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A GUIDE FOR INCORPORATING ECOSYSTEM SERVICE VALUATION INTO COASTAL RESTORATION PROJECTS

A process for measuring socioeconomic benefits of salt marshes, living shorelines and oyster reefs

By Elizabeth Schuster and Patty Doerr

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This guidebook is a living document. Please provide feedback to Elizabeth Schuster at eschuster@tnc.org for consideration in future editions.

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Executive Summary

The intent of this guidebook is to provide a framework to practitioners, natural resource managers and coastal restoration managers in the Mid-Atlantic region so that they can incorporate ecosystem service valuation into restoration projects at the beginning, rather than at the end. This guidebook presents numerous reasons why applying ecosystem service valuation to coastal restoration projects has multiple advantages, including greater stakeholder support and greater likelihood of project success. The goal of an ecosystem service valuation study is to quantify the *benefits to people* provided by a particular ecosystem service. Benefits can include flood risk reduction to homeowners, improvements to commercial fisheries or increased recreational opportunities. By conducting these valuation studies, managers and practitioners can improve the management and design of projects for both people and nature, and increase community support and funding for restoration projects.

For the purposes of this guidebook, restoration is defined as:
"The process of establishing or reestablishing a habitat that in time can come to closely resemble a natural condition in terms of structure and function." (Baggett et al., 2014)

Thus, the scope of the guidebook includes restoration, enhancement and creation of new coastal habitat. Although the emphasis of the guidebook (and particularly the literature review in Appendix A) is on salt marsh and oyster reef restoration, the process and framework provided will also apply to a wider range of coastal restoration decisions that improve the health of coastal habitats. And while we are not recommending that all coastal restoration projects have an accompanying ecosystem service valuation study, we would like to encourage studies for restoration projects where ecosystem service benefits can be valued over time. By doing so, we will develop a greater understanding of the performance of ecosystem service benefits and economic impacts from these types of restoration projects and continue to inform decision making into the future.

Ecosystem service valuation is not a new concept, with its popularity significantly increasing over the past two decades. However, Barbier (2013) emphasizes a notable lack of valuation studies for coastal areas, stating, "with the exception of recreational fishing, **the coastal and marine valuation literature is generally insufficient to support effective policy-making**, as most coastal habitats such as wetlands have not been well studied, key values have not been estimated, geographical coverage is incomplete, and the application of methodologies is uneven [emphasis added]" (Barbier, 2013). Thus, one motivation of this guidebook is to present a process to more effectively and efficiently value ecosystem service benefits from coastal restoration projects. Consequently, in the future these values can regularly be incorporated into coastal policy-making.

A key component of conducting more ecosystem service valuation studies is selecting biophysical and socioeconomic metrics and collecting the appropriate data. However, ecosystem service valuation is embedded in a much larger iterative process that includes the steps highlighted in Figure 1:

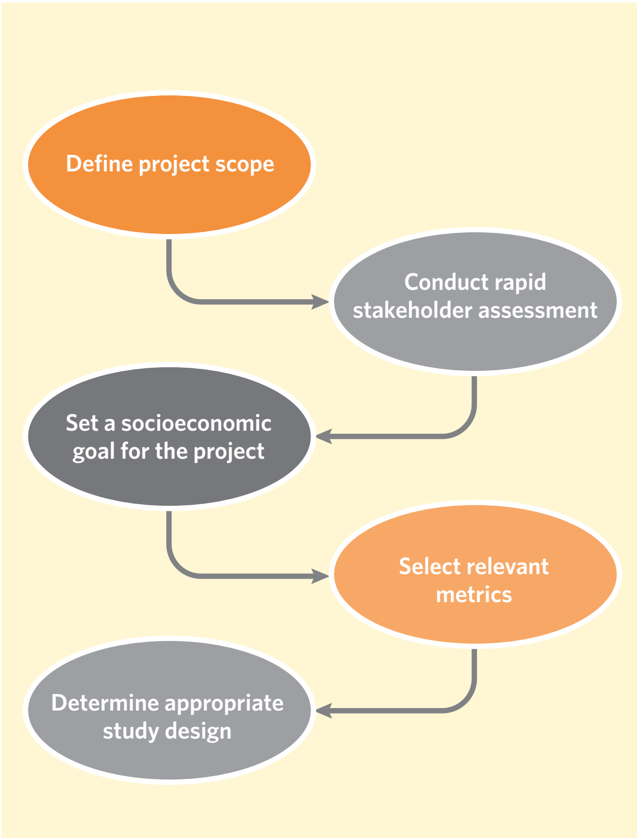


Figure 1. Overview of steps for conducting an ecosystem service valuation study for a coastal restoration project.

While this guidebook only provides guidance for the steps shown in Figure 1, important subsequent steps in the process are implementation of the monitoring plan, design and construction of the restoration project, adaptive management, and communication. Implementing the ecosystem service valuation study is another important step in the process. However, solely providing *information* to decision makers in the form of an ecosystem service valuation study will not be sufficient to successfully increase the health of coastal habitats. When the results are communicated effectively, conducting an ecosystem service valuation study can lead to an increase in awareness among local decision makers about the benefits provided by coastal habitat. A change in **awareness** is typically followed by a change in **will** before a change in **action** occurs (Coffman & Beer, 2015). For that reason, an ecosystem service valuation study will be a more effective tool at leading to changes in policy if it is accompanied by stakeholder engagement and the setting of a socioeconomic goal that is meaningful to decision makers. Changes in policy are also more likely if a restoration project is accompanied by an advocacy strategy. Following the entire process in Figure 1, as well as the subsequent steps in the process, are all important for improving the success of coastal restoration and enhancement projects and supporting healthier, natural coastlines and increased ecosystem service benefits to coastal communities.

There are two distinct ways in which this guidebook can be used. First, the guidebook can be used as a framework for conducting a full ecosystem service valuation study (i.e., putting a dollar value on the benefit(s) resulting from ecological restoration projects). By placing a dollar value on the social well-being associated with nature, those values are more likely to get a seat at the table in decision-making processes. The second use of the guidebook is to apply an ecosystem service framework to a restoration project to help ensure that a project is designed to provide relevant ecosystem services without taking the last step of valuing a particular benefit. Applying the process still can lead to greater success for restoration projects and greater likelihood of increasing ecosystem service benefits to stakeholders, which can lead to increased stakeholder support for restoration projects.

This guidebook is a living document and will be updated as new processes, metrics and methods are developed. Please submit feedback to the guidebook authors for consideration in future editions. For more detailed information on standardized biophysical metrics and developing a monitoring plan, please refer to the following document, which was developed in conjunction with this guidebook: *A Framework for Developing Monitoring Plans for Coastal Wetland Restoration and Living Shoreline Projects in New Jersey* (Yepsen, Moody, & Schuster, Forthcoming spring 2016), *a* report prepared by the New Jersey Measures and Monitoring Workgroup of the NJ Resilient Coastlines Initiative. A number of components of this guidebook were developed in conjunction with the New Jersey Measures and Monitoring Workgroup, including several steps of the methodological process for data collection, certain terminology, and the structure of the socioeconomic metrics table. We intentionally adopted the same language and methodological steps whenever possible to ensure that the two documents Are both complementary and compatible.

Introduction

Salt marshes and oyster reefs play an important role in maintaining the health of coastal systems. These coastal systems provide numerous services — often referred to as **ecosystem services** — to people, including buffering homes and roads from flooding, reducing wave energy from storms, providing nursery and feeding resources for fish, supporting nature-based tourism activities, offering aesthetic qualities in terms of an appealing view for residents and visitors, and improving water quality by allowing water to be filtered through marshes and oyster reefs. These ecosystem services provide tangible economic value to communities by reducing damage costs to homeowners, increasing revenues for fishers, and generating more money spent by tourists interested in birding, boating and hiking.[1]

While it is well documented that coastal ecosystems provide benefits to people, many data gaps exist quantifying the *change* in the level of ecosystem services resulting from ecological restoration. That change can be measured in terms of the quantity of the service (e.g., the increase in number of fish caught after a restoration project) or in terms of the **dollar value** of the service (e.g., the increase in revenues to a fisher resulting from the increase in fish caught because of the restoration project). **Ecosystem service valuation** is the term for the process of quantifying the value of the ecosystem service benefits to people provided by a given landscape or habitat type in a defined location. While it is common to value the benefit in terms of its worth in dollars, other units of measurement can be used, such as the measures of human well-being provided by the benefit (e.g., the rate and frequency of flooding is reduced for an important evacuation road to a barrier island, and the value residents place on that improvement in safety is the human well-being value). The key is that the units can allow for comparison of preferences when making decisions about the allocation of scarce resources.

Although many guidebooks describe methods for ecosystem service valuation that could be applied to coastal restoration, very few resources exist focusing specifically on ecosystem service valuation and socioeconomic metrics related to marsh and oyster reef restoration and other living shoreline enhancement projects. Thus, *a major component of this guidebook is the integrated and interdisciplinary approach to data collection and the development of goal-based socioeconomic metrics provided in Chapter Four.*[2] The selection of relevant socioeconomic metrics is part of a larger process that includes stakeholder engagement and socioeconomic goal setting. Stakeholder engagement during project planning is important to get early stakeholder buy-in for restoration projects, to better understand which ecosystem service benefits are important to stakeholders, and to ensure overlap with stakeholder goals and conservation goals.

Goal setting is desirable because clearly articulating project goals helps ensure that projects are designed and managed to meet those stated goals and then monitored to ensure the goals were met. While this may seem obvious, there are many choices project managers must make related to trade-offs from different project designs that could favor one goal over another; an oyster reef restoration project could be designed to maximize fish habitat *or* erosion reduction benefits, but one might need to make a choice about which of those two goals is more important. Further, the project team can better measure success if they have a quantifiable socioeconomic goal (e.g., reduce flood damage by 10 percent per storm to the first row of homes behind a marsh) in addition to an ecological goal.

In addition, it is worth defining the scope of restoration projects for the purposes of ecosystem service valuation. For the natural sciences, a separate monitoring plan for the biophysical data collection would typically be written

1 Refer to Appendix A for a summary of studies valuing and quantifying ecosystem service benefits from salt marsh and oyster reefs.

2 Because there is much overlap between economic and social metrics, we do not attempt to separate the two categories and will often combine them under the broader category of socioeconomic metrics.

for *each* of the different restoration techniques (though the plans might be compiled together into a single document). For an ecosystem service valuation study, it frequently makes sense to include a larger scope. For example, Figure 2 shows a coastal system that includes a living reef breakwater, open water, nature-based living shoreline, newly planted marsh, and upland habitat with some development. For many of the expected benefits, it tends to be more practical to conduct an ecosystem service valuation study for the entire system shown in Figure 2. This makes sense, because many of the potential benefits — like damage costs avoided to homeowners from reduced flooding, increase in revenues to fisherman, or increase in recreational value to birders — are likely to be supplied by the entire coastal system, not just from a single feature of that system. In some cases, depending upon the specific socioeconomic goal, it might also make sense to narrow the scope and conduct a separate ecosystem service valuation study for each restoration technique.

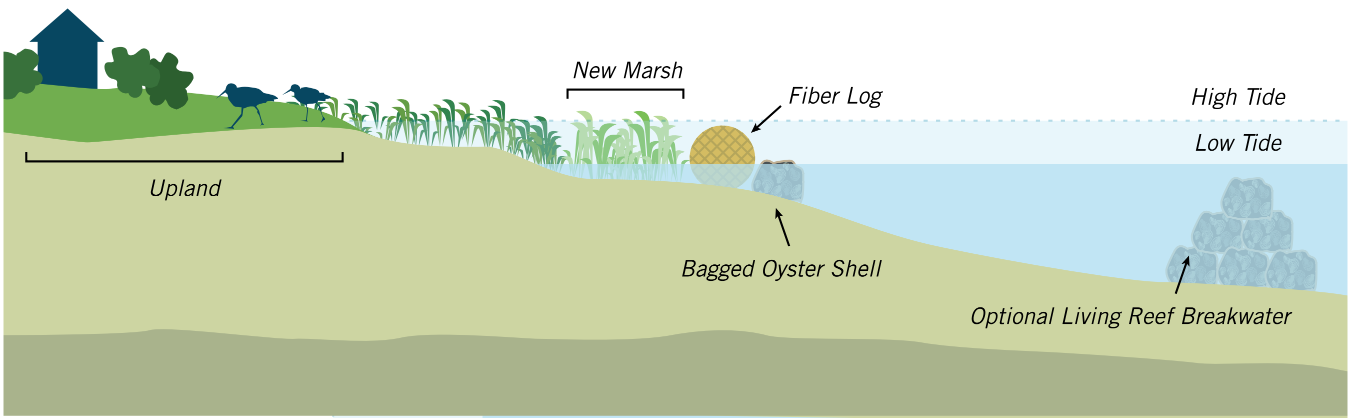


Figure 2. A shoreline demonstrating multiple restoration techniques. © Jon Ferland

Advantages of Ecosystem Service Valuation

While there are several advantages to conducting an ecosystem service valuation study, one of the primary benefits is the **incorporation of social well-being** into the development of restoration projects. Ecosystem service valuation frequently means placing a dollar value on the ecosystem service benefits provided by nature, and it can be an important step to take to ensure that values of social well-being have a seat at the table in the decision-making process. Ecosystem service valuation can mean monetizing the ecosystem service benefit by using the market price, such as by quantifying the value of fish harvested based upon the market price of fish. But it can also capture the value of change in well-being of people affected by a change in ecosystem services. For example, contingent valuation studies ask respondents about their willingness to pay for a clean bay, healthy river or other resource, and survey responses can be analyzed to estimate the social value of ecosystem services. Even though no real dollars change hands in the market, such an analysis still provides an estimate of the increase in well-being that might be associated with increase in ecosystem services. The social well-being value also might be based upon the value an ecosystem service provides to human health, cultural and historic values, aesthetic, or the value that one places on knowing that a natural resource will continue to exist for future generation. Often, those additional values to society are not captured in governmental decision making. Conducting an ecosystem service valuation study that represents social well-being in terms of a dollar value is one way to compare the differences in social well-being that could be provided by two different management options.

The ecosystem service valuation process described in this guidebook is flexible and can be applied to a range of management decisions, whether they are surrounding ecological enhancement or restoration projects, selection of nature-based solutions to flood mitigation versus traditional hardened infrastructure options (such as bulkheads and seawalls), or understanding the impact of inaction (e.g., what would happen if salt marshes in a given area are not restored and are lost to habitat degradation and sea level rise). There are several advantages to applying the ecosystem service valuation process to restoration, especially at the beginning of a coastal restoration project. These advantages include:

- **Improved site selection and project design.** By being able to measure the multiple benefits of restoration projects, project managers will learn lessons to be applied to future projects in a way that can increase the multiple ecosystem service benefits obtained. A better understanding of multiple ecosystem service benefits might also influence site selection for the current project, if it has not yet been determined;
- **Increased community support or stakeholder buy-in for project.** Engaging stakeholders early in the process can help increase the likelihood that community priorities are considered, that optimal levels of benefits to people are reached, and that greater levels of collaboration and success of restoration projects are realized. Also, more effective communication regarding trade-offs can help managers make more informed decisions when selecting among multiple management options, particularly when facing the challenge of balancing the needs of multiple stakeholder groups;
- **Better communication and coordination among an interdisciplinary project team and more efficient data collection.** The ecosystem service valuation process serves as a framework for interdisciplinary ecological restoration teams to communicate and share information. Cases where benefits are quantified without proper communication among natural scientists, economists and other informed individuals with knowledge about the project benefits can lead to a gross overestimation or underestimation of benefits. Thus, considering ecosystem service benefits during the planning phase for restoration projects is important to ensure that benefits are quantified more accurately and that all parties fully understand the assumptions and limitations associated with the study;
- **More effective adaptive management for the full life of the restoration project.** If the resulting benefits of a restoration project are not of the expected magnitude, changes in management of the site might be possible to increase the benefits. This will be made easier if relevant socioeconomic and biophysical baseline data is collected and monitored several years after the restoration project is complete;
- **The ability to leverage existing or new funding opportunities.** By linking restoration projects to socioeconomic benefits, groups have greater opportunities to leverage additional funding and support for restoration. Additional funding and support is crucial to be able to move beyond small-scale, opportunistic restoration projects and move toward more large-scale projects to truly achieve a healthier and more resilient coastline.

It will be more effective to apply an ecosystem services framework before a project begins, rather than after, to obtain the aforementioned advantages. In many cases, attempting to incorporate ecosystem service benefits into a project after a site has already been selected and restoration has begun may mean that opportunities have been missed.

How to Navigate this Guidebook

The objective of this guidebook is to outline that full process for incorporating ecosystem service valuation studies into the planning phase and design of restoration projects. Although it may still be necessary to consult with an environmental economist[3] before conducting an ecosystem service valuation study, this guidebook provides important context, frameworks, definitions, references and metrics that will be crucial for beginning to think about incorporating socioeconomics into coastal restoration projects.

3 This guidebook refers occasionally to "environmental economists," though these experts go by many titles with slightly different specializations but an overall similar focus. Other titles include resource economist, agricultural economist, and ecological economist. If seeking a potential consultant, environmental economists often can be located in colleges and universities, consulting firms or environmental groups.

There are two distinct ways in which this guidebook can be used. First, the guidebook can be used as a framework for conducting an ecosystem service valuation study. This is important because many times, residents and other stakeholders place a social value on nature. Communities may value nature because of the cultural, health, aesthetic or recreational value provided by the lands and waters near their homes. Residents may value nature because they strive to maintain the rural and historic character of their town or because they see nature as playing a key role in coastal resilience planning. These social values provided by nature are often not recognized in decision-making processes. By placing a dollar amount on the economic and social well-being value of nature, those values are more likely to get a seat at the table in decision-making processes.

The second use of the guidebook is to apply an ecosystem service framework to a restoration project but not complete the final step of conducting an ecosystem service valuation study. Instead, the ecosystem service benefits can be identified or quantified but not monetized. Applying the process still can lead to greater success for restoration projects because articulating and measuring socioeconomic goals that are relevant to a target audience can increase stakeholder buy-in for projects.

This guidebook is comprised of the Executive Summary and Introduction, five chapters and three appendices. For the convenience of the reader, in addition to the full bibliography included in the references section at the end of the guidebook, we will also include relevant hyperlinks within the guidebook, when available, to webpages, articles and other resources. Also note that the examples and citations referenced in this guidebook — particularly in the introduction, Chapter One and Appendix A — may be useful when applying for funding.

The first chapter provides an **overview** of ecosystem services terms and concepts. Then, the chapter presents additional information on Figure 1, which outlines the entire process of valuing ecosystem service benefits from coastal restoration projects.

The second chapter is focused on **stakeholder engagement**. If the reader already has a solid understanding of ecosystem services and ecosystem service valuation, then it might make sense to jump directly to Chapter Two. This chapter describes a "rapid stakeholder assessment" process for identifying expected ecosystem services that may result from a restoration project, who would benefit, how to determine which benefits are likely to be important to stakeholders, and to what extent. The chapter also explains how to identify and understand project trade-offs that may impact target stakeholders.

Chapter Three walks the reader through the process of **setting a socioeconomic goal** for a restoration project, taking into consideration multiple factors such as stakeholder priorities, conservation strategies and target audience. The chapter also defines types of restoration project goals — ecological and socioeconomic. This is important because project goals may be a combination of both types, and clearly articulating goals allows the project team to better assess whether the project succeeded at meeting its goals and allows the project team to have a shared vision that informs their restoration strategies and design. The last section of the chapter provides an overview of the difference between monetary and non-monetary metrics, presenting the identify-quantify-value scheme.

Chapter Four presents a table of **suggested socioeconomic metrics** that can be applied to salt marsh, living shoreline, and oyster reef restoration projects and guides the reader through the process of selecting metrics, including the relevant ecological metrics that would accompany the socioeconomic metrics.

Chapter Five focuses on **study design**, selection of appropriate methods and level of rigor, and budgetary and resource considerations. Chapter Five also includes an example application of how to apply the ecosystem service valuation process described in this guidebook.

Appendix A provides an overview of **existing literature** quantifying and/or valuing the ecosystem service benefits from salt marsh and oyster reef restoration, with an added emphasis on those examples relevant to the Mid-Atlantic region.

Appendix B provides two **case studies** to show how the processes in this guidebook could be applied to actual coastal restoration projects. The first is titled *Engaging private landowners in oyster reef restoration* and focuses on an example from Mobile Bay, Alabama, taking a broader look at a process that includes community engagement, social science research and non-traditional funding sources for oyster reef restoration. The second example is *Lower Cape May Meadows ecosystem restoration* from New Jersey, which takes a deeper look how the steps in the ecosystem service valuation process were used to measure ecotourism and flood reduction benefits from a coastal restoration project.

Appendix C provides a summary of ecosystem service valuation **methods and definitions** of other common environmental economic terms referred to in this guidebook.

Chapter One

THE WHAT, WHY AND HOW OF ECOSYSTEM SERVICE BENEFITS

A healthy, properly functioning ecosystem provides a range of goods and services. These services may include climate regulation, water regulation, soil formation, nutrient cycling and others. However, not all of these goods and services are relevant to stakeholders, and not all services should be quantified in an ecosystem service valuation study. **An ecosystem valuation study measures the *final benefit* only: *how that service benefits people*.**[4]

Focusing only on the final benefit is important to reduce the risk of double-counting benefits and thus overestimating the total value (Boyd & Banzhaf, 2007). The emphasis on final benefits provided to people is also fundamental because these benefits "are things we experience, make choices about, and that have real meaning for people," (Ringold, Boyd, Landers, & Weber, 2013, p. 98). Moreover, policy changes based upon ecosystem service valuation studies are more likely if one selects benefits relevant to decision makers and influential stakeholders.

As shown in Figure 3, the process of measuring the change in ecosystem service benefits starts from understanding the baseline level of benefits provided. Then a management and/or restoration action is implemented, leading to a change in ecosystem condition, which results in a change in the level of ecosystem goods and services, leading to the final *net ecosystem service benefit*. That net ecosystem service benefit is the benefit that would be quantified in an ecosystem service valuation study. In the context of salt marsh and oyster reef restoration, the net is the change in benefits resulting from a restoration project, all else being equal. One example is a large-scale oyster restoration project that provides water quality benefits to people. The result chain might look like this: measure baseline water quality of the bay -> significant oyster restoration results in greater oyster density and oyster size -> increase in water filtration services by oysters -> improvement in water clarity -> increase in property values for homes close to the bay. Many studies have shown that polluted water can negatively impact home values, whereas an improvement in water clarity provides an visual signal to home buyers that the bay is healthier and can lead to an increase in home values, all else being equal (while taking into consideration other attributes of the home and neighborhood).

Final benefits may include the value that visitors place on birding at a site or the health benefits to residents who go hiking on a trail along a salt marsh. Reducing flooding does not have an economic benefit to people if the flooding occurs where no people are located, but might be the final benefit if it improves the quality of life for proximate homeowners. Similarly, an improvement in water quality may not be the final benefit in many cases (Keeler et al., 2012). Rather, the improved water quality may improve fisheries and thus increase the benefit to recreational fishers; improved water quality could also lead to fewer beach closings and thus result in an improvement in beach experience for visitors interested in swimming.

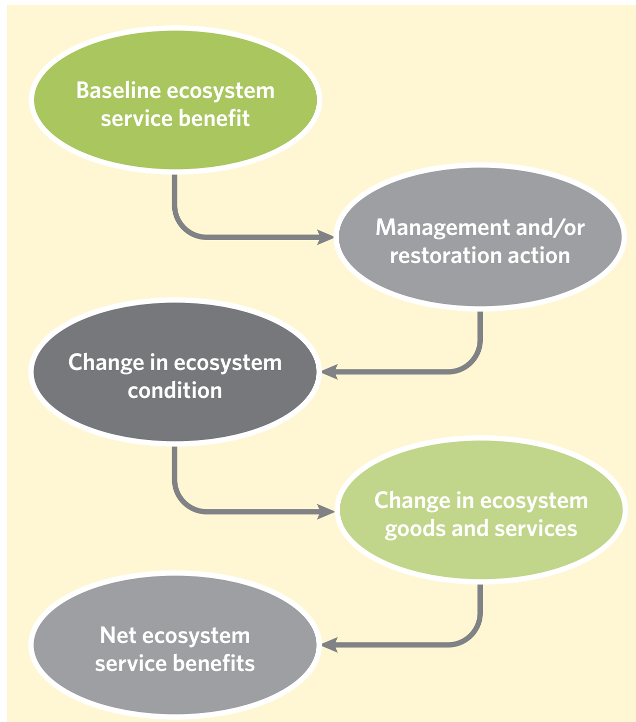


Figure 3. Sequence of steps from management action to final net ecosystem service benefits. (Adapted from Wainger and Mazzotta, 2011)

4 An additional resource on the difference between final and intermediary ecosystem services is The Environmental Protection Agency's (EPA) report titled *Final Ecosystem Goods and Services Classification System* (FEGS-CS) (Landers and Nahlik, 2013). The report gives a solid overview with definitions related to ecosystem services, metrics and recommendations on how to use FEGS-CS. The report does not cover ecosystem service valuation approaches.

This emphasis on how restoration benefits people does not mean that wildlife and habitat benefits from restoration are secondary. **Restoration projects can simultaneously have an ecological and a socioeconomic goal.** There is currently a greater recognition in the conservation field that an interdisciplinary approach is needed — one that does not overemphasize the role of either *nature for itself* or *nature for people* (Mace, 2014).

In the recent past, many studies quantifying ecosystem services came either from the natural sciences or from an economic perspective, but were conducted with little cross-disciplinary communication. This new era of conservation is more collaborative, balancing and integrating the perspectives of multiple disciplines, ideally from the beginning of a project. As practitioners, when selecting and designing projects, it is simply a matter of identifying our assumptions when making decisions and being clear on why we choose human-centric or nature-centric restoration goals, or designing projects with a combination of goals for both people and nature. However, if we do choose to include ecosystem services benefits to people in our goal-setting process, then it is important to be as consistent as possible in how we identify these benefits.

Figure 4. Framing of conservation: Changes over time and key ideas. (Adapted from Mace, 2014)

Although there is an overall consensus that a balanced approach to restoration with both ecological and socioeconomic goals is a good way to move conservation strategies forward, there are cases where an ecosystem services approach to coastal restoration may not be needed. In cases where the project is in a highly rural area and not directly affecting people, or when there are no known conflicts surrounding the resource, it might not be worth the additional resources required to apply an ecosystem services framework.

Steps for Conducting an Ecosystem Service Valuation Study for a Coastal Restoration Project

The process of linking ecosystem service valuation studies to management decisions is much broader than the data collection and analysis portion of a project. The full process includes stakeholder engagement, the setting of suitable socioeconomic goals for a project, the selection of relevant metrics and methods, and the communication of the results. The process presented in this guidebook was developed through a thorough review of existing guidebooks and frameworks, extensive research, and numerous interviews with practitioners and coastal restoration experts involved in ecosystem restoration. That research lead to the development of the following five-step process for applying an ecosystem service valuation framework to coastal restoration projects:

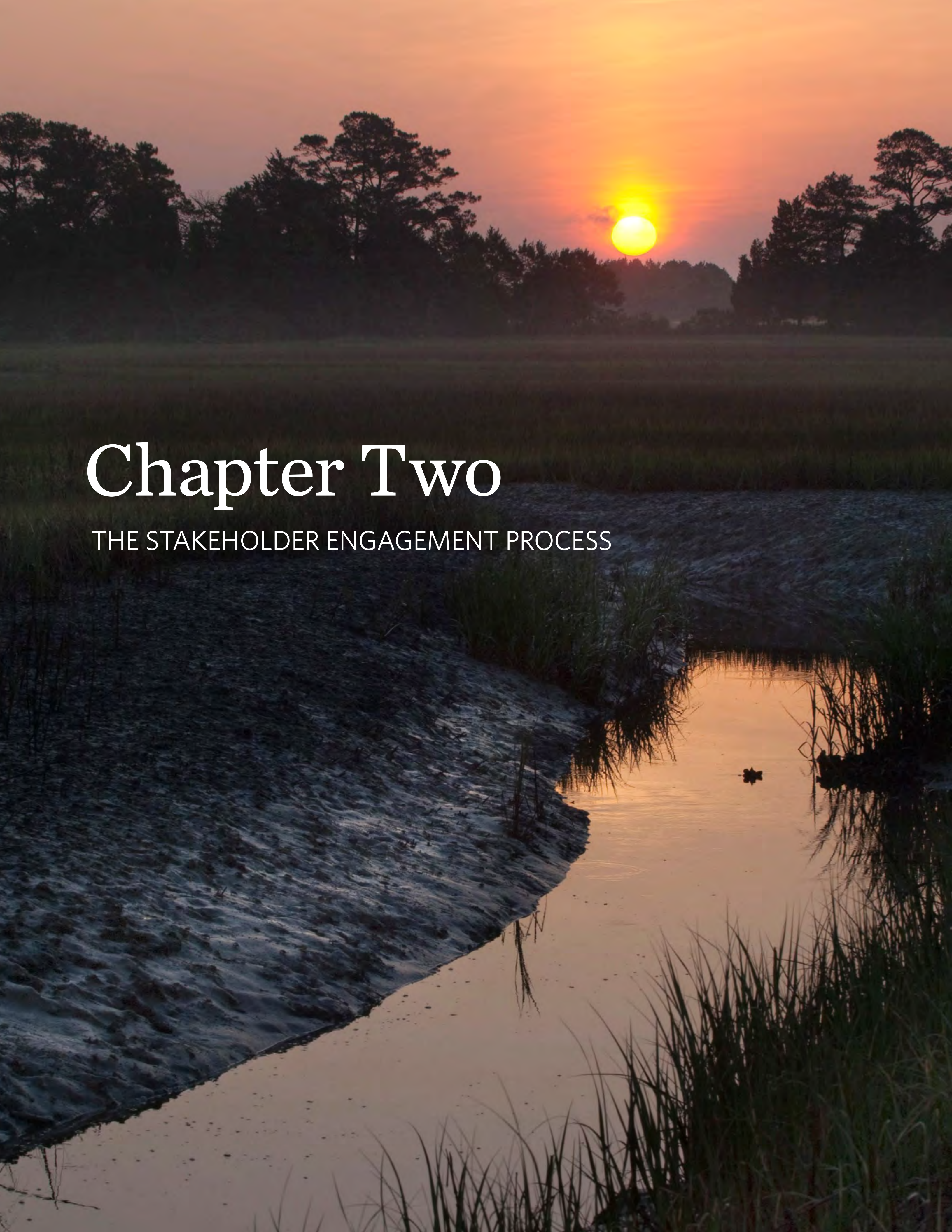
1) **Determine the full scope of project(s) to be included.** A more accurate depiction of the full benefits provided by that restoration project can be achieved by evaluating the benefits from several projects located in close proximity to each other. For instance, a wetland restoration project might be occurring in

conjunction with the construction of a boat ramp, a new trail with interpretive signage and an environmental education center. To better capture the multiple benefits provided to a diverse mix of stakeholders, consider the expected change in benefits of all these projects together before designing a study. (*Discussed further in Chapter Two*)

2) **Conduct a rapid stakeholder assessment.** This process includes identifying and engaging stakeholders, understanding the expected ecosystem services that will be provided by a project, understanding which benefits are important to influential project stakeholders, and understanding the trade-offs between management alternatives. Understanding the trade-offs will involve making predictions about the level of benefits expected from a given project and whether these benefits are expected to increase, decrease or stay the same. (*Discussed further in Chapter Two*)
3) **Set a socioeconomic goal for the project.** Based upon expected benefits of the restoration project, stakeholder priorities and target audience (see description below), set a socioeconomic goal for the project. This will become the centerpiece of your ecosystem valuation study. Categories of socioeconomic goals can include improved community resilience, enhanced cultural values, increased economic development opportunities, increased recreational opportunities or improved water quality. It is possible to have multiple goals for the project. (*Discussed further in Chapter Three*)
    a. **Clearly identify who your target audience is for your *valuation study*.** What change do you hope will occur as a result of quantifying or putting a dollar value on the ecosystem service benefits of a salt marsh or oyster reef project? Common target audiences include influential groups of stakeholders, governmental officials, non-governmental organizations and regular voters. (*Discussed further in Chapter Three*)
4) **Select relevant metrics to meet project's socioeconomic goals.** Socioeconomic metrics are used to assess whether the socioeconomic goal was met. Socioeconomic metrics may be represented with dollar value (e.g., change in damage costs to surrounding homes) or may be non-monetary (number of people benefitting from flood reduction). Meeting the socioeconomic goal will be dependent upon certain ecological changes; thus it is often necessary to choose a mix of socioeconomic and ecological metrics. Incorporate these metrics into a single monitoring plan when feasible. (*Discussed further in Chapter Four*)
5) **Determine appropriate study design to evaluate the selected metrics.** The study design and methods selected will depend upon the goals and metrics for the restoration project, the target audience, the budget/resources, timeline, level of necessary rigor and level of technical expertise.

This guidebook focuses on the five steps outlined above, though the full process continues past what is listed in Step 5. After the data collection and study are complete, communicate the results of the study to relevant stakeholders. Communication around the entire project and promotion of results is important to ensure that the results of the study are applied to decision-making processes. Create a communications plan for the project. When possible, remove technical language and jargon when presenting results to community members.

Use communication and community engagement as tools to facilitate the process of turning the results into changes in behavior. Collecting data and conducting an ecosystem service valuation study alone will not change behaviors or influence decision-making processes. Take into consideration that the target audience is likely to consider multiple criteria when making a decision, not only the value placed on a particular benefit provided by a restoration project. Decision makers will consider project costs, the regulatory environment, public perception, technical expertise, whether they've seen a similar project demonstrated in another site, expected project performance, and associated risk, among other factors. Thus, while ecosystem service valuation studies from salt marsh and oyster reef projects are an important piece of the puzzle, decision makers may need additional information to change a policy, practice or behavior.



Chapter Two

THE STAKEHOLDER ENGAGEMENT PROCESS

The motivation to restore salt marshes and oyster reefs may arise from the many potential benefits salt marshes and oyster reefs provide (see Appendix A for more information). Monitoring budgets for restoration projects are often the first budgets to be cut in times of scarcity. Given this context, coastal restoration managers might find that it is not possible to measure all of the parameters demonstrating ecosystem service benefits. Thus, a small investment of time to better understand who will benefit from a marsh or oyster reef restoration project and which ecosystem services are a priority to key stakeholders can lead to more efficient and accurate monitoring efforts. The following chapter:

- Describes the importance of stakeholder engagement for coastal restoration and provides tools for identifying and engaging stakeholders;
- Provides low-cost methods for understanding which ecosystem services matter most to decision makers and other stakeholders through a rapid stakeholder assessment process;
- Provides guidance on how to determine the full project scope;
- Helps project managers better understand the trade-offs between different management and restoration alternatives. Understanding trade-offs is important in the context of stakeholder engagement, since small changes in the design of projects or switching from one restoration technique to another can lead to disproportionate changes in the benefits provided to various stakeholder groups.

Overview of Stakeholder Engagement

Starting the stakeholder engagement process early (while in the restoration project planning phase) has several important advantages, including reducing conflict and increasing support for restoration projects. The NOAA Coastal Services Center published a report, Introduction to Stakeholder Participation (2007), which succinctly highlights a full suite of reasons why engaging communities before beginning a restoration project makes sense. Community engagement can:

- Produce better outcomes or decisions
- Garner public support for agencies and their decisions
- Bring to light important local knowledge about natural resources
- Increase public understanding of natural resource issues or management decisions
- Reduce or resolve conflicts between stakeholders
- Increase compliance with natural resource laws and regulations
- Help agencies understand flaws in existing management strategies
- Create new relationships among stakeholders

Source: NOAA Coastal Services Center, 2007

If resources are available, it is often worthwhile to conduct a more in-depth analysis of the degree of stakeholder support in the region for an upcoming restoration project. This is particularly true for restoration projects that are large in scale, have potential negative impacts on certain stakeholder groups and/or are potentially politically controversial. NOAA's Introduction to Stakeholder Participation (2007) provides valuable information on identifying and analyzing stakeholders. Chapter Three of The Nature Conservancy's guidebook on Strengthening the Social Impacts of Sustainable Landscapes Programs (Wongbusarakum, Myers Madeira, & Hartanto, 2014) is also a good reference for engaging stakeholders. Although aimed at indigenous communities in developing countries, most of the process is still relevant to the United States, particularly when working with communities that are relatively dependent upon natural resources.

Rapid Stakeholder Assessment

Once you have identified a potential upcoming restoration project, a rapid stakeholder assessment should be conducted in order to: 1) understand which stakeholder groups interact with those aspects of the natural system that may be changed by the restoration project, and how they interact with the system, which can lay the groundwork for increasing project buy-in from key stakeholders; and 2) better match conservation strategies with community needs. The intent of a rapid stakeholder assessment is to be efficient and low-cost, though we recommend that you allow for at least two to three months to conduct the analysis. **To conduct a rapid stakeholder assessment for an upcoming ecological restoration project, follow these simple steps (Table 1):**

STEP	DESCRIPTION
Convene an interdisciplinary work group.	The work group should include individuals representing a variety of specializations, such as ecology, engineering, economics, hydrology and political science.
Define the geographic boundaries, scale of interest and full scope for an ecosystem service valuation study.	Boundaries will vary depending upon biophysical aspects of the restoration project, hydrology, jurisdiction, and location of stakeholders who are benefiting or impacted by the project.
List the ecosystem service benefits that will result from the upcoming restoration, protection, or management project(s).	As discussed in Chapter One, focus on final ecosystem service benefits that affect people, not on the services themselves. As needed, consult with subject experts to determine how a restoration project may result in changes in benefits to people.
List all relevant stakeholders to the project.	Based upon the benefits identified in the previous step, list stakeholder groups who are potential beneficiaries. Also include stakeholder groups who might be impacted negatively and those who have the power to influence the success of the project.
Determine the relative importance of each ecosystem service benefit.	Get a sense of which benefits, relatively speaking, are more important or relevant for a larger number of people.
Analyze trade-offs in ecosystem service from various management alternatives.	Understand and be able to effectively communicate potential trade-offs in ecosystem service delivery (described in the following section of this chapter).
Set an socioeconomic goal for the restoration project.	Taking into consideration conservation priorities, the results from the rapid stakeholder assessment, trade-offs and target audience, a goal can be set for a restoration project (described in Chapter Three).

Table 1. Steps in a rapid stakeholder assessment.

A rapid assessment will not answer all research questions, but it can help to highlight information and data gaps, as well as to establish next steps. *Note that while the seven steps in Table 1 are listed chronologically, the process is iterative and may involve circling back to previous steps as additional information is gained.*

Begin by convening an ad hoc, **interdisciplinary work group** of individuals associated with the restoration project to discuss the steps in the rapid stakeholder assessment, the key being that the group includes representatives from a variety of disciplines (e.g., engineering, ecology, economics, etc.). The interdisciplinary work group is an important vehicle for sharing specialized knowledge about different aspect of the restoration project, and this same work group can continue to meet after the rapid stakeholder assessment is completed to set a socioeconomic goal, select relevant metrics and determine appropriate study design.

The interdisciplinary work group can work together to define and discuss **the geographic boundaries and scale of interest** for the rapid stakeholder analysis. Opt for a scale larger than that of the project to better understand a wider range of ecosystem service benefits provided across the landscape. This additional effort is worthwhile because it provides important context for how the current project fits into the larger landscape. The information collected is still relevant if the project site is moved, as well as for future projects.

Next, determine the **full scope for the ecosystem service valuation study**, which may be larger than the current ecological restoration project being planned. The scope can be narrowed, if the project team deems it desirable, when setting socioeconomic and ecological goals for the restoration project. Determining the full project scope means to account for all ecosystems impacted and all changes in service flows, whether these service flows are increasing or decreasing in magnitude. Often, multiple restoration activities will be occurring in a proximate area. One might find an oyster restoration project next to a salt marsh restoration project, adjacent to an area where renovations are taking place to a marina, or next to a site where construction of an education center or boat ramp is taking place. Because of the interconnectedness among project components, it is important to not focus only on one feature at this phase in the process.

Moreover, in many cases, complementary inputs will accompany a restoration project. In the world of economics, complementary inputs are built or manufactured materials (such a boat, boat ramp, or packaging for seafood sold by a commercial fisherman) that will increase the value of that ecosystem service benefit to people. Commercial fisherman cannot receive economic benefits from fish without additional complementary inputs, such as a fishing boat and other equipment. Visitors interested in ecotourism may not be able to achieve the full benefits associated with wildlife viewing without complementary inputs such as a wildlife viewing platforms, parking lot, trails and/or a kayak launch. Conversely, other manmade features might negatively impact ecosystem service benefits (e.g., a culvert that is installed in conjunction with a restoration project, if not designed to proper ecological standards, could impact fish passage, ultimately having a negative impact on recreational fishing). Thus, including the full project scope increases the accuracy with which one can predict expected increases or decreases in benefits to a wide range of stakeholders.

To determine the full scope for the ecosystem service valuation study occurring in the region where the restoration project will occur, one may need to contact local partners to inquire about which additional activities may be planned at or near the proposed restoration site. From our experience with Hurricane Sandy recovery efforts, the partner landscape is crowded, so the extra time spent communicating with partners working in a similar geography is worth the effort.

Next, list expected ecosystem service benefits for a project. Benefits can be identified, quantified and/or valued (refer to Chapter Three for more information on the stepwise process of identifying, quantifying and valuing benefits). *In a majority of cases, at this early phase in the process, it will be more practical to solely identify ecosystem services and describe those benefits qualitatively.* However, if resources are available, the additional rigor of also quantifying and/or valuing benefits might be useful to inform the decision-making process, particularly when selecting among many management alternatives for a given site. One example of a resource for quantifying or valuing ecosystem service benefits is the Toolkit for Ecosystem Service Site-Based Assessment (TESSA), which provides low-cost methods for measuring relative values of a suite of common ecosystem services, and also, although much less common, one might choose to model the ecosystem service benefits to inform the decision-making process.

When identifying and listing expected benefits, include benefits from the full project scope as determined in the previous step. It is advantageous to list the full suite of expected benefits that may result from the upcoming restoration project for three reasons:

1) It will lead to more effective stakeholder engagement;
2) A project leading to multiple benefits can often enable you to access additional funding (e.g., the location of an education center on your project site could make you eligible for a new funding source); and
3) It can help the project team understand the interconnectedness between project components and manage the trade-offs across a single landscape. Management and restoration alternatives implemented at one site may have an impact on other locations. Not all ecosystem service benefits will increase — some may decrease (e.g., a marina renovation could negatively impact an oyster reef). For more information on these types of trade-offs, refer to the following section in this chapter, titled Better Understanding Project Trade-offs.

When listing all relevant stakeholders to the project, include project beneficiaries, stakeholders who may be negatively impacted by the project, and stakeholders who have the ability to influence the outcome of the project or could have political influence over the restoration strategy in the long-term. For certain expected ecosystem service benefits, such as shoreline stabilization and flood reduction, one can identify potential project beneficiaries based upon physical characteristics within and surrounding the restoration site. For shoreline stabilization projects, in addition to historic images from Google Earth, one can also access historic images from Historic Aerials to view how shoreline position has changed over time. Geographic information system (GIS) applications can also be used to identify the number of homes or structures that have the potential to benefit from an upcoming shoreline stabilization project. For marsh restoration projects with potential flood reduction benefits, several approaches exist to determine beneficiaries located in the marsh-influenced zone. Approaches include defining a distance buffer surrounding the site, identifying which people or structures are located in the flood zone adjacent to the site, or using the watershed area upland of the project (Christine Shepard, personal communication, October 23, 2015).

Once you have determined relevant stakeholders for your project, the next step is to **determine the relative importance of each ecosystem service benefit**. Relative importance depends upon numerous factors, though the two principal factors are *expected magnitude of change and number of beneficiaries*. It makes both intuitive and economic sense that the larger the magnitude of change and the greater the number of beneficiaries, the greater the value of the ecosystem service benefit. Local knowledge and experience can also be utilized when assessing relative importance of ecosystem service benefits (in the context of this rapid stakeholder assessment), as certain cultural, political, social or historic aspects may influence what is important to a given community.

For those coastal restoration practitioners on a shoestring budget, the most efficient way to collect information on ecosystem service benefits, relevant stakeholders and the relative importance of each ecosystem service benefit is typically through a combination of a desktop analysis and expert and key informant interviews and/or focus groups. When conducting the desktop analysis, background research to answer the questions in the rapid stakeholder assessment can include but is not limited to the following:

- Reviewing organizational websites from local groups;
- Searching for relevant reports and gray literature;
- Reading relevant newspaper articles;
- Reviewing data from the region (for instance, USDA Agricultural census data or agricultural statistics which are provided by state and by county, U.S. Census data, FEMA flood maps, or NOAA tides and storm surge data);
- Reviewing published academic articles when available and relevant to the local context and conditions. These are especially useful when they contain survey data from your geography of interest; and
- Accessing GIS data layers.

For a good list of data sources, refer to the Watershed Approach Handbook: Improving Outcomes and Increasing Benefits Associated with Wetland and Stream Restoration and Protection Projects (2014). Although the handbook emphasizes watersheds in a freshwater context, many of the data sources also apply to coastal restoration, such as Environmental Protection Agency (EPA) data on water quality.

In addition to conducting a desktop analysis, once can also conduct key informant interviews. *Key informants* are individuals in a community who are knowledgeable about the community or a specific stakeholder group. Key informants may include governmental officials, business owners, academics, extension agents, nonprofit leaders, health care employees, residents or religious groups, among others. Key informants can either be identified through the background research or through word of mouth. It is recommended to set a predetermined list of eligibility criteria, such as a minimum number of years living in the region, certain areas of expertise or demonstration of other relevant characteristics. Unlike surveys, these interviews can be fairly unstructured, without a formal list of questions. Nonetheless, it helps to identify a small list of informal questions through background research before beginning. One important question to always ask, "Who else would you recommend that I interview on this subject?" Social scientists refer to this as *snowball sampling,* where each interview leads to more contacts and more interviews.

If time permits, *focus groups* can be an additional source of information on a community or issue. A focus group consists of approximately six to 12 individuals. The focus group may include individuals from a single stakeholder group or may include a diverse mix of stakeholders, depending upon the specific research questions. Focus groups are an efficient way of gaining additional information because they allow a researcher to obtain answers from multiple individuals in a single setting. Focus groups can also be useful because the cross-dialogue can inspire additional conversation. However, focus groups are not recommended in situations where the subject matter is controversial or sensitive and could result in privacy concerns.

If resources and time are limited, information can be obtained from stakeholders of interest by attending community meetings. Key informants may provide insights into which local meetings would yield the highest number of key stakeholders in attendance. Additionally, it is possible to place your topic on the agenda of a community meeting in order to serve as a quick, informal focus group. When suitable, community meetings are useful because the discussion in these meetings frequently will give initial insights into the current issues the community is facing, top concerns or opportunities of the community, and which stakeholder groups are more active and/or vocal in the community.

Questions for key informant interviews, focus groups or community meetings will vary depending upon the stakeholder group being interviewed (e.g., whether the interviewee is a municipal official or a resident) and which ecosystem service benefits are most pertinent for the restoration project. Questions might include a subset, or alternate wordings, of the following sample questions:

1) What are the biggest challenges facing your coastline?
2) Thinking specifically about the coastline in your community, how do residents use the coastline?
3) Which recreational activities do you believe are most popular along the coastline for residents? For visitors?
4) Are there activities (e.g., birding or kayaking) that might be less popular at the current time, but that when accompanied with the appropriate marketing and tourism strategies have the potential for increasing in popularity among visitors?
5) *For longtime residents:* Are there benefits that these natural systems used to provide to residents that they no longer do in their current condition?
6) Using this map, could you please circle your favorite natural or scenic area along your municipality's coastline? Why did you choose this location?
7) On a scale of one to five, how important do you think water quality [*or insert another category, like fishing, swimming, coastal erosion, etc.*] is to the residents of your municipality?
8) What benefits do you believe the coast CURRENTLY provides to businesses of your municipality [*or county*]?
9) What benefits do you believe the coast COULD provide that are not currently being captured by businesses?
10) How many times since 2010 has the municipality where you live [*or work*] experienced severe flooding? We characterize severe flooding by significant damage to multiple homes and/or public infrastructure.
11) This next question looks specifically at nuisance flooding. We describe nuisance flooding as minor, more frequent flooding sufficient to cause public inconvenience such as road closures and overflowing storm drains. How many times a month does nuisance flooding affect your home or your commute?
12) Could you describe how salt marshes have brought or might bring economic value to your community?

If you intend to conduct multiple interviews, lead focus groups or implement surveys during the stakeholder engagement phase, it is worth investigating whether your institution has a standard operating procedure regarding research involving human subjects. Typically, the researcher must submit a proposal to their institution's human subject review committee. The committee is designed to ensure proper respect and ethics related to those who are being asked to participate.

Better Understanding Project Trade-Offs

A core component of stakeholder engagement is **to understand how different restoration alternatives will affect diverse stakeholder groups either positively or negatively**. While this guidebook is focused only on ecological restoration projects, it is worth noting that often decision makers will be evaluating trade-offs between a wider range of coastal management decisions. We define *restoration and adaptation alternatives* as a suite of options that include ecological restoration and enhancement, taking no action, building an engineered structure, or other coastal adaptation options that include both hardened and ecological features. Generally speaking, all restoration and adaptation alternatives affecting coastal habitat will either increase or decrease ecosystem service benefits provided to coastal stakeholders, which can have tangible economic impacts on communities. Thus, when using the trade-off matrix described in this section, keep in mind that the restoration project might be compared to a different management alternative (e.g., an engineered structure versus a nature-based solution for shoreline stabilization). In addition, the provision of ecosystem services might vary spatially and with the design of the restoration project. Thus, creating a trade-off matrix may be a helpful communication tool when interacting with stakeholders and project partners, particularly in cases where the restoration project is still in the planning phase and the design and techniques have not yet been confirmed.

The National Ecosystem Services Partnership (NESP) has developed an informative guidebook, the Federal Resource Management and Ecosystem Services Guidebook (FRMES), walking natural resource managers through the process of how to compare these management alternatives and their outcomes in a rigorous but user-friendly way (National Ecosystem Services Partnership, 2014). **The FRMES process is important because one typically finds that for each management alternative, some benefits will increase while others will decrease**, and it allows decision makers to use a structured approach to compare those trade-offs between management alternatives, reducing the risk of unintended consequences (i.e., reducing the risk of unintentionally decreasing an ecosystem service benefit through a management alternative).

Ecosystem service benefits will not increase in all management scenarios. For instance, in cases where coastal erosion and sea level rise are significant threats, inaction can lead to the loss of functionality and ecosystem services. In other cases, benefits are competitive — as one benefit increases, another benefit decreases. An example can be seen with salt marsh restoration, where water quality (and filtration services) and wave attenuation services are competitive under certain conditions. A salt marsh with a high rate of water filtration services can reach a point where excess nutrient loading leads to a loss of below-ground biomass,

which makes the marsh unstable and can lead to conversion of the marsh to mud flat (Deegan et al., 2012). A mud flat with little to no vegetation loses important wave attenuation services, which can result in lower levels of flood reduction benefits to surrounding communities.

Thus, accounting for ecosystem services for all management options is important. Creating a **trade-off matrix** (also called an alternatives matrix) can be an informative exercise to help guide the scoping and site selection process. The FRMES Guidebook includes an entire section guiding natural resource managers through the process of how to create trade-off matrices to compare management alternatives (National Ecosystem Services Partnership, 2014).

This section on creating a trade-off matrix was placed after the rapid stakeholder assessment section of this guidebook for a specific reason. The rapid stakeholder assessment provides the restoration project team with a better understanding of which services and benefits are relevant to the stakeholder groups of interest. Therefore, do not include all potential ecosystem services in the trade-off matrix. Instead, narrow the list to the services relevant to stakeholders. A trade-off matrix does not need to be based on an extensive quantification of the expected changes. Rather, it is typically sufficient to understand the relative magnitude and the direction of the change (whether it is expected to increase or decrease). For the example shown in Table 2, we use a five-point scale: larger decrease in the service (--), smaller decrease in the service (-), no change in service (0), smaller increase in service (+), larger increase in service (++). The trade-off matrix is likely to be more accurate if an interdisciplinary work group (described earlier in this chapter) fills it out together, bringing in the specialized knowledge needed to make hypotheses about the expected changes from the restoration project. Although the direction and magnitude of changes are only hypotheses, and not guaranteed, the matrix is a powerful communication tool for groups to discuss alternatives and underlying assumptions.

For this example, we'll assume that an oyster reef is designed with fisheries enhancement as the primary socioeconomic goal, while a hybrid project is designed with shoreline stabilization as the primary socioeconomic goal. In Table 2, the negative signs indicate an expected decrease in recreation services: We expect that recreation services might decrease in cases where the reefs or hardened structures block navigational routes. The potential increase in recreational services from an increase in blue crab or striped bass harvest is captured under the fisheries habitat category.

ECOSYSTEM SERVICE	OYSTER REEF RESTORATION	HYBRID DESIGN WITH OYSTERS AND HARDENED STRUCTURE
Oyster habitat	++	+
Fisheries habitat	++	+
Erosion reduction	+	++
Water quality	++	+
Recreation (boating)	-	-

Table 2. Trade-off matrix comparing ecosystem services from two management alternatives.

Early engagement can allow for stakeholder priorities to feed into restoration design and implementation, as well as allow for project managers to better anticipate concerns surrounding trade-offs. The final restoration project goal(s) may be a blend of the interests of several stakeholder groups.

In summary, stakeholder engagement can lead to more successful projects, and a rapid stakeholder assessment is a good first step toward successful stakeholder engagement. When stakeholders are interviewed, they are more likely to feel that their voice has been heard and thus, the interview process itself can lead to greater buy-in for the project. The rapid stakeholder assessment may help in early identification of potential conflicts. And in the context of goal setting for a salt marsh or oyster reef restoration project, a rapid stakeholder assessment can help the project manager to understand and prioritize potential benefits from restoration that resonate most with stakeholders.

Case Study on Adapting to Coastal Flooding and Storms from Connecticut

The following case study is a successful example of how the stakeholder engagement process can be applied to the issue of coastal adaptation planning, where one output from the process was a study valuing salt marshes and beaches. The Nature Conservancy of Connecticut and the George Perkins Marsh Institute/Clark University collaborated on a recent effort to evaluate adaptation options for current and future risks associated with coastal storms and flooding. Two coastal communities in Connecticut were selected: Waterford and Old Saybrook. The project included two years of stakeholder engagement, a social survey, and an analysis valuing the trade-offs between *protecting natural versus built resources and selecting nature-based versus hardened adaptation options*. An interesting aspect of this study is that the research process involving focus groups to develop the survey-based choice experiment instrument was stakeholder engagement with *residents*. It was through that process that the researchers understood which benefits and trade-offs were relevant to the residents of the communities, which risks are likely to be a concern, and also which language should be used in the survey that would be most readily understood. Further, the project's interdisciplinary study team, consisting of natural scientists and economists, worked together to develop the social survey, such as through the incorporation of sea level rise projections (from the Coastal Resilience Tool) into the questions.

The study included at least two types of questions, 1) those aimed to understand the residents' attitudes regarding coastal hazard risk; and 2) preferences for adaptation options for coastal hazards, with questions designed to mimic an actual voter-referendum. The results provide powerful insights for municipal decision makers into the social value of the various adaptation options, showing that residents value adaptation and are willing to pay for a variety of options. An excerpt from the results of the Waterford community:

> *Residents have strong opinions about many methods and outcomes of coastal adaptation, and these opinions differ. However, on average, residents are more concerned with the protection of the town's natural/built resources and public services than with potential changes in taxes/fees, flood insurance rates, or development restrictions. Furthermore, residents are more concerned with the protection of public resources such as beaches, natural resources and public services than with the protection of private homes.* (Johnston, Whelchel, Makriyannis, & Yao, 2015b, p. 3)

The survey did not directly ask about preferences for particular ecosystem services, though it still gleaned key insights into resident preferences indirectly. For instance, the majority of residents (70 percent) placed high importance on protection of recreational areas — such as beaches and parks — indicating that these recreational ecosystem services are important to the community. An implication of that finding is that as the community moves forward in selecting and implementing adaptation options, messaging the recreational benefits of adaptation would help increase community support for adaptation projects.

Additionally, the results of the study were designed to have a direct influence on municipal resilience planning efforts. In many cases, municipal resilience planning does not adequately include resident preferences. To the best of the authors' knowledge, this is the first example where a choice experiment will be directly translated into on-the-ground actions that include resident preference for adaptation options, level of protection and where adaptation options are implemented.

Chapter Three

GOAL SETTING

After the rapid stakeholder assessment is completed, the increased understanding of the social context surrounding a restoration project can lead to more informed **restoration project goal setting**. Projects can have multiple goals, which can be both ecological and socioeconomic (refer to Figure 5). **Socioeconomic goals** will directly inform the selection of socioeconomic metrics, which will be the centerpiece of an ecosystem value study should you choose to undertake one at the end of this process. From a recent article (Beck et al., 2014):

"Social-Ecological Restoration is not just ecological restoration that happens to deliver — on the side — ecosystem services. By design, it aims to meet multiple objectives. It explicitly means trade-offs and balances; for example, not necessarily doing restoration in the places that are the very best in ecological terms but in places that can deliver the best combination of social and ecological benefits ... This represents a real change from past efforts."

PROJECT GOALS	
ECOLOGICAL GOALS	SOCIOECONOMIC GOALS
• Erosion control • Water quality • Habitat • Hydrological enhancement	• Community resilience • Cultural values • Economic development • Recreation • Water quality

Figure 5. Characterizing two categories of project goals — examples of ecological and economic.

While a restoration project may have both an ecological and a socioeconomic goal, **this chapter focuses primarily on setting socioeconomic goals**. In certain cases, there is significant overlap between the two categories of goals. For instance, imagine a rural community that aims to increase ecotourism opportunities by increasing bird habitat from a salt marsh restoration. In this case, many of the vegetation and wildlife metrics that are relevant for an ecological goal may also apply to the socioeconomic goal. Thus, the two categories of goals may be complementary. In fact, one advantage of conducting a rapid stakeholder assessment is explicitly to find those areas of overlap between conservation (ecological) and community (socioeconomic) goals. Identifying these areas where ecological goals also meet stakeholder needs can provide opportunities to engage new partners and access additional funding streams. The following sections provide more information on how to consider the political context when setting a goal, how to set a socioeconomic goal, and a discussion on the differences between measuring a goal in terms of monetary or non-monetary measures.

What decisions are you trying to influence?

Project goal setting should begin with linking the project goal to your organization's internal goals and strategies. Because the project goal should feed into organizational strategic goals, it is worthwhile to look at both direct *project* stakeholders and beneficiaries and also those stakeholders who may influence the success of a *strategy* in the long-term. **The idea is not to change one's organizational goal based upon stakeholder interests, but rather to find the areas of overlap among conservation goals and stakeholder needs and interests.**

Next, it is important to consider the following questions: What is the policy change or change in behavior you would like to see result from the economic valuation study? What decisions are you trying to influence and who are the decision makers and influencers? A policy change could involve a federal, state or local policy that would lead to additional funding or a critical enabling condition that would make future projects more feasible (e.g., a change in the permitting process). A behavior change could include incentivizing private landowners to adopt certain best management practices or living shorelines. In the ecosystem services literature, this is part of the scoping phase of the planning process. The World Resources Institute report on Coastal Capital: Ecosystem Service Valuation for Decision Making in the Caribbean (2014) provides a useful list of sample questions to help narrow one's policy question. *When identifying the policy questions, they suggest considering:*

1) What are the coastal ecosystem services at stake? (e.g., tourism, fisheries, shoreline protection)
2) What is the appropriate geographical scale that would be affected by a targeted policy change? (i.e., beyond the restoration site, what is the area that may be affected by the restoration project and desired policy changes; this may be site-specific/protected area, subnational, national, regional)
3) What are the policy options or range of possible futures under consideration?
4) What are current and desired human uses of the environment?
5) What are the likely economic effects of policy action or inaction? What is likely to change?
6) What is the necessary level of accuracy of the study?[5]

Source: Adapted from Waite et al., 2014

5 Covered in more detail in Chapter Five.

Once the policy or behavioral change that is in strategic alignment with conservation goals is clearly articulated, refer back to the findings from the rapid stakeholder assessment to select an appropriate **target audience**, which is a stakeholder group who has the potential to directly or indirectly influence the policy or behavioral change. Consider the target audience when designing the project goal to ensure that the goal, metrics and ecosystem service valuation study will be relevant and meaningful for that target audience.

Setting a Socioeconomic Goal

Taking into consideration stakeholder priorities, expected benefits of a project and project trade-offs, a socioeconomic goal can be set for a restoration project. Setting an ecological goal for restoration is already considered a best practice. The Society for Ecological Restoration states, "Goals are the ideal states and conditions that an ecological restoration effort attempts to achieve. Written expressions of goals provide the basis for all restoration activities, and later they become the basis for project evaluation. We cannot overemphasize the importance of expressing each and every project goal with a succinct and carefully crafted statement." (Society for Ecological Restoration, 2005). Setting a socioeconomic goal for restoration projects is a newer concept, yet equally applicable. If one aims to make claims about the socioeconomic benefits of an ecological restoration project in the future, then setting a socioeconomic goal before a project begins is important. This will allow for proper selection of metrics to demonstrate whether or not a project achieved the stated socioeconomic goal, and can also inform project design.

Let's consider a hypothetical case. A goal might start with a higher-level vision, such as this goal from a project involving beneficial reuse of dredge materials for salt marsh restoration: "The goal of each trial project is to increase the elevation of the marsh plain such that the elevation increase improves local coastal community resiliency, provides ecological uplift and does not have any harmful impacts on the marsh." Examples of more specific socioeconomic project goals could include:

- Stabilize shoreline to a level that is equivalent to level of shoreline stabilization of a hardened structure, resulting in a reduction in installation costs by at least 30 percent (compared to what the installation costs of a hardened structure would have been).
- Reduce damage costs from flooding to the first row of homes adjacent to the restored marsh by 10 percent per year.
- Reduce by 25 percent the number of times per month that a road is flooded from nuisance flooding.[6]
- Increase the number of birders to the site by 15 percent.
- Increase the number of jobs in the tourism industry in a given municipality by 10.

Given the actual timeline of the project, specific dates or timelines can be added to the goals, as well. However, because of a lack of data on the performance of coastal restoration projects, setting specific goals might not be possible. Rather, broader socioeconomic goals may be necessary, such as:

- Measure the cost-effectiveness of the oyster reef compared to a bulkhead.
- Quantify the change in economic benefits provided by the project to visitors interested in wildlife viewing.
- Measure the increase in spending by recreational fishers after the project.
- Demonstrate the effectiveness at flood attenuation and reducing damage costs for homeowners through thin-layer placement of dredged materials on salt marshes.

6 Nuisance flooding is minor, more frequent flooding sufficient to cause public inconvenience such as road closures and overflowing storm drains.

Socioeconomic metrics: to identify, quantify or value?

Once the restoration team has determined a socioeconomic goal for the restoration project, that goal can be measured in terms of a socioeconomic metric, which represents the change in a final ecosystem service benefit resulting from the restoration. That metric can be represented in terms of dollars or in terms of a quantity. In this section, we take a deeper dive into the difference between *monetary* and *non-monetary* metrics.

The premise behind measuring a change in ecosystem service benefits resulting from a project is generally as follows:

1) We expect a shift in ecological structure and function to occur as a result of a restoration project, which leads to a change in condition;
2) We connect that shift in ecological condition to a change in the level of ecosystem services provided;
3) We link those ecosystem services to human well-being.

Linking ecosystem service benefits to human well-being (Step 3) can be further dissected into the following three steps: **identify** ecosystem services that are likely to benefit people, **quantify** the change in those ecosystem services as a result of the project and **value** the benefits (refer to Figure 6). The steps are sequential; one would need to identify and quantify the ecosystem services in order to value those services. In the identification step, we are listing services and describing them in a qualitative way. In the quantify step, the change in the level of services is represented by a non-monetary metric or indicator, often referred to as a benefit indicator. A **benefit indicator** is a non-monetary measure quantifying the magnitude of a change in provision of a given ecosystem service in a way that is meaningful for people. To be meaningful for people, ask two questions: 1) How many people benefit? and 2) How much are people likely to benefit? (Mazzotta, Wainger, Bousquin, Hychka, & Berry, 2015). In contrast, in the value step, the change in benefits is usually represented by a monetary metric, representing either economic or social value. As mentioned earlier, it might not always be necessary to value ecosystem service benefits with a monetary value. In many cases, only identifying and/or quantifying the ecosystem services will still help provide greater information to the decision-making process.

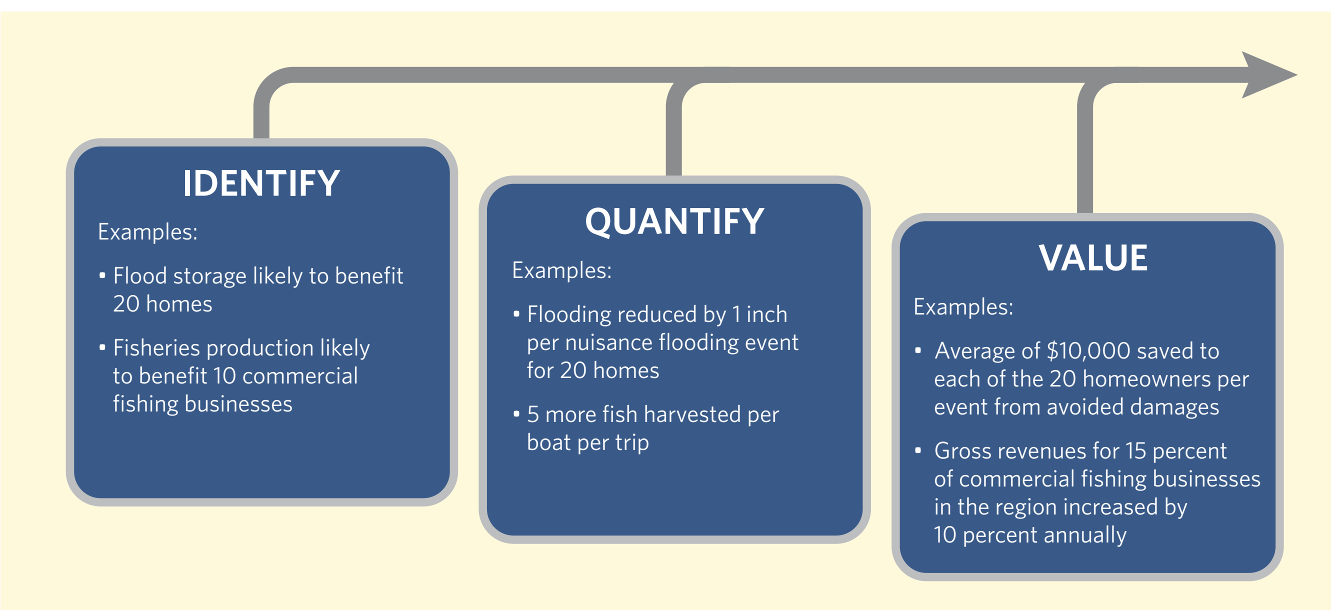


Figure 6. Identifying, quantifying and valuing ecosystem services.

Identification of ecosystem services is a *qualitative* (not quantitative) step, meaning that the service provision can be described in words rather than numerically. There are cases where simply identifying services is sufficient, and quantifying and monetizing them are not necessary. For instance, identifying where flood storage services of salt marshes are located geospatially might be sufficient if the purpose is site selection of a restoration project. Flood storage services for salt marshes will not have a direct benefit on human well-being if there are no homes or infrastructure in close proximity to the marsh. Thus, when identifying marshes that may provide flood reduction services, one may want to determine a minimum distance that homes, buildings or other infrastructure are located from a given marsh and take that distance into consideration when identifying flood storage services.

Quantification of ecosystem services is important if one aims to link a restoration project to a change in ecosystem service production (as compared to a similar site without a restoration project). Quantification of flood reduction services would not show the economic change for people, but it would demonstrate a change that benefits a given number of people or structures. Quantification of services might be sufficient, without having to monetize the services, if one's restoration goal is primarily ecological improvement and quantifying benefits to people is a secondary goal. For example, one may be able to demonstrate that a restoration project reduced flooding by one inch per nuisance flooding event and affected 20 homes. Such an analysis may be useful to show that the project had benefits to the surrounding community, without the need to place a dollar value on that benefit.

Valuing is the third and final step in the sequence. While valuing human well-being does not have to be represented in terms of a dollar value, representing value in monetary units is common. Monetization can be useful to compare the project benefits to benefits from other projects with the same unit of measurement. For this reason, monetization is necessary if the benefits will be used in a cost benefit analysis. Monetization also can be a more accurate reflection of the benefit for people. For instance, let's imagine that one quantifies the flood storage service and the change is minimal: a 5 percent reduction in flooding. That minimal change might lead one to believe the project failed. However, if that 5 percent reduction in flooding led to a high level of avoided costs to homeowners, the project may have been a success, based upon the substantial benefit to people. Monetization of services is particularly useful when one's target audience is highly incentivized by costs and benefits.

It is important to note that valuation of ecosystem service benefits in monetary units is not an exact representation of the "true" economic value of that resource. Rather, the valuation is typically based upon available data and serves as a proxy for the actual value of the resource. Further, if a study values a single ecosystem service provided by a habitat, instead of valuing all services provided by that particular site, then the valuation will underestimate the full economic value of that resource to society. Ecosystem service valuation studies also won't capture the distributional and environmental justice effects of a project; in other words, a valuation study won't indicate whether a benefit applies only to higher income communities or if a loss in benefit (or conversely, an increase in pollution) negatively impacts only lower income communities. However, information on the distribution of project benefits can also be reported to give a more complete picture to inform decisions.

While valuing services is not always necessary, ecosystem service valuation studies remain an important tool to measure performance of coastal restoration projects by putting a dollar value on the net benefits provided by the restoration. The following chapter provides a table of sample goal-based socioeconomic metrics for meeting the established socioeconomic goal (the table includes examples of both monetary and non-monetary metrics).

Chapter 4

SELECTING METRICS BASED UPON GOALS

The objective of this chapter is to outline the process for selecting final socioeconomic metrics, starting with a table of socioeconomic metrics that may apply to a salt marsh and oyster reef restoration project, moving into the assessment that links biophysical and socioeconomic metrics, and ending with the selection of relevant biophysical and socioeconomic metrics. If a restoration project also has an ecological goal, for more information on ecological goal-based metrics, refer to: *A Framework for Developing Monitoring Plans for Coastal Wetland Restoration and Living Shoreline Projects in New Jersey* (Yepsen, Moody, & Schuster, Forthcoming spring 2016).

It is worth reiterating that although a major theme in this guidebook is ecosystem service valuation, where benefits are often represented in terms of their economic value, there is considerable overlap between metrics and goals that might be described as "economic" versus those that are considered "social." Therefore, it is more accurate to think of the full suite of metrics and goals as "socioeconomic." Further, as described in Chapter Three, one can *identify*, *quantify* or *value* ecosystem services; thus, the table includes a mix of metrics that are monetary and non-monetary (monetary metrics are identified with a dollar sign image). While most of the socioeconomic metrics in Table 3 represent a change in ecosystem service benefits, a small number of metrics are not measures of ecosystem service benefits (e.g., change in public awareness of living shorelines). By providing sample socioeconomic metrics for coastal restoration projects, the intent is that practitioners can utilize this information to measure success toward meeting socioeconomic goals.

Table of Socioeconomic Metrics

Once a socioeconomic goal for a restoration project is determined, a final socioeconomic metric will be selected to measure whether the goal is met. However, in many cases, additional biophysical metrics may also be needed to assess whether the socioeconomic goal was met — meaning that the process of selecting metrics may go beyond selecting a single socioeconomic metric. *It is important to refer to the following two sections in this chapter to assess linkages among metrics and for guidance on selecting those additional metrics.*

Table 3 below highlights sample metrics that can be used to measure the success of socioeconomic goals for coastal restoration projects, with an emphasis on salt marsh and oyster reef restoration. In addition, many of the metrics in the following table will also apply to other types of living shoreline projects (e.g., nature-based living shorelines made from a coconut fiber material biolog or marsh sills, which can provide ecological uplift to salt marshes by reducing the rate of erosion of the marsh edge). Not all metrics will be applicable to all projects; some metrics will only apply to larger restoration projects with multiple techniques and components.

An important caveat must be highlighted, that our knowledge of ecosystem service benefits from coastal ecosystems is still incomplete. Appendix A provides a literature review of existing studies quantifying the economic benefits provided by salt marsh and oyster reef restoration, yet data gaps still exist on the performance and provision of the benefits in a wider range of conditions. For example, there is still a lack of data on how effective salt marshes are at reducing flooding as a result of reduction of wave energy under a wide range of storm types (smaller, nuisance-flooding events as compared to hurricanes). Thus, while we know that in many cases salt marshes and oyster reefs provide benefits to people, researchers are still continuing to fill data gaps on their performance. While the long-term goal may be to quantify the *increase* in benefits to people provided by coastal restoration, in the short-term, we are still testing hypotheses as to *which* of these metrics increase, stay the same or decrease with restoration, the magnitude of the change, and what factors and conditions influence the change.

The first column is the class of metrics, such as community resilience — flooding. The class of metrics is a broad category representing potential overarching socioeconomic goals for a project. Within a class, one can select from among several options for final metrics. All final metrics in Table 3 aim to represent a change in condition resulting from the restoration, *all other things being equal*. Then, there are two columns for methods. The first column represents **data collection methods**, such as surveys. The second column represents **valuation methods or type of analysis**.[7] In certain cases, there will be no analysis needed, and the method will be listed as not applicable (NA). The final column lists **user considerations**. There is a range of user considerations listed, such as additional information on how to collect data or conduct an analysis, hints on when it is appropriate to use a given metrics, or reference to other examples. The user considerations column is *not* meant to be comprehensive, but rather, to list top considerations that a user may want to consider for a given metric.

7 For more information on ecosystem service valuation methods, refer to Appendix C. *For additional resources, refer to the following documents*: Written for non-technical audiences, a summary and description of ecosystem valuation methods can be found in Ecosystem Service Valuation for Wetland Restoration (Stelk & Christie, 2014, pp. 22–31) and also in Marine and Coastal Ecosystem Services: Valuation Methods and their Practical Application (UNEP-WCMC, 2011, pp. 13–34). Common methods described in these resources are also summarized in Appendix C.

TABLE 3. SAMPLE GOAL-BASED SOCIOECONOMIC METRICS FOR COASTAL RESTORATION PROJECTS

CLASS OF METRICS	FINAL METRIC (UNIT OF MEASUREMENT)	DATA COLLECTION METHODS	VALUATION METHODS OR TYPE OF ANALYSIS	USER CONSIDERATIONS
Community resilience — erosion	$ Difference in cost between hardened structure and a living shoreline	• Project budgets • Existing data sources	• Substitute cost method	Substitute cost method compares the construction and maintenance costs between two or more options (e.g., living shoreline versus a e.g., bulkhead), with the assumption that the equivalent level of functionality is provided by both options.
	# Cost-effectiveness of structure for shoreline stabilization (rate of erosion reduction per unit cost)	• Project budgets	• Cost-effectiveness analysis	A cost-effectiveness analysis for erosion reduction will include a combination of biophysical goal-based metrics and project costs. In addition to looking at rate of erosion reduction per cost, one could also look at cost-effectiveness for a wider range of goals achieved per unit cost, in which case a wider range of goal-based metrics would be needed.
	# Number of homes or structures benefitting	• Visual assessment • GIS Analysis	• NA	Identifying number of homes or structures benefiting from a restoration project is a non-monetary metric that that may be useful in the site selection phase of the project or in qualitatively describing how a project affects people. It could be accompanied by interviews with homeowners or focus group meetings or by information on the social vulnerability of households benefiting from the risk reduction or resilience project.
Community resilience — flooding	$ Change in damage costs to surrounding homes	• FEMA NFIP claim data when available • Surveys • Existing data sources	• Avoided cost method • HAZUS modeling	Obtaining Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) claim data can be challenging. Municipal-level data is easier to obtain than parcel-level data. In some cases, researchers have been successful at submitting a Freedom of Information Act (FOIA) request to FEMA and receiving parcel-level data. If going this route, keep in mind it will take many months to obtain the data. Damage costs avoided can also be modeled using free software such as HAZUS, FEMA's Methodology for Estimating Potential Losses from Disasters.
	$ Change in damages to surrounding structures, roads or other public infrastructure	• Surveys or interviews • Data from municipality or county	• Avoided cost method • HAZUS modeling	Most likely, data on damage to public infrastructure will have to be obtained directly from the municipality (e.g., the public works department). Damage costs avoided can also be modeled using software such as HAZUS.
	$ Value of time saved by individuals driving on a road where flooding is reduced	• Surveys	• Avoided cost method	Surveys or focus group meetings may need to be accompanied with hydrological modeling to ascertain where flood reduction benefits are most likely to occur and by how much.
	# Changes in the number of days per month that road is flooded	• Surveys or focus group meetings	• NA	Surveys or focus group meetings may need to be accompanied with hydrological modeling to ascertain where flood reduction benefits are most likely to occur and by how much. Survey or focus group meetings can support the argument qualitatively that individuals are benefitting from the decrease in days per month that the road is flooded.
	# A decrease in number of days that businesses are closed after a storm or flood event	• Interviews	• NA	For this metric, one likely will want to target businesses in a particular sector or in a particular location, instead of including all businesses in the region.
	# Number of homes or structures benefitting	• GIS Analysis	• NA	Identifying number of homes or structures benefiting from a restoration project is a non-monetary metric that that may be useful in the site selection phase of the project or in qualitatively describing how a project affects people. It could be accompanied by interviews with homeowners or focus group meetings or by information on the social vulnerability of households benefiting from the risk reduction or resilience project.

TABLE 3. SAMPLE GOAL-BASED SOCIOECONOMIC METRICS FOR COASTAL RESTORATION PROJECTS

CLASS OF METRICS	FINAL METRIC (UNIT OF MEASUREMENT)	DATA COLLECTION METHODS	VALUATION METHODS OR TYPE OF ANALYSIS	USER CONSIDERATIONS
Community resilience — flooding	# Number of beneficiaries who benefit from a decrease in flood risk among socially vulnerable populations in a community	• Existing data sources • Use of online mapping portals	• NA	This metric involves two steps: 1) first identifying beneficiaries, and 2) doing an assessment of social vulnerability. Census-based demographic information can be obtained online for the vulnerability analysis. Mapping portals like Coastalresilience.org and NOAA's Sea Level Rise Viewer also provide vulnerability information. For a more comprehensive risk assessment incorporating future sea level rise, refer to Shepard et al. (2012).
Cultural values	$ Social value that individuals place on the resource	• Surveys • Existing data sources	• Contingent valuation or choice experiment • Benefit transfer	The social value individuals place on the resource (or habitat type) can come from a range of factors related to well-being, such as the cultural, historic or aesthetic value — or the value that individuals place on the continued existence of a resource for future generations.
	# Number of students benefiting from environmental education/ research	• Surveys • Focus group meetings • Tracking with a log • Focus groups	• NA	It may be possible to coordinate with elementary schools, high schools, and/or universities to create a simple log to track number of students directly benefiting from the site through research or nature walks.
	Perceived quality of shellfish harvested (as an indicator of sense of place) (scale ranking 1 to 5)	• Focus groups	• Mixed methods analysis combining sense of place with cultural ecosystem service indicator approaches	Specific cultural values that are relevant are likely to vary by community — for instance, communities may value recreation or aesthetic attribute of the scenery. The focus groups allow the researcher to determine which cultural values are most important. Note that "quality" in this metric includes both size and abundance attributes as perceived by residents. For salt marsh and oyster reef restoration, the type of shellfish may be blue crabs, depending upon how the community ranks its cultural connection to shellfish harvesting. See Donatuto et al. (2014) for additional information on the methodology.
Economic development — commercial fishing	$ Change in revenues for commercial fisherman	• Surveys • Interviews • Existing data sources	• Partial budget analysis	A partial budget analysis looks only at the portion of the budget that will be changed by the change in resources — in this case, the increase in revenues from the increase in fish caught, while subtracting out the associated variable costs from the increase in fish harvested.
	# Change in number of commercial fish harvested	• Surveys • Existing data sources	• NA	Fisheries data available through the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service website.
	# Change in shellfisheries' closing days	• Existing data sources	• NA	Determine local agency responsible for tracking information on shellfisheries' closing days, such as a university, governmental agency or shellfisheries group for the industry.
Economic development — general	$ Regional economic impact of an industry or sector	• Surveys • Existing data sources	• IMPLAN or other regional economic modeling, such as input-output models	The IMPLAN (IMpact analysis for PLANning) input-output modeling software is used to assess the "ripple effects" or multiplier effects of an increase or decrease in spending. By modeling the interactions between every industry in an economy and tracking the flow of goods and services, one is able to estimate the total economic impact (jobs, income, sales) for the region in question.

TABLE 3. SAMPLE GOAL-BASED SOCIOECONOMIC METRICS FOR COASTAL RESTORATION PROJECTS

CLASS OF METRICS	FINAL METRIC (UNIT OF MEASUREMENT)	DATA COLLECTION METHODS	VALUATION METHODS OR TYPE OF ANALYSIS	USER CONSIDERATIONS
Economic development — general	# Number of new jobs created directly in the restoration activity	• Surveys • Interviews	• NA	The number of new jobs created will be relative to the size of the economy in that region. In densely populated areas, the number of new jobs created might have more weight if it is a large number, but keep in mind that for some rural areas, even a small number of new jobs created is considered important.
Economic development — tourism	$ Economic impact of ecotourism	• Surveys • Existing data sources	• IMPLAN or other regional economic modeling, such as input-output models	The IMPLAN (IMpact analysis for PLANning) input-output modeling software is used to assess the "ripple effects" or multiplier effects of an increase or decrease in spending. By modeling the interactions between every industry in an economy and tracking the flow of goods and services, one is able to estimate the total economic impact (jobs, income, sales) for the region in question.
	$ Change in spending by birders	• Surveys • Existing data sources	• Economic impact assessment	Quantifying change of spending is a two-part process, where first the number of visitors before and after the restoration must be quantified, and then the average spending per visitor must be quantified. One should differentiate between spending by locals and spending by visitors from outside of the region; in order to consider the spending an economic impact, it must be from visitors from outside of the region.
	$ Change in spending by anglers	• Surveys • Existing data sources	• Economic impact assessment	Quantifying change of spending is a two-part process, where first the number of visitors before and after the restoration must be quantified, and then the average spending per visitor must be quantified. One should differentiate between spending by locals and spending by visitors from outside of the region; in order to consider the spending an economic impact, it must be from visitors from outside of the region.
	# Number of new jobs created in tourism-related industries	• Surveys • Interviews	• NA	The number of new jobs created will be relative to the size of the economy in that region. In densely populated areas, the number of new jobs created might have more weight if it is a large number, but keep in mind that for some rural areas, even a small number of new jobs created is considered important.
	# Number of new businesses	• Interviews	• NA	One would want to demonstrate that the restoration, at least in part, can be attributed to the opening of a new business (e.g., a restaurant or outfitter). While this metric should be considered qualitative, this type of metric can still be useful in building the case that a restoration project had a role in supporting local businesses.
Market value (e.g., payments for ecosystem services)	$ Market value of carbon credits (i.e., blue carbon)	• Existing data sources	• Market price	Blue carbon credits are not currently sold in the United States, though the potential exists for this market to develop in the future.
	$ Market value of water quality credits	• Existing data sources	• Market price	Water quality credits for oysters are not currently sold in New Jersey, though they are allowed in certain parts of the Chesapeake Bay.
Property values	$ Change in property value because of aesthetic improvements to view	• Existing data sources	• Hedonic valuation	There might be a lag time, if the restoration loses aesthetic appeal in the first two years post-restoration. This metric will only be relevant to certain projects and is more likely to be relevant in urbanized regions where open space is less abundant.

TABLE 3. SAMPLE GOAL-BASED SOCIOECONOMIC METRICS FOR COASTAL RESTORATION PROJECTS

CLASS OF METRICS	FINAL METRIC (UNIT OF MEASUREMENT)	DATA COLLECTION METHODS	VALUATION METHODS OR TYPE OF ANALYSIS	USER CONSIDERATIONS
Property values	$ Change in property value because of reduction in rate of erosion	• Existing data sources	• Hedonic valuation	For an example, see Gopalakrishnan et al. (2011). Although the focus was on beach erosion and dunes, the method will still be similar for erosion related to salt marshes.
	$ Change in property value because of decrease in flood risk	• Existing data sources	• Hedonic valuation	For an example, see Bin, Dumas, Poulter and Whitehead (2007). Although linked generally to sea level rise and not to a specific restoration project, the methods will still be similar.
	$ Change in municipal property taxes because of the change in property value	• Existing data sources	• Hedonic valuation	This metric requires two steps: 1) hedonic valuation, and 2) linking the changes in property values to changes in municipal property taxes collected.
Public Perception	Change in public awareness of living shorelines	• Surveys • Focus group meetings	• NA	Survey should include questions that seek to understand if residents (unprompted) list living shorelines when asked "Could you list the different types of shoreline stabilization projects (or techniques) that you know about?" This metric could also apply to public awareness of other restoration techniques.
	Change in political will or public support to living shorelines	• Surveys • Interviews		While the previous metric of "awareness" is solely based upon knowledge of living shorelines, this metric gets at a willingness to change behaviors and increase support for living shorelines. It is important to recognize that there are likely to be multiple groups advocating a change in political will toward living shorelines. This metric could also apply to other restoration techniques.
Recreation and public access (e.g., birding, fishing, swimming, etc.)	$ Value visitors to the site place on their experience	• Surveys • Existing data sources	• Contingent valuation or choice experiment • Benefit transfer	Note that value placed on the individual experience represents the *social value* of the visitor experience, or the value *beyond* the actual amount spent. This method of valuing public preferences is common when comparing policy alternatives to understand which policies have the largest benefit for the most people. Benefit transfer is a lower-cost option than contingent valuation. However, benefit transfer should only be used if the conditions and demographics of the initial study site are similar to the current restoration site. When possible, benefit function transfer and meta-analysis are more accurate than simple benefit transfer.
	$ Value boaters place on their experience	• Surveys • Existing data sources	• Contingent valuation or choice experiment • Benefit transfer	Note that value placed on the individual experience represents the *social value* of the visitor experience, or the value *beyond* the actual amount spent. This method of valuing public preferences is common when comparing policy alternatives to understand which policies have the largest benefit for the most people. Benefit transfer is a lower-cost option than contingent valuation. However, benefit transfer should only be used if the conditions and demographics of the initial study site are similar to the current restoration site. When possible, benefit function transfer and meta-analysis are more accurate than simple benefit transfer.
	# Number of visitors to the restoration site	• Car counter • Surveys • Geospatially referenced social media methodology	• NA	This is a common non-monetary metric that can be applied at a relatively low cost to any restoration project with a public access component. See Wood, Guerry, Silver and Lacayo (2013) for their methodology of using of geospatially referenced photos on Flickr to estimate visitation rates.
	# Number of fish caught per angler trip	• Surveys • Existing data sources	• NA	Existing data may also be available from other sources, such as through the following link from NOAA's National Marine Fisheries Service website.

TABLE 3. SAMPLE GOAL-BASED SOCIOECONOMIC METRICS FOR COASTAL RESTORATION PROJECTS

CLASS OF METRICS	FINAL METRIC (UNIT OF MEASUREMENT)	DATA COLLECTION METHODS	VALUATION METHODS OR TYPE OF ANALYSIS	USER CONSIDERATIONS
Recreation and public access (e.g., birding, fishing, swimming, etc.)	# Number of anglers	• Surveys • Existing data sources	• NA	Existing data may be available from state agencies who issue fishing permits.
	# Change in number of beach closing days	• Surveys • Existing data sources	• NA	Most likely, salt marsh or oyster reef restoration projects will only have a quantifiable impact on improving water quality and reducing the number of beach closings because of water quality when a sufficiently large number of acres are restored. This metric is not likely to be relevant to small-scale projects.
Water quality	$ Value of visitors place on the improved water quality (boaters, anglers, beach visitors, etc.)	• Surveys • Existing data sources	• Contingent valuation or choice experiment • Benefit transfer	Note that value placed on the individual experience represents the *social value* of the visitor experience, or the value *beyond* the actual amount spent. This method of valuing public preferences is common when comparing policy alternatives to understand which policies have the largest benefit for the most people. Benefit transfer is a lower-cost option than contingent valuation. However, benefit transfer should only be used if the conditions and demographics of the initial study site are similar to the current restoration site. When possible, benefit function transfer and meta-analysis are more accurate than simple benefit transfer.
	$ Market value of water quality credits in a water quality market	• Existing data sources	• Market price	Water quality credits for oyster restoration are not currently sold in most Mid-Atlantic states, though they are allowed in certain parts of the Chesapeake.
	$ Change in property value because of water clarity improvements	• Existing data sources	• Hedonic valuation	Literature shows that proximity to polluted water can lead to lower property values, all else being equal. Water clarity tends to be the preferred water quality parameter, since it is observable by the prospective home buyer.
	$ Willingness to pay for improved water quality on a water utility bill	• Surveys	• Contingent valuation or choice experiment	By framing the survey in terms of a potential referendum that would result in a fee on a water utility bill, the respondent to the survey is more likely to state an accurate value of what they would be willing to pay, removing the hypothetical bias. Thus, willingness to pay questions should be framed in such a way that the respondent believes that his/her survey answers are likely to impact policy.
	# Change in number of visitors because of reduction in number of beach closings	• Surveys • Existing data sources	• NA	Most likely, salt marsh or oyster reef restoration projects will only have a quantifiable impact on improving water quality and reducing the number of beach closings because of water quality when done at the landscape scale. This metric is not likely to be relevant to small-scale projects.

Assessment of Relevant Metrics

Perhaps the most important piece of information to keep in mind is that socioeconomic metrics cannot be selected in isolation from ecological metrics. **One must simultaneously assess and consider the relevant socioeconomic and ecological metrics to ensure that the ecological changes from restoration are linked to changes in socioeconomic metrics.** This section shows the process for assessing changes in biophysical and socioeconomic conditions and linking the changes logically from one outcome to the next.

Before we move into assessing biophysical and socioeconomic metrics, let's step back and set the stage with an example goal for a marsh vegetation enhancement project. Vegetation enhancement is a general category that includes salt marsh restoration projects designed to either improve physical, biological or chemical parameters for the promotion of healthy, native vegetation, or to directly augment vegetative communities through the addition of native species or the removal of non-natives (Yepsen, Moody, & Schuster, forthcoming spring 2016). This example project might contain two goals, one socioeconomic and one ecological: 1) to measure if there is any change in level of damage caused by flooding to surrounding homes, and if so, by how much and to how many homes, and 2) to improve the quality and quantity of marsh vegetation (if possible, specific numbers for reduction of damage and vegetation enhancement can be inserted as well).

The next step is to work with an interdisciplinary work group to create a result chain to show the linkages between the expected ecological and economic changes, and which metrics could be used to quantify those changes (National Ecosystem Services Partnership, 2014).[8] Result chains represent a logical series of sequential events or changes connecting an action to a final change. One of the advantages of creating a result chain is that it allows the researchers to clearly call attention to underlying assumptions. Discussing the result chain with an interdisciplinary group is a valuable activity because it allows the researchers to discuss these otherwise unstated assumptions and make hypotheses about the expected direction of change — whether the parameter is expected to increase, decrease or stay the same. Your interdisciplinary work group may be similar to, or even the same as, the one referenced in Chapter Two as part of the rapid stakeholder assessment — an interdisciplinary team of ecologists, engineers, economists and hydrologists.

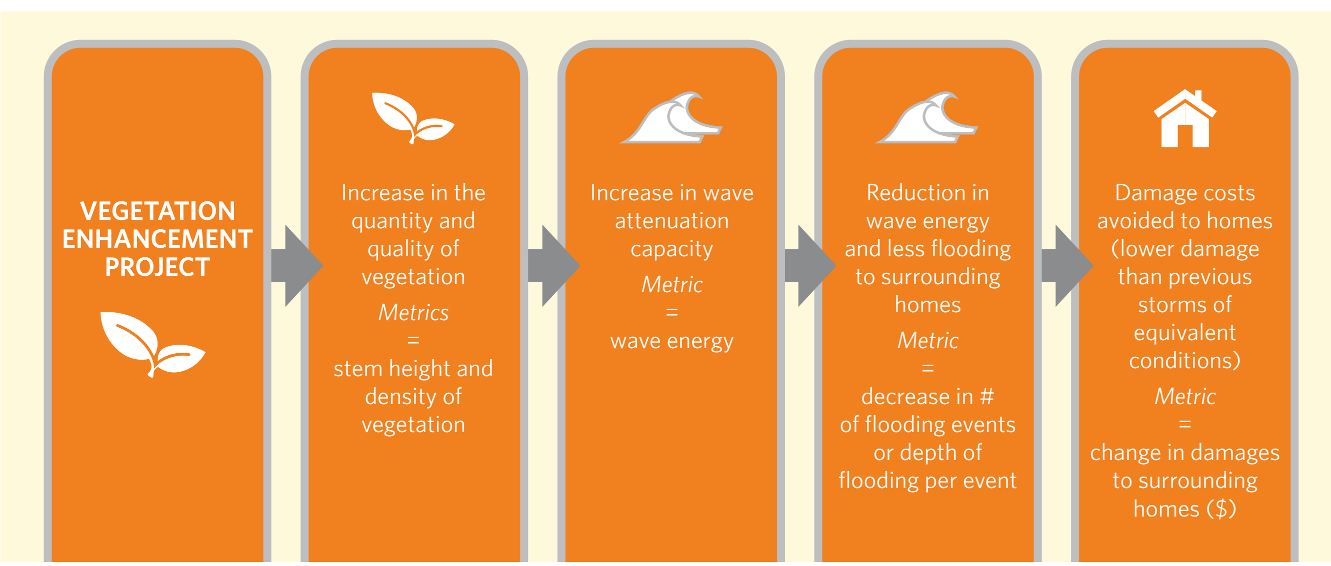


Figure 7. A result chain to illustrate hypotheses and assumptions underlying a salt marsh vegetation enhancement project.

8 Result chains are referred to as means-ends diagrams in the NESP FRMES guidebook. Refer to the NESP guidebook website for more detailed information on constructing a means-end diagram.

We'll continue with the same vegetation enhancement project for a salt marsh, where the result chain is shown in Figure 7. This represents one example of a result chain that could apply to the goals listed in the previous paragraph. *There are metrics in each step of this result chain that could be measured to confirm actual performance over time.* Each step is contingent upon fulfillment of the previous step. If the final ecosystem service benefit is not realized, it could be from a failure of one of the previous steps or because of an additional factor that was not accounted for such as a change in hydrology or marsh platform elevation. The magnitude of the final ecosystem service benefit — the damage costs avoided to homes — will also be dependent upon the extent of revegetation. In cases where the salt marsh had converted to mud flat, revegetation is likely to provide greater ecological uplift and thus, lead to high economic benefits. In cases where revegetation efforts are minimal, the change in economic benefits will be of a lower magnitude.

Showing the linkages from one box (and metric) to the next makes it clear that all of the changes in conditions shown in the result chain need to occur to successfully achieve the final metric. As described in the following section, the result chains can be used as a tool for determining which models or methods are needed to quantify biophysical and socioeconomic changes, and which metrics are necessary for those models. Then, one can determine which of the metrics identified in the result chain need to be included in the monitoring plan.

Selection of Relevant Metrics

Based upon the information presented in this chapter, let's see how metrics and analysis fit into an ecosystem services framework. We can build upon Figure 2 from Chapter 1, as follows: A baseline level of ecosystem service benefits are measured at the project site. A management or restoration action leads to a change in ecosystem condition. There is a functional relationship between the ecosystem conditions and attributes and the ecosystem services that are provided, which can be quantified through a biophysical model. The biophysical model quantifies the change in ecosystem goods and services. The output of the biophysical model is then used as an input into the ecosystem service valuation study. The final output is a quantification of the net ecosystem service benefits. Visually, this process is represented in Figure 8.

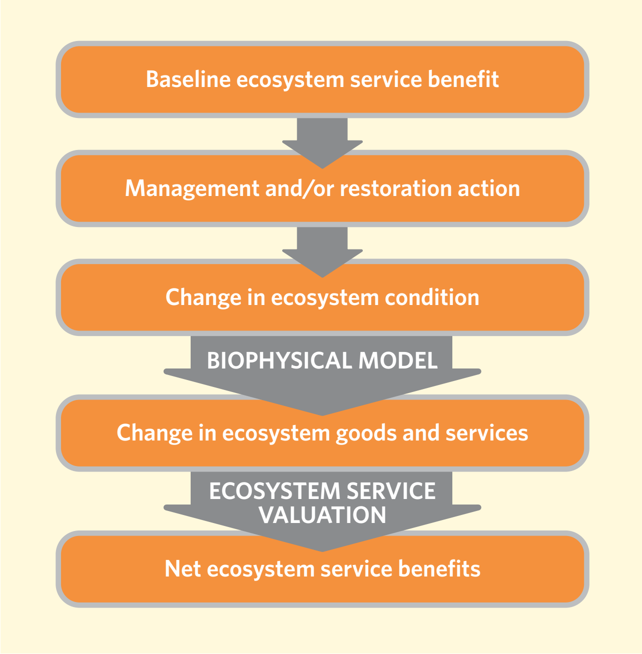


Figure 8. Sequence of steps from management action to final net ecosystem service benefits with analysis included.

How can one use the process in Figure 8 to inform the selection of relevant metrics?

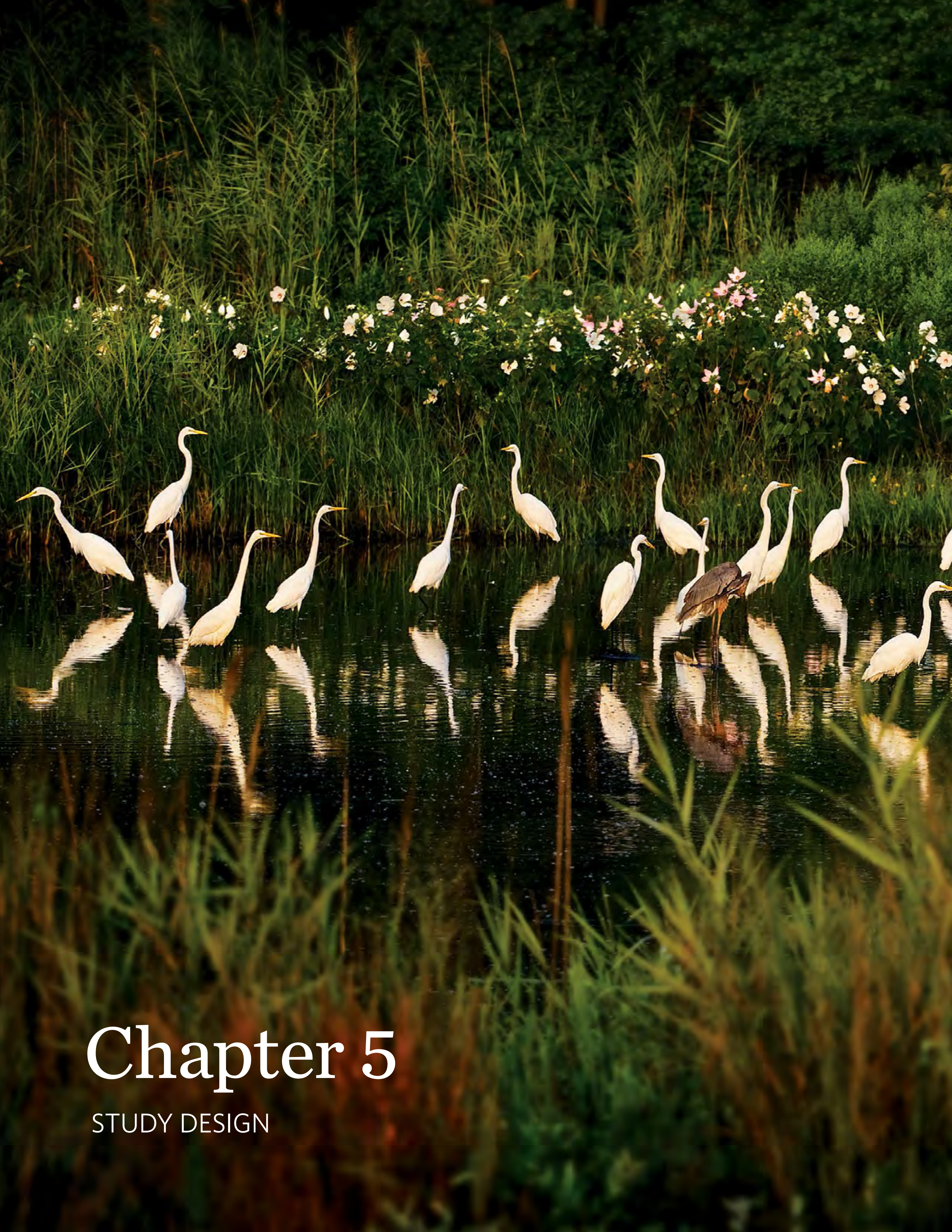
- **Consider available biophysical models when selecting relevant biophysical metrics.** Biophysical models have specific data requirements. Thinking ahead of time about which data is needed for a particular biophysical model is important because the ecosystem service valuation study is often dependent upon the results from the biophysical model. Many biophysical models already exist that quantify ecosystem services.[9] Examples include some of the InVEST models (e.g., nutrient retention model), the Soil and Water Assessment Tool (SWAT), Federal Emergency Management Agency's (FEMA) Coastal Hazard Analysis Modeling Program (CHAMP), FEMA's Wave Height Analysis for Flood Insurance Studies (WHAFIS), and population models/population viability analysis that can estimate changes in fish production.
- **If no biophysical model exists, consider which metrics may need to be included in the monitoring plan in order to develop a new biophysical model.** Many ecosystem services do not yet have a model in existence that quantifies the functional relationship between the habitat and services provided. Data collected in conjunction with a restoration project can also support the development of new biophysical models. Even if the restoration team does not have the capacity to develop the new model, the data could be made available to other researchers to develop the model with aggregated data from multiple projects. Consult with subject experts as needed on the data needs for the development of new biophysical models.
- **If the restoration team decides to apply a BACI[10] design to a project, then a biophysical model is not needed to measure the final socioeconomic metric.** The selected socioeconomic metric would be measured before and after the restoration at both a control site and the restoration site, and the change could be directly attributed to the restoration (one would not need to collect data on biophysical metrics). Many ecological restoration projects can take three to five years to be completed. Expert experience suggests that certain wetland restoration projects may take closer to 10 years to be completed. Other social benefits (such as wildlife viewing by visitors) may occur immediately after the restoration. Keep in mind these temporal aspects of data collection when developing the monitoring plan. Collect baseline data for the socioeconomic metric at the current time, and then the interdisciplinary work group can discuss temporal issues and determine when to collect post-construction data. Only after the final data is collected can the final ecosystem service valuation study be completed to show the change in benefits. However, it is worth noting that expert experience suggests that in practice, it may be challenging to find a comparable control site for evaluating socioeconomic impacts resulting from these types of ecological restoration projects.
- **If no biophysical model or BACI design will be applied, one can "build the case" that the restoration activity directly contributed to the change in ecosystem service which led to a change in ecosystem service value.** Depending upon resource and budgetary constraints, this might mean collecting data for some or all of the metrics identified in the result chain. For instance, if no biophysical model exists for birds and salt marsh restoration, one could collect data on vegetation, since birds are sensitive to vegetation structure. Next, one could monitor changes in bird utilization. Finally, one would assess whether the number of birders and/or spending by birders increased because of that change in birds. Also take into consideration the same temporal issues mentioned in the previous bullet. While this approach may not be as rigorous as an approach that utilizes a BACI design, for certain target audiences this level of rigor may be sufficient.
- **Not all socioeconomic metrics are linked to biophysical models.** For instance, the socioeconomic metric "*change in public awareness of living shorelines*" might not rely upon any direct biophysical changes, aside from the completion of the project itself. If the interdisciplinary work group determines that no biophysical metrics are needed to link the project to the change in socioeconomic metric, then it might be sufficient to select only the socioeconomic metric.

9 Environmental economists also call these models ecological production functions (described in greater detail in Appendix A).

10 A *Before-After Control-Impact* (BACI) study design indicates that baseline data (pre-restoration) and post-restoration data have been collected at the restoration site and at a control site. While economic studies do not include reference sites, a reference site may be necessary for the ecological portion of the analysis. A *reference site* is one that involves the same type of ecosystem as the restoration site, but represents high-quality habitat. Both the control site and the reference site should have conditions similar to the restoration site.

The same interdisciplinary work group referenced in Chapter Three and earlier in this chapter can continue to meet to select metrics, models and methods, and develop a monitoring plan, all of which can help ensure that metrics are being accurately measured, as well as help increase the efficiency of the data collection process.

In summary, each ecosystem service benefit and restoration technique will have a slightly different suite of metrics and different biophysical models associated. Currently, the process for integrating biophysical and socioeconomic metrics is still being developed, and the common metrics, methods and biophysical models for all ecosystem services and restoration techniques are not yet established. In the future, when more restoration projects have been completed, a more standardized approach to selecting metrics may be developed. As more information becomes available, that will be incorporated into future editions of this guidebook. The following chapter describes in greater detail the factors to consider when selecting data collection methods and designing the study to analyze the final socioeconomic metric.



Chapter 5

STUDY DESIGN

Once socioeconomic metrics have been selected, and any accompanying biophysical metrics, the final step is to design and implement your study. The first section in this chapter describes how to consider varying levels of rigor and confidence in results when designing a study. The next section describes various budgetary and resource considerations that may influence study design. The third section walks the reader through an example applying the full process outlined in this guidebook.

Study Design Considerations

There are many methods available for data collection and analysis. The methods provided in Table 3 in Chapter Four are not the only methods available, though they do tend to be among the more common and well-established ones. The **study design** for assessing a final socioeconomic metric will often include multiple methods. Studies can be implemented with varying levels of intensity that influence whether the study will be more or less rigorous. Thus, before selecting the full suite of methods needed to assess a socioeconomic metric, it is important to define and recognize the level of rigor required for the study. The level of rigor required will likely be based upon project goals and the target audience, and be influenced by resources available and technical considerations.

In general, we make the assumption that more rigorous studies lead to more robust results. Studies to evaluate metrics can range from qualitative assessments based largely upon anecdotal evidence to more rigorous, quasi-experimental designs. Figure 9 shows how as the rigor of study design increases, so too do the complexity of methods and the confidence in the results of the study. For internal learning and adaptive management, simpler, less rigorous studies may be sufficient. These can include **qualitative assessments**, such as anecdotal evidence from focus groups and photo documentation. The next level of increasing rigor is **quantitative trend analysis**, which may be over time (when time series data are available), spatially across a landscape, or comparisons of different groups or attributes. Then, an additional level of rigor is to apply a **mixed methods analysis**, which combines qualitative and quantitative methods; this adds rigor because getting data and information from multiple sources serves as a form of triangulation to increase confidence in the results. Quantitative analysis often involves statistical analysis, which also can help demonstrate a higher (or lower) confidence in results. Finally, a **quasi-experimental design** involving both a control and treatment group (or site) and before and after data is the highest level of rigor available for these types of restoration projects. Take care to choose the appropriate study design to ensure that the data collection and analysis behind final socioeconomic metrics is sufficiently rigorous for the target audience and project goals.

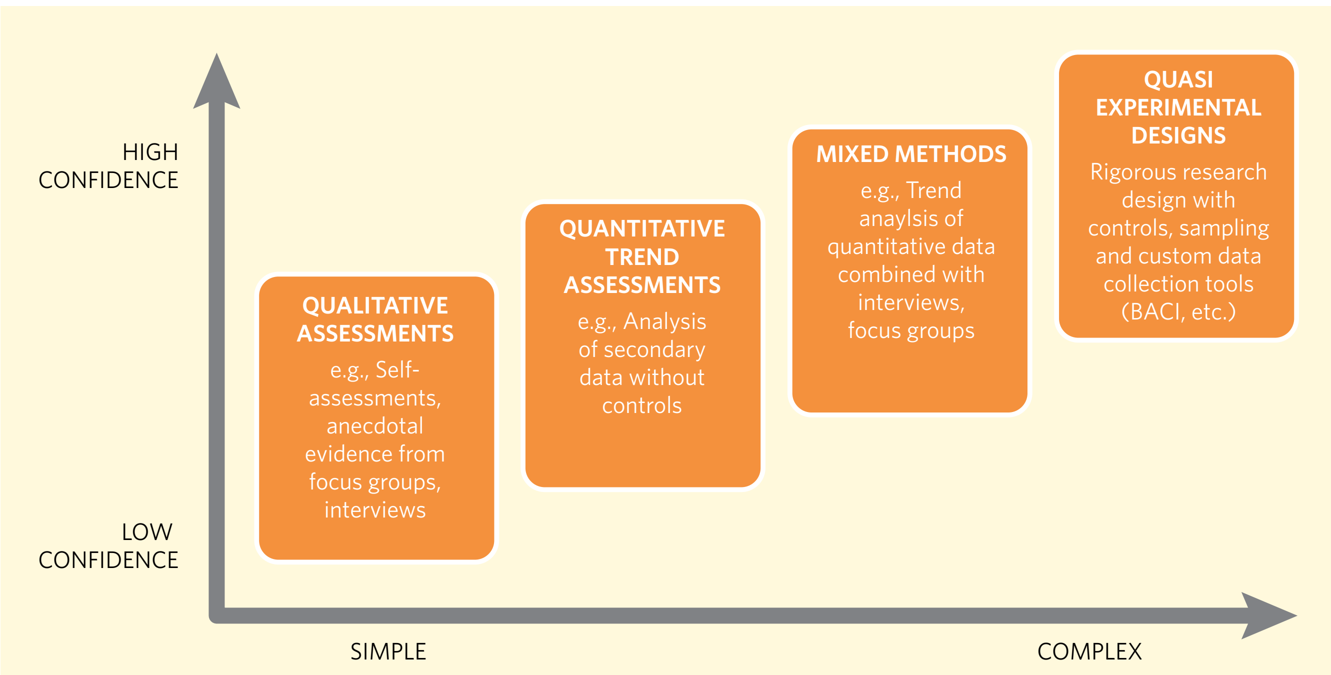


Figure 9. Increasing complexity in study design and confidence in results, (Shishkova, Masuda, and Hadley, 2015)

Let's consider a simple example where the study goal is to measure the change in the level of economic benefits provided by the reduction in flooding from a salt marsh restoration. We'll show how the level of rigor varies depending upon the study design, using the four categories in Figure 9. The final socioeconomic metric being evaluated might be *change in damage costs to surrounding homes ($)*.

If the intended use of the study is to offer a rough estimate of the potential benefits from the project to people, a qualitative assessment might be sufficient. For instance, is the study goal to allow staff to better communicate the benefits of their work to their Board of Trustees? Do you hope to use the results of the study to inform internal strategic planning? If so, a lower-cost, less rigorous approach like interviewing five to 10 homeowners next to the salt marsh restoration project might be a good approach. The analysis may involve collection of anecdotal evidence on people's memory of whether flooding appears to have been reduced after the restoration. However, be careful with the wording of the interview questions if going with this approach. Asking broad questions like, "Do you believe the level of flooding in your neighborhood has changed over the past 10 years?" is likely to be too vague. It is more effective to highlight specific storms and dates of the storm (e.g., Hurricane Sandy hit the coast of New Jersey on October 29, 2012). Then, ask questions to help interviewees remember exactly where they were during the storm, how they responded, and what happened to their home. Some interviewees might be able to provide a quantitative indicator that can give objectivity to their assessment, such as the point on their driveway or house to which the water level reached. Asking the right questions that are specific enough and including a mix of questions to compare conditions before and after the restoration can be a successful way to build an anecdotal case that a restoration project did have a positive effect on people — in this case by reducing flooding to homes. Note that the further back in history the respondent has to remember, the worse his or her memory will be and the lower the quality of response.

A qualitative assessment, however, will only provide a coarse assessment of whether the effect of the restoration may have been positive or negative. That is, it can show the likely direction of the change of benefits, but not the magnitude or statistical significance. Increasing rigor could be applied to the analysis by using National Flood Insurance Program (NFIP) claim data on damage to homes in a single community over a series of years, before and after the restoration. Additional time series data can be included as well, such as storm surge, precipitation and storm duration. Time series data can be combined with anecdotal evidence from homeowners through interviews. This middle level of rigor — a combination of qualitative and quantitative data — may be relevant to state-level policy making. State-level policy makers often make decisions based on the average effects of a policy across the state, and thus, providing average values may be sufficient.

If one desires to conduct a rigorous impact assessment to demonstrate the success of the project, a full BACI design could be applied. One will need baseline data, data from a control site, and post-restoration data. When choosing a control site, select a site that has similar attributes and conditions. If possible, choosing multiple sites to compare and controlling for features like presence of seawalls, elevation and distance from storm can add rigor, as well.

Data are required over time to ensure that observed benefits were not the result of an abnormal year. Certain stakeholders may desire such a rigorous assessment. If the goal is to contribute to the academic literature, then such an approach might be desirable. Some decision makers, such as a municipal engineer or a water supply utility, may also desire a high certainty in the results before they would be willing to implement a similar project, especially if they feel a personal sense of liability related to the success (or lack thereof) of a project.

Having sufficient quantity and quality of data from treatment and control sites and proper study design can allow a researcher to demonstrate the *direction of change*, *magnitude* and *statistical significance*. **Using a sufficiently rigorous study design improves one's ability to make claims attributing the coastal restoration project to the change in level of benefits** (in this example, damage costs avoided to homeowners from flooding being reduced because of the salt marsh restoration project).

Budgetary and Resource Considerations

There are many budgetary and resource considerations to apply to the final study design. *A Framework for Developing Monitoring Plans for Coastal Wetland Restoration and Living Shoreline Projects in New Jersey* (Yepsen, Moody, & Schuster, forthcoming spring 2016) provides provides a comprehensive list of user considerations, beyond what is covered in this guidebook (e.g., seasonality of monitoring, permitting requirements and comparability of data across projects). This guidebook focuses largely on budgetary considerations and technical expertise. Generally speaking, the following factors will influence the cost of obtaining and analyzing the data for a given metric.

1) **Cost will increase the more rigorous the study.** For instance, a full BACI design will cost more than a study that does not include a control site and both before and after project data.
2) **Certain methods are lower cost than others.** Benefit transfer is the process of applying the value of an ecosystem service benefit quantified from one site to a different site with similar characteristics, and may be a lower cost method than those that involve primary data collection. Be cautious when using benefit transfer. When sufficient care is not taken to ensure similar biophysical and socio-economic characteristics of the locations, the values can be inaccurate and lead to false representations of the actual value of the ecosystem service to be provided. Refer to Johnston and Rosenberger (2010) for a more complete discussion of benefit transfer. It is worth noting that one of the objectives of this guidebook is to encourage practitioners to produce more economic valuation studies for representative restoration projects based upon new data collected in the field. The result will be more studies with varying location and context specific data, which in turn will further the ability to apply the benefit transfer methodology with greater confidence in the results.
3) **Cost can be impacted by the total number of goals and metrics for the project.** In general, having a larger number of goals and metrics is expected to be associated with higher costs related to data collection and analysis. However, if the data needed for the ecological metrics is highly complementary to the socioeconomic metrics, having multiple metrics might not increase the cost. For example, imagine a project manager is interested in conducting a cost-effectiveness study comparing the ability of a living shoreline to reduce erosion versus a bulkhead on a per cost basis. If the monitoring plan already includes a shoreline position metric, then it might be an easy effort at almost no increase to the project budget to calculate cost-effectiveness with only a couple of additional pieces of information: the *implementation costs* for a bulkhead and living shoreline per linear foot. There also might be efficiencies if data on one metric is already being collected at a given site and data on a different metric can be collected at the same time. Thus, it is worth assessing how data on the full set of metrics will be collected before assuming having multiple metrics is too expensive.
4) **Project size and duration can affect data collection costs.** Cost will increase as the scope and size of the project increase, and as the frequency and duration of data collection increase.
5) **Cost is usually higher when monetizing economic metrics.** In Chapter One, the process of identifying ecosystem services, quantifying benefits and valuing the benefits was highlighted. In general, quantifying benefits and using non-monetary indicators is lower in cost than monetizing. Thus, if putting a dollar value on an ecosystem service benefit is not necessary, in many cases, selecting non-monetary metrics might be a way to reduce costs. However, in certain cases, if data is readily available from public sources (e.g., if the researcher has access to data on the market price and quantity of fish harvested in a given region), then monetizing ecosystem service benefits might not be more expensive.
6) **Access to existing data sets reduces costs.** Cost will decrease if the project manager or researcher on the project has access to existing data sets (e.g., water quality data through a governmental website, census data, etc.).

Technical expertise is also an important consideration when setting a socioeconomic goal for a restoration project. The capacity of the organization or the need to hire a consultant to conduct the analysis may affect the cost of the analysis and the decision as to which socioeconomic metrics your organization is able to quantify.

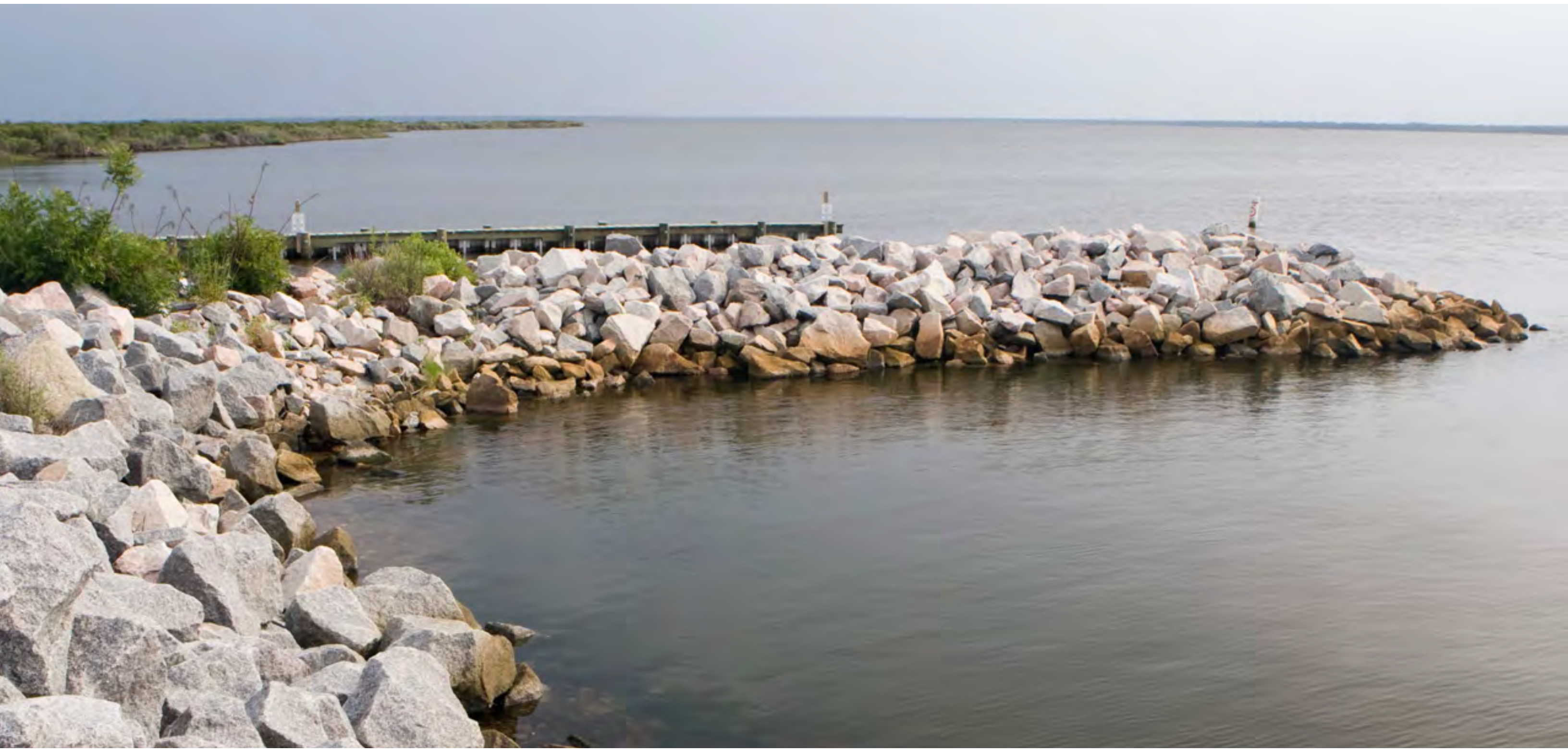
If the current budget is insufficient to collect data on the appropriate metrics for your chosen goal, one option is to re-assess the socioeconomic goal of the project. If the data for the metrics is essential for demonstrating project success, it might be worth applying for additional funding through grants or philanthropic donations to fully cover the monitoring and evaluation. A second option is to collect data on the relevant metrics at the current time, and wait until the future to conduct an ecosystem service valuation study. This serves to stagger the costs and postpone the need to fundraise or apply for grants to cover the ecosystem service valuation study. This option is recommended when possible to avoid missing important opportunities to be able to measure the success of projects at meeting an economic goal in the future. A third possibility is to build a collaborative partnership with a university, nonprofit organization or governmental agency and encourage that group to take the lead on the economics portion of the project.

Example Application of Ecosystem Service Valuation Process

An example will allow the reader to view application of the entire process: 1) define the project scope, 2) conduct rapid stakeholder assessment, 3) set a socioeconomic goal for the project, 4) select relevant metrics, and 5) determine appropriate study design. The example is for beneficial reuse of dredge materials, where clean dredged sediment is being utilized to increase the elevation of the marsh platform. Increases in elevation are being designed to bring native vegetation to the high end of its optimal growth range to prevent imminent and future loss to sea-level rise and erosion. The process is simplified in this example for the convenience of the reader; refer to the case studies in Appendix B for additional examples.

The **project scope** incudes only marsh restoration — there are no additional techniques being applied (such as a living shoreline restoration) or additional components, such as a boat ramp or other type of public access. Next, the **rapid stakeholder assessment** begins. An ad hoc, interdisciplinary work group of individuals associated with the restoration project is convened and includes an engineer, ecologist, economist, hydrologist and GIS specialist. The work group begins with defining the geographic boundaries for the rapid stakeholder assessment. In this example, the location of the project site has not yet been confirmed, meaning that the locations of the project beneficiaries have also not yet been identified. The work group decides to include the full back-bay area and adjacent coastline for a single county. Next, the work group lists all **potential ecosystem service benefits** for the project. Ecosystem services benefits from this project include increased opportunities for birders, anglers, commercial fisherman; aesthetic improvements for surrounding homeowners; flood reduction; and carbon sequestration (blue carbon). A quick initial desktop analysis of the existing literature reveals that not enough is known about migratory fish patterns in this area — meaning that not enough information is available to link the restoration to an increase in fisheries.

The work group proceeds with a series of **key informant interviews**, which for this project may include municipal officials, local floodplain managers, and homeowners located adjacent to the restoration project. Through the key informant interviews, the group learns that the community is not interested in the carbon sequestration benefits and potential recreation and tourism benefits. Instead, the overwhelming majority of stakeholders interviewed stated their perception was that the communities' top interest was in the potential flood reduction and coastal resilience benefits. The work group determines that the **target audience of this study** is residents. They learned from the interview process that while residents are interested in flood reduction efforts to protect homes and infrastructure, they were unfamiliar and even skeptical about the use of natural infrastructure (i.e., salt marshes) to reduce flooding. Thus, the work group decided to target residents in their goal setting and selecting of metrics to demonstrate to the residents the effectiveness of marsh restoration at flood reduction. The long-term strategy is that if the restoration is successful, then over time increasing public support can lead to a change in political will and an increase in support for public funding.



The work group presents their findings of the rapid stakeholder assessment to the full project team for the restoration. The team agrees on two goals — **an ecological goal and a socioeconomic goal** — and identifies a list of possible metrics to evaluate those goals. The anticipated outcomes of the *vegetation enhancement* goal is increasing the habitat benefits associated with improved vegetation, which could be quantified through numerous metrics, such as above- and below-ground biomass, plant community composition, percent cover, stem height and species richness. The *coastal resilience goal* has an ultimate goal of reducing flooding to surrounding homes, which could be quantified using metrics such as change in damages to surrounding homes or change in damages to surrounding structures, roads or other public infrastructure.[11]

Based on the various considerations of the project team, **the study design to quantify** the avoided costs to homes and infrastructure needs to use an integrated approach, where the biophysical changes are modeled first and then, the economic changes are modeled. The result chain in Figure 7 was designed for this example, and includes the key metrics needed for the socioeconomic goal. The interdisciplinary work group determines that for the biophysical models they will run, data on marsh platform elevation will be necessary as well.[12] A GIS specialist in the work group recommends Federal Emergency Management Agency's (FEMA) Coastal Hazard Analysis Modeling Program (CHAMP), Wave Height Analysis for Flood Insurance Studies (WHAFIS) and HAZUS models, based upon the fact that these are free, publicly available programs and well known in the industry. CHAMP is FEMA's software for coastal engineering analysis, WHAFIS is for wave height, and HAZUS is FEMA's tool for estimating potential economic losses from disasters. The biophysical changes, i.e., the flood modeling, are based upon the 1 percent annual chance storm and high resolution digital elevation model (DEM), which serves as the baseline (preexisting conditions). CHAMP model is run to quantify wave height over transects, and then fed into the HAZUS model, allowing HAZUS to take into consideration both storm surge and wave height.

11 Note that beneficial reuse of dredge materials for marsh habitat restoration is still considered a new technique for certain Mid-Atlantic States such as New Jersey. Therefore, when designing project goals, the project team will also be thinking about a larger, overarching goal of testing and demonstrating a new technique.

12 Additional factors not listed in this example will also affect the level of economic benefits provided by this example project to communities. When the site is selected, distance from homes and other infrastructure and the quantity of homes will affect the level of benefits. Also, in a Barnegat Bay study (Barone et al., 2014), they found that the larger the buffer of marsh between an open water with a large fetch and the population, the higher the economic benefits.

Data collection then occurs over a period of at least three seasons after the restoration, as needed for the vegetation to recover. For many projects, data collection will need to occur for three to five years post-restoration, or even longer. To assess the economic value of the restoration, a new scenario is created with the higher elevation from the thin-layer placement of the dredged materials. Real vegetation data (stem height and vegetation density) are included in the WHAFUS model (a module of CHAMP), which is fed into the HAZUS model. The new elevation data[13] were also imported into HAZUS when the model is rerun. The final report will show **damages per census block**, including building damage, debris removal and displacement costs (the default for census data can be used). Additional scenarios could also include removing the marsh completely and if the marsh were a mud flat, with no vegetation.

Conclusion

In conclusion, this guidebook presents a process for using ecosystem service valuation as a tool to support coastal restoration projects. Placing a value on ecosystem service benefits has many advantages, such as greater stakeholder support for projects, increased access to a wider range of funding sources, and greater likelihood that the social and economic value placed on nature will be considered in decision-making processes. Further, applying the process described in this guidebook can also increase our ability to achieve ecosystem service benefits for people from ecological restoration projects. Incorporating ecosystem services and socioeconomic considerations into the *beginning* of a coastal restoration project will enable teams to more effectively set and meet both ecological and socioeconomic goals for restoration projects. Even if your project team does not conduct an ecosystem service valuation, applying the process described in this guidebook can still lead to greater success for restoration projects.

While the process described in this guidebook does include the selection of metrics and methods, it is about much more than data collection — it is about a process that includes stakeholder engagement, understanding trade-offs, goal setting and collaboration. Communication is another recurring theme in this guidebook. A key aspect for successfully applying an ecosystem services framework to coastal restoration is communication among the various experts involved in the restoration project — among ecologists, hydrologists, engineers, economists. This leads to more accurate ecosystem service valuation studies, which in turn will lead to more information on the performance of coastal restoration projects.

Communication with project stakeholders is also crucial throughout the process. Including stakeholder engagement early in the planning process for a restoration project has numerous advantages, such as increasing project buy-in and decreasing the risk of delays in project implementation because of conflicts around scarce resources. Stakeholder engagement can also result in new partnerships that can lead to greater support for restoration, either directly or indirectly (e.g., a tourism organization decides to invest in improvements for public access, trails, parking lot and signage to supplement a restoration project). Communication of the ecosystem service valuation study results to target audience and key stakeholders and ongoing community engagement after a restoration is complete is also recommended.

This guidebook is a living document and will be updated as additional restoration projects are completed and as additional methods and processes are developed.

13 Assume for this example that elevation data is measured using RTK surveys.

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Appendix A

Past Studies on Ecosystem Service Benefits from Salt Marshes and Oyster Reefs

For decades, the "business as usual" approach in coastal areas has been reliance upon hardened structures such as bulkheads and seawalls for shoreline stabilization and flood reduction. However, implementation of these engineered structures has led to hardening of vast stretches of the Atlantic coastline and replacing of habitat and benefits provided by nature in those areas. Alternatively, **natural infrastructure** is a broad category of natural features, like wetlands and vegetated shorelines, used to address issues like flooding, erosion and water quality that traditionally would have been addressed using concrete and metal structures. In the Mid-Atlantic since Hurricane Sandy in 2012, there is an increasing emphasis on utilizing natural infrastructure strategies for risk reduction and in adaptation and recovery efforts. What is not as broadly understood is that natural infrastructure provides a range of benefits to communities beyond traditional risk-reduction techniques. While traditional techniques may only provide a single benefit, such as flood reduction or shoreline stabilization, natural infrastructure also increases opportunities for recreation (fishing, birding) and the economic impact resulting from the spending by anglers and birders, as well as water quality and aesthetic improvements to the landscape.

The following sections provide an overview of the evidence and past research related to the quantification of ecosystem service benefits to people from salt marsh and oyster reef restoration. Please refer to Appendix C for the definitions of common ecosystem service valuation methods.

Evidence on the Benefits Salt Marshes Provide to People

Salt marshes, and wetlands overall, are valuable intertidal zones linking land and sea. Early American settlers and developers viewed salt marshes as useless wasteland suitable only to be drained, filled or exploited as waste dump sites. Since that time, numerous studies have been published detailing salt marsh productivity and ecological importance. In coastal areas around the world, salt marshes have been demonstrated to provide the following ecosystem services:

1) Storm protection and reduction in inland flooding
2) Reduction in shoreline erosion
3) Wave attenuation, reducing both wave height and wave energy
4) Improved water quality through the filtration of chemicals and processing of other nutrients
5) Critical nursery habitat and food source for important commercial and recreational finfish, blue crab and shrimp
6) Bird habitat for certain species of interest to birders, such as northern harrier, saltmarsh sparrow and willet

While these services are valuable for humans as well as for the ecological health of the system, few studies have been published to meaningfully quantify the services in terms of their economic value for people. This review will present an overview of past ecosystem service valuation studies for salt marshes on the eastern and southern United States coastal areas. Also, it is worth noting that in many cases, a restoration project or a policy may be designed with a specific primary goal in mind, such as water quality, yet also provides co-benefits as an auxiliary benefit. Thus, even when a restoration project doesn't focus on all of the multiple benefits listed in this review, it can be useful to recognize that all of the co-benefits listed in this section contribute to the full value of a salt marsh.

Risk-Reduction Benefits

In recent years, increasing attention has been placed on the role of salt marshes in risk reduction. One recent study that analyzed 34 major hurricanes in the United States since 1980 found that a loss of just one acre of coastal wetland leads to an increase of $13,360 in damage to communities during each storm (Costanza et al., 2008). The analysis was conducted at a coarse scale, covering Atlantic and Gulf coasts, with wind speed being the only storm variable included in their regression. Thus, although the study is important as a first look into the economic value wetlands contribute to damage reduction during hurricanes, the analysis was not conducted at a fine enough scale to make inferences about the value of salt marsh restoration at the project scale. The quality of salt marsh habitat varies across the landscape, and those differences in quality will lead to vastly different risk-reduction benefits, meaning that applying average values may lead to over- or under-estimating the actual value of the salt marsh.

Gedan et al. (2010) applied a meta-analysis to determine the role of vegetation in risk-reduction benefits of salt marshes. They found ample evidence to support the case that vegetation is a critical factor in the wave attenuation and erosion reduction benefits of salt marshes, when taking into consideration both direct and indirect vegetation effects (direct effects are from the structural presence of the vegetation and indirect effects are a result of the role the vegetation plays in sediment accretion). While it is useful to have a better understanding of which biological parameters (in this case, vegetation) play a role in wave attenuation, the study did not link those ecosystem services to benefits for people, such as flood-reduction benefits. Barbier et al. (2013) used simulations of four levels of storm surge and demonstrated that salt marsh vegetation and wetland connectivity is linked to quantifiable reductions in economic damage to homes in the Gulf of Mexico. However, because the models are based upon simulations, future work that includes physical data collection and location-specific damage to homes to corroborate the models will increase our confidence in the results. Möller et al. (2014) conducted a recent experiment on the wave attenuation services provided by salt marshes. They found that 60 percent of the reduction in wave energy by salt marshes can be attributed to the vegetation. Studies such as this are crucial to advance the science behind the risk-reduction benefits provided by salt marshes at the project scale, though the study does not provide an economic value resulting from the wave attenuation services. The extent to which salt marshes reduce wave energy will provide direct economic value to people only if there are people, homes or infrastructure close enough to those marshes to benefit from the services. Fagherazzi (2014) provides a summary of the study by Möller et al., also bringing in additional citations on the varying roles of salt marshes and wave attenuation depending upon the magnitude of a storm, and thus serves as useful reference as well.

Barone et al. (2014) completed an initial assessment of a pilot marsh restoration in the Barnegat Bay of New Jersey, analyzing whether restoration of marsh edges using dredged sediment is sufficient to result in economic benefits to communities from flood reduction. Barone utilized two models, FEMA's CHAMP (Coastal Hazard Analysis Modeling) and HAZUS (Hazards-US) to quantify the changes in marsh edge restoration scenarios and subsequently to quantify the economic value for the 1 percent annual chance storm. At two of the three sites, the economic value was positive but the magnitude was minor (a 0.02 percent reduction in economic damage), though the hypothesis is that under the 2 percent storm scenario the value would increase somewhat. At the third site, the change was negligible. These small values are likely attributed to the fact that the projects involve restoring only a narrow edge of marsh, and future projects that include marsh interior restoration are expected to result in higher damage costs avoided than marsh edge restoration alone.

Reguero et al. (2014) conducted an analysis of the cost-effectiveness of nature-based defenses versus artificial defenses in coastal areas, with an emphasis on conditions in the Gulf of Mexico. Given the economic losses predicted with climate change, the researchers sought to assess how cost-effective natural solutions are at reducing risk in coastal areas. To conduct the analysis, first a database of assets exposed was accessed from HAZUS, and then damage to the assets was quantified in various climate scenarios. The second component of the analysis was the cost-effectiveness comparison of 14 different adaptation measures, ranging from wetland and oyster reef restoration to levees to home elevation, with measures for both erosion and flood reduction. The analysis showed that natural defenses are highly cost-effective, particularly oyster reef and marsh restoration, and are likely to perform best under smaller, more frequent storm events. Location of the project is among the most important factors influencing the benefits provided. Somewhat surprisingly, bringing in additional services such as the fisheries benefits did not significantly change the cost-effectiveness of these projects.[14] However, the analysis relied on several assumptions, and robust, further research should continue to assess and refine our understanding of cost-effectiveness of oyster reef and salt marsh restoration and how that varies in different geographical and socio-economic contexts.

Reddy et al. (2015) also conducted an analysis comparing costs and benefits of coastal protection defenses — natural marshes, built structures (a levee), and a hybrid approach combining a levee and marshes. The team took into consideration wave energy, storm surge, flood depth, and several sea level rise and land use scenarios, as well as the costs and benefits associated with each option. The final metric was net present value (summing damage costs avoided, business interruption and levee costs). While the marsh defense scenario did provide benefits in terms of damage costs avoided, with a net present value of $15 million (2010 US$), the hybrid scenario involving both marshes and levee performed significantly stronger, at $229 million (2010 US$).

14 If fisheries production is a primary goal of a restoration project, then it still remains important to recognize and quantify those benefits, even if they were not contributing to the cost-effectiveness of a project designed for risk-reduction purposes.

Fishery Production Benefits

Salt marshes provide necessary plant food material and habitat for the spawning and growth of many young commercial fish, shrimp and crustaceans. For example, almost half of the U.S. East Coast fishery haul per year is Atlantic menhaden. In their first year of life, menhaden live in the sheltered salt marsh habitat and feed on detritus from its plants (Lewis & Peters, 1984). While fishery production value appears to be easily calculable by simply multiplying the total catch in a given area by the market price, in practice the calculation is challenging because of a variety of factors, including poor quality data on fish caught, lack of detailed information on migratory patterns of fish, lack of knowledge regarding location of salt marshes where fish most likely feed, and insufficient baseline data on fisheries populations. Still, many methodologies have been applied to tease out the true worth of salt marshes for fisheries. One of the first attempts by Gosselink et al. (1974) was to provide an overview of Florida salt marsh fishery value. The total value of all commercial fish caught in 1971 was $43.2 million dollars, to which the authors added a processing percentage and divided the resulting dollar amount by Florida marsh acre. Their resulting value was $75 per marsh acre. This approach was limited in scope and applied economic value solely to the marshes, ignoring other inputs such as human labor and technology and also failing to recognize that the quality of salt marshes varies. The authors acknowledged these flaws, but more importantly, they assumed all acres of marsh were of equal value, rather than account for the fact that the first acre of salt marsh protected or restored may have a different value than the 1,000th acre of salt marsh protected or restored — the concept of marginal production value (defined in the text box). The idea of marshes' marginal production value evolved in later studies.

In the context of ecosystem service valuation, an **ecological production function** (EPF) is the quantitative relationship between the underlying ecological function and the resulting ecosystem service.[15] The EPF is not an economic function but rather an ecological function. **Marginal production value** can be defined as the value of one additional unit of service, as defined by the EPF. The marginal production value helps to better explain the effect that a stressor (like a decrease in water quality) has on the supply of a given ecosystem service. That information is then used when quantifying the change in economic value as a result of that stressor.

The concept of marginal production value is important because not all units of salt marsh will contribute the same amount to fisheries production. Researchers realized that past a certain point, any additional marsh acreage would not have an equally great effect on fishery productivity. This makes intuitive sense — if a fishery already has sufficient area for feeding, restoring additional acreage of marsh would lead only to a minimal increase in fisheries production, if any. In the generic image of a production function below (Figure 10), we have *physical capital* on the x-axis and *output* on the y-axis. *Physical capital* is a bucket (borrowed from the discipline of economics) that includes any known and quantifiable factors that will influence the level of fisheries production. In this simplified example, the salt marsh itself is one type of physical capital that goes into the production of

15 In Chapter Four of this guidebook, we refer to biophysical models. In the context of this guidebook, biophysical models are synonymous with ecological production functions.

fisheries (though more complicated examples may tease out the biological, chemical and physical parameters within a salt marsh that lead to fisheries production). The *output* is the level of fish production (for a given fishery). The shape of the curve shows that at first salt marsh restoration would lead to exponential increases in the level of fisheries — in other words, at first the marginal value from salt marsh restoration will be much larger. Over time, the marginal value will decrease, leveling out over time (and potentially reach zero or even become negative). **Very few ecosystem service valuation studies acknowledge where they lie on the ecological production function — toward the left or right end of the graph. This represents a data gap in the literature and a promising area for future research.**

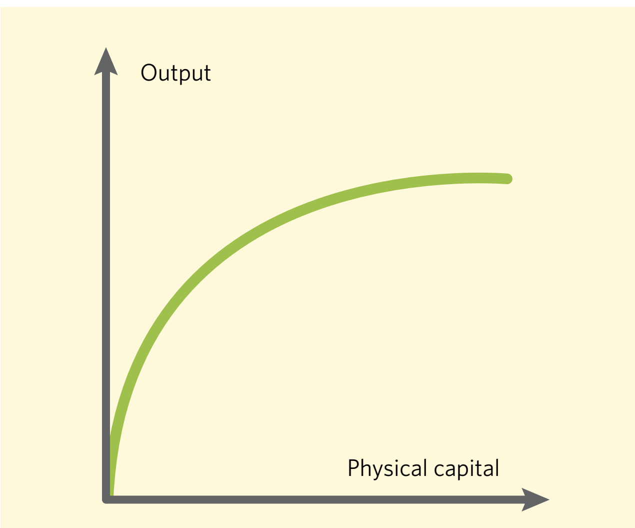

Figure 10. Generic image of an ecological production function.

Lynne et al. (1981) deal directly with the idea of marginal production and attempt to view marshes as a factor of production. That is, if inputs for bringing fish to the market include the vessel, equipment and labor, one can calculate the value of the salt marsh by considering it as one would consider any input to the production process. The authors focused on the productivity of Florida blue crab fisheries and created a production function model to quantify biomass production (and thus population increases) in one year. This was an improvement over past models for two reasons: first, because they based their modeling on past fish production response studies, showing a greater linkage between the natural sciences and economics than in previous studies; and second, because they incorporated a variable that represents human labor. An estimated $2 million industry overall, Lynne at al. attributed blue crab fishing a value of $3 per marsh acre at the margin. A notable finding came from the authors' production function model, which showed the variable for human labor elasticity was much larger than that for marsh acreage elasticity. **Elasticity** measures how responsive a variable is to a change in conditions, and includes the level of change and the direction (whether it increases or decreases). This suggests that human labor has a larger impact on fishery productivity than marsh acreage, meaning that there will be notable limitations if using models that do not account for human labor.

Bell (1997) built from Lynne et al.'s marginal production function, but applied it to recreational fishing yields on the eastern and western Florida coasts. Bell created a model and then cross-analyzed it with salt marsh acreage and recreational fishing data. This data included the total number and weight of marsh-dependent finfish, as well as the total number of fishing trips made. The authors found similar elasticity values as Lynne et al., with human labor providing a higher impact than marsh acreage, leading to similar conclusions. However, the study acknowledged recreational fishers are motivated differently than commercial fishers and that yields differ geographically on Florida' eastern and western coasts, with the final valuation at $6,471 per acre for the east coast and $981 per acre for the west coast.

Jivoff and Able (2003) also analyzed the role of salt marshes in fisheries production, focusing on the blue crab. Unlike Bell, Jivoff and Able quantified the change in production as a result of a salt marsh restoration project in the Delaware Bay, whereby old salt hay farms were converted back to salt marsh with significant hydrological improvements (reworking old dykes) as well as a subsequent return of native vegetation to the sites. As compared to reference sites, the number and size (rate of growth) of blue crabs was higher at the restored sites, indicating that the restoration had a positive effect on the population. This suggests that improving the quality of salt marshes can lead to economic benefits to communities for commercially important species such as the blue crab. It is worth noting that the Jivoff and Able study was part of a larger restoration project — the full restoration project began in 1994, resulting from a mitigation case whereby the Public Service Enterprise Group (PSE&G), a power provider in the Delaware Bay, was required to restore 20,000 acres of salt marsh to compensate for fish kills resulting from changes in water temperatures. No study to date has been conducted linking the increases in fisheries production to specific economic gains by the local fisherman from the PSE&G restoration.

Studies Quantifying Multiple Benefits

Fishery production is a market-based method to quantify marsh services — but what about quantifying benefits that are not sold in markets, such as recreation or the value that individuals place on the existence of a species? Commonly, environmental economists rely upon stated preference methods, approaches which rely upon surveys to assess the public's perceived value of a resource. Stated preference surveys often ask for a person's willingness to pay (WTP) for a resource, then applies a statistical analysis to bring in other factors (such as demographics or distance to the resource) to calculate the total dollar value for that resource. Like any other valuation method, however, there have been many different approaches within its confines to find the most accurate results.

Johnston et al. (2002) performed a stated preference study, surveying Rhode Island residents on their preferences related to salt marshes restoration and management. Unlike previous contingent valuation studies that look at a single attribute (e.g., continued existence of salt marshes), Johnston et al. included multiple attributes. The authors consulted with wetland experts over the course of two years to devise a set of 21 "primary attributes" that the Narragansett Bay salt marshes provided, an important step for ensuring that the economic metrics accurately reflect ecological and physical processes of the salt marshes. These attributes were organized into multiattribute restoration plans, each plan weighted to prioritize one attribute. The respondents would then choose between two restoration plans within a given budget. The aggregated data showed the respondents' most-valued services were 1) mosquito control, 2) shellfish habitat improvement, 3) fish habitat improvement, and 4) bird habitat improvement. By comparing which attributes the respondents chose over others, Johnston et al. were able to place a value on a given plan. For example, respondents were willing to pay $13.42 for a plan that favored fish habitat restoration over bird habitat restoration. The use of a stated preference approach allowed the authors to complexly compare each service the Narragansett Bay salt marshes provided, and how they were valued in the eyes of the public, with the goal of incorporating these preferences into public policy to optimize welfare for both the marsh and the public. However, conjoint analyses tend to be highly context-specific and it might be challenging to transfer the specific values obtained to different policy contexts.

Johnston, Whelchel, Makriyannis and Yao (2015b, 2015a) conducted choice experiments in the coastal communities of Waterford and Old Saybrook, Connecticut. Unlike the Johnston et al. (2002) study, this study quantified the value of wetlands and beaches based upon residents' willingness to pay for their future protection under sea level rise, relative to their preference for protecting infrastructure and homes. The advantage of conducting a choice experiment is that it allows researchers to view preferences relative to a wider suite of adaptation options, unlike a study designed to look in isolation at a resident willingness to pay to protect wetlands. The researchers found that Waterford residents value protection of beaches twice as much as they value wetlands ($21.90 for acre of beaches saved, and $9.40 per acre of wetland saved), on an annual basis per household. Somewhat unexpectedly, residents also value protection of natural resources at a higher level than protection of private homes, where preventing flooding (in a Category 3 storm) to 135 homes has the same value as protecting one acre of coastal habitat from loss to sea level rise and erosion. Based upon the results and the focus group meetings that preceded the study, the authors hypothesize that the reason for putting less value on protection of private homes lies in the residents' overall belief in responsibility of private homeowners to adapt, rather than the municipality bearing the responsibility. In Old Saybrook, residents placed a higher relative value on beaches compared to wetlands ($28.90 for acre of beaches saved, and $2.50 for each acre of wetland saved), and they place a higher value on adaptation options that highlight natural options (as opposed to hard defenses such as sea walls). These two studies serve as good examples because they involved significant stakeholder engagement and also integrated natural science (e.g., sea level rise projections) into the survey design; however, this methodology is time and resource intensive, and might be cost-prohibitive in many cases.

Recreational fishing valuation has already been explored, but it falls under the larger umbrella of recreational services — services that escape typical market valuation. Bergstrom et al. (1990) aggregated a list of all recreational values of Louisiana wetlands including hunting, fishing, boating and existence values (the value of simply knowing a wetland exists). The authors designed a use survey and questionnaire for recreationists across all types of Louisiana wetlands. Questionnaire respondents were asked to record expenditures per person per recreational trip (for things like fuel, site fees, lodging, bait and ammunition). Respondents were also asked if they would pay a given dollar amount to preserve the wetland, thus evaluating their WTP. The responses were analyzed using a statistical analysis that yielded a mean WTP, of $360 per recreationist per year. Using this WTP plus the recreationists' expenditures, Bergstrom et al. estimated an aggregate economic value of $145,236,000 per year for wetlands recreation, or $1,911 per user per year. (Note that in contrast to economic valuation of fisheries, which has the value in a per-acre unit of measurement, it is common to state recreational studies on a per-person basis). Such a methodology that results in large, aggregate values can be useful in certain federal and state policy contexts, though if not properly designed, might be too coarse to be useful when looking at the increase in recreational value obtained from a single restoration project.

Denitrification

A less visible service that salt marshes perform is nitrogen fixing and denitrification of the soil, which are important processes in cycling nitrogen. In a North Carolina wetland system, researchers Piehler and Smyth (2011) measured the amount of nutrients and gases trapped within sediment and water samples. The amounts were evaluated using a replacement-cost methodology, estimating replacement rates by applying actual dollar values from an already-established North Carolina nutrient offset program. (If they build on nutrient-rich areas, developers must make reparations to the local government.) Salt marshes had some of the highest denitrification rates of the five types of wetlands tested. Although stating their caution about extrapolating from limited data, Piehler and Smyth had promising results. With nitrogen valued at $13/kilogram in the nutrient offset program, the authors estimated salt marshes were worth $2,500 per acre per year for denitrification services alone.[16] They concluded by stressing the need for more comprehensive study within single systems, as well as between multiple systems.

Waste water filtration is an additional service that has potential for further study, as current policy carefully limits the amount of waste water allowed into wetlands so as to not overwhelm and destroy the ecosystem. Breaux et al. (1994) advocate for wetland waste water treatment as a substitute for conventional treatment methods. A trial wetland treatment of municipal waste water in Thibodaux, Louisiana, reduced nitrate and phosphate levels by 72 percent to 85 percent and 31 percent to 76 percent respectively. This was considered an effective treatment of the waste water. However, the authors acknowledge the study was limited to one year and thus did not observe or consider adverse side effects to the wetlands. They projected a value of $785 to $885 per acre of saved treatment cost. While Breaux et al. explored a promising wetland service, much further research is required to examine the impact of such actions on the health of the wetland. Further, evidence suggests that excessive nutrient application to salt marshes can have negative consequences for marsh health and can lead to a reduction in other ecosystem services, such as risk reduction.[17]

16 This type of value will likely only be relevant if there exists a market for nutrient offsets.

17 Salt marshes with excess nutrients may appear healthy, but might in fact be losing crucial below ground biomass that is necessary to maintain the elevation and stability of the marsh platform (Deegan et al., 2012).

Summary

All wetlands, and specifically salt marshes, provide numerous ecosystem services. These services are manifested and valued differently based on a range of factors including availability of complementary inputs, individual behaviors, income levels and governmental policy. Further, not all acres of salt marsh are valued equally, varying with geographic location and scarcity of the resource. After the impact of Hurricane Sandy on the U.S. eastern coast, many people have become increasingly aware of the need for greater storm protection. Restoring salt marshes has great potential to provide a cost-effective solution that brings with it many additional ecosystem services. We propose a greater consideration of natural infrastructure in coastal management planning and expect this review to provide points of entry into measuring the value of salt marsh restoration in a given policy context. However, to date more of the ecosystem service valuation studies look at an aggregate or landscape scale, and we still lack a good number of studies looking at the change in ecosystem service values because of a restoration project. The need remains to increase the number of sufficiently rigorous and comprehensive studies on ecosystem service valuation for salt marshes.

Evidence on the Benefits Oyster Reefs Provide to People

Figure 11. A good example of a location of an oyster reef restoration project with a goal of reducing erosion: Gandy's Beach 2006 (left), Gandy's Beach 2010–2011 (right). (The Nature Conservancy 2011)

Oyster reefs are just one of many natural infrastructure techniques that one could choose from a portfolio of living shoreline designs that attenuate waves and reduce shoreline erosion, while providing significant ecological benefits. Oyster reefs may be preferred over hardened, gray infrastructure options for the multiple benefits they offer. Whereas engineered solutions such as seawalls have a single benefit — shoreline stabilization — oyster reefs provide economic, social and ecological benefits. The ecosystem services provided by oyster reef restoration projects include, but are not limited to (refer to a comprehensive list with citations in Appendix 1 of Kroeger, 2012):

1) Wave attenuation, reducing both wave height and wave energy
2) Reduction in shoreline erosion
3) Provision of habitat for commercial and recreational fisheries, such as blue crab, American eel and white perch, which can lead to an increase in these populations over the long term
4) Improvement of water clarity
5) Removal of nitrogen from water (denitrification)
6) An improvement in habitat for certain recreational fisheries (fish such as striped bass tend to congregate over the oyster reef, increasing the fishing opportunities for anglers)
7) An improvement in habitat for certain commercial fisheries, which also include striped bass and blue crabs

Oyster reef restoration is of particular importance because of the rapid decline of oyster populations over the past 130 years. Resulting from a combination of pressures, including overfishing and disease, 85 percent of oyster reefs globally have been lost since the late 19th century (Beck et al., 2011). Although the commercial value of oyster reefs has long been recognized, scientists have only recently been quantifying the multiple benefits that these ecological systems provide. The following paragraphs present the results from recent reports and published literature showing economic valuation of oyster reefs, while showing the methods used, data collected (if any) and recommendations from each case.

Studies Quantifying Multiple Benefits

Grabowski et al. (2012) provide a comprehensive overview for valuing the full range of ecosystem service benefits provided by oyster reefs, including references of past studies and valuation methods used. The authors report that the estimated annual value of oyster reefs is between $10,325 and $99,420 per hectare, with the cost of investment paid back in two to 14 years when using the median cost of restoration. These values range depending upon the location of the oyster reef and the specific services quantified for that oyster reef though, despite being a large range, the numbers serve to convey that by incorporating multiple ecosystem services into the economic analysis, oyster reef restoration can be cost-effective in a variety of circumstances.

The authors rely upon past studies using a variety of methods for valuing ecosystem services, including productivity method and avoided costs,[18] showing the economic value for water quality, fisheries and shoreline stabilization, though all data was aggregated from existing data sources and should be considered average values. Average values do not take into consideration marginal production value. (Refer to the text box in the previous section on EPFs and marginal production values). For instance, a minimum amount of habitat for fisheries may be necessary to support a given fishery, and the benefits at a specific site might not accrue if that site is below a threshold. Thus the Grabowski analysis is an important first step for understanding the potential benefits for oyster restoration, and future research should focus on refining the location-specific conditions under which benefits will most likely accrue.

An Army Corps of Engineers' report also found that the additional benefits of oyster reefs can be higher than the value of harvesting the oysters, in an analysis using cost data from recent Chesapeake Bay projects and benefits transferred from other studies, (Henderson & O'Neil, 2003). They recommend collaborating with local stakeholders to better identify the expected site-specific benefits of a proposed project.

A recent analysis of a northern Gulf of Mexico oyster reef restoration in Mobile Bay, Alabama, was among the most comprehensive assessments completed to date quantifying the cumulative benefits from improved fisheries, nitrogen abatement, wave attenuation and economic impact from construction (Kroeger, 2012; Kroeger and Guannel, 2014). Often researchers only have the resources to quantify a single type of ecosystem service benefit from a restoration project, while the research by Kroeger and Guannel gets us closer to the full value provided by the

18 Methods are described in Appendix C.

multiple benefits resulting from oyster reef restoration. The drawback is that at times, conducting studies that quantify the value of multiple benefits might mean that less rigor is applied to each benefit, though that is not always true. The analysis relies upon a variety of valuation approaches — including a welfare analysis, benefit transfer and avoided costs — and serves as a good example of integration of biophysical and economic methods in a single study.[19] The components of the study, methods, and results are summarized in the following bullets:

- To quantify the fisheries enhancement from the restoration, the researchers obtained data from recent fisheries monitoring in Mobile Bay and supplemented that with data from published literature to show the increase in fish biomass, taking into consideration the minimum required size for harvest. Next, the benefits from recreational fishing were quantified in terms of consumer surplus, which is the value that anglers place on the fishing experience. The **consumer surplus** was quantified through benefit transfer,[20] where the value was obtained through social surveys from past studies in locations with similar demographic and ecological conditions. While the researchers tested four different models for transferring benefits from one policy context to another, they selected the benefit transfer method that led to the most conservative value.
- The commercial fisheries benefits were analyzed using a welfare analysis, which is a method that assesses whether society is better or worse off with a given policy change. The researchers quantified the fisheries benefits using existing data on dockside prices, potential changes in prices from altered behaviors by consumers and average profit rates from other studies.
- Combining the results for recreational and commercial fisheries, total net benefit for the 2.37 hectare restoration was estimated at between $83,700 and $89,300 annually.
- The wave attenuation benefits were first modeled using the InVEST coastal protection model. The results of the InVEST model, in conjunction with average cost data for conventional shoreline armoring, were used to calculate potential avoided costs in the future (that is, that the oyster reef could replace the need to implement shoreline stabilization alternatives, such as bulkheads). The potential net benefits for shoreline stabilization are $207,000.

Future studies should look at a longer time series before the restoration for the fisheries data to lower the potential that any increases are from other environmental factors and to ensure that increases are caused by the oyster reef restoration. Also, the InVEST model is best for sandy soils, so regions with different soil types might be better off applying different methods for measuring erosion reduction, such as physical monitoring at restoration and control sites. Further, while the Kroeger example did not include homes behind the restored oyster reef, future studies where homes are located behind the reef can use hedonic modeling[21] to quantify the change in property values or could calculate actual costs avoided from homeowners not having to install bulkheads or revetments.

Shoreline Stabilization Benefits

Stricklin et al. (2010) also quantified the shoreline stabilization benefits of constructed oyster reefs in intertidal deltaic settings, and then compared them to natural oyster reefs over a 21-month period in the Great Bay of Mississippi. Although the researchers found the constructed oyster reefs to outperform natural reefs as measured by reduction in marsh edge erosion, they also found considerable variability across the sites. The variability likely results from differences in level of boat traffic, sediment type and areas with higher wave energy. These results suggest that coastal restoration practitioners should carefully consider location-specific conditions when estimating potential benefits of an oyster reef restoration project, as the level of benefits will vary substantially given these localized conditions. Additionally, the results show that smaller oyster reef restorations (55.8 m^2) were sufficient to reduce marsh edge erosion, demonstrating that even small-scale restoration projects can generate quantifiable marginal

19 Methods are described in Appendix C.

20 Described in Appendix C.

21 Described in Appendix C.

benefits. Nonetheless, none of the constructed sites led to an accumulation of sediment at the marsh edge, indicating that larger-scale projects might be necessary if the goal is to reverse the erosion process. Future studies should consider monitoring for a longer time period and under a wider range of ecological and biophysical conditions to ensure that the results are relevant for a wider diversity of geographical regions.

Fewer studies exist on the wave attenuation benefits of **subtidal oyster reefs**, which are fully submerged reefs (even at low tide). Subtidal oyster reefs tend to be more appropriate for the conditions in the mid-Atlantic region (such as in the Delaware Bay). Intertidal oysters, which are exposed to the air at low tide, would not survive during the winter because of the cold temperatures. One relevant study on subtidal oyster reef restoration involved a field-based experiment by Scyphers et al. (2011) in Mobile Bay, Alabama. The researchers collected data at treatment and reference sites, and included data on shoreline erosion and bathymetric changes. One subtidal oyster restoration site saw a reduction in shoreline erosion of more than 40 percent, though their results across sites were variable. Part of the variability was linked to unexpected flattening of the reefs, and they recommend better design of the subtidal oyster reef in areas prone to high wave energy. Fisheries data was collected, as well, and restored sites were shown to have higher diversity of species than control areas with no reefs. The researchers note that there may be trade-offs between providing higher quality habitat and providing higher shoreline protection. Further research should involve improving our ability to balance engineering and ecology, which has the potential in the future to reduce these trade-offs, increasing both habitat benefits and reducing erosion more significantly. The researchers also reinforce the findings from previous studies that benefits vary significantly and can be highly localized, making it challenging to accurately predict the expected benefits before designing an oyster reef project.

Further, in certain cases engineered structures such as bulkheads reflect back wave energy and have been documented to *increase* localized erosion, as documented through homeowner surveys (Scyphers, Picou, & Powers, 2014). The researchers refer to this as a "cascading" effect, where when one homeowner chooses to invest in a bulkhead or other hardened structure, it leads to an increase in erosion on neighboring properties and prompts other homeowners to need to invest in hardened structures.Therefore, if the erosion reduction value of restored subtidal oyster reefs were low, there might still be an improvement over bulkheads in terms of long-term coastal resilience.

Fishery Production Benefits

The restoration of oyster reefs provides a three-dimensional substrate that benefits many invertebrate and fish populations. Among other benefits, oyster reefs provide habitat for spawning and nurseries, protection from predators, and prey resources. According to a report by Stokes et al. (2012), an acre of oyster reef can increase fisheries benefits by $4,200/year (a value the authors aggregated from several different studies). A New Jersey study by Evert and Hale (2007) compared levels of the commercially important blue crab between a restored oyster reef and a control site and found the blue crab levels to be 25 percent higher at the restored site, though they did not associate a dollar value with this figure. Scyphers et al. (2011) found both higher abundance and biodiversity of fish and mobile invertebrates around oyster reefs when

compared to control sites. Blue crabs increased the most, at 297 percent. Again, this increase was not linked to recreational or commercial fisherman behaviors, and thus, no dollar value was assigned.

Kellogg et al. (2013) tested the level of macrobenthic organisms on restored oyster reefs and found 24,585 organisms per square meter on the reefs, compared to 2,265 per square meter on the control sites. Although this study does not look only at recreationally and commercially important species, it is an important study given the sheer magnitude of the difference in organisms. Given food chain linkages, there are likely many species that are benefitting commercially and recreationally important species. Peterson, Grabowski and Powers (2003) conducted a comprehensive analysis of existing literature and concluded that in the southeastern United States, 10 square meters of oyster reef restoration will yield a 2.6 kg increase in large mobile crustacean and fish numbers. While the number of studies on the increase in fisheries production from oyster reef restoration projects is substantial, the existing studies do not cover all species of fish, nor do they cover the full range of geographical and ecological conditions, and they often do not put a dollar value on the fisheries benefits (rather, they only quantify the fisheries production services); thus more studies are needed to fill these data gaps.

Water Quality Benefits

At the estuary scale, Zu Ermgassen et al. (2012) estimate water filtration rates and the subsequent losses over time as a result of declines in oyster populations. They found that in 12 of the 13 estuaries filtration rates declined, where 9 of the 13 dramatically declined with median losses at 85 percent. However, in many cases the water quality benefits are challenging to quantify at scale, largely because many oyster reef restoration projects are at such a small scale that measuring the impact on water quality from a single project is difficult. Still, localized improvements in water quality have been observed because of restoration of oyster reefs (Coen et al. 2007). Recent research has found positive but statistically small impacts when looking at aquaculture oysters and water quality improvements (Higgins, Stephenson, & Brown 2011) and denitrification (Higgins et al., 2013). Kellogg et al. (2013), in contrast, studied the denitrification benefits because of wild oyster reef restoration and found them to be substantial, removing up to 10 times more than a control group. It is unclear the precise reason for the difference in magnitude between the first two studies and the Kellogg study, though one hypothesis is that it is related to the design of the oyster reef.

We can conclude that in general, oyster restoration has been linked to improvements in water quality. Much less common are studies monetizing the value of water quality improvements. One reason for this is that water quality in most cases is not the final benefit. Improved water quality could eventually lead to an increase in fisheries production, and thus, the economic value could be calculated by valuing the benefits to commercial or recreational fishers. Or if the reef were located near a public beach, the value of the water quality improvement could be calculated by showing the increase in benefits to visitors swimming at the beach. One of the few cases where the economic value of water quality in estuarine settings can be quantified is when the water quality improvements can be traded in a nutrient market.

Tourism and Economic Impacts

The American Sportfishing Association (ASA) conducted research on the role of recreational fishing and tourism in the United States. They reported that in New Jersey, approximately 257,000 non-resident anglers visit the state each year to fish on the Atlantic Coast or Delaware Bay, spending an estimated $106 million each year (Southwick Associates 2013). Angers contribute to the tourism industry, impacting regional economics, and the ASA estimates that each dollar spent by an angler creates $2.40 of economic benefits throughout the community (ibid.). Thus, for certain communities, oyster reef restoration may be a valuable component of their long-term economic development planning.

Summary

While oyster restoration efforts have been scaling up since the 1990s, and numerous studies have been conducted on biological and structural parameters associated with these restoration projects, there remains a lack of rigorous studies on the *net* economic benefits of restorations. Further, few studies exist demonstrating the location-specific benefits and costs of subtidal oyster reef restoration in the Delaware Bay and mid-Atlantic region. There is a significant data gap to be filled, and future studies should seek to show the effectiveness of the projects in providing benefits to people, quantify the economic value of the important benefits of oyster reef restoration projects, and demonstrate the multiple benefits in a wider range of ecological, political and social contexts.

Appendix B
Case Studies

ENGAGING PRIVATE LANDOWNERS IN COASTAL HABITAT RESTORATION

A case study from Mobile Bay, Alabama, provides us with an interesting example of how using ecosystem service valuation can create an opportunity to leverage funding from private landowners. The Nature Conservancy and numerous partners in the Gulf of Mexico are working together to restore coastal ecosystems, focusing on oyster, sea grass and salt marsh habitats. While the full restoration strategy focuses on multiple habitat types, this case study emphasizes the work surrounding oyster reef restoration. Although oyster reef restoration in the Gulf of Mexico is taking place at many, many locations across the gulf and into the bays, the common shoreline stabilization approach of landowners still tends to be traditional armoring techniques. Conservation organizations have collected extensive amounts of data on the effectiveness of oyster reefs in terms of the habitat benefits to oysters at the restoration site, but were still lacking the data to make the case that private landowners behind an oyster reef receive the benefits that reefs provide. Targeting private landowners is critical in Mobile Bay, since nearly 75 percent of the shoreline is privately owned. Conservation partners knew that shoreline stabilization benefits would be important but were unsure about which other benefits and which shoreline protection criteria were most important to landowners.

Thus, The Nature Conservancy and Steven Scyphers of Northeastern University (previously with the Dauphin Island Sea Lab of Alabama) spearheaded a multi-phase project in Mobile Bay to engage private landowners, test the effectiveness of oyster reefs for erosion reduction and develop finance mechanisms. Phase 1 has included three components — ecological, community engagement and social science components. The goal of the ecological component was to monitor and collect additional data on oyster reefs restored in front of private lands, while comparing different reef designs and costs (for instance, some designs included oyster castle breakwaters while others had shell bags). Thus, the ecological component includes the measuring of the ecosystem services provided by the oyster reef. Through a mix of funding sources including National Fish and Wildlife Foundation grants and a smaller portion of funding from private sources, they completed restoration projects in front of eight different properties of homeowners, which they continue to monitor. The data and metrics (such as shoreline position) are then used for adaptive management. For instance, in cases where unexpected flattening of the reefs occurred, adaptive management led the restoration team to return after the third year of the project to add solid structures to the reefs to improve both the habitat quality and wave attenuation benefits at the site.

Meanwhile, the community engagement component has involved partnerships with local organizations as well as participation in community meetings. Through the community meetings and presentations on the trial oyster reef projects, interest has been high for additional participants to receive an oyster reef in front of their property, and the waiting list had between 50 and 80 individuals at the time this guidebook was being written. The Nature Conservancy also continues to engage community members to volunteer in the monitoring of the oyster reef restoration projects, getting as many as 850 volunteers at the larger events.

Scyphers led the social science component, where he developed the waterfront landowner survey, which was designed to capture relevant landowner and property characteristics, information on decision making regarding shoreline armoring, and perceived value of coastal habitats (Scyphers, Picou, & Powers, 2014). Of the 1,000 surveys that were mailed out, they had a 36 percent response rate. For shoreline types, the respondents had a mix of vertical walls, revetments and natural shorelines. Effectiveness, cost and durability were ranked as the most important criteria for landowners deciding to engage in shoreline stabilization techniques. Having information on landowner and property characteristics will be valuable for informing future research and also can help inform tactics for engaging stakeholders and producing key messaging that resonates with communities. Additionally, the survey also provided evidence of the negative effects of vertical walls to neighboring properties. While natural scientists have long understood that hardened shorelines can exacerbate erosion to surrounding lands, Scyphers et al. provide data showing when a single property owner implements a vertical wall, it "trigger[s] a chain reaction of armoring" as a response by surrounding owners because of their observation of either an increased rate of erosion or increased wave energy.

With Phase 1 of the project completed, The Nature Conservancy and Steven Scyphers are moving into Phase 2, which will include an economic study as well as the development of a cost-share mechanism for private landowners. Surprisingly, it is not necessarily a willingness to pay study that is lacking to begin a cost-share program between landowners and public partners, but rather a lack of understanding of how to create a finance mechanism. Several enabling conditions required to develop a cost-share mechanism are (1) identifying a governmental partner, (2) establishing selection criteria of landowners, (3) developing the application process, and (4) establishing the fund or other instrument for the transfer of payments. This case study serves as a fabulous example of how a combination of ecological, social and economic data can lead to positive outcomes for community engagement, oyster reef restoration and additional private funding. This case study reinforces the theme that ecosystem service valuation is not only about data and analysis, but also about the full process of engaging and learning about project stakeholders, identifying sites and implementing restoration projects, collecting a variety of data, identifying funding sources and policy levers, and bringing all the pieces together.

LOWER CAPE MAY MEADOWS ECOSYSTEM RESTORATION

In a recent analysis of ecosystem service benefits resulting from the Lower Cape May Meadows ecosystem restoration, the flood reduction benefits to homeowners and ecotourism impact to the county were quantified from a beach, dune and wetland[22] restoration project that was completed in 2007 (Schuster, 2014). This report serves as a useful case study to show a different set of methods, metrics and data sources that could be used for ecosystem service valuation of a coastal restoration project. However, the restoration was conducted in 2007, before the processes presented in this guidebook were developed. Thus, the full process including the rapid stakeholder assessment and collection of baseline data on socioeconomic metrics was not followed. Even so, an ecosystem service valuation study was able to be conducted based upon existing data sources. That being said, the results of the study could have been even stronger if the full process recommended in this guidebook were followed (examples of lessons learned are included at the end of this case study).

First, the avoided damages from flood reduction services were quantified. The example presented in the last section of Chapter Four relied upon modeling of the flooding before and after the restoration and then used the results of the initial analysis to quantify the economic benefits of the project. However, for the Lower Cape May Meadows Ecosystem restoration, time series data were used to show the effects of the restoration on the provision of services. In part, this was necessary because there are multiple components of the restoration that were likely to lead to a decrease in flooding, including the hydrologic alterations, and dune and beach restoration. Thus, a simple result chain might look like this:

Wetland, dune and beach restoration -> Increase in wave attenuation, storage capacity and drainage -> Reduction in flood depth to surrounding homes -> Reduction in damages to surrounding homes

Because of limited access to fine-scale data (e.g., parcel-level flood damage values), the lack of a rigorous pre-restoration analysis and no comparable control site (because of the lack of a site that had equivalent coastal protection infrastructure, density of housing, hydrology and percent impervious cover), alternative data sources had to be explored. These data availability issues were overcome by obtaining time series data from National Flood Insurance Program (NFIP) claim data from the Federal Emergency Management Agency. Time series data were collected for each major storm from 1985 through 2013. Because of privacy protections for individual property owners, we were unable to access parcel-level claims data. Nonetheless, aggregation of data to the borough level was appropriate because of the relatively small number of homes (~600 homes) in the analysis and because all homes in the borough fell within the area influenced by the wetland — that is, at a higher elevation than the restored wetland and thus, draining into the wetland. Note that the area draining into the Lower Cape May Meadows wetlands was delineated using GIS tools and based largely upon LIDAR data, with adjustments made where appropriate based upon location of storm-water infrastructure and upon expert knowledge from the office of the county engineer.

Obtaining NFIP claim data can be challenging. In the case of the Lower Cape May Meadows economic analysis, the process of accessing the NFIP data was accelerated by not going directly through FEMA, but rather, by building relationships with municipal and state-level contacts, who put the request into FEMA. Post-Sandy, FEMA has increased efforts to help municipal emergency managers and planners gain access to parcel-level data, so having a municipal-level official submit the request to FEMA, then share the aggregated data, can be an effective strategy to access the data. In other cases, some organizations have been successful at submitting a Freedom of Information Act (FOIA) request to FEMA and receiving parcel-level data. If going this route, keep in mind to allow for many months for the data to be obtained.

Additionally, data on precipitation, storm duration and storm surge was gathered from each of storms in the analysis. The precipitation data was from the Cape May weather station, which is a National Weather Service (NWS) Cooperative Observer Program (COOP) reporting

22 Although the restoration in this example involves a freshwater wetland, the data sources and metrics are still applicable to salt marshes.

station. The data were obtained from the National Climatic Data Center (NCDC), which acts as the nation's archive for weather and climate data. For storm duration, a proxy was used: total "three-day precipitation, where larger three-day totals tend to be correlated with longer storms. The storm surge data were obtained from the National Oceanic and Atmospheric Administration (NOAA) web-based database. Storm surge data is not directly available from the NOAA website. However, since the dataset was small (15 storms), we were able to calculate the storm surge per storm, though this would be challenging with large datasets. One way to calculate storm surge is to follow these steps:

1) Navigate to the NOAA Tides and Currents webpage: http://tidesandcurrents.noaa.gov/gmap3/index.shtml?type=TidePredictions&region=
2) Click on the U.S. state of interest.
3) Within that state, click on the appropriate tide gauge.
4) A call box will appear with the station name and a list of links. Click on the link labeled "*Water levels*."
5) Follow the prompts on the screen to enter in the date range required.
6) Where the dialogue box lists "*Interval*," select H/L.
7) Plot the data. Note the high water mark. Subtract *Predicted* from *Verified*. The difference is the storm surge.

The avoided damage costs to homes as a result of the reduction in flooding from the restoration was calculated by a simple trend analysis, quantifying the **average damage per storm per foot of storm surge** and then **average damage per storm per inch of precipitation** before the restoration. Then, those values were used to calculate the rate of damage before the restoration on an

average annual basis. Next, that *rate* was applied to determine what the damage would have been after the restoration if it occurred at the same rate as before the restoration, and subtracted from the actual damage after the restoration. Finally, we extrapolated the results out for 50 years. We estimated that avoided damages would be valued at at least $2,000,000 and could be as high as $17,300,000.[23] Although this analysis was simple and did not include modeling to account for climate change over the next 50 years, the analysis was nonetheless of the appropriate level of rigor for the audience of the study.

The second portion of the analysis was to quantify the economic impact from total spending by birders to the site. A simple result chain might look like this:

Wetland, dune and beach restoration -> Increase in the abundance and diversity of birds -> Public access to site was improved -> The number of birders to the site increased -> The total spending by birders to the county increased

Site-specific baseline and post-restoration data on birds were not available. Thus, while evidence suggests that birds benefited from the restoration, it was not possible to *prove* that the abundance and diversity of birds increased as a result of the restoration. Instead, it was necessary to rely upon citizen science data on the number of birders to the site. We accessed data from Cornell Lab of Ornithology's web-based bird sightings database, eBird, from two birding hotspots, the restoration site and a control site about one mile away, and compared the increase in the number of birding trips at each site before and after the restoration. The restoration site showed an increase in the number of birding trips of three to four times more than the control site. Although we recognize that other factors may also have contributed to that increase — such as issues with self-reporting on the eBird site and naturally occurring shifts in habitat — the analysis was sufficient to show the trend in change in birder numbers at the restoration site, relative to a control. Other researchers have also successfully used eBird in coarse analyses that contribute to public policy discussions, and given the ubiquity of the data and the low-cost nature of the site,

23 The large range is a result of the fact that the $2,000,000 value is what the damage would be if the damage *only came from storm surge*, and the $17,000,000 comes from if the damage were only *from precipitation*. In reality, storm damage results from storm surge and precipitation induced flooding, and the actual total value of damage costs avoided is likely to fall between these two extreme values.

eBird should at least be considered as a viable source of data for certain audiences (Sullivan et al., 2014).

Data on spending by birders per trip to the region were obtained from a past report written on the same geography, and adjusted for inflation using the U.S. Department of Labor Consumer Price Index Inflation calculator, at http://data.bls.gov/cgi-bin/cpicalc.pl. Total visitor numbers were obtained from the Cape May County Department of Tourism. Also from the same source, we were able to confirm reason for visit (that is, that the visitor chose Cape May County because of birding and not because of its beaches), determine which visitors went to the southernmost point of Cape May County, and determine which visitors were from outside of the state (in order to consider visitor spending an economic impact, it must be spent by visitors from outside the region).

The final metric was calculated by multiplying total birders from outside of the region who visited the southernmost point of Cape May County by total spending per trip. The total economic impact of the restoration was found to be $313 million per year, which is a reasonable estimate compared to a total tourism economy for the county of $5.5 billion per year. However, one final step was needed. Based upon the knowledge that there was an increase in the number of birding trips of three to four times more than the control site, what was the change in economic impact because of the restoration? We concluded that the restoration led to an increase by approximately $210 million to $235 million per year above the previous annual spending by birders.

What lessons learned can we glean from the Lower Cape May Meadows economic analysis?

1) The study was intended to be a proof of concept, raising awareness of a wide variety of stakeholders that restoration can successfully increase the value of ecosystem service benefits, and the avoided damages calculated serve to show the order of magnitude of the change.
2) The study reinforced the idea that taking into consideration the target audience when conducting an ecosystem service valuation study — collecting data on relevant benefits or metrics with an appropriate level of rigor for the audience — is worthwhile. In this case, the objective was to raise awareness of the benefits of natural infrastructure, and thus, a full BACI design was not considered necessary and would have also been infeasible given the budget and timeline.
3) This serves as a good example of, when possible, how to reduce data collection costs by accessing existing data.
4) Timelines for data collection might be longer when relying upon relationships with partners to access data that would not otherwise be publicly available. Much of the data that were obtained for this study was accessed through word-of-mouth, so relationship building is an important component of a successful economic study.
5) As mentioned earlier, insufficient baseline data were collected to complete the analysis. Therefore, the total estimate for avoided damage costs is likely an underestimate. The restoration also benefits portions of West Cape May and Cape May City that include an additional 710 homes, and we were not able to access NFIP claim data on those homes because of a tight timeline to complete the analysis. Further, we were not able to access data on damage to public infrastructure, such as roads. Had we had more time to build relationships with municipal emergency and public works managers from the beginning, it would have been easier to collect additional flood damage data.
6) Also we had insufficient baseline data on site-specific visitation. Thus, because we had to apply county-level data to our analysis, our visitor numbers possibly included surrounding sites in addition to our restoration site. If possible, it would have been advisable to collect site-specific baseline data on visitation. Site-specific baseline data can be collected using a basic car counter such as those available at http://www.trafx.net/, which are mid-value car counters, making them more affordable for a wider range of organizations than certain pricier models.[24] Also, many counties collect traffic data as well as data from county park systems, so contacting the county can also result in visitation data when available. A third option is to leverage data from social media sites such as Flickr, where researchers have been able to confirm that social media data can serve as a reasonable proxy for visitation data (Wood, Guerry, Silver, & Lacayo, 2013).

24 At the time of the writing of this guidebook, car counters were available for $2,245 for three, though verify the website for pricing information at http://www.trafx.net/sales.htm. These counters can be buried at the entrance of parking lots and will count each car that enters. Assumptions will need to be made about the number of visitors per car. The counters can also be placed on trails to capture foot traffic, though theft of the device may be an issue.

Appendix C

Summary of Environmental Economics Terms

Ecosystem Service Valuation Methods

The following is a brief summary of common ecosystem service valuation methods (Adapted from Stelk & Christie, 2014).

- MARKET PRICE METHOD: For ecosystem service goods and services that are directly traded on a market — such as timber or certain fisheries — the market price of that good can be used as the basis of the analysis to represent the value of the ecosystem service benefit.
- PRODUCTIVITY METHOD: This method is based upon the value of various inputs into the production of a good or service. For instance, a salt marsh provides valuable habitat for feeding for certain fisheries such as the blue crab, and the value of the salt marsh can be estimated as a portion of the total market price of the blue crab.
- AVOIDED COST METHOD: If a resource manager is able to avoid a cost because an ecosystem service benefit is maintained or restored, then the value of the avoided cost can be used in an analysis to represent the value of the ecosystem service benefit. For example, if evidence shows that homes in a certain area would have received a given level of damage, and

that risk of damage was reduced because of the increase in flood storage capacity of a restored wetland, then the avoided damage costs can be used as a proxy for the value of that wetland.

- REPLACEMENT OR SUBSTITUTION COST METHOD: If a resource manager would be required to replace an ecosystem service benefit if it were lost, then the value of that replacement item (or substituted item) can be used to represent the value of the ecosystem service benefit. For instance, if the storm buffering and flood attenuating services of a salt marsh were lost, the value of a seawall or other hardened structure installed to replace those services could be used as a proxy for the value of the ecosystem service benefit.
- TRAVEL COST METHOD: We expect that the distance a visitor is willing to travel is proportionate to the value the visitor places on a natural site. Thus, if a visitor is willing to travel further and/or more frequently, then the value placed on that site is expected to be higher. Assumptions can be made about the value of the time of that visitor, and used to calculate the value of the site. Travel cost method estimates the **consumer surplus**, or the value that visitors place on the experience beyond what they spend. It makes intuitive sense that when visitors travel to a rural site with no entrance fee, the amount they pay is often zero, yet the actual value the visitor has on the experience is higher — the visitor would be willing to pay more for the experience. Thus, economists observe visitor behavior — the distance they are willing to travel — to reveal the underlying value the visitor places on the experience.
- HEDONIC PROPERTY VALUE METHOD: Homes near open space (e.g. forests, marshes, beaches, etc.) with aesthetic qualities, recreational opportunities, shoreline stabilization benefits, or flood reduction benefits may have a higher property value than equivalent homes. An analysis can be conducted taking into consideration the attributes of the home and neighborhood and all else being equal, the portion of the natural resource that is capitalized into the price of the home can be calculated to represent the value of that ecosystem service benefit.
- CONTINGENT VALUATION: Contingent valuation is a method where through the use of surveys, respondents are asked their willingness to pay to protect, maintain or restore a resource. Their stated value serves as a proxy for the value of the ecosystem service benefit and is the most common method for quantifying non-use ecosystem service benefits, such as existence value of a specific species or habitat type.
- CHOICE EXPERIMENT: Choice experiments are a type of survey design that allow for respondents to state their willingness to pay for ecosystem services based upon *multiple attributes*. Attributes could include specific ecosystem service benefits (e.g., recreation benefits versus flood-reduction benefits) or could also allow for assessing preferences between management alternatives (e.g., ecological restoration options versus hardened, gray infrastructure options). From Carías Vega and Alpízar (2011), the four steps for designing and implementing a choice experiment are 1) definition of attributes and attribute levels, 2) experiment design, 3) experiment context and preparation of questionnaire, and 4) choice of sample and sampling strategy (p. 11). Preferably, attribute levels will be based on scientific data. Often, the survey is designed with input from an interdisciplinary work group and involves many focus group meetings with stakeholders.
- BENEFIT TRANSFER: Benefit transfer is the process of applying a value obtained from an ecosystem service valuation study from one policy context to another. The value can be applied directly, or applied using a benefit function transfer. A **benefit function transfer** is where the functional relationship among variables was determined in one policy context, and thus the variables that are relevant to the new policy context can be inserted into the function to calculate a new ecosystem service value (for instance, by taking into consideration the number of visitors or the rate of fisheries production at a specific site). A third approach to **benefit transfer is called a meta-analysis**. A benefit transfer using meta-analysis involves the aggregation of numerous studies valuing a particular ecosystem service benefit, where these values are analyzed statistically to determine which characteristics (such as size of a watershed, study method, population, etc.) systematically influence the magnitude of the benefit,

and to what extent that influence might be. Take caution when applying benefit transfer. To achieve accurate results, the ecological conditions, demographics and local policy context must be sufficiently similar between the original study site and the new site, or adjusted for using benefit function transfer or meta-analysis. When conditions are not sufficiently similar, benefit transfer can lead to dramatic overestimation or underestimation of ecosystem service benefits.

Additional Vocabulary from Environmental Economics

- WELFARE ANALYSIS: A welfare analysis is a method that quantifies how a policy change will affect society. This method is often used by governmental agencies to determine how a policy change may impact the public in a given region, by estimating whether there are net gains to society or net losses because of that policy change.
- LIFECYCLE COSTS: A study that looks at lifecycle costs assesses the full costs associated with a project, from beginning to end, including long-term maintenance costs. In the context of natural infrastructure, this type of study may involve a comparison between the lifecycle costs of a gray (hardened) infrastructure technique and a natural infrastructure.
- COST EFFECTIVENESS: Cost effectiveness is a measure of the unit of benefit received per dollar spent (calculated by dividing the total of a given type of benefit by the total cost to obtain that type of benefit). The unit of benefit can be a conservation benefit or an ecosystem service benefit for people.
- STATED PREFERENCE: The stated preference method is an umbrella category of several different types of ecosystem service valuation methods. They are distinguished by the fact that, usually through the use of social surveys, the researcher directly asks the individual the value that he/she places on a good, service or experience. These are often referred to as willingness-to-pay studies, since they are asking what an individual would hypothetically pay. Contingent valuation is an example of a stated preference method.
- REVEALED PREFERENCE: Revealed preference method is an umbrella category of several different types of ecosystem service valuation methods that determines the value of a benefit indirectly. Researchers use observations of actual behaviors to infer the value that an individual places on a given good, service or experience. Market price, travel cost, hedonic property value and avoided cost are all examples of revealed preference methods.
- ECOLOGICAL PRODUCTION FUNCTION: In the context of ecosystem service valuation, an ecological production function (EPF) is the quantitative relationship between the underlying ecological function and the resulting ecosystem service. The EPF is not an economic function but rather an ecological function. The EPF is the first step in an ecosystem service valuation study. After the EPF is established, the EPF can be used to inform an ecosystem service valuation analysis.
- MARGINAL PRODUCTION VALUE: Marginal production value can be defined as the value of one additional unit of service, as defined by the EPF. The marginal production value helps to better explain the effect that a stressor (like a decrease in water quality) has on the supply of a given ecosystem service. That information is then used when quantifying the change in economic value because of that stressor.
- ELASTICITY: Elasticity measures how responsive a variable is to a change in conditions, and includes the level of change and the direction (whether it increases or decreases).

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