Habitats	Geography	Carbon Sequestration Rate	Carbon Sequestration Stock
Non-Forested Peatlands [b2]	Puerto Rico	0.000375 (TgC/yr)/km^2	0.000125 PgC/km^2
Forested Peatlands [b2]	CONUS	0.00012003 (TgC/yr)/km^2	0.000107782 PgC/km^2
	Alaska	5.22011E-05 (TgC/yr)/km^2	6.96015E-05 PgC/km^2
Non-Tidal, Non-Forested Wetlands [b2]	CONUS	0.000101893 (TgC/yr)/km^2	1.37302E-05 PgC/km^2
	Alaska	5.6767E-05 (TgC/yr)/km^2	4.84342E-05 PgC/km^2
	Puerto Rico	0.000119048 (TgC/yr)/km^2	2.38095E-05 PgC/km^2
Mangroves	Southwest Florida and Gulf of Mexico	98 ± 12 gC/m^2/yr [e]	31.8 kgC/m^3 [d]
Shrublands [b4]	CONUS	20.56 Tg/yr/106km^2	2786.12782 Tg/106km^2
Submerged Aquatic Vegetation [b2]	Atlantic Coast	0.43 tC/ha/yr) [f] (Global)	2 kgC/m^3
	High Latitude Sub-Regions		2 kgC/m^3
	Gulf of Mexico		3.1 kgC/m^3
	Pacific Coast		1.4 kgC/m^3
Tundras [b3]	Alaska	N/A	0.729166667 (PgC/(106km^2))

* CONUS = Contiguous United States

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(Back Cover) Nanticoke River, Maryland / USFWS