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How Ecosystem Services are Measured and Why it Matters for Florida[1]

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Introduction

"Ecosystem services" is a term used to describe the benefits that ecosystems and their inhabiting species provide to humans. Ecosystem services include things that are easily assigned economic values because they are traded, bought, and sold, like harvested fish, wood, or collected water. But they also include services that are not as easy to put prices on, like animals or plants that prevent storm damage, nutrient cycling or biodiversity that helps to support life, or ecosystems that provide humans enjoyment and recreation. Ecosystem services are increasingly important in scientific literature, and many scientists measure the ecosystem services of different ecosystems or assess how ecosystem services might change under management actions. Ecosystem services are also increasingly discussed by decision makers and management agencies who want to ensure the services are sustained into the future. This means how ecosystem services are measured determines the values assigned to them and influences management decisions.

This publication describes some of the ways ecosystem service values are measured. First, we give a brief overview of ecosystem services and then provide descriptions of the approaches commonly used to assess them. The publication should help the interested public, management agencies, and Extension agents to better understand the different ways of measuring ecosystem services, and why it may matter for making management and policy decisions.

A Brief Overview of Ecosystem Services

When people talk about ecosystem services, they can mean many different things (Boyd and Banzhaf 2007). The definition varies because ecosystem services encompasses so many of the benefits nature provides. The primary categories of ecosystem services are described below:

- **Provisioning ecosystem services** include the products that humans either directly consume, sell or buy, including resources like oysters, grouper, pine trees, fresh water, phosphorous, fuel, etc.
- **Regulating ecosystem services** moderate environmental conditions or natural processes in a way that benefits humans directly or indirectly. They include resources like oysters or mangroves limiting erosion and providing shoreline protection, plants and animals that filter and clean water, animals that offer pest control, etc.

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- **Cultural ecosystem services** provide human enjoyment and fulfillment, necessarily linked to consumption, such as recreation, tourism, and aesthetic and spiritual services. Common examples could be joy that birds provide birders, or the emotional uplift a natural spring provides those who love seeing it, or even just the excitement of knowing that rarely seen animals like the Florida panther still exist.
- **Supporting ecosystem services** help to support other services, like providing habitat that allows for sustained plant and animal species that are important for provisioning, regulating, and cultural services. For example, in addition to other ecosystem services, oysters provide supporting services by creating habitat that is used by recreationally and commercially important fish species.

In all, every Florida ecosystem provides an assortment of ecosystem services (Figure 1). More information about this can be found in some related EDIS publications indexed here, and a particularly applicable overview of ecosystem services in Florida is available here.

Figure 1. Florida coastal ecosystems, like this salt marsh in St. Johns County, provide myriad ecosystem services, such as provisioning, cultural, and supporting services.
Credits: Edward Camp

Descriptions and Advantages of the Two Main Categories of Measuring Ecosystem Services

There are two main approaches used to assess ecosystem services with specific assessment methods (Figure 2): **sociocultural methods** and **monetary methods**. Neither approach is considered superior. Rather, the different approaches use different assumptions and methods to provide different information about ecosystem services. These approaches have been applied to a plethora of ecosystem services, each with differing populations, and used in various regions and countries. Here we briefly describe some, but not all, of the methods of each approach, including their advantages and disadvantages.

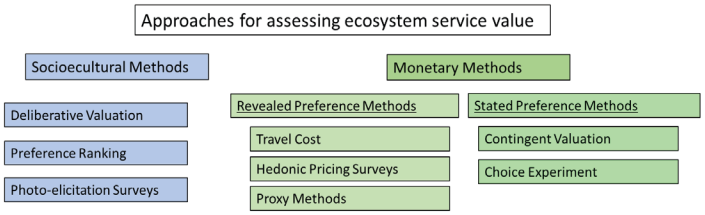

Figure 2. A conceptual diagram of sociocultural and monetary approaches and commonly used methods to assess the value of ecosystem services.
Credits: undefined

First, sociocultural methods for valuing ecosystem services seek to understand the perceived social values of ecosystem services (Harrison et al. 2018). Sociocultural methods include **deliberative valuation**, **preference ranking**, and **photo-elicitation surveys** (defined below). These methods are not used to find the economic or market value of ecosystem services. Instead, they provide insight into how ecosystem services are perceived by stakeholders (Harrison et al. 2018). These methods should be considered in studies where researchers want to consider stakeholder interaction/dialogue or collect data on preferences, values, and worldviews (Harrison et al. 2018).

Second, monetary methods estimate the economic or market values of ecosystem services (Harrison et al. 2018). These approaches can be used to put an actual dollar value on the ecosystem service. These methods account for changes in the resource's asset value, determine economic liability associated with resource impairment, demonstrate value to raise awareness, analyze the profitability of alternatives, rank projects, and price single ecosystem services. These methods differ from sociocultural methods, in which the outcome is a better understanding of how ecosystem services are valued socially. Two distinct groups of methods are used to find the economic or market value of ecosystem services: **revealed preference** and **stated preference** methods. Revealed preference methods rely on actual market data where individuals have "revealed" their value for the ecosystem service by actually paying for it. Stated preference methods involve asking individuals questions that can be used to infer or understand the value of ecosystem services (Whitehead, Haab, and Huang 2014; Harrison et al. 2018).

Sociocultural Methods

There are many sociocultural methods. We describe some of the most often used ones here, and more complete

listings can be found in the literature (e.g., Harrison et al. 2018).

Deliberative valuation is a sociocultural method that can determine a group's opinion on a specific topic (Keleman et al. 2013). Deliberative valuations are completed in discourse-based focus groups. These are typically groups of stakeholders that are facilitated to promote interactions among participants such as opinion formation and collective learning (Keleman et al. 2013). Thus, the deliberative valuation method emphasizes developing consensus rather than negotiation or debate (Wilson and Howarth 2002), and demonstrates how participants conceptualize and value ecosystem services more than it estimates the value of those ecosystem services (Kelemen et al. 2013). This method would typically involve a smaller number of stakeholders but provide greater depth in understanding from each of them. Effective deliberative valuation studies usually require facilitation and other skills used in anthropology and some human dimensions disciplines.

Preference rankings is a survey-based sociocultural method for assessing qualitative and/or relative ecosystem service values. Preference ranking assessments are usually conducted by a Likert-scale survey. With such a survey, stakeholders are usually presented with a statement about ecosystem services and asked to respond how much they agree with the statement, usually on a numbered scale (Calvert-Mir et al. 2012). Although this method is good for stakeholders that directly benefit from an ecosystem service (e.g., people who live near the coast benefiting from oysters or mangroves that stabilize shorelines), preference rankings can also be compared with stakeholders that indirectly benefit (such as people benefiting from evapotranspiration that trees perform) (Calvert-Mir et al. 2012). Therefore, researchers can use preference rankings to find the average value of ecosystem services and how types of ecosystem services are ranked by stakeholder category (e.g., regulating, provisioning, supporting) (Calvert-Mir et al. 2012). This approach is suitable for sampling larger populations, potentially with defined spatial areas that allow comparisons across stakeholder groups. Compared to deliberative methods, it is likely to provide a broader, population-level qualitative assessment of ecosystem services, but generally will not provide as much insight into the thought process behind these approaches and will not involve shared learning.

Photo-elicitation surveys compare one landscape to another using photos to reveal stakeholders' aesthetic preferences (Garcia-Llorente et al. 2012). This is typically done by asking respondents to rank landscape photos on a 1 to 5 scale of perceived attractiveness (Garcia-Llorente et al. 2012). To determine if other factors play a role in landscape preferences, researchers can ask about stakeholders' relationships to some of the following: study area, perceptions of important ecosystem services, recreation, or land-use personal behaviors. Researchers may also connect and compare photo rankings to **aesthetic use-values** (values from how things look, like a mountain or an ocean) and **existence** or **non-use values** (value from knowing things exist even if people may not use or see them, like the Florida panther) (Garcia-Llorente et al. 2012; Borisova et al. 2019). For more information on use and non-use values, see FE1064. Since questions about additional attributes can include stated numeric values and qualitative measures, photo elicitation is sometimes combined with other sociocultural or economic methods (Garcia-Llorente et al. 2012). Similar to preference ranking, photo-elicitation emphasizes assessments of the broader human populations (such as via probability sampling) rather than depth of understanding or shared learning of specific stakeholders (as would be done in focus groups).

Several other ecosystem valuation approaches fall under the sociocultural methods umbrella (Harrison et al. 2018). **Deliberative mapping** asks participants to draw, map, or describe what ecosystem services exist and where they are located. This approach is useful for incorporating local (ecological) knowledge. **Narrative analysis** elicits stakeholder descriptions of their actions and experiences with local ecosystem services. **Participatory scenario development** typically requests participants describe possible scenarios for how the future may unfold. They can help understand stakeholder perspectives and potentially build consistency within stakeholders' narratives and beliefs. For all the sociocultural methods, the emphasis is on understanding how ecosystem services are valued, rather than producing a dollar value for the ecosystem service (though some may include this as well). Appropriate implementation of these approaches will involve skills typically used in human dimensions and social science research, such as focus groups and stated preference survey design.

Monetary Methods

REVEALED PREFERENCE METHODS

Travel Cost is a revealed preference method that involves inferring values of something by analyzing how far people travel to enjoy it (Bockstael and McConnell 2007). Travel cost methods are most often used for valuing cultural ecosystem services, like recreational or leisure activities (e.g., hiking, visiting springs or lakes, recreational fishing, etc.). However, they have been applied to provisioning and

regulating services as well (Plant, Rambaldi, and Sipe 2017). An example of a travel cost study is to evaluate how much demand for visiting different parks varies depending on what ecosystem services those parks have while accounting for the cost of travel to them. Like choice experiments (CE), which are explained in the "Stated Preference Methods" section in this publication), travel cost methods usually require sophisticated economic analyses, but unlike CE, they are not easily applied to situations that have not yet occurred (e.g., future ecosystem changes).

Hedonic pricing surveys assess the monetary value of ecosystem services by analyzing how these services affect market prices (Sirmans, Macpherson, and Zietz 2005; Borisova et al. 2020). Generally, hedonic pricing will involve the regression (prediction) of market price as a function of ecosystem services present while controlling for other attributes that are expected to be important. Probably the most common example of this technique involves housing prices (e.g., Czembrowksi and Kronenberg 2016). For example, researchers might assess how real estate sale prices are affected by ecosystem services on or near the property while controlling for other factors that should affect price, such as size, number of bedrooms, location, income, etc. Hedonic pricing surveys have an advantage of being related to actual market pricing. One drawback is that this approach will not be available for all ecosystem services. Another is that, like all revealed preference methods, it does not allow for empirical estimation of future changes in ecosystem services (though projection from relationships is possible). Hedonic studies are typically performed by natural resource economists who prefer these empirical approaches to choice-based modeling. They usually entail generalized linear modeling and sometimes special time-series approaches, though in some cases (difference-in-difference cases) they can also be performed with ordinary least squares routines. Overall, this makes hedonic pricing a moderately challenging method that is often used in economic sub-fields. More information on hedonic price methods can be found in FE1062.

The **proxy market** method (sometimes called market price of exchange-based methods), is probably one of the most-used monetary approaches for valuing ecosystem services (Wilson and Carpenter 1999; Harrison et al. 2018). A proxy market involves estimating what the market cost of providing the ecosystem service would be, or alternatively, what it would cost to replace the ecosystem service with a manmade one. For example, to assess the monetary value of oyster reefs that increase shoreline stabilization, one could estimate the actual cost of restoring eroded habitat or of building seawalls to prevent erosion (Grabowski et al. 2011). Another example would be calculating the cost of building a water treatment plant that would be needed to supply drinking water if a natural catchment and aquifer system was not available. Sometimes, proxy costs are used to actually implement a market for ecosystem services. This technique involves an agency setting a monetary value on an ecosystem service, and then setting up an actual market in which humans can buy and sell ecosystem services credits. For example, if a coastal developer building houses destroys habitat that can naturally remove nitrogen (which in excessive quantities can hurt ecosystems), they would need to offset that loss by creating new habitat or purchase credits. The developer might buy offset credits from area oyster farmers. The farmers in this scenario would receive credits based on the amount of nitrogen removed from the oysters they farm. This is usually determined by state agencies. For information on Florida's credit program see here, and see Piehler and Smyth 2011 for an example from North Carolina. Similar approaches and payment schemes exist now for multiple services throughout the world (Gómez-Baggenthrun et al. 2010). Though proxy evaluations are widely used for many systems and ecosystem services, they often rely on previously published values applied to current case studies. Reusing proxy values does not require as much research as other monetary approaches, but it can lead to errors when the systems or ecosystem services are not comparable. Errors may be propagated across studies, leading to potential widespread problems with valuing ecosystem services.

A final method not described in detail here is **benefits transfer**. Benefits transfer involves using previously published studies of the specific values of ecosystem services and applying them to new contexts. Because this approach can be so readily applied without collecting (much) new data, it is often used when a rough estimate will suffice, or to compare to other primary methods (Constanza et al. 2006). Care must be taken to avoid applying values derived from other, incomparable systems.

STATED PREFERENCE METHODS

Contingent Valuation Method (CVM) is a survey-based approach that estimates individual preferences on public goods and services by inquiring about people's willingness to pay (WTP) for the sustenance or improvements of a good or service (Mitchell and Carson 2013). While the values produced from CVM are typically expressed in dollar amounts, they are most often used for services that are not bought and sold on a market—i.e., non-market services. Typically, CVM surveys contain 3 elements: (1)

a description of hypothetical situations to help orient respondents to the questions that will follow, (2) questions that elicit respondents' WTP, and (3) demographic and other questions to help explain responses. Sometimes CVM studies compare among groups, such as assessing how WTP for an improvement in the quality of ecosystem service could differ between rural and urban residents (Bergmann, Colombo, and Hanley 2008). CVM studies can provide insight into preferences of both broader and more local populations. Typically, CVM studies are conducted by natural resource economists and human dimensions researchers and require robust survey design, development, and implementation approaches, as well as quantitative assessment of results. CVM study questions that ask for stated numeric values will usually be analyzed via standard statistical approaches (e.g., generalized linear regression and standard statistical tests). An advantage of this method is the ease of obtaining (via statement) dollar-value responses, and the ease of statistically assessing quantitative differences across groups. A disadvantage of this approach is that the approach relies on a hypothetical situation that the respondent does not actually experience. This can lead to bias in the reported values, with biases potentially not symmetrical across respondent groups (Van Houtven et al. 2014).

Choice Experiments (CE) are stated preference surveys in which respondents are asked to choose between several different options that correspond to levels of ecosystem services and different costs (Shoyama, Managi, and Yamagata 2013; Johnston et al. 2017). By having respondents select their preferred alternative, CE studies are thought to offer more realistic insight (relative to CVM) into how different ecosystem services are valued (Barkmann et al. 2008). By adding different choice experiment attributes, CE approaches are used to develop quantitative, functional relationships between covariables (e.g., amount of a service) and the value. This type of information is critical for predicting how the numeric value of ecosystem services will change with changes in the actual ecosystem service (Wallmo and Lew 2011). For this reason, CE studies are often used to understand stakeholder perceptions of management objectives and goals (Shoyama, Managi, and Yamagata 2013). While choice experiments can reduce some bias expected from stated preference methods, they cannot altogether remove it. In addition to general survey skills like those required for stated preference methods, CE studies usually involve more complex statistical analyses. Since the data returned are what the respondent chooses, the proper statistical analysis usually involves specialized computer software (e.g., platforms that excel at random utility and choice model estimations). They are typically employed by natural resource economists and quantitative human dimensions researchers.

Summary and Discussion of Monetary Methods

The two main monetary methods, stated and revealed preference, each have positives and negatives. Stated preference methods are direct in that they simply ask the value of services or changes and can be applied to things that have not yet occurred (like management changes or anticipated changes in ecosystems. But it can be very challenging to assess if how someone says they will value something is descriptive of how they will actually behave when faced with the choice. Conversely, the main advantage of revealed preference approaches is that they depend on actual human behavior as opposed to hypothetical behavior. However, because they rely on what has occurred, they cannot easily be extended to situations that have not yet occurred (e.g., possible future changes in ecosystem services).

Monetary methods have some general advantages and disadvantages relative to sociocultural methods. Monetary methods generally allow for quantitatively measuring the value of ecosystem services, which makes them at least superficially easier to compare and to calculate things like return on investment that can be used to inform decisions. These methods are also helpful since they estimate a market price for something, ecosystem services, that usually has no real market. Probably the most common drawback of using monetary approaches it is difficult to understand how people think about ecosystem services and make decisions about them—things that are better addressed with sociocultural approaches. Also, like many quantitative approaches, the assignment of a numeric value may make it seem that the method is more precise than it is (Spanenberg and Settele 2010), since all the monetary approaches involve uncertainty that can be difficult to integrate across multiple values (Eigenbrod et al. 2010). An even bigger drawback of monetary methods is that they rely upon what humans now think ecosystem services are worth, or the current market value of ecosystem services (Chan, Satterfield, and Goldstein 2012). These values may be influenced by several factors, including how much is known about different ecosystems, but ultimately rely upon a set of human-derived notions of commodification and privatization required by markets in a capitalist society. Ecosystem services may be more appropriately thought of as public goods that should not be valued with market-based approaches (Costanza et al. 2014).This could mean that current management decisions based on how some humans and markets value

ecosystems services now will not prove prudent for future humanity.

When should each approach be used?

The value of ecosystem services can be assessed using both socio-cultural and monetary methods. People who want to study or use the concept of ecosystem services must understand the scope and intended depth to make the concept useful. For projects that seek to facilitate stakeholder dialogue and interaction while collecting data on preference values and worldviews about ecosystem services, socio-cultural methods are best. But if researchers want to estimate the economic values for ecosystem services to account for changes in resources asset value, determine economic liability of ecosystem damage or impairment, demonstrate value to raise awareness, analyze the profitability of alternatives, rank projects, and price single ecosystem services, then monetary methods work better. Individual sociocultural or monetary methods can be used validly by themselves, but they can also be combined to create multicriteria analyses for understanding how people view ecosystem services.

Application to Florida and Conclusions

Florida has a number of especially important and likely valuable ecosystems. Some are well-known, like the Florida Everglades and the spring ecosystems. Others are endemic and not found elsewhere, like the Lake Wales Ridge Scrub ecosystem. Ecosystem services that provision market-sold, natural resources like fisheries and forests are critical to the state's current economy. Estuarine habitats like mangroves, oysters, salt marsh, and seagrasses not only support provision and cultural services (like commercial and recreational fisheries) but provide provisioning (e.g., shoreline stabilization) and regulating services (e.g., nutrient cycling) of their own that can help increase resilience to climate change (Lorenzen et al. 2012). Management agencies in Florida are now working to ensure these ecosystem services are appropriately considered when management decisions are made. This involves assessing what current ecosystem services are, as well as how these services may change under alternative management decisions and environmental conditions. Good choices about Florida's ecosystem services will depend on good assessments of their value. However, as this publication shows, there is no single best way to value ecosystem services. Further, the valuation method probably most often used for Florida's ecosystems is the proxy method, which does not actually account for either the way that people think about ecosystem services nor for how they would actually be valued on a market. Since (as shown in this publication) different valuation methods will provide different insights, including multiple ecosystem service valuations is recommended. For example, using both sociocultural and monetary methods to value services provided by oysters in an estuary will provide decision makers with better quantitative data for comparison, as well as deeper insight into what oysters mean to local stakeholders. This follows some of the most important points from this document, including:

- There are multiple ways to measure ecosystem services.
- No way is perfect; each has strengths and weaknesses.
- Sociocultural methods provide more understanding about what ecosystem services mean to people.
- Monetary methods are better at placing numeric values and sometimes understanding the market prices for services.
- The methodological difference means values from different methods cannot often be directly compared. This is not bad, it just means to understand the full value of ecosystem services, multiple approaches must be used.

Around the world and in Florida people are more concerned than ever with appropriately valuing ecosystem services. While doing so well is not easy, it is likely essential for ensuring verdant ecosystems, and our own long-term survival.

Glossary

Choice Experiments (CE): A monetary approach in which survey respondents are asked to choose between different options that correspond to levels of ecosystem services and different costs. Sometimes these are called stated preference choice experiments (SPCE) or discrete choice experiments (DCE).

Contingent Valuation Method (CVM): A survey-based, monetary method that involves asking individual about how much they would be willing to pay for sustenance or improvements in an ecosystem good or service.

Deliberative mapping: An approach that includes multiple specific methods that generally involve asking stakeholders to map, draw, or describe what and where ecosystem services are.

Deliberative valuation: A sociocultural method that involves discussing ecosystem services with a group of stakeholders to determine a consensus, usually qualitative assessment of ecosystem services.

Hedonic pricing surveys: A monetary method that assesses the monetary value of ecosystem services by analyzing how these services affect prices of market goods, most often housing.

Monetary methods: An approach to assessing ecosystem services that seeks to understand how the service would or should be valued if it were a marketed commodity. This approach usually focuses on numeric assessment, more than a depth of understanding of how humans feel about a service.

Narrative analysis: An approach that involves asking stakeholders to describe their actions and experiences with local ecosystem services.

Participatory scenario development: A method by which stakeholders describe possible scenarios for how the future may unfold.

Photo-elicitation surveys: A sociocultural method that involves comparing one landscape to another using photos to reveal aesthetic preferences of stakeholders.

Preference rankings: A non-economic, survey-based sociocultural method that assesses especially qualitative and/or relative ecosystem service values.

Proxy market: A monetary approach that involves estimating what the market cost of providing the ecosystem service would be, or alternatively what it would cost to replace the ecosystem service with a manmade one.

Revealed preference: A monetary method that involves analyzing what observed, actual human choices indicate about how people value various ecosystem services.

Sociocultural methods: An approach to assessing ecosystem services that depends on how ecosystem services are perceived by stakeholders. Sociocultural methods emphasize what and how people think about ecosystem services more than an economic or market numeric value.

Value transfer: A method that uses previously published studies of the specific values of ecosystem services, and applies them to new contexts.

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