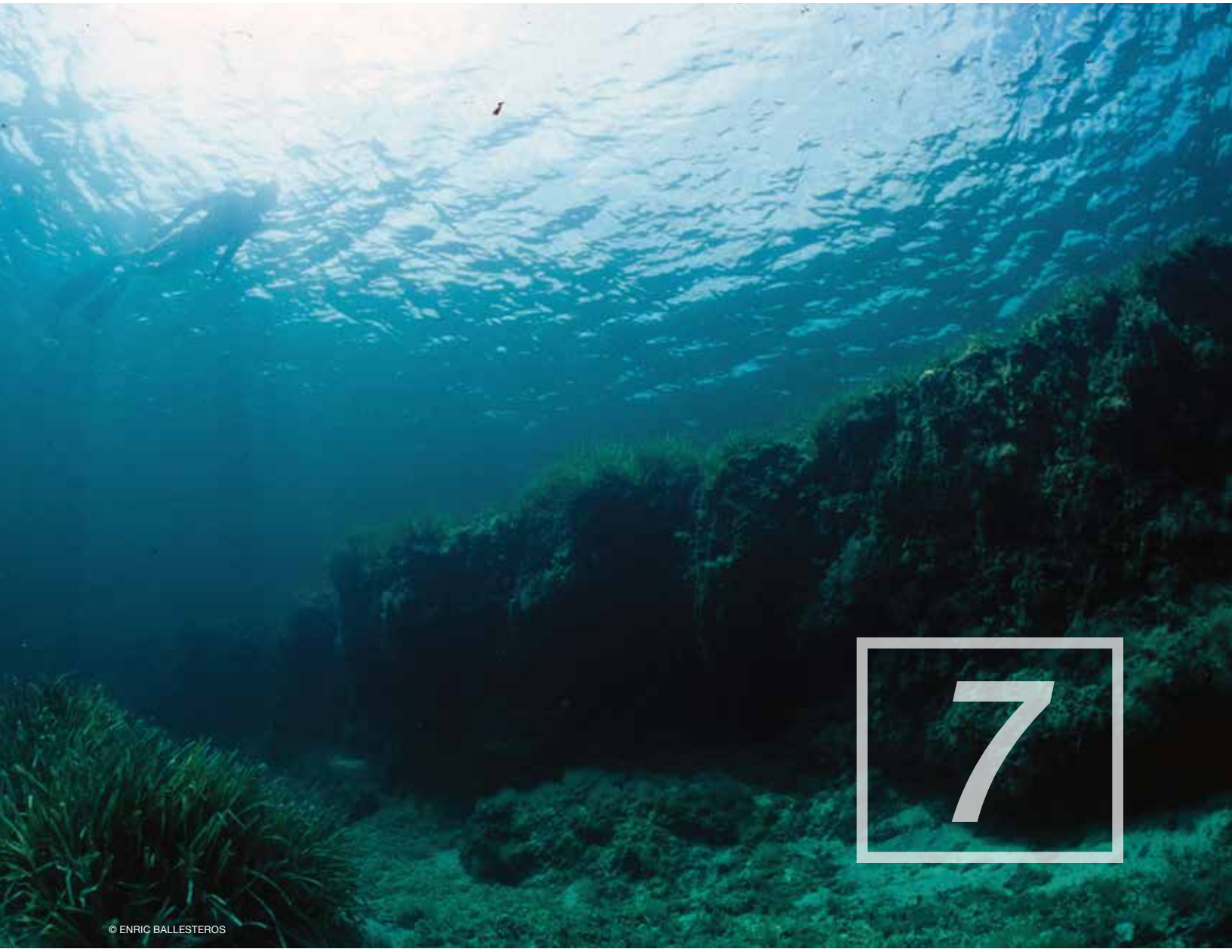

Data Management

INTRODUCTION

Effectively recording, managing, and archiving the data collected using the methods described in Chapters 2–5 is essential for accurate and reliable analysis and use. This not only includes scientific analysis of carbon in coastal ecosystems, but also using carbon values in the design and implementation of coastal conservation and management practices or the inclusion of coastal ecosystems in greenhouse gas accounting. Further, making ecosystem data widely accessible will support broader application.

Unfortunately coastal ecosystem carbon data sets are often not widely accessible, and/or the specific data in them is incomplete or of insufficient resolution to support broader use. The data that is available is often collected using different parameters, units of measurement, time scales, and more, making comparisons across studies exceedingly difficult or impossible. To alleviate this situation, a uniform structure and format of data collection and management is recommended here to allow data inter-compatibility.

REASONS TO MANAGE AND PUBLISH YOUR DATA

Management of coastal carbon data should be a priority for any project no matter the scale or scope. Effective data management is beneficial for (MITLibraries):

- **Documentation:** Effectively documenting data ensures that proper descriptions of your data are maintained to support future use. Doing so also ensures that other users can properly acknowledge the data source and authors.
- **Meet reporting requirements:** Certification and/or funding for carbon projects—including scientific research, conservation, and policy actions—now require some form of data management plan to be in place to ensure project integrity.

In addition to the direct benefits of proper data recording and management, it is strongly recommended that data is publically available for use by others. This can mean publishing data in scientific papers, giving seminars, acting as advisors to other projects or programs, and submitting your data to open access data repositories, such as the Global Costal Carbon Data Archive described below. Benefits of data dissemination include:

- **Facilitation and support for other projects or research:** Enabling other users, including researchers, to use your data prevents duplication of effort, supports projects that might not have the capacity or resources to collect data, and allows for broader and synthetic analysis and comparison.
- **Dissemination:** Enabling a data repository to house and disseminate your data alleviates the work required to respond to requests for your data and time spent creating a system (like a personalized website) to house your data yourself.
- **Increased visibility:** Making your data useable and available to other users (such as policy-makers, project developers, or scientific researchers) through broadly accessible repositories increases the visibility and relevance of your program.

Access to quality controlled data, based on transparent and standardized protocols for interoperability, will result in profound decisions across sectors with regard to blue carbon habitats. For example:

- **Blue Carbon:** Improved assessments of blue carbon to support inclusion of coastal ecosystems in national climate mitigation and adaptation strategies;
- **Ecosystem Services:** More complete assessments of the ecosystem benefits provided to coastal communities and other beneficiaries;
- **Finance:** Support for viable market-based instruments for conserving coastal ecosystems;
- **Vulnerability Assessment:** Stronger representation of coastal ecosystems in environmental impact assessments and risk assessments for development activities; and
- **Increased Capacity:** Strengthened capacity to effectively incorporate appropriate coastal management measures into national management and protection strategies.

DATA COLLECTION

The data generated through assessments of carbon in coastal ecosystems is collected as measurements in the field and the laboratory. All data should come with metadata that describes the conditions, location, and other details of how the measurements were made. See **Table 7.1** for examples.

Table 7.1 Examples of the types of data collected in a typical coastal blue carbon project

EXAMPLES	*REMOTE SENSING*	*FIELD WORK*	*LABORATORY*
Data	Hectares of mangrove habitat	Tree diameter at breast height	Carbon content of a soil sample
Associated Metadata	Satellite information (organization, type, ID), sensor used, dataset used, parameters, proxies, etc.	Date of measurement, species of the tree, location of the tree (latitude and longitude), tool used to measure diameter, description of where on the tree the measurement was taken, etc.	Date, type of tool used (make and model of the elemental analyzer, or furnace for LOI), sample ID and description, controls used, protocol used, etc.

Written Descriptive Data

To ensure that all needed data and associated metadata are recorded, it is essential to record the data during, or soon after, collection. There are several methods for recording data (written notes, audio taping, videotaping, etc.). However, written notes are the most cost effective method of data collection. Establishing a data collection plan prior to conducting field work should be a top priority. Ensure that the plan takes into account the exact variables and the extent of data collected during any field study or laboratory analysis. The compilation of field and lab notes may appear to be straight forward; however, predetermining what to write down, how to write it down, and when to write it down will ensure all needed data is collected.

What to write down: It is often helpful to have premade worksheets that are used by all personnel in the field or laboratory. This will not only keep the data organized in a similar

fashion but also will ensure that all relevant field and laboratory data and associated metadata is consistently collected. The type of information collected depends on what is being sampled and the wider project goals (**Appendices F–H**).

How to write it down: It is useful to predetermine the level of detail required for data and metadata descriptions, units of measure to use, and types of data to be recorded. If codes/shorthand is to be used, be sure to have a predetermined reference list that defines codes or abbreviations. In the field, it is productive to have a single person in each team tasked with recording measurements and taking notes so that the recorded data are consistent. This also allows the team members taking measurements to be more efficient in moving on to the next task rather than stopping to take notes. In the lab, each researcher should have a personal lab notebook and be responsible for his or her own note taking.

When to write it down: In principle, one should aim to make notes as soon as possible after a measurement is taken (e.g., record core length at the time that the core is removed) and rely on memory as little as possible. The importance of meticulous note taking cannot be overemphasized; thus, it is imperative that the amount of time needed to accurately record data be integrated into the schedule.

Photographic Data

In addition to written descriptive data, it is valuable to establish a photographic record, especially in the field. Photos of the field site, soil cores, vegetation, people involved in the study, sampling processes as they happen, etc. are all useful for establishing a record and documenting data.

Protocols are usually established so that photographic data is consistent for all sampled plots.

- For example, in mangroves, it is common practice to take four photos—one in each cardinal direction (N, S, E, W)—from the plot center (Hall 2001a, b) (**Fig. 7.1A**).
- For seagrasses and tidal salt marshes, it is sufficient to take photos looking down on the plot. The number of photos needed per plot depends on how many it requires to get a representative idea of the health of the entire plot (**Fig. 7.1B**).

Metadata such as the name and affiliation of the photographer, location (GPS coordinates if available), and date of each photograph should be recorded in the written notes as the photos are taken to assist in easy photo identification later. All photos should be stored electronically with other project data. It is important to back up photos as well as record the metadata associated with each.

Photography can be a useful and simple mechanism for monitoring changes in an ecosystem. A photo point monitoring system can be established by taking photographs at the same location with the same field-of-view at different points in time. Such photo point monitoring is an easy and inexpensive, yet effective, method of tracking vegetation and ecosystem change. With appropriate site marking and documentation, photos can be precisely replicated by different people many years apart (Hall 2001a, b).

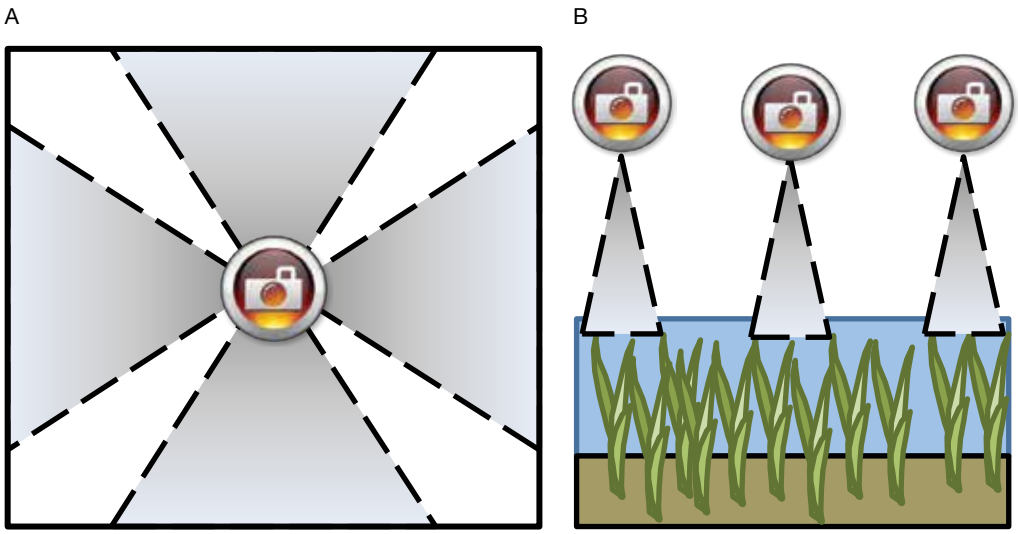

Figure 7.1 Photo point monitoring. (A) For mangrove plots, the person taking the photos stands in the center of the plot and takes a photo in each direction. (B) For seagrasses and salt marshes, photos are taken looking straight down and in various locations to get a general idea of the appearance of the site.

DATA QUALITY ASSURANCE AND QUALITY CONTROL

At the end of every day of field research, all data records should be collected by a data reviewer. The data reviewer should immediately review all the data for completeness, legibility, and accuracy in the presence of the person who recorded the data in case there are any inconsistencies or questions. Once satisfied by the quality of data recorded, the reviewer should write his or her name and the date of the review, along with any notes on issues that were noticed during the review so that they can be prevented in the future (**Fig. 7.2**).

Laboratory data should be recorded in notebooks which should stay in the lab at all times to prevent them from being lost or damaged. Upon completion of a study, photocopies of the relevant pages should be made and stored in the lab for future reference. Regular lab meetings can serve as venues to discuss results and address any issues.

Once the field and laboratory data have been vetted by the data reviewer, it needs to be entered into a computer to aid in analysis and for uploading to a database (see next section). Once the person entering data has checked the computer entry against the data sheet and corrected any errors, he or she should write his or her name at the bottom of the data sheet and the date of data entry (**Fig 7.2**). Any issues should be noted so that they can be corrected in the future. In addition, a subsample of data sheets (~ 10%) should be compared to the computer entry by someone other than the person who entered the data. The data entry reviewer should also write his or her name and the date of the data review along with any notes on issues that were apparent or corrections that were made (**Fig. 7.2**). It is important that the field supervisor be made aware of all issues noted on the data sheets so that preventative measures can be taken.

The procedure for data quality assurance and quality control is as follows:

- Collect field data using a predetermined worksheet (**Appendices F–H**)
  - Each day submit worksheets to data reviewer
  - Data reviewer checks and signs off on each worksheet
- Collect laboratory data and record it in a lab notebook
  - Review data each week at a lab meeting
- Enter data into a computer
  - Data reviewer enters all data into a predetermined program (e.g., Excel spreadsheet)
  - A different person reviews what has been entered to ensure that the data is accurate and understandable

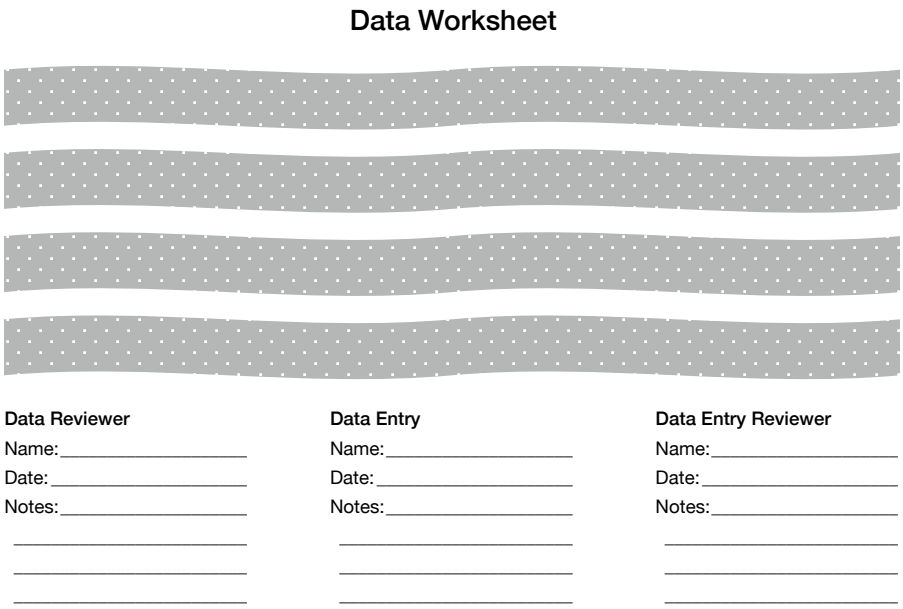

Figure 7.2 Example of a data sheet with a method for recording who was responsible, quality control, and quality assurance for each step in data recording.

REPORTING

Reporting may be as simple as presenting the total carbon stock for an ecosystem of a certain area with all of the components combined into a single measurement. Reporting can be more specific by breaking down the portion of the total carbon stock that can be contributed to each specific pool (soil, trees, shrubs, grasses, litter, etc.). Partitioning ecosystem pools allows for clearer interpretation and more accurate determination of shifts in carbon stocks through time that may occur due to changes in land management, land use, or climate change. It also facilitates reporting of statistical analyses, which can test for changes in the pool size of individual components as well as changes in total ecosystem stocks through time.

Graphical displays are useful tools for illustrating the different carbon pools (e.g., bar or pie charts). Photos accompanying carbon stock results may assist in interpreting how plant composition and structure relates to ecosystem carbon pools. Graphical data are valuable for rapid interpretation of the size of individual carbon pools and how they compare to other structural components of the ecosystem. They are also valuable for comparing structural

differences between like ecosystems (i.e., tidal marshes in different locations) or between different ecosystems (i.e., mangroves and other forest types).

DATA SHARING AND ACCESSIBILITY (DATABASES)

Open access to high quality data is viewed by many as a public good. Sharing data encourages scientific inquiry and debate, promotes innovation, leads to new collaborations between data users and data creators, reduces the cost of duplicating data collection, provides credit to the researcher that collected the data, and provides resources for project development, policy, education, and training. One of the most efficient ways to share data is through an open access database.

Uploading Data

Recognizing that the value of data often depends on its timeliness, if you choose to upload your data to a database or repository, it is best to do it as soon as possible after the study is complete and the results have been published or used for their project purpose. Hence, data from small studies can be analyzed and submitted relatively quickly. However, data from large studies that are collected over several time periods could be released as it becomes available or as specific analyses and results are finalized and published.

Criteria for Selecting a Database

In general a database is considered useful and reputable if it meets the following criteria:

- Provides common data and metadata standards and formats;
- Allows for data submission by any group in the world in generic format;
- Is well recognized and referenced by the scientific community; and
- Addresses data ownership issues by assigning a digital object identifier (DOI) number to each submission in order for it to become instantly citable;

Currently, there is no coordinated data infrastructure to support blue carbon research and monitoring efforts globally. Local datasets do exist, but many are difficult to access, subject to license restrictions, and/or being developed using incompatible approaches. The International Blue Carbon Scientific Working Group has identified management of coastal carbon data as a priority activity necessary for supporting the conservation, effective management, and creation of incentives for blue carbon coastal ecosystems through research, policy development, and field implementation. As a unifying community initiative, they have decided to establish a Global Costal Carbon Data Archive (hereafter referred to as Data Archive, see next section) to support better data management practices and standardization, and to bring all the available carbon data for coastal ecosystems together in a common format.

International Blue Carbon Initiative's Global Costal Carbon Data Archive

Blue carbon has considerable and growing support within multiple sectors throughout the international community. However, the degree to which our general understanding of blue carbon ecosystem spatial distributions and carbon stock levels has limited our ability to incorporate blue carbon issues into local and national policy. Carbon stock and flux data for coastal ecosystems are extremely patchy globally, and those that are available have not yet been integrated. In addition, considerable field work is being done around the world to collect these data, but there are limited pathways for sharing it. The International Blue Carbon Initiative hopes to improve on these issues by creating a blue carbon data archive. The archive will also increase the accuracy of and confidence in global estimates of carbon storage and emissions of blue carbon ecosystems. This data archive will serve as a central foundation upon which the coastal blue carbon science community can continue to grow. The archive will be sub-divided into three categories, one for each of the blue carbon coastal ecosystems (mangroves, tidal salt marshes and seagrasses), and each will be tailored to accommodate ecosystem-specific needs. The entire collection as well as pre-determined sub-collections of the full dataset and links to metadata will be permanently stored at the data archive and will be freely available to the public. A DOI number will be assigned to each data set upon submission making each individual data set citable, thus resolving data ownership issues.

The data archive aims to:

- Increase cost-efficiency of projects by designing them based on known spatial, temporal and process-related data coverage;
- Create a platform for modeling studies based on maximized input quality and quantity;
- Allow for the possibility of web-based visualization of data (i.e., mapping); and
- Provide a strong base for more accurate predictions, which in turn will strengthen policy recommendations at the community to national level.

Development plans for the data archive are already underway. The Initiative hopes to have the database fully functional by 2015.

Appendices

A

APPENDIX A
Additional Guidance Documents

This table provides a list of guidance documents for measuring blue carbon and for obtaining carbon credits. The documents listed either refer to the need, or attempts to provide, internationally accepted measurement and monitoring procedures for greenhouse gas accounting. This manual is meant to compliment the currently available methodologies and result in data that meet the criteria for relevant standards.

TITLE	ORGANIZATION[2]	DATE RELEASED	CATEGORY	GOAL OF THE DOCUMENT
Greenhouse Gas Offset Methodology Criteria for Tidal Wetland Conservation	Restore America's Estuaries	2015 (expected)	Carbon accreditation	Outlines the Verified Carbon Standard (VCS)-approved procedures to estimate net GHG emission reductions and removals resulting from conservation of tidal wetlands. The conservation activities intend to protect environmental benefits, including emission reductions and the net sequestration of GHGs.
Methodology for Tidal Wetlands and Seagrass Restoration	Restore America's Estuaries	2014 (expected)	Carbon accreditation	Outlines the VCS-approved procedures to estimate net GHG emission reductions and removals resulting from restoration of tidal wetlands and seagrass beds along the entire salinity range. The restoration activities intend to protect and re-establish environmental benefits, including emission reductions and the net sequestration of GHGs.
2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands	Intergovernmental Panel on Climate Change (IPCC)	2014	Carbon accreditation	Updates default data for estimation of carbon stock changes in mangroves, living biomass and dead wood pools for coastal wetlands, CO_2 emissions and removals from organic and mineral soils (for extraction, drainage and rewetting, and revegetation activities), and default data for the estimation of anthropogenic CO_2 emissions and removals from wetland soil. It addresses N_2O emissions from aquaculture and CH_4 emissions from rewetting and revegetation of mangroves and tidal salt marshes.
Methodology for Coastal Wetland Creation (VM0024)	Louisiana Coastal Protection and Restoration Authority	2014	Carbon accreditation	This methodology quantifies the greenhouse gas benefits of wetland creation activities. The scope of this methodology includes two primary project activities—substrate establishment and vegetation establishment—typically implemented in combination in order to create new wetlands (e.g., to restore wetlands that have degraded to open water). The methodology also allows for implementation of either project activity individually.

2 Only the lead organization is listed

TITLE	ORGANI-ZATION[2]	DATE RELEASED	CATEGORY	GOAL OF THE DOCUMENT
Restoration of Degraded Deltaic Wetlands of the Mississippi Delta	Tierra Resources LLC	2013	Carbon accreditation	Details procedures for GHG emission reduction accounting from wetland restoration activities implemented on degraded wetlands of the Mississippi Delta. The modular format provides flexibility for numerous types of wetland restoration projects (including those that require hydrologic management), and allows the user to decide whether wetland loss will be included in the baseline.
Afforestation and Reforestation of Degraded Mangrove Habitats (AR-AM0014	Clean Development Mechanism (CDM)	2013	Carbon accreditation	Outlines CDM-approved procedures to estimate net GHG emission reductions and removals resulting from afforestation or reforestation of mangroves. Project activities applying this methodology may choose to exclude or include accounting of any of the carbon pools of dead wood and soil organic carbon, but cannot include the litter carbon pool.
Simplified Baseline and Monitoring Methodology for Small Scale CDM Afforestation and Reforestation Project Activities Implemented on Wetlands (AR-AMS000)	CDM	2013	Carbon accreditation	Outlines CDM-approved procedures to estimate net GHG emission reductions and removals resulting from afforestation or reforestation of wetlands following the simplified modalities for small-scale projects under the CDM.
REDD+ Methodology Modules (VM0007)	Avoided Deforestation Partners	2010–2015	Carbon accreditation	Intends to cover the entire range of project activities eligible under three VCS project categories (reducing emissions from deforestation and forest degradation (REDD), reforestation and revegetation activities (ARR), wetlands restoration or conservation (WRC)), or combinations of these, providing maximum flexibility in the use of accounting procedures in complex settings where conservation and rehabilitation are combined, as well as in single category interventions. Under the WRC banner, peatland conservation and rewetting procedures are included in 2014, while coastal wetlands will be added in 2015.

TITLE	ORGANI-ZATION[2]	DATE RELEASED	CATEGORY	GOAL OF THE DOCUMENT
Guiding Principles for Delivering Coastal Wetland Carbon Projects (working title)	United Nations Environment Programme (UNEP), Center for International Forestry Research (CIFOR)	Expected 2014	Guidance on blue carbon measurement and project design	Draws together experience in carbon project and coastal wetland project development to demonstrate best practice principles in enacting blue carbon interventions. These interventions may range from policy activities leading to improved management of coastal resources recognizing climate change mitigation along with other ecosystem service, through to projects supported by carbon finance. The guidance is based upon experience developed by the project team supplemented by field missions and interviews.
Blue Carbon Practice Manual (working title)	RAE, Silvestrum	Expected 2014	Guidance on blue carbon measurement and project design	Provides detailed guidance on how to apply RAE's Methodology for tidal wetlands and seagrass restoration and develop a blue carbon project under the VCS standard.
Building Blue Carbon Projects: An Introductory Guide	Abu Dhabi Global Environmental Data Initiative (AGEDI)	2014	Guidance on blue carbon measurement and project design	Aims to stimulate discussion regarding projects that support the conservation and restoration of coastal ecosystems based on a Blue Carbon approach. It serves as a snapshot of potential common blue carbon project elements based on existing projects and an introduction of key issues for consideration. The guide is intended to complement existing blue carbon reports and initiatives and potentially stimulate support for further project development.
Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests	CIFOR	2012	Guidance on blue carbon measurement and project design	Describes the approaches necessary for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests. Because of their value as carbon stocks and sinks and their numerous other benefits, mangroves could be excellent candidates for carbon mitigation programs including REDD+ and Enhancing Forest Carbon Stocks in Developing Countries.

APPENDIX B
Equations

Chapter 1

Total Carbon (MgC/ha) * Area (ha) = Tier 1 total carbon stock for the project site (Mg)

- Where Total Carbon = the mean carbon stock for a given ecosystem (from **Table 1.2**)
- Area = the area of the ecosystem being investigated

Total potential CO_2 emissions per hectare (Mg CO_2/ha) = Conversion factor for the CO_2 that can be produced from the carbon present in the system * carbon in the system

- Conversion factor = 3.67, the ratio of the molecular weights of CO_2 (44) and carbon (12)
- Carbon in the system = the mean carbon stock for a given ecosystem

Chapter 3

Compaction correction factor = length of the sample recovered (cm) / length of core penetration (cm)

Corrected sampling of a compressed core = depth interval * compaction correction factor

Dry bulk density (g/cm^3) = Mass of dry soil (g) / Original volume sampled (cm^3)

Pre-dried volume of soil sample = [π * (radius of core barrel)^2] * (height of the sample, h)

% Loss on Ignition (% LOI) = [(dry mass before combustion (mg) – dry mass after combustion (mg)) / dry mass before combustion (mg)] * 100

% Inorganic Carbon (% IOC) = [((dry mass before acid treatment (g) – dry mass after acid treatment (g)) * 0.12) / dry mass before acid treatment (g)] * 100

- Where 0.12 is derived from the contribution of carbon to carbonate's molecular weight (12%)

Organic carbon content of a sample = Total carbon content (elemental analyzer or LOI %) – (Inorganic carbon content of ashed subsample * (Weight of subsample after ashing/Dry weight before ashing)

Soil carbon density (g/cm^3) = dry bulk density (g/cm^3) * (% C_{org}/100)

Amount carbon in core section (g/cm^2) = Soil carbon density (g/cm^3) * thickness interval (cm)

Core #1 carbon content = Amount carbon in core section A (g/cm^2) + Amount carbon in core section B (g/cm^2) + Amount carbon in core section C (g/cm^2) + …. all the samples from a single core

Total core carbon (MgC/hectare) = Summed core carbon (g/cm^2) * (1 Mg/1 000 000 g) * (100 000 000 cm^2/1 hectare)

Average carbon in a core = Carbon content for core #1 (determined in step 4) + Carbon content for core #2 + Carbon content for core #3+…. n) / n

Standard Deviation between Cores $$(\sigma) = \left[\frac{(X_1 - \overline{X})^2 + (X_2 - \overline{X})^2 + \ldots (X_n - \overline{X})^2}{(N-1)} \right]^{1/2}$$

- $\overline{X}$ = average carbon in a core
- X_1 = individual result for core #1, in MgC/hectare; X_2 = individual result for core #2, in MgC/hectare, etc.,
- N = total number of results

Total organic carbon in a project area (MgC) = (average core carbon from Statum A (MgC/hectare) * area Statum A (hectares)) + (average core carbon from Statum B (MgC/hectare) * area Statum B (hectares) + …

Standard Deviation between Strata $$(\sigma_T) = \sqrt{(\sigma_A)^2 + (\sigma_B)^2 + \ldots (\sigma_N)^2}$$

- Where σ_T = the total variability associated with the measurements,
- σ_A = standard deviation of the core average MgC for stratum A * area of stratum,
- σ_B = standard deviation of the core average MgC for stratum B * area of stratum, and
- σ_N = standard deviation of the core average MgC for remaining stratum * area of each individual stratum

Chapter 4

General Biomass equation for mangroves (Americas) = $0.168*\rho*(D)^{2.471}$

- ρ = wood density (g/cm^3)
- D = diameter at breast height

General Biomass equation for mangroves (Asia) = $0.251*\rho*(D)^{2.46}$

- ρ = wood density (g/cm^3)
- D = diameter at breast height

General Biomass equation for mangroves = $0.0509*\rho*(D)^2*H$

- ρ = wood density (g/cm^3)
- D = diameter at breast height
- H = height

Biomass for lianas (kg) = (Diameter 130 cm from the soil surface (cm))$^{2.657}$ * $e^{0.968}$ x ln (Diameter 130 cm from the soil surface (cm))

Biomass for pneumatophores (kg) = Average dry mass of sampled pneumatophores * number of pneumatophores in the microplot

Biomass of litter (kg) = (dry mass of subsample (g) / wet mass of the subsample (g)) * wet mass of all the litter in the sample plot (kg)

Downed wood biomass (kg/ha) = volume (m^3/ha) * average wood density (kg/m^3)

Belowground tree biomass (kgC) = 0.199 * ((wood density (g/cm^3)$^{0.899}$) * (tree diameter at breast height (cm))$^{2.22}$

Carbon content of vegetation (kg C) = biomass (kg) * carbon conversion factor

- Conversion factor mangrove trees = 0.46–0.5
- Conversion factor scrub mangrove trees = 0.46–0.5
- Conversion factor dead standing mangrove trees = 0.5
- Conversion factor lianas = 0.46
- Conversion factor palm fronds = 0.47
- Conversion factor palm trees = 0.47
- Conversion factor pneumatophores = 0.39
- Conversion factor litter (mangroves/marshes) = 0.45
- Conversion factor litter (seagrass) = 0.34
- Conversion factor downed wood = 0.5
- Conversion factor belowground tree components = 0.39
- Conversion factor marsh grass = 0.45
- Conversion factor marsh shrubs = 0.46–0.5
- Conversion factor seagrass = 0.34

Carbon in total vegetation component (kg C/m^2) = (carbon content of plant #1 + carbon content of plant #2 + ……. Plant #n) / area of the plot (m^2)

Elliptical crown area = (W1 * W2/2)^{2}*π

- W1 = Widest length of canopy
- W2 = Canopy width perpendicular to W1

Crown Volume = Elliptical crown area * crown depth

Estimating the top-diameter of a broken-topped dead tree (cm) = the measured basal diameter (cm) – [100 * tree height (m) * ((the measured basal diameter (cm) – diameter at breast height (cm) / 130)]

Dead tree volume (cm^3) = [π * (100 x tree height (m)) / 12] * [base diameter (cm)^2 + top diameter (cm)^2 + (base diameter (cm) x top diameter (cm))]

Decay Status 3 dead tree biomass (kg) = Volume of the dead tree (cm^3) * wood density (g/cm^3)

Wood density (g/cm^3) = Dry weight (g) / volume of fresh wood (cm^3)

Quadratic mean diameter (cm) = $\sqrt{(\sum}$diameter of each piece of wood^2) / number of pieces sampled

Wood volume for fine, small, and medium classes per unit of ground area (m^3/ha) = (π^2 x [number of samples x quadratic mean diameter for the size class (cm))^2 / (8 x transect length (m))]

Wood volume of large (> 7.6 cm diameter) down wood per unit of ground area (m^3/ha) = π^2 * [$\sum$diameter of each piece of wood^2 / (8 x transect length (m))]

Vegetative component carbon pool (Mg C/ha) = Carbon density (kg C/m^2) * (Mg/1000 kg) * (10 000 m^2/ha)

Total vegetative carbon in a plot (Mg C/ha) = component #1 (Mg C/ha) + component #2 (Mg C/ha) + component #3 (Mg C/ha) + …

Average vegetative carbon in a plot = Total vegetative carbon for plot #1 (Mg C/ha) + Total vegetative carbon for plot #2 (Mg C/ha) + Total vegetative carbon for plot #3 (Mg C/ha) +…. n) / n

Standard Deviation between plots $$(\sigma) = \left[\frac{(X_1 - \overline{X})^2 + (X_2 - \overline{X})^2 + \ldots (X_n - \overline{X})^2}{(N-1)} \right]^{1/2}$$

- $\overline{X}$ = average vegetative carbon in a plot
- X_1 = individual result for plot #1, in MgC/hectare; X_2 = individual result for plot #2, in MgC/hectare, etc.,
- N = number of plots

Estimate of vegetative carbon in a stratum (Mg C) = Average vegetative carbon in a plot (Mg C/ha) * area of stratum (ha)

Total carbon in a project area (MgC) = Estimate of vegetative carbon in stratum #1 (Mg C) + Estimate of vegetative carbon in stratum #2 (Mg C) + Estimate of vegetative carbon in stratum #3 (Mg C) + …

Standard Deviation between strata $$(\sigma_T) = \sqrt{(\sigma_A)^2 + (\sigma_B)^2 + \ldots (\sigma_N)^2}$$

- Where σ_T = the total variability associated with the measurements
- σ_A = standard deviation of the core average MgC for stratum A * area of stratum
- σ_B = standard deviation of the core average MgC for stratum B * area of stratum
- σ_N = standard deviation of the core average MgC for remaining stratum * area of each individual stratum

Stock-difference method = total carbon stock at T2 (sum of all carbon pools) – total carbon stock at initial measurement T1 (sum of all carbon pools)

- T1 = initial assessment
- T2 = subsequent assessments

Gain-loss method = Carbon stock at T1 – (carbon losses at T2 (land use change, natural disasters, erosion, etc.) + carbon gains at T2 (soil accretion, growth, restoration, etc.))

Soil elevation changes = vertical accretion based on the marker horizon – elevation changes based on SET measurements

Annual change in carbon stock (Mg C/year) = (total carbon stock at T2 – total carbon stock at initial measurement T1) / (T2 – T1)

Gas molecules in the static chamber (moles) = (Pressure (atmos) * Volume of the chamber (L)) / (Gas Constant (L*atmos/K*mol) * Temperature (Kelvins))

- Pressure = 1 atmos
- Gas constant = 0.0820 L*atmos/K*mol
- Temperature = 273 + temp in ºC

Gas flux of a specific GHG (µmole/minute) = µmole/mole/minute of GHG * moles of gas molecules total in the chamber

Amount of specific GHG emitted per minute per unit area (µmole/m^2/min) = Gas flux of a specific GHG (µmole/minute) / Chamber area

Specific GHG emitted over time (Mg/ha/day) = Amount of specific GHG emitted per minute per unit area (µmole/m^2/min) * (10 000 m^2/1 ha) * (1 mole/1 000 000 µmole) * (molecular weight of GHG (g)/1 mole) * (1 Mg/1 000 000 g) * (1440 min/1 day)

C

APPENDIX C
Example

I have a project area located in a salt marsh and it is comprised of 3 strata (76, 186, and 253 hectares respectively). I want to know the total amount of blue carbon found in the top one meter of soil and vegetation and the potential emissions that could be released if I convert this area to waterfront hotels.

In each stratum I took soil core samples from 3 plots, 3 cores per plot; each core was a total of 1 meter in length, using a highly aggregated sampling scheme, entire core sections were homogenized and subsamples were removed for a total of 5 subsamples. I am sending the samples to an outside lab for elemental analysis and will determine inorganic carbon content using the acidification technique.

FOR STRATUM #1, PLOT #1, CORE #1, SAMPLE A

Dry bulk density

- Volume of the sample = 125 cm^3
- Dry mass of the sample = 100 g
- 100 g /125 cm^3 = **0.8 g/cm^3**

Organic carbon content (using a subsample of sample A)

- Dry mass of subsample = 150 mg
- Elemental analyzer results = 25% C_{org}
- Organic carbon content
  - 150 mg * 0.25 = **37.5 mg**

Inorganic carbon content (using a subsample of sample A and acid technique)

- Dry mass of subsample = 150 mg
- Dry mass of subsample after acid treatment = 116 mg
- Mass of carbonate (inorganic carbon is in the form of carbonates such as calcium carbonate, $CaCO_3$)
  - 150 mg – 116 mg = 34 mg
- Mass of inorganic carbon component of carbonate (carbon makes up 12% of the molecular weight of calcium carbonate ($CaCO_3$)
  - 34 mg * 0.12 = 4.08 mg
- Percent inorganic carbon
  - (4.08 mg /150 mg)*100 = **2.72%**

Organic carbon content, correcting for inorganic carbon component

- Elemental analyzer determined organic carbon content = 37.5 mg
- Percent carbon that originated from carbonate = 2.72%
- Amount of the carbon content estimated by the elemental analyzer was carbon from carbonate
  - 37.5 mg * 0.0272 = 1.02 mg
- Actual organic carbon content
  - 37.5 mg – 1.02 mg = 36.48 mg
  - (36.48 mg /150 mg) * 100 = **24.32%**

Soil carbon density

- Dry bulk density = 0.8 g/cm^3
- Organic carbon content = 24.32%
- 0.8 g/cm^3 * (0.2432) = **0.195 g/cm^3**

Carbon content per sample

- Soil carbon density = 0.195 g/cm^3
- Sample thickness = 5 cm
- 0.195 g/cm^3 * 5 cm = **0.975 g/cm^2**

REPEAT FOR ALL SUBSAMPLES FROM CORE #1

Estimated carbon per core

- Sample A = 0.975 g/cm^2; Sample B = 0.865 g/cm^2; Sample C = 0.659 g/cm^2; Sample D = 0.510 g/cm^2; Sample E = 0.452 g/cm^2
- Total length of the core = 100 cm
- (0.975 g/cm^2 + 0.865 g/cm^2 + 0.659 g/cm^2 + 0.510 g/cm^2 + 0.453 g/cm^2) / 5 = 0.692 g/cm^2
- 0.692 g/cm^2 * 100 cm = **69.2 g/cm^2**

Convert Soil carbon density to MgC/ha

- Total carbon content in the core = 69.2 g/cm^2
- 1 Mg = 1 000 000 g
- 1 hectare = 100 000 000 cm^2
  - 69.2 g/cm^2 * (Mg/1 000 000 g)*(100 000 000 cm^2/ha) = **6920 Mg/ha (for the top meter of soil)**

REPEAT FOR ALL CORES

Average carbon stock per stratum

- Core #1 = 6920 Mg/ha
- Core #2 = 5018 Mg/ha
- Core #3 = 6111 Mg/ha
- (6920 Mg/ha + 5018 Mg/ha + 6111 Mg/ha)/3 = **6016 Mg/ha**

Standard deviation in carbon stock measurements

- Average carbon content per core = 6016 Mg/ha
- Number of cores taken per stratum = 3
- $[((6920\ Mg/ha - 6016\ Mg/ha)^2 + (5018\ Mg/ha - 6016\ Mg/ha)^2 + (6111\ Mg/ha - 6016\ Mg/ha)^2) / (3-1)]^{1/2}$ = **954 Mg/ha**

REPEAT FOR ALL STRATA

Total organic carbon in the project area

- Stratum #1 = 6016 Mg/ha; area = 76 ha
- Stratum #2 = 5342 Mg/ha; area = 186 ha
- Stratum #3 = 5826 Mg/ha; area = 253 ha
- (6016 Mg/ha * 76 ha) + (5342 Mg/ha * 186 ha) + (5826 Mg/ha * 253 ha) = **2 924 806 Mg C**

Standard deviation in carbon stock measurements

- Stratum #1 = 6016 ± 954 Mg/ha C
- Stratum #2 = 5342 ± 1265 Mg/ha C
- Stratum #3 = 5826 ± 1227 Mg/ha C
- $(954^2 + 1265^2 + 1227^2)^{1/2}$ = **2004**

THE SOIL CARBON POOL FOR MY PROJECT AREA IS:

2 924 806 ± 2004 MgC

The vegetation in all three strata consists of grasses, roots and rhizomes, and leaf litter. I spent all my funding sending soil samples to a lab for analysis by elemental analyzer. So the carbon content will be based on carbon conversion factors found in the literature. The most accurate numbers I could find are based on a study done about 600 km south with similar species.

Three plots of 20 m x 20 m were set up per strata, and each plot had six microplots of 30 cm x 30 cm.

FOR STRATUM #1, PLOT #1, MICROPLOT #1

Grass Component:

Develop an allometric equation

- 110 grass stems were collected
- The height of each stem (living portion) was measured and the biomass after heating was determined

STEM ID	HEIGHT (cm)	BIOMASS (g)
1	15	0.36
2	23	0.51
3	46	1.17
… n		

- Results were plotted with height on the x-axis and biomass on the y-axis
- Regression analysis was done to determine a relationship between height and biomass using the Microsoft Excel program
  - $Y = -0.006 (height) + 0.0002 (height)^2$
  - $R^2 = 0.91$
  - Y = biomass
- The biomass for all other stems in all the other microplots can now be found based on height alone

Carbon content of the grass

- Sum the biomass of each stem (as determined by allometric equation)
  - Stem #1 Biomass (g) + Stem #2 Biomass (g) Stem #3 Biomass (g) + …… Stem #n Biomass (g) = Biomass of the grass in the microplot
  - 0.36 g + 0.51 g + 1.17 g + ……. n = 74.8 g
- Carbon in the grass component (g/cm^2) = (Total estimated biomass * carbon conversion factor (0.45)) / area of the microplot (cm^2)
  - (74.8 g * 0.45) / (30 cm * 30 cm) = 0.0374 g/cm^2

Root and Rhizome component:

- Vegetative material was collected from a 1 meter soil core washed over a 1 mm screen, weighed and was found to be 27.8 g, dried to a constant weight and weighed again and was found to be 14.3 g
- Biomass (g) = dry mass (g) / wet mass (g)
  - 14.3 g / 27.8 g = 0.51 g

- Biomass of roots and rhizomes per core (g/cm^2) = biomass (g) / area sampled (based on core diameter)
  - Biomass = 0.51
  - Core diameter = 10 cm
  - Area = πr^2
    - 3.14 * 52 = 78.5 cm^2
  - 0.51 g / 78.5 cm^2 = 0.006 g/cm^2

Carbon content in the roots and rhizome component

- Carbon in the root and rhizome component (g/cm^2) = Biomass per core (g/cm^2) * carbon conversion factor (0.34)
  - 0.006 g/cm^2 * 0.34 = 0.002 g/cm^2

Leaf litter component:

- Biomass of leaf litter (g) = (dry mass of subsample (g) / wet mass of subsample (g)) * wet mass of all the litter in the microplot
  - Subsample wet weight = 13 g
  - Subsample dry weight = 9.8 g
  - All leaf litter in the microplot wet weight = 40.3 g
  - (9.8 g / 13 g) * 40.3 g = 30.4 g

Carbon content in the leaf litter

- Carbon in the leaf litter (g/cm^2) = (leaf litter biomass * carbon conversion factor (0.45)) / area of the microplot (cm^2)
  - (30.4 g * 0.45) / (30 cm * 30 cm) = 0.015 g/cm^2

Total vegetative carbon

- Total carbon = grass carbon component (g/cm^2) + root and rhizome carbon component (g/cm^2) + leaf litter carbon component (g/cm^2)
  - 0.0374 g/cm^2 + 0.002 g/cm^2 + 0.015 g/cm^2 = 0.054 g/cm^2

REPEAT FOR ALL MICROPLOTS

Average carbon per plot (6 microplots per plot)

- Microplot #1 = 0.054 g/cm^2
- Microplot #2 = 0.124 g/cm^2
- Microplot #3 = 0.982 g/cm^2
- Microplot #4 = 1.222 g/cm^2
- Microplot #5 = 1.450 g/cm^2
- Microplot #6 = 0.073 g/cm^2
- (0.054 g/cm^2 + 0.124 g/cm^2 +0.982 g/cm^2+ 1.222 g/cm^2+ 1.450 g/cm^2+ 0.073 g/cm^2) / 6 = 0.651 g/cm^2

Convert vegetative carbon to Mg/ha

- Total vegetative carbon = 0.651 g/cm^2
- 1 Mg = 1 000 000 g
- 1 hectare = 100 000 000 cm^2
- 0.651g/cm^2 * (Mg/1 000 000 g)*(100 000 000 cm^2/ha) = **65.1 Mg/ha**

REPEAT FOR ALL PLOTS

Average vegetative carbon per stratum

- Plot #1 = 65.1 Mg/ha
- Plot #2 = 76.9 Mg/ha
- Plot #3 = 79.3 Mg/ha
- (65.1 Mg/ha + 76.9 Mg/ha + 79.3 Mg/ha) / 3 = 73.7 Mg/ha

Standard deviation between plots in stratum #1

- Average vegetative carbon per plot = 73.7 Mg/ha
- Number of plots per stratum = 3
- $[((65.1 \text{ Mg/ha} - 73.7 \text{ Mg/ha})^2 + (76.9 \text{ Mg/ha} - 73.7 \text{ Mg/ha})^2 + (79.3 \text{ Mg/ha} - 73.7 \text{ Mg/ha})^2) / (3-1)]^{1/2}$ = **7.6 Mg/ha**

REPEAT FOR ALL STRATA

Total organic carbon in the project area

- Stratum #1 = 73.7 Mg/ha; area = 76 ha
- Stratum #2 = 85.9 Mg/ha; area = 186 ha
- Stratum #3 = 103.6 Mg/ha; area = 253 ha
- (73.7 Mg/ha * 76 ha) + (85.9 Mg/ha * 186 ha) + (103.6 Mg/ha * 253 ha) = **47 789 Mg C**

Standard deviation in carbon stock measurements

- Stratum #1 = 73.7 ± 7.6 Mg/ha C
- Stratum #2 = 85.9 ± 10.4 Mg/ha C
- Stratum #3 = 103.6 ± 18.3 Mg/ha C
- $(7.6^2 + 10.4^2 + 18.3^2)^{1/2}$ = **22.4**

THE VEGETATIVE CARBON POOL FOR MY PROJECT AREA IS:

47 789 ± 22.4 MgC

Total Carbon in the Ecosystem

- Total carbon = Soil carbon + vegetative carbon
  - Conservative estimate = (Soil carbon – standard deviation) + (vegetative carbon – standard deviation)
    - (2 924 806 MgC – 2004 MgC) + (47 789 – 22.4 MgC) = 2 970 569 MgC
  - High estimate = (Soil carbon + standard deviation) + (vegetative carbon + standard deviation)
    - (2 924 806 MgC + 2004 MgC) + (47 789 + 22.4 MgC) = 2 974 621 MgC
  - The total carbon stock for my project area is 2 972 595 ± 2026 MgC

Potential CO_2 emissions

- Potential CO_2 emissions = total carbon stock * 3.67 (conversion factor)
- 2 972 595 MgC * 3.67 = 10 909 420 ± 7435 Mg CO_2

THE TOTAL CARBON STOCK / CO_2 EMISSIONS FOR MY PROJECT AREA IS:

2 972 595 ± 2026 MgC

10 909 420 ± 7435 Mg CO_2

APPENDIX D
% LOI in Mangroves, Tidal Salt Marshes, and Seagrasses

D

% LOI IN MANGROVES

A positive, yet not particularly strong relationship (r^2 = 0.59) between the organic matter determined via % LOI and the carbon content (% C_{org}) has been found for mangrove soils (Kauffman *et al*. 2011), showing that roughly 40% of the organic matter (% LOI) was organic carbon (% C_{org}) (**Fig. D1**). In other locations a slightly different relationship may exist.

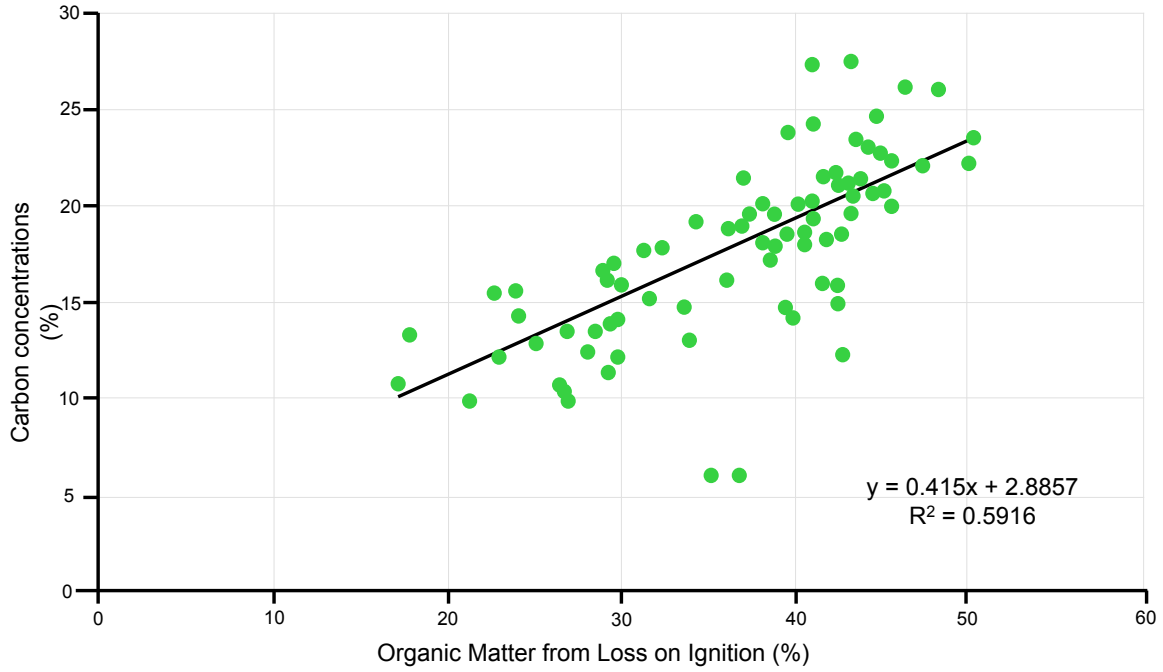

Figure D1 The relationship of organic matter calculated via loss on ignition to carbon concentration (percent) calculated via dry combustion for mangrove soil samples from the republic of Palau (Kauffman *et al*. 2011).

% LOI IN TIDAL SALT MARSHES

In tidal marshes in Maine, Craft et al. (1991) determined that in both mineral and organic rich marsh soils, pretreated for carbonate removal, and containing less than 11% clay, % LOI, as determined by heating samples for eight hours at 450 ºC, could successfully predict the organic carbon content (% C_{org}) in the soil (Craft *et al*. 1991). However, more recent studies conducted in similar tidal salt marshes in Maine reveal that there is some variability in the relationship between % C_{org} and % LOI. This new evidence shows that roughly 46% of the organic matter in marsh soils is organic carbon (**Fig. D2**). Because of the variability measured in various studies, we recommend whenever possible creating your own curve in the region of interest.

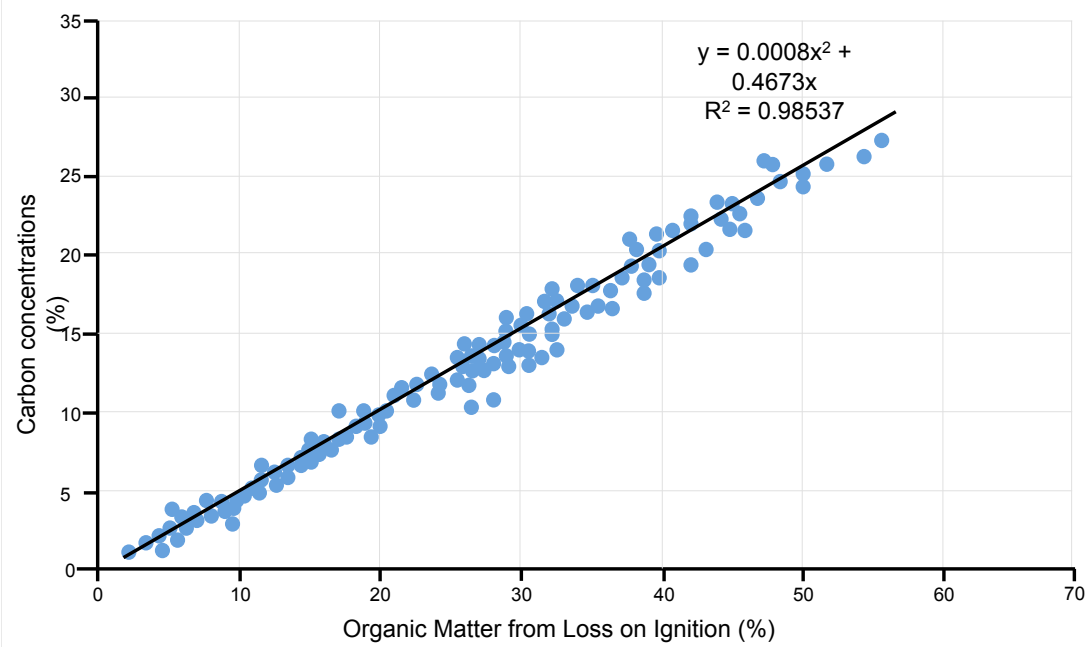

Figure D2 The relationship of organic matter (% LOI) with organic carbon (% OC) for tidal salt marsh samples in Maine (Johnson *et al*. in prep).

% LOI IN SEAGRASSES

In seagrass meadows, Fourqurean et al. reported that % LOI, as determined by heating samples for at least 3 hours at 550 ºC, was a good predictor of the % OC content in the soil (Fourqurean *et al*. 2012b). To improve the predictive capacity of the % LOI measurements two different linear equations were developed for samples with % LOI higher or lower than 0.2 % (**Fig. D3**).

For seagrass soils with % LOI < 0.20 % OC = -0.21 + 0.40 (% LOI);

For seagrass soils with % LOI > 0.20 % OC = -0.33 + 0.43 (% LOI).

Note that each of these equations has intercepts significantly different from zero (e.g., there is some losson ignition even in soils with no C_{org} content). It is likely that this loss represents the loss of water from mineral phases or oxidation of non-organic compounds. For the entire range of the data, the slope of the relationship between LOI and organic carbon was 0.43 and the intercept was -0.33 ± 0.02; indicating that samples with no organic carbon content would have a calculated LOI of 0.77% dry weight. In addition, Fourqurean et al. (2012a) observed that LOI is a less accurate proxy for organic carbon for soils with very low organic carbon contents.

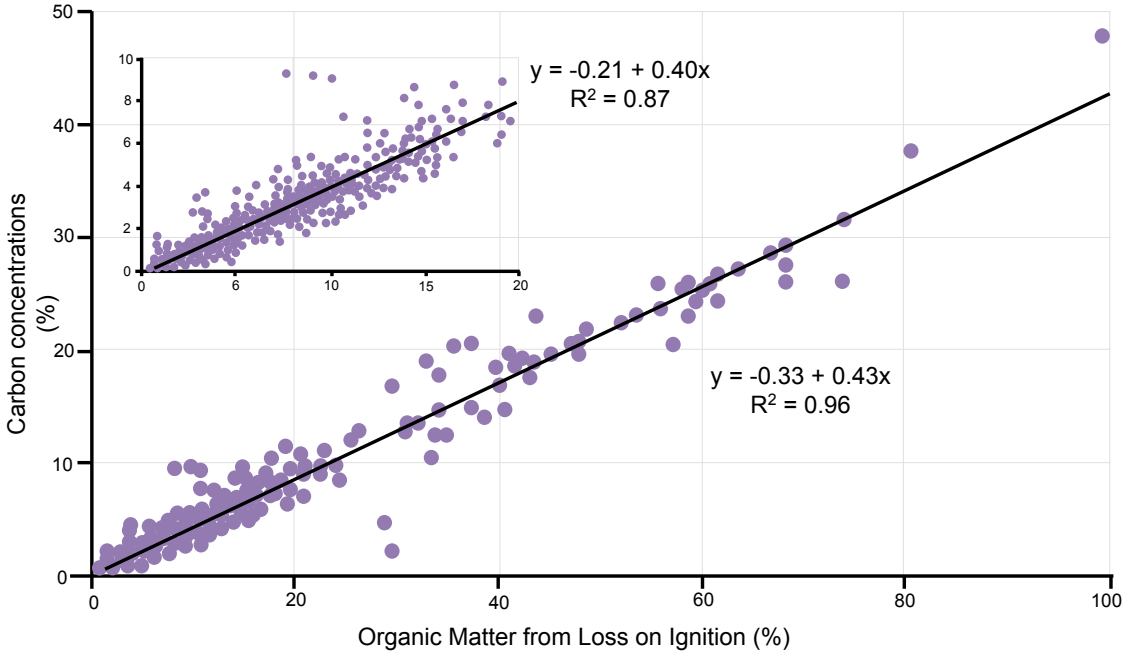

Figure D3 The relationship of organic matter (% LOI) with organic carbon (% OC) for seagrasses (Fourqurean *et al*. 2012b).

E

APPENDIX E

General Steps for Mapping Mangroves and Tidal Salt Marshes

Below is a streamlined methodology to map extent, height, and biomass of mangrove forests (Simard *et al*. 2006; Simard *et al*. 2008; Fatoyinbo & Simard 2013). However, the proposed method can be limited by current abilities to distinguish between tidal and adjacent inland ecosystems such as fresh water marshes and tropical forests.

STEP 1: IDENTIFY REGION POTENTIALLY INFLUENCED BY TIDAL INTRUSION.

A land cover map can be produced using optical instruments like Landsat and/or any other data in hand to identify the extent and geomorphology of the tidal wetlands. First, a mask of elevation should be produced to identify regions within the tidal range. Using SRTM elevation data with a threshold of about 40 meters (or expected maximum mangrove canopy height) or less than 2–5 meters for tidal salt marshes is sufficient. No tidal marshes exist above the tidal range.

STEP 2: MAP ECOSYSTEM EXTENT

Using Landsat imagery within the potential tidal range (Step-1), perform an isodata classification using any commercial or open-source software, or simply hand draw contours through visual interpretation.

STEP 3: MAP CANOPY HEIGHT

Produce a mask of mangrove or salt tidal marsh from the land cover map and crop the SRTM or TanDEM-X elevation map. Generally, both SRTM and TanDEM-X are referenced to sea level. To verify, identify any salt flat or bare ground areas within or adjacent to the mangrove or tidal flat so that elevation is within tidal range. Otherwise validate with field data as described later. Canopy height can be obtained from interferometric radar (inSAR) or Lidar data assuming ground elevation can be obtained from other datasets or assuming height is relative to mean sea level. For mangrove forest, Step-3 already provides a means of estimating canopy height. In the case of tidal salt marshes, one should use TanDEM-X relative to mean sea level and using neighborhood elevation measurement over salt flats and bare ground. Airborne Lidar may also be used to estimate ground elevation accurately.

STEP 4: MAP BIOMASS

There are several ways of estimating biomass through allometry relating biomass with a) radar backscatter, b) canopy cover from optical imagery, or c) lidar or inSAR-derived canopy height.

a) Radar backscatter (intensity of reflected microwave) can be used to estimate biomass within the wetlands. Assuming backscatter increases with biomass, it is possible to identify regions of low and high biomasses. However, radar backscatter tends to saturate at high biomass. The biomass level at which saturation occurs depends on the wavelength. At X-band, saturation can occur at very low biomass ~ 25t/ha, at C-band around 50t/ha, and L-band around 100t/ha. Other mechanisms related to flood level impact the backscatter. At microwave frequencies water acts are a mirror, enhancing reflection through the so-called double-bounce scattering mechanism. In other words, the radar pulse reflects both on the water and vertical component of the vegetation. This is just like throwing a ball to the foot of a wall to bounce on the floor (water) and then a wall (trunk). This phenomenon changes with water level and may complicate time-series analysis. However, given a single snapshot in time, a preliminary but spatially explicit map of biomass can be obtained using radar backscatter if current field estimates of biomass are available. It is recommended to use radar data obtained during low tide to maximize interaction with plants.

b) Vegetation cover is the fraction of land covered with plants. It can be derived from optical remote sensing given the spectral signature of vegetation and soil differ.

c) To obtain biomass estimates from remote sensing derived-height, allometry relating height and biomass must be available from field measurements.

APPENDIX F
Data Recording Worksheet for General Ecosystem Status

FIELD	Person/Institution (and contact information)			
	Date			
	Hour and tide information			
		Minimum	**Optimal**	**Ideal**
	Area	In hectares	% cover per area	Detailed distribution maps
	General Condition	Impacted/good/ pristine	Type of impact	Level, location, and description of impacts
	Substrate	Muddy, sandy, calcareous, etc.		Grain size per slice
	Water and sediment nutrient conditions	Oligotrophic/ eutrophic/cultural euthroficated	Mean value [N] Mean value [P]	Mean value [N] and mean value [P] with methods, time of the measurement
	Bathymetry	Position in the intertidal zone— low → high	Position relative to LAT or mean sea level (some fixed point)— method (unit)	Local bathymetry— digital elevation model with ecosystem mapped onto the bathymetry.
	Temperature	Average air temperature at a meteorological station close to the site of measurement		Water/air temperature at the site
	Salinity	Estuarine/marine	Single measurement of salinity at site	Multiple measurments of salinity at site over time

NOTES/COMMENTS

APPENDIX G
Data Recording Worksheet for Soil Samples

FIELD	Person/Institution (and contact information)	
	Date	
	Hour and tide information	
	Core ID	
	General location (area, country)	
	GPS position	
	Depth of water column (if applicable)	
	Coring device material	
	Internal diameter of the core	
	Total length of the corer (cm)	
	Coring system	
	Corer-end (cutting head/hypodermic)	
	Coring vertically (Y/N)?	
	Total length of corer outside sediment after core insertion (cm)	
	Total length of soil core (cm)	
	Sliced in X cm-slices (whole core or hemi-core?)	
	Total number of samples	

NOTES/COMMENTS
E.g., Coring issues? Sealing correct? Study site: Plant density/cover? Additional pictures of sampling site? Presence of shells, gravel, mud, plant debris, etc.
Visual description of the core (high-resolution digital picture)

CREATE A SHEET FOR EACH SAMPLE

LAB		
	Person/Institution	
	Date	
	Core ID	
	Sample ID	
	Slice depth (cm)	
	Slice thickness (cm)	
	Dry bulk density (g/cm^3)	
	Carbonate present (Y/N)?	
	Method used to determine inorganic carbon content	
	Inorganic carbon content (%)	
	Organic carbon content (corrected for inorganic portion, g)	

NOTES/COMMENTS
E.g., Any deviations from standard operating protocols? Any machinery malfunctions?

CREATE A SHEET FOR EACH CORE

LAB		
	Person/Institution	
	Date	
	Core ID	
	Corresponding sample IDs	
	Total carbon in core (MgC)	

G

FINAL CARBON ANALYSIS

Person/Institution	
Date	
Location	
Number of cores taken	
Average carbon content of the cores (MgC)	
Total area of strata (ha)	
Total soil carbon (per top X meters) of the strata (MgC/ha, in top X meters of soil)	

APPENDIX H
Data Recording Worksheet for Vegetation

FIELD		
	Person/Institution (and contact information)	
	Date	
	Hour and tide information	
	General location (area, country)	
	GPS position	
	Ecosystem (mangrove, marsh, seagrass)	
	Depth of water column (if applicable)	
	Vegetation	
	Mono or mixed	
	Dominant species	
	Ranked list of all species	
	Number of trees sampled	
	Number of shrubs sampled	
	Description of other components sampled	
	Lianas	
	Grasses	
	Pneumatophores	
	Litter	
	Deadwood	
	Other	
	Total number of samples	

NOTES/COMMENTS
E.g., Coring issues? Sealing correct? Study site: Plant density/cover? Additional pictures of sampling site? Presence of shells, gravel, mud, plant debris, etc.
Visual description of the core (high-resolution digital picture)

CREATE A SHEET FOR EACH SAMPLE

LAB		
	Person/Institution	
	Date	
	Sample ID	
	Sample type (wood, shrub, leaf litter, etc.):	
	Allometric equation used	
	Dry bulk density (g/cm^3)	
	Sample parameters (if applicable)	
	Height (m)	
	Diameter at breast height (cm)	
	Width (cm)	
	Volume (cm^3)	
	Decay status	
	Biomass (kg)	
	Organic carbon content (g)	

NOTES/COMMENTS
E.g., Any deviations from standard operating protocols? Any machinery malfunctions?

CREATE A SHEET FOR EACH PLOT

LAB		
	Person/Institution	
	Date	
	Plot ID	
	Corresponding sample IDs	
	Total carbon in plot	

FINAL CARBON ANALYSIS

Person/Institution	
Date	
Location	
Components being included	
Average vegetative carbon in plot (MgC)	
Total area of strata (ha)	
Total soil carbon in the strata (MgC/ha)	

A

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