IISG18-RCE-SCI-010

ECOSYSTEM SERVICES VALUATION *in the Indiana Coastal Zone*

by Margaret Schneemann, Lauren Schnoebelen, & Leslie Dorworth

Photo: IOak Savanna in Miller Wood, Save the Dunes

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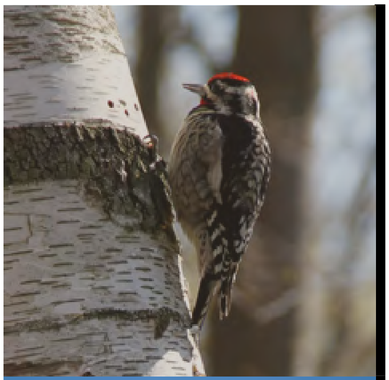
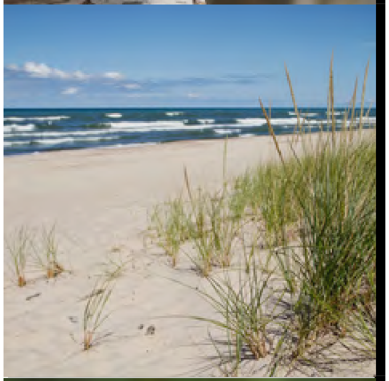




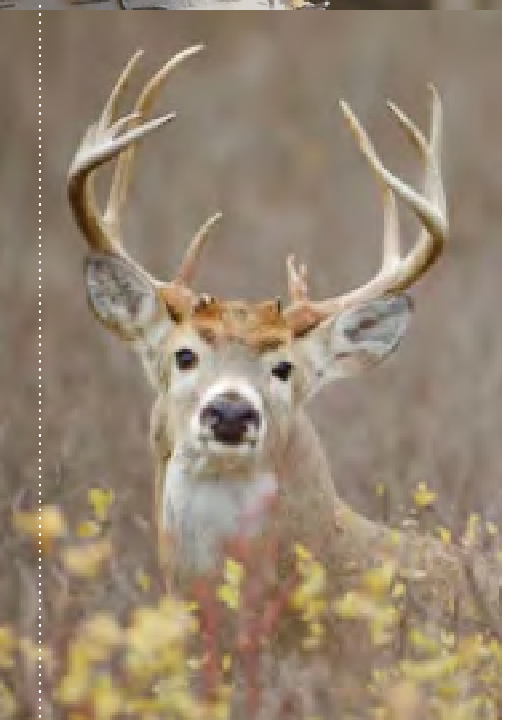


Photo: Yellow Bellied Sap Sucker Woodpecker, Indiana Dunes National Lakeshore

Introduction

Indiana coastal resources benefit people in many ways. The benefits that people, communities, and economies receive from nature are called *ecosystem services*. Ecosystem services provided by the Indiana coastal zone are far ranging from game and fish production to existence value. Benefit contributions to human well-being from these ecosystem services can be valued (*ecosystem services valuation*), and thoughtful consideration of ecosystem services and their values can enhance decision-making.[1]

This primer introduces ecosystem service valuation to coastal zone managers, policymakers, and planners. Ecosystem services valuation allows decision makers to better address resource management challenges and communicate how actions can impact or benefit the public. Ecosystem service valuation begins with a conceptual model illustrating how a human action (management decision, policy change, restoration project) ultimately results in a change in human well-being. The logic of why it is important to conduct an ecosystem services valuation is:

1. Ecosystems provide a baseline level of ecosystem services to people.
2. Human actions impact an ecosystem's condition.
3. An ecosystem's condition is linked to the ecosystem services provided to humans.
4. Changes in ecosystem condition can therefore result in a change in ecosystem services provided by the ecosystem.
5. Changes in ecosystem services impact human well-being.
6. Changes in human well-being can be measured using valuation methods.

1 Incorporation of ecosystem services may improve communication with stakeholders and the public, help with making more informed decisions, improve project evaluations, and provide an opportunity to identify and involve new partners (U.S. Army Corps of Engineers, 2016).

Figure 1 demonstrates a causal chain illustrating the logic of an ecosystem services valuation. The National Ecosystem Services Partnership (NESP) suggests considering the following questions when constructing a causal chain (NESP, 2015):

- How does the human action (policy change, management decision, restoration project) impact the ecosystem condition?
- How does a change in ecosystem condition impact the ecosystem services provided to people?
- How does the change in ecosystem services change benefits to human well-being?

Figure 1: Ecosystem services causal chain:
Translating a coastal zone management decision into ecosystem service benefits
Figure adapted from Schuster & Dooer, (2015)

An ecosystem service valuation requires multi-disciplinary knowledge. A simple model involves specifying three main relationships (Freeman, 1993):

(1) The relationship(s) between the human action and the resulting impact on the ecosystem condition/functioning.
(2) The relationship(s) between the ecosystem condition and the ecosystem services provided to people.
(3) The relationship(s) between ecosystem services and the benefits to human well-being.

Relationship (1) is within natural science disciplines, relationship (3) is within economics, and relationship (2) requires integration of both natural and social science (Freeman, 1993). An example of these relationships in a causal chain between human action and a change in human benefits is shown in **Figure 2**. In this example:

(1) A reduction in wastewater discharge leads to a water quality improvement, as indicated by physical and biological measurements (relationship 1). To examine relationship 1, water quality models are used to forecast the change in indicators resulting from a reduction in wastewater discharge.
(2) Improvements in water quality lead to changes in the human uses of water, indicated by changes in the ecosystem services provided (relationship 2). For

example, water quality can impact water supply, fishery production, and recreation. Understanding relationship 2 involves both natural science (modelling the impact of water quality changes on fish populations and species distribution) – as well as social science (examining how recreational use rates change as water quality changes, as well as how tradeoffs between alternate recreational uses are made as water quality changes).

(3) Changes in ecosystem services can be valued. For example, regarding a water quality impact on recreational fishing, an angler will likely place a larger value on an improved catch rate and catching a more desirable fish (relationship 3). Relationship 3 is in the realm of economists, who can use valuation techniques to monetize the change in human uses resulting from a change in water quality as well as social scientists who use models to assess non-monetary metrics.

Photo: Yellow Perch, Sarah Stei, Purdue University

Figure 2: Example: Translating a reduction in wastewater discharge into an ecosystem service value

Source: Adapted from Freeman, (2003).

HUMAN ACTION
Reduction of Discharges

Biochemical oxygen demand
Suspended solids
Floating solids
Heat
Toxics
Miscellaneous chemicals
Radioisotopes

RELATIONSHIP 1: NATURAL SCIENCE

ECOSYSTEM CONDITION CHANGE

Changes in Physical & Chemical Water Quality Indicators

Dissolved oxygen
Temperature
Turbidity
Odor
Nutrients
Other Chemical
pH

Changes in Biological Water Quality Indicators

Fish Populations
Algae
Zooplankton
Bacteria

RELATIONSHIP 2: NATURAL AND SOCIAL SCIENCE

ECOSYSTEM SERVICE CHANGE

Changes in Human Direct Use

Water supply
Fisheries
Recreation

Changes in Human Indirect-Use

Waste Assimilation
Flood Control
Habitat and Population Maintenance

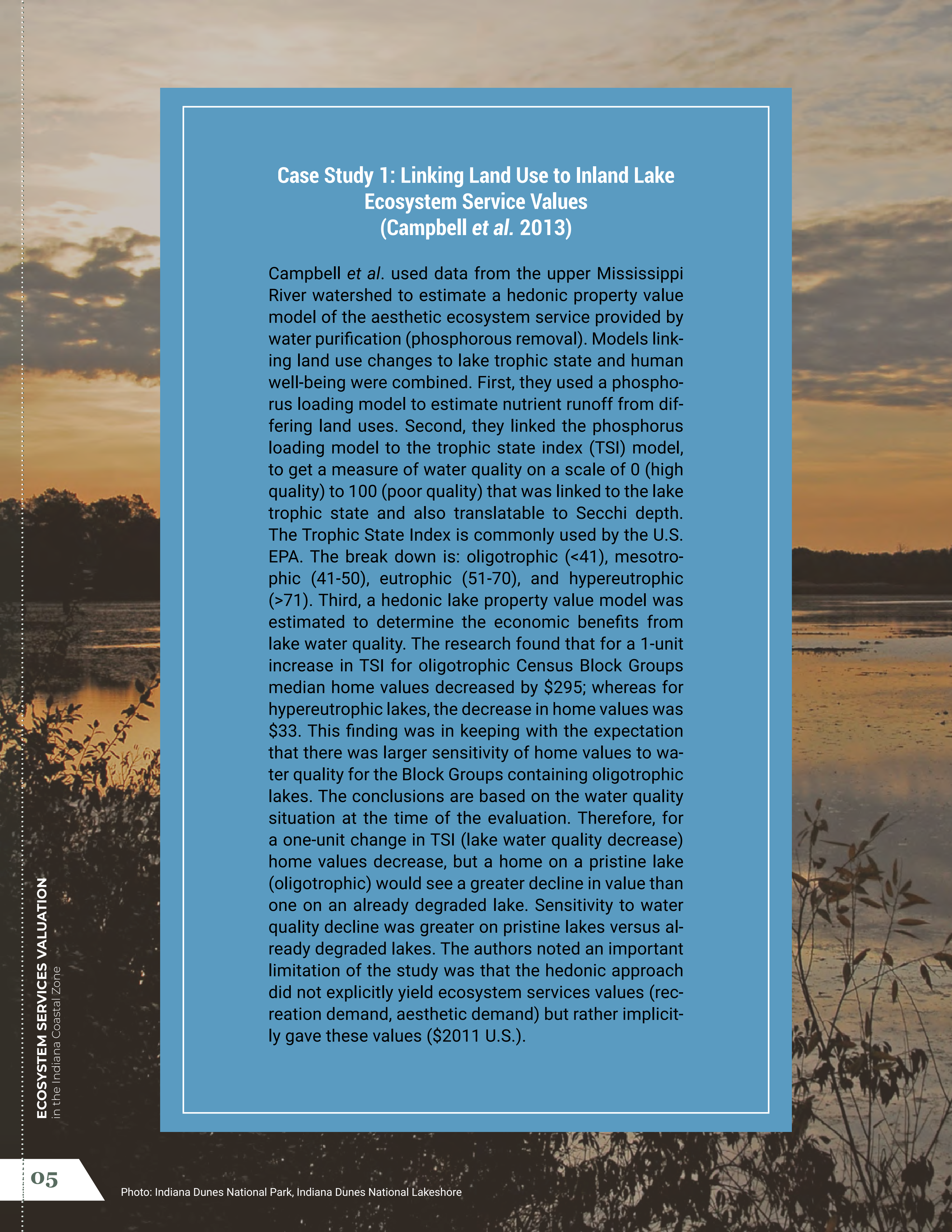
Changes in Non-Use

Spiritual Approach
Cultural Heritage
Resources for Future Generations
Biodiversity
Option for Future Uses

RELATIONSHIP 3: ECONOMICS

VALUES OF HUMAN DIRECT AND INDIRECT-USE AND NON-USE

Measured in monetary units
Measured in non-monetary units



Case Study 1: Linking Land Use to Inland Lake Ecosystem Service Values (Campbell *et al.* 2013)

Campbell *et al*. used data from the upper Mississippi River watershed to estimate a hedonic property value model of the aesthetic ecosystem service provided by water purification (phosphorous removal). Models linking land use changes to lake trophic state and human well-being were combined. First, they used a phosphorus loading model to estimate nutrient runoff from differing land uses. Second, they linked the phosphorus loading model to the trophic state index (TSI) model, to get a measure of water quality on a scale of 0 (high quality) to 100 (poor quality) that was linked to the lake trophic state and also translatable to Secchi depth. The Trophic State Index is commonly used by the U.S. EPA. The break down is: oligotrophic (<41), mesotrophic (41-50), eutrophic (51-70), and hypereutrophic (>71). Third, a hedonic lake property value model was estimated to determine the economic benefits from lake water quality. The research found that for a 1-unit increase in TSI for oligotrophic Census Block Groups median home values decreased by $295; whereas for hypereutrophic lakes, the decrease in home values was $33. This finding was in keeping with the expectation that there was larger sensitivity of home values to water quality for the Block Groups containing oligotrophic lakes. The conclusions are based on the water quality situation at the time of the evaluation. Therefore, for a one-unit change in TSI (lake water quality decrease) home values decrease, but a home on a pristine lake (oligotrophic) would see a greater decline in value than one on an already degraded lake. Sensitivity to water quality decline was greater on pristine lakes versus already degraded lakes. The authors noted an important limitation of the study was that the hedonic approach did not explicitly yield ecosystem services values (recreation demand, aesthetic demand) but rather implicitly gave these values ($2011 U.S.).

Photo: Indiana Dunes National Park, Indiana Dunes National Lakeshore

There are challenges in describing and measuring links between ecosystem structure and function and ecosystem services (National Resource Defense Council, 2004). Ecosystem structure and function create ecosystem services. Ecosystem structure is the physical and biological make up of an ecosystem; and ecosystem function is any process that takes place due to interactions between living and non-living parts of that ecosystem. Together, ecosystem condition and function create ecosystem services such as water purification, flood control wilderness areas, and more. A conceptual causal chain of how the ecosystem's structure and function is related to the provision of ecosystem services is shown in Figure 3.

Figure 3: Understanding the production of ecosystem services

Finding direct links between ecosystem structure and function and ecosystem service is important in ecosystem services valuation to foster communication between multi-disciplinary project teams. Case Study 1 provides an example of linking water purification processes to homeowner perception of water quality.

Improvements in the condition of aquatic, and associated terrestrial, ecosystems of the Indiana coastal zone therefore result in benefits to people that can be valued. The next section provides background on these ecosystems, and the following section provides a step-by-step overview of conducting an ecosystem services valuation.

For More Information:

On the Indiana Lake Michigan Coastal Program (ILMCP):
www.in.gov/dnr/lakemich/6039.htm

On incorporation of ecosystem services into Federal Decision Making:

Federal Resource Management and Ecosystem Services Guidebook:
https://nespguidebook.com

Best Practices for Integrating Ecosystem Services into Federal Decision Making:
https://nicholasinstitute.duke.edu/sites/default/files/publications/es_best_practices_fullpdf_0.pdf

Figure 4: The Indiana Lake Michigan Coastal Zone

Figure: Jennifer Birchfield, Save the Dunes

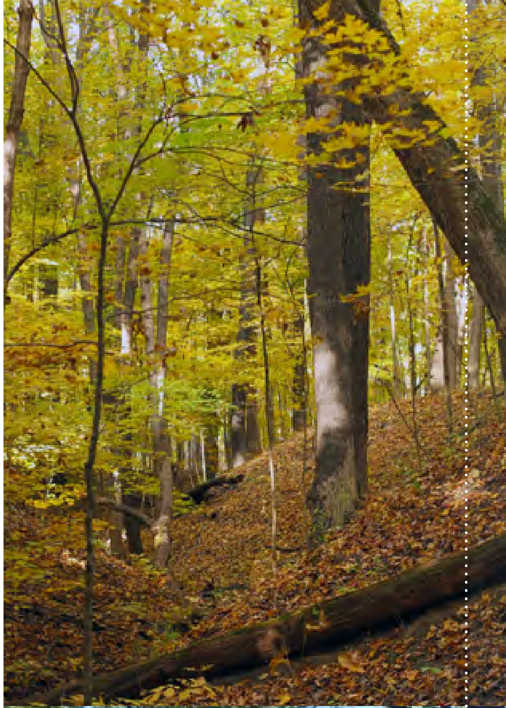
Aquatic and Related Terrestrial Ecosystems in the Indiana Coastal Zone

In Indiana, the coastal zone region consists of a portion of the Lake Michigan Basin watershed, an area over 600 square miles of land and 240 square miles of Lake Michigan (**Figure 4**). This area is made up of three ecoregions, the southern Great Lakes, central forest-grassland transition, and an oak savanna ecoregion, which contain five natural community classifications: forest, prairie, savanna, aquatic and coastal sand dune. These natural communities support a diversity of flora and fauna, and are the result of climatic and geologic events occurring tens of thousands of years ago, that continue to benefit the present generation. The study boundaries are defined by Indiana's coastal zone, which is in the care of the Indiana Lake Michigan Coastal Program (LMCP).

The forest community in northwest Indiana consists of uplands, dunes, floodplains, and flatwoods, with sugar maple and beech comprising 80 percent of tree species found in the area. Basswood, oaks, and hickories can be seen in drier areas; whereas elms, ashes, and red maples are typically in the wetter parts of the region. Although little forest habitat remains, the southern Great Lakes ecoregion contains some rare ecological phenomena, including extensive interior wetlands, and freshwater bodies with dune systems, such as those found at the Indiana Dunes National Lakeshore and the Indiana Dunes State Park. Intradunal ponds support unique plant communities and are seen as major staging areas for migrating birds.

These ecosystems contribute directly and indirectly to human well-being by providing a wide-array of goods and services of value to people. These include air and water purification, nutrient storage and recycling, soil conservation, crop pollination, climate regulation, carbon sequestration, protection against storm and flood damage, and hydrology and water supply maintenance. Indiana coastal zone managers identified threats to the functioning of these ecosystems as including, but not limited to: nutrient runoff from agriculture, forests, urban areas, combined sewer overflows, and septic systems; climate variability (especially through associated habitat and shoreline change(s)); hydro-modifications; and invasive species.[2]

Even though habitat and shoreline modifications are considered threats, especially due to climate variability, they have been occurring for millions of years. Before modern development, the Lake Michigan coastline was susceptible to changing lake levels, coastal storms, and erosion and sedimentation processes due to wind, wave energy, currents, and tides. The concerns today are the increasing speed of shoreline erosion, which poses risks to property and other infrastructure assets.



Photos: Izaak Walton Preserve, Daniel Bovino; Oak Savanna in Miller Wood, Save the Dunes; Forest near Chellberg Farm, Indiana Dunes National Lakeshore

2 Illinois-Indiana Sea Grant (IISG) facilitated a Coastal Services Ecosystem Valuation Workshop attended by 10 Indiana coastal zone stakeholders, including The Nature Conservancy, Indiana Dunes State Park, Indiana Dunes National Lakeshore, United States Geological Survey, Urban Waters Federal Partnership, Indiana Dunes Learning Center, Lake Michigan Coastal Program, and Purdue University Northwest. The meeting began with a brief introduction highlighting the scope and mission of the Lake Michigan Coastal Program. Attendees then reviewed meeting materials. The group was asked to identify the top five threats to the coastal ecosystem. They identified: nutrients, climate change (with resultant habitat and shoreline change), water cycle changes (due to hydro-modifications and increasing impervious surfaces), invasive species, and airborne pollution (specifically, nitrogen). For the next stage of the workshop, IISG distributed a handout that listed Indiana coastal zone ecosystem services. Working together, attendees identified the services in the watershed that they considered most threatened. The group identified the following services: water purification; native flora and fauna; recreation (aesthetic and spiritual); and erosion/sediment/flood control. These prioritized services are in the review of the economic valuation literature. https://iiseagrant.org/publications/valuing-ecosystem-services-in-the-indiana-coastal-zone-literature-review/

In simple terms, erosion presents a cost to property owners because they lose private land, and accretion is a benefit, because they gain or retain private land. In certain cases, accretion may not be a benefit because dredging may be necessary.

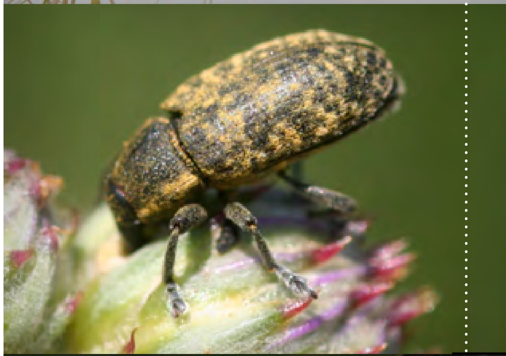
Photo: Seidner Dune and Swale, Irene Miles

Terrestrial Ecosystems

Coastal dunes is a community type in northwest Indiana containing the littoral zone, beaches and foredunes. One of the most important features of the habitat is the foredunes, which run along the coastline of Lake Michigan. They provide buffer protection from coastal storms and impacts from flooding and erosion, sand replenishment service, coastal flora and fauna habitat protection, and scenic and recreational attributes. This coastal habitat supports a wide variety of species including white-tailed deer, red fox, eastern chipmunk, northern cardinal, wood thrush, screech owl, green heron, wild turkey, Fowler's toad, and eastern hognose snake, just to highlight a few of the fauna.

Having such a variety of flora and fauna in an ecosystem normally signifies a healthy system but certain plants and animals are, in fact, non-native and/or invasive (Lefchecket *et al*., 2015). An example of this is the invasive musk thistle head weevil (*Rhinocyllus conicus*) that is impacting the federally endangered Pitcher's thistle (*Cirsium pitcheri*). Both thrive in sandy dune environments. The Pitcher's thistle, which is reliant on pollinators for seed production and survival, is seeing a decline in seed production due to the weevil's consumption of said seeds (Pavlovic *et al*., undated). With many factors impacting the success of this plant, the weevil adds one more. The Pitcher thistle, along with many other species, contribute to the diversity of the dune habitat.

Some other species in the region listed as threatened or endangered under the Federal Endangered Species Act are the Karner blue butterfly (*Lycaeides melissa samuelis*), Mead's milkweed (*Asclepias meadii*), Indiana bat (*Myolis sodalist*), northern long-eared bat (*Myotis septon trionalis*), piping plover (*Charadrius melodus*), rufa red knot (*Calidris canutus rufa*), and Mitchell's satyr butterfly (*Neonympha mitchellii*) (U.S. Fish and Wildlife Service, 2015). As this document was written, it is believed that the Karner blue butterfly became extinct in the Indiana Lake Michigan coastal zone.



Photos: Indiana wildflowers, Abigail Bobrow; *Rhinocyllus conicus*, Whitney Cranshaw; *Lycaeides melissa samuelis*, Catherine Herms

The prairie community of northwest Indiana can be broken down into prairie, sand prairies, and hill prairies. The dominant plant types are tall grasses and other dense herbaceous species as well as shrubs and trees, such as black and bur oak (Indiana Department of Natural Resources, 2016). Fire is needed to maintain the natural condition and diversity of the prairie habitat. When fire is suppressed, shrub and tree species will start to increase in number and may lead to the formation of savannas, especially in drier environments. If fire continues to be suppressed, many understory plants will over grow the savanna and put endangered ecosystems such as black oak savannas, at risk of turning into a forest. Due to the prevention of natural fires, prescribed prairie burns are set by trained professionals.

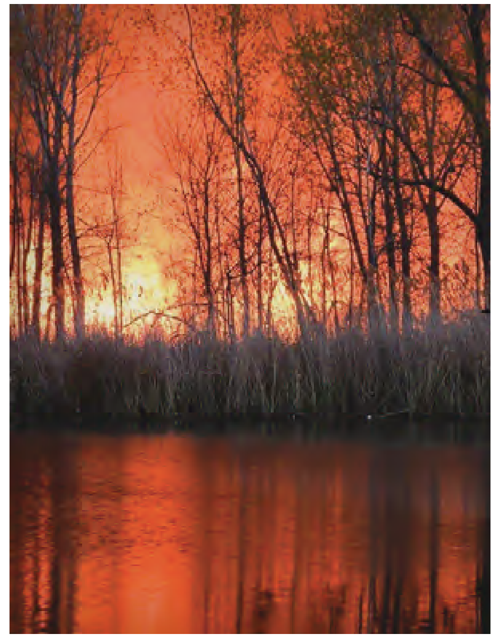


Photo: Forest Fire Burning Phragmities, Daniel Bovino

Aquatic Ecosystems

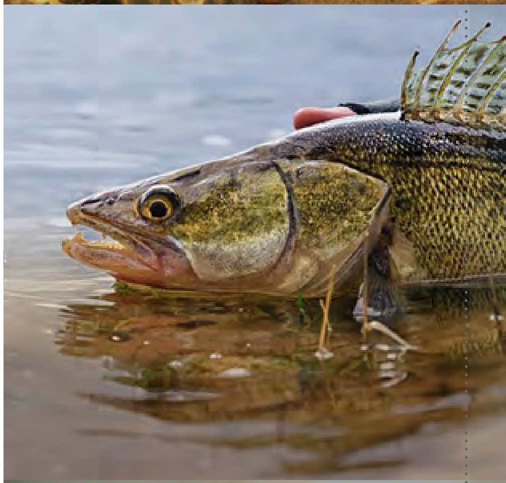
There are many aquatic communities in northwest Indiana, including open water, marshes, swamps, bogs, sedge meadows, pannes, seeps, and springs. Aquatic habitats can be found in areas between open water and surrounding habitats such as forests or savannas. In the coastal zone, one may find water covering the ground or near the surface, possibly year round. Plants found in these habitats are well adapted for this type of environment. Some species found in these areas are cattails, bald cypress, willows, and lily pads (Indiana Department of Environmental Management, 2016). Wetlands can help with flood control, recharge groundwater sources, and retain sediments, toxins (heavy metals, pesticides, pathogens), and nutrients (nitrogen, phosphorous. These chemicals are absorbed and filtered by vegetation.

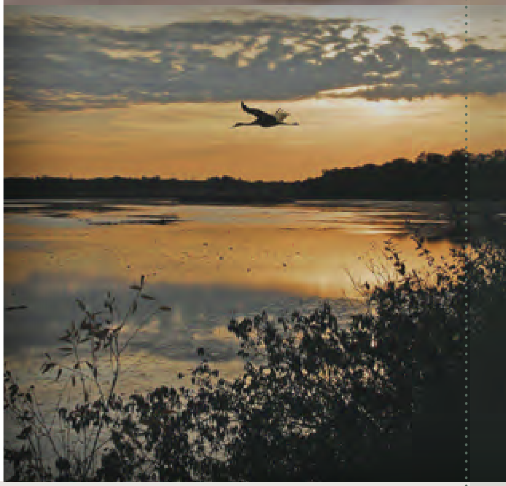
Ecosystems provide places where people and the environment can connect, and people can forge belief and value systems based on human-nature interactions (Cross, 2001). The uniqueness and diversity of the many habitats in northwestern Indiana and the southern coastline of Lake Michigan attract tourists and outdoor enthusiasts. Some outdoor recreational activities include biking, painting, kayaking, cross country skiing, bird watching, hiking and snowshoeing. Opportunities to interact with these ecosystems provide an economic incentive to preserve these lands (Syerrisson, 2008).

Photo: Douglas David painting, Indiana Dunes National Lakeshore

Aquatic, and related terrestrial, ecosystems are affected by land development and other human activities. For example, non-point source pollution results from rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants that are deposited in waterways, impacting water quality. Increased nutrient loadings can cause eutrophication, impairing the use of water for industry, recreation and possibly drinking.

In summary, all of the aquatic and related terrestrial ecosystems in the Indiana coastal zone benefit people. The next section provides an overview of the steps in valuing the benefit contributions to human well-being from the services provided by these ecosystems.





Photos: Indiana Dunes National Park, Indiana Dunes National Lakeshore; Bottom of Coffee Creek in Indiana Dunes National Park, Daniel Bovino

For More Information:

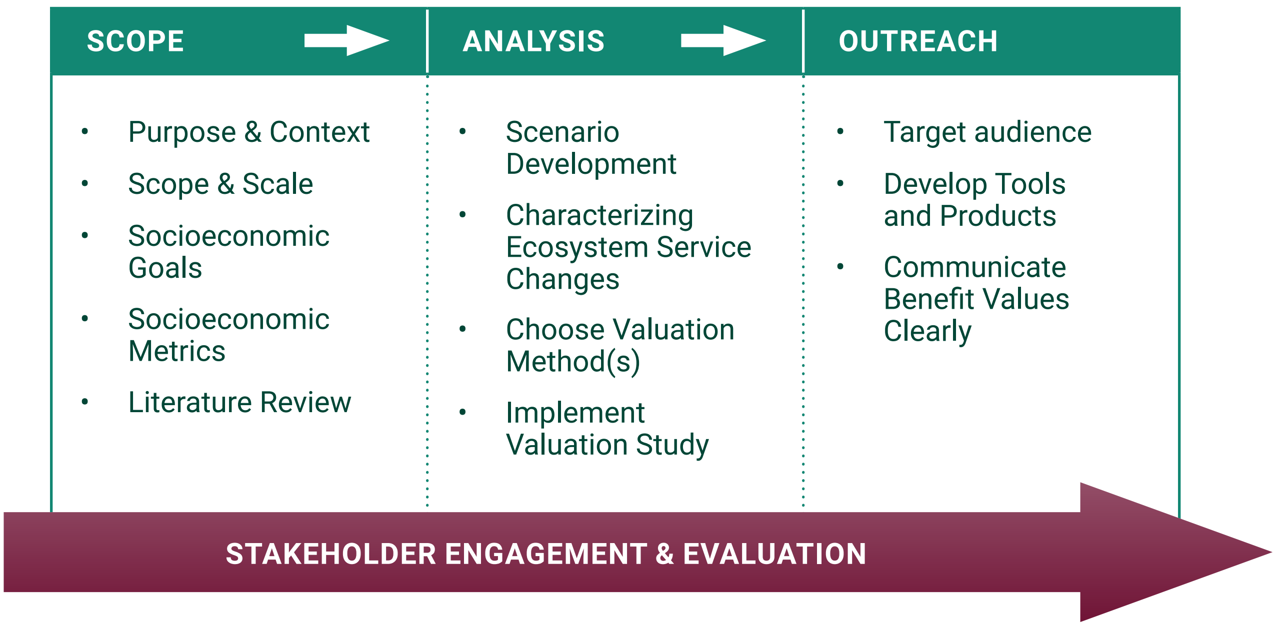
NOAA Office for Coastal Management Digital Coast:
https://coast.noaa.gov/digitalcoast/about/

Watershed Approach Handbook: Improving Outcomes and Increasing Benefits Associated with Wetland and Stream Restoration and Protection Projects:
www.eli.org/sites/default/files/eli-pubs/watershed-approach-handbook-improving-outcomes-and-increasing-benefits-associated-wetland-and-stream_0.pdf

Ecosystem Service Valuation Steps[3]

The primary steps in conducting an ecosystem services valuation study include scope, analysis, and outreach (Waite *et al*., 2014). In addition, stakeholder engagement and evaluation or monitoring are performed throughout all steps of the ecosystem service valuation (**Figure 5**).

Figure 5: Ecosystem service valuation steps



Step 1: Scope

The scoping step involves the following: (1) defining the valuation purpose and context, (2) defining the scope and scale of the valuation, (3) setting socioeconomic project goal(s), (4) selecting metrics, and (5) reviewing literature.

Define the valuation purpose and context: It is important to determine the purpose of the ecosystem services valuation in the decision-making context. Is the purpose to raise awareness about the ecosystem? To set overarching resource priorities? To assess trade-offs between management actions? Is the valuation legally required? For some projects, identifying ecosystem services may be enough information to make a decision. Valuation may not be necessary (for example, a map of ecosystem services can be used to make a decision on a project location). Clarity about the reasons for undertaking an ecosystem service valuation means common pitfalls of valuation exercises, such as the danger of providing a value that is being used as

3 The following discussion is largely based on Schuster & Dooer, (2015), Waite, *et al*. (2014), and National Ecosystem Services Partnership, (2014).

the sole criteria for decision making, are avoided.[4] Additional questions to address include: What information does the valuation give us that we didn't have before? How and to whom is this value useful? How does the analysis (and associated outreach) impact decisions and policy? Pascual *et al*., (2010) suggest the following purposes for undertaking an ecosystem valuation study:

- Missing markets – non-marketed goods and services.
- Imperfect markets and market failures.
- Alternatives and alternative uses of biodiversity goods and services (trade-offs).
- Demand and supply uncertainty of natural resources.
- Designing biodiversity or ecosystem conservation programs.
- Natural resource accounting.

Whether and how results are integrated into decisions depends on the ecosystem service valuation context. Economic valuation is considered most useful when decision makers desire to include benefit-cost analysis of alternate actions as a decision criterion.[5] Alternately, when societal values for an ecosystem service have been implicitly stated, valuation may not be necessary since society has already made a value-based decision to protect the ecosystem. In other cases, non-monetary valuation may be sufficient for the task at hand. Or, results can be used as a communication tool to encourage decision-makers to incorporate non-market values into broader policy contexts without conducting a formal benefit-cost analysis.

Specify the valuation scope and scale: Some decisions regarding the scope and scale of the valuation include: how many and which ecosystem services will be valued; what types of value will be captured; what is the ecosystem geography; whose values are included; and what is the time frame of the analysis.

First, a decision needs to be made whether one ecosystem service, multiple ecosystem services, or the full range of ecosystem services are valued. When multiple ecosystem services are being considered, the relationship between these services (both ecologically and economically) needs to be defined to avoid double-counting.[6] Alternatively, excluding values can result in under-counting benefits, so care must be taken to

4 It is rarely useful to talk about the total value of the services generated by an entire ecosystem because without ecosystems, we all die. The total value of ecosystems is logically infinite. It is much more useful to talk about how the value changes in relation to status quo in response to proposed human actions. The exception is a policy action that would completely destroy or eliminate the ecosystem.

5 Benefit-cost analysis is used in public policy analysis to quantify the societal impacts of policy actions (in dollar terms). For a more extensive discussion of the use of benefit-cost analysis in decision-making, see Brower & Pearce (2005) and Boardman *et al*., (2011).

6 Not all ecosystem services are relevant to the ecosystem services valuation study, only the final ecosystem services that benefit stakeholders and people. This avoids double counting, see final ecosystem goods and services classification system (Landers & Nahlik, 2013).

ensure that the full range of ecosystem services appropriate for the project's context has been considered.

A second concern is the types of economic values to be included in the analysis. Economic values can be broadly categorized into use value and non-use value. Non-use values, such as intrinsic values (values for possible future use of a resource or service and the value of knowing that a resource or service simply exists), can be difficult to fully incorporate into a valuation study. Yet, these types of values can play a large part in decision making and policy issues. If only use values are considered, non-use values can be under weighted, resulting in sub-optimal resource management decisions (Bishop, *et al*., 1987). **Table 1** explains the different components of economic value.

Photo: Beach Prairie, Irene Miles

Table 1: Components of Economic Value

Use Value – How much an environmental or ecosystem good or service is valued by a person when it is used directly or indirectly.
Direct Use Value – The value a person places on ecosystem services or products that they use or consume (such as using wood for a bonfire or catch-and-release fishing).
Consumptive Value – Values that reflect services or products bought or removed by individuals to be enjoyed (such as hunting or mushroom picking).
Non-consumptive Values – Values that reflect services or products that do not need to be consumed or removed to be enjoyed (such as hiking or bird watching).
Indirect Use Value – The benefit values that a person receives from environmental and ecosystem functions even though they do not directly use the service (such as water filtration and clean air production by trees).
Option Value – How much a person values the option to use an environmental or ecosystem service or product in the near or distant future, even if they do not currently use the service or product.
Non-use Values – How much a person values an environmental or ecosystem service that they will not use (such as knowing that there are bald eagles because they have patriotic symbolism in the U.S.).
Bequest Value – How much a person from the current generation values knowing that an environmental or ecosystem service will be available for future generations, even if they will not enjoy it themselves.
Existence Value – How much a person values knowing a service or good exists, even if they will never visit or use it (such as knowing the Great Barrier Reef exists even they are unable to visit it).
Altruist Value – How much a person values knowing that an environmental or ecosystem good is used by other people, but they might never use it.

Spatial (ecosystem and population geography) and temporal factors need to be considered when assessing the value of ecosystem services as they impact provision of an ecosystem service.[7] According to the Natural Resource Defense Council (2004), ecosystem size (number of acres, for example) influences the supply of ecosystem services.[8] The scale at which different ecosystem services function effectively can also vary. For example, some services such as nutrient uptake, can happen on a smaller scale, but others, such as carbon storage, happen on a larger scale. The geography of ecosystems, therefore, determines the level of ecosystem service provision and therefore, the valuation. This means that valuation numbers (monetary values) cannot be directly translated into geography by simple math. For example, it cannot be assumed that two acres of restoration have twice the ecosystem service value as one acre.

The geography of the ecosystem valuation includes both the area containing the ecosystem that supplies the ecosystem service (ecosystem geography) as well as the human population benefiting from the ecosystem service (human population). The geographic location of the project and the project scale impact the value of ecosystem services as follows (Boyd, 2008):

- The scarcer an ecological service, the greater its value.
- The scarcer the substitutes for an ecological service, the greater its value.
- The more abundant the complements to an ecological service, the greater its value.
- The larger the population benefiting from an ecological service, the greater its value.
- The larger the economic value protected or enhanced by the service, the greater the value.

Since values come from people, and the larger the population benefiting from a service, the greater its value, it is important to identify relevant populations. The geography of the study population is likely to vary from the ecosystem geography, for example "… in valuing possible damages from a major oil spill, should calculations reflect damages to the local population, to the population within the state, to the population within the nation, or to the world population?" (Natural Resource Defense Council, 2004). In this example, the geography of the human population impacted by the oil spill is not the same as the geography of the ecosystem impacted by the oil spill.

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7 Indeed, "most aquatic ecosystems change overtime; ponds fill in or dry up, rivers meander and get dammed and tidal marshes erode. All of these changes alter the capacity of an ecosystem to perform functions over very short to very long time periods" (Natural Resources Defense Council, 2004).

8 This point also illustrates that, besides scale, resistance and resiliency also play a role in ecosystems and their services. Resistance is the ability of an ecosystem to withstand disturbance without any major change occurring, while resiliency is how well an ecosystem can return to its original state after a major disturbance happens. In some circumstances, too much change can prevent an ecosystem from returning to its original state. This is known as an ecological threshold. When a disturbance surpasses a community's ability to withstand change, reestablishment can often succeed only in conditions significantly less stressful than is currently experienced due to a lag in the community's response time (Natural Resource Defense Council, 2004).

Another consideration is temporal scale, which refers to the time frame of the analysis. This means reconciling the period of time[9] over which the action impacting the ecosystem occurs with the period of time that people experience the resulting change in the level of ecosystem service provision. An additional consideration here is whether the impact is a stock or flow impact. Stocks are a measurement at a specific time and flows are a measurement over a period of time. Another temporal issue is whether an ex-ante or ex-post measurement of event is used. Ex-ante is using information and values that have been collected before an event, such as before a dam is built across a river flowing to a lake, to predict what might happen to the lake and river ecosystems. Ex-post is using information and values collected after the installation of the dam to understand the impacts on the ecosystems. These are some of the temporal scale issues to consider when undertaking a valuation.

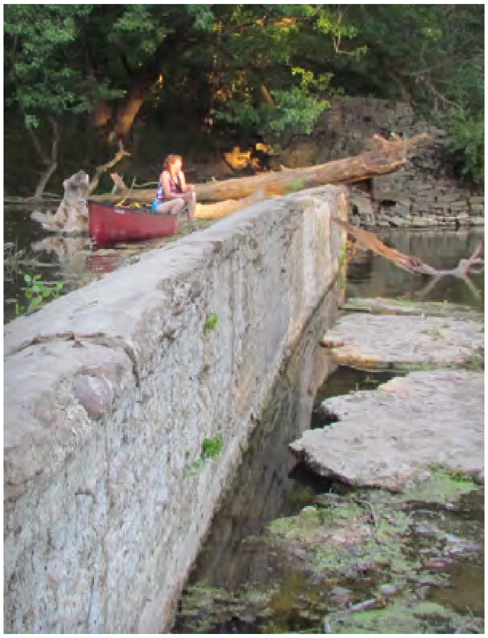


Photo: Liberty Mills Dam, Eric Bradley

Set socioeconomic goals: Successful ecosystem services valuation requires integrating ecological goals (for example, improved water quality) with socioeconomic goals (increased number of beach-going days). **Table 2** presents some examples of ecological and socioeconomic goals. While most coastal restoration management projects have an existing ecological purpose, ecosystem service valuation goals are socioeconomic, not ecological. This is because people value what is most relevant to them and what closely impacts their well-being. The goal should align not only with implementing the organization's mission, but also consider the desired behavior and/or policy change as a result of the valuation, and furthermore, how people impacted by the ecosystem service change experience the impact. Ask: What decisions are you trying to influence? Who are the decision makers or influencers? Who is impacted by the decision, and how?

9 Information and values from stock are recorded at an exact time such as the last day of a month or the end of a year. Information and values from flow occur at a certain rate over a period of time. A lake can provide an example. During the year, a river empties a certain amount of water every day into the lake; this would be considered a flow. It does not have to be the same every day. It can increase due to rainfall and snowmelt or decrease due to drought conditions. At the same time each day you record the water level to see how it changes over time. These measurements are stocks because it is the water level of the lake at that exact moment and it might change later that day.

Table 2: Examples of Ecological and Socioeconomic Project Goals

ECOLOGICAL GOALS	SOCIOECONOMIC GOALS
Improve fish spawning habitat	Increase anglers experience
Improve water quality (reduce nutrient concentrations)	Increase beach recreational use
Remediate sediment	Increase property value

Select socioeconomic metrics (*benefit-relevant indicators*): Metrics enable managers and policymakers to measure progress in meeting goals and objectives. Metrics also help to ensure that ecological or biophysical metrics can be linked to economic or social metrics. **Figure 6** illustrates steps in using metrics to link changes in ecosystem services to changes in values. First, the ecosystem service impacted by the project is identified (for example, flood reduction); second, the change in the level of provision of the ecosystem service is quantified (for example, a 25 percent reduction in community basement flooding); and third, the change in ecosystem service is monetized (for example, $1,300,000 annual stormwater control benefits).

Figure 6: Linking changes in ecosystem benefits to changes in human well-being[10]

IDENTIFY	QUANTIFY	VALUE
a qualitative description of ecosystem services	*a quantitative description of the change in ecosystem services resulting from a management or restoration action*	*a monetization of the quantified ecosystem service change*
Reduced flooding, healthier aquatic habitats, improved water quality, and increased water table recharge in a community	Reducing basement flooding by 25% and improving environmental quality by 25%	Average of $1 million per year in benefits to the community for stormwater control

10 Adapted from Schuster & Dooer, (2015) with an illustration of results from Cadavid & Ando, (2013).

Review literature: Identifying data gaps and research needs in the causal chain shown in **Figure 6** requires assessing the baseline level of knowledge. Due to the complexity of ecosystems, knowledge gaps may exist in translating human actions to changes in ecosystem condition, in translating changes in the ecosystem condition to changes in ecosystem functioning, as well as in translating changes in the ecosystem condition and functioning to changes in ecosystem services. Due to the challenges of conducting economic valuation for non-market goods, economists may be lacking valuation information. Conducting a review of both the ecological and economic literature can help fill in the links of the conceptual causal chain with available data and identify any information gaps.

Photo: New York, Pexels

For example, Weber (2015) uses a review of the ecological and economic literature to fill in knowledge gaps about the value of green infrastructure in the Northwestern Indiana Regional Planning Commission (NIRPC) planning region. One service included in the analysis is water purification. The study notes that green infrastructure slows down runoff, allowing water to infiltrate and settle, thereby purifying water by removing pollutants. A review of the ecological literature finds that metrics for measuring water purification include: reduction of nitrogen, phosphorous, chloride, sediment, bacteria, and other pollutants. The study then reviews the economic literature to find studies on the value of water purification. In this way, the study combines valuation estimates from the literature (in this example, showing that preservation of forested land allowed New York City to avoid spending $6–8 million on constructing new water treatment plans, translating into $1,300 per acre/year in avoided treatment costs) and land-use data in the NIRPC region (number of woodland or forested acres) to map the corresponding value of the water purification ecosystem service. Note this method assumes similarities between the study site (New York) and the policy site (NIRPC region).

Photo: Water Treatment Plant, Antiksu

Step 2: Analysis

The analysis phase includes: (1) developing scenarios, (2) analyzing the ecosystem service change, (3) choosing the valuation method, and (4) implementing the valuation study.

Develop scenarios: In this step, scenarios are developed to reflect alternative visions of the future state of the resource. To increase scenario realism, workshops can be conducted with stakeholders who are knowledgeable about the resource, restoration science, public use (both current and desired), and the policy and management environment.

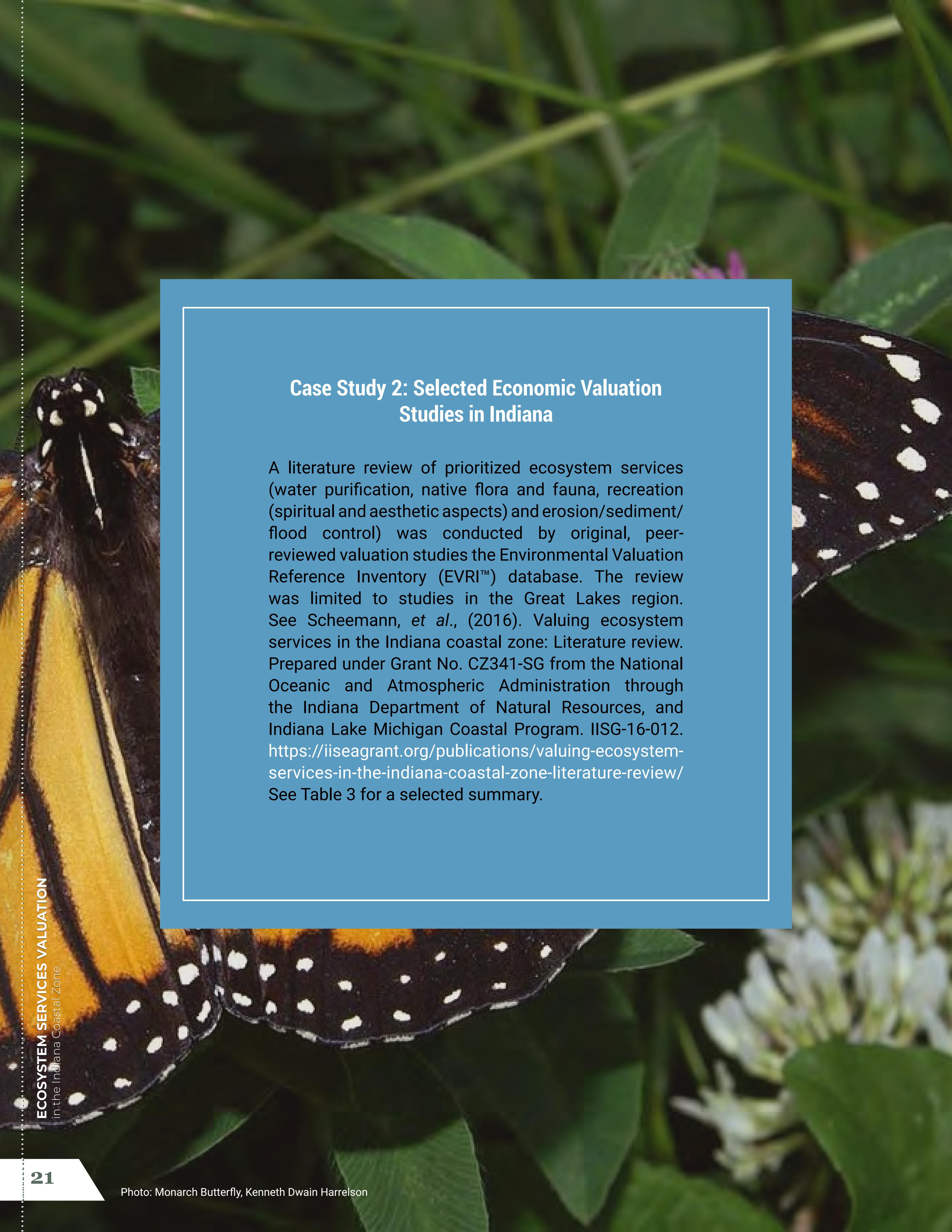


Photo: Monarch Butterfly, Kenneth Dwain Harrelson

Case Study 2: Selected Economic Valuation Studies in Indiana

A literature review of prioritized ecosystem services (water purification, native flora and fauna, recreation (spiritual and aesthetic aspects) and erosion/sediment/flood control) was conducted by original, peer-reviewed valuation studies the Environmental Valuation Reference Inventory (EVRI™) database. The review was limited to studies in the Great Lakes region. See Scheemann, *et al.*, (2016). Valuing ecosystem services in the Indiana coastal zone: Literature review. Prepared under Grant No. CZ341-SG from the National Oceanic and Atmospheric Administration through the Indiana Department of Natural Resources, and Indiana Lake Michigan Coastal Program. IISG-16-012. https://iiseagrant.org/publications/valuing-ecosystem-services-in-the-indiana-coastal-zone-literature-review/ See Table 3 for a selected summary.

Table 3: Selected Economic Valuation Studies for Indiana[11]

Policy Questions	Study
REDUCED POLLUTION	
How does pollution prevention impact drinking water?	Henry *et al*., (1991) used actual expenditures to examine drinking water contamination from rock salt applications for highway deicing.
How does water quality impact recreational use?	Patrick, *et al*., (1991) used travel cost methods to determine the benefits of reducing suspended solids and nutrient runoff into streams and lakes that are used for recreational purposes.
RECREATION	
How do different types of ecoregions influence outdoor recreation (e.g. sightseeing, camping, or boating)?	Bhat, *et al*., (1998) used travel cost methods to value outdoor recreation for different ecoregions. In the northeast and Great Lakes regions, activities included sightseeing, pleasure driving, cold water fishing, big game hunting, developed and primitive camping, motor boating and waterskiing.
How is recreational travel time valued?	Feather & Shaw (1999) looked at how to determine opportunity costs of leisure time for water-based recreation.
What is the benefit of open space for residential use?	Waddington *et al*., (1994) used contingent valuation to determine the value for bass and trout fishing, deer hunting, and wildlife viewing.
CLIMATE VARIABILITY	
What impact does soil erosion have on reservoir water levels?	Hansen & Hellerstein (2007) used replacement costs to determine the benefits soil conservation has on reservoir service.
COASTLINE DEVELOPMENT	
How does development impact the coastline of the Great Lakes?	Braden *et al*., (2010) used actual expenditure to determine the costs of hazardous waste from former industrial sites on property values.

11 Dorworth, L., & Schneemann, M. (2016). Valuing Ecosystem Services in the Indiana Coastal Zone Literature Review. Retrieved from https://iiseagrant.org/publications/valuing-ecosystem-services-in-the-indiana-coastal-zone-literature-review/

Because change in the ecosystem condition is so complex, capturing stakeholder input, values, and priorities in the scenario development is important – causal chains will not be discarded wholesale due to lack of research and science.[12] Ideally, information in the causal chain is retained and incorporated into policy and valuation metrics, even when ecological and economic models are missing and/or incomplete.

An illustration of a very simple causal chain between a human action (implementing an agricultural best management practice) to a change in an ecosystem service (recreational fishing) from a valuation study incorporating scenarios is shown in **Figure 7**.[13]

Figure 7: Causal chain between human actions (scenarios) and resulting changes in human well-being and economic value[14]

	SCENARIO	EFFECT ON ECOSYSTEM	CHANGE IN ECOSYSTEM SERVICE	CHANGE IN BENEFITS MEASURES	CHANGE IN VALUE
A	A **small increase** in agricultural best practices, such as drip irrigation systems	**1%** reduction in total suspended solids from the current baseline	Fish production, water purification, and aesthetic enjoyment	A **small increase** in fish quantity, quality, and aesthetic benefits	Benefits of **$0.52** per fishing trip
B	A **large increase** in agricultural best practices, such as drip irrigation systems	**15%** reduction in total suspended solids and other pollution discharges from the current baseline	Fish production, water purification, and aesthetic enjoyment	A **large increase** in fish quantity, quality, and aesthetic benefits	Benefits of **$7.99** per fishing trip

12 For more information on involving stakeholders in the strategy and analysis process refer to Step 4.

13 For a much more detailed example of scenario development is see the Shoreline Restoration and Management Plan/Final Environmental Impact Statement (National Park Service, 2014) developed to address continuing erosion along the Indiana Dunes National Lakeshore.

14 Adapted from Waite *et al*. 2014 with information from Patrick *et al*. (1991), National Ecosystem Services Partnership, (2014).

The resource scenarios will, in turn, be used to frame the valuation – both the baseline level of ecosystem service provision as well as the change in the ecosystem service resulting from the human activity should be made clear to participants in the valuation exercise. Note in the example in **Figure 7** that this does not necessarily require presenting valuation exercise participants with the full ecological information in the causal chain (how the BMP results in a reduction in total suspended solids (TSS), and how reductions in TSS impact ecosystem services), only information relevant to the ecosystem benefits received (change in catch rate, species caught).

Characterize ecosystem service changes: After scenarios have been developed, changes in ecosystem services occurring under each scenario or strategy are quantified, based on the metrics identified in step 1 above. In this step, the causal chain link that translates a human action to an ecosystem service change in **Figure 7** is characterized. This can include a simple description of the impact of human actions on changes in ecosystem services, but unless this relationship is quantified empirically, it will not be possible to undertake a complete evaluation of the human action.

Some questions to consider in characterizing ecosystem service changes include:

- What is the baseline information known about the ecosystem?
- How will the scenarios under consideration impact the ecosystem services provided by the ecosystem?
- What methods and data could be used to assess the impacts above?
- Who are the stakeholders that will be impacted, and how will you engage them?
- How do these key stakeholders rank the ecosystem service impacts under the different scenarios?
- What measures would eliminate or reduce any potential negative impacts from the ecosystem service changes?

Three methods for estimating changes in ecosystem services are: modeling using biophysical and ecological production function models; relying on expert opinion, including stakeholder resource experts; and transferring information from existing studies (Waite et al., 2014). A conceptual example of linking biophysical modeling to ecosystem services is shown in **Figure 8**. Many tools are available to aid in the characterization of ecosystem services (see below).

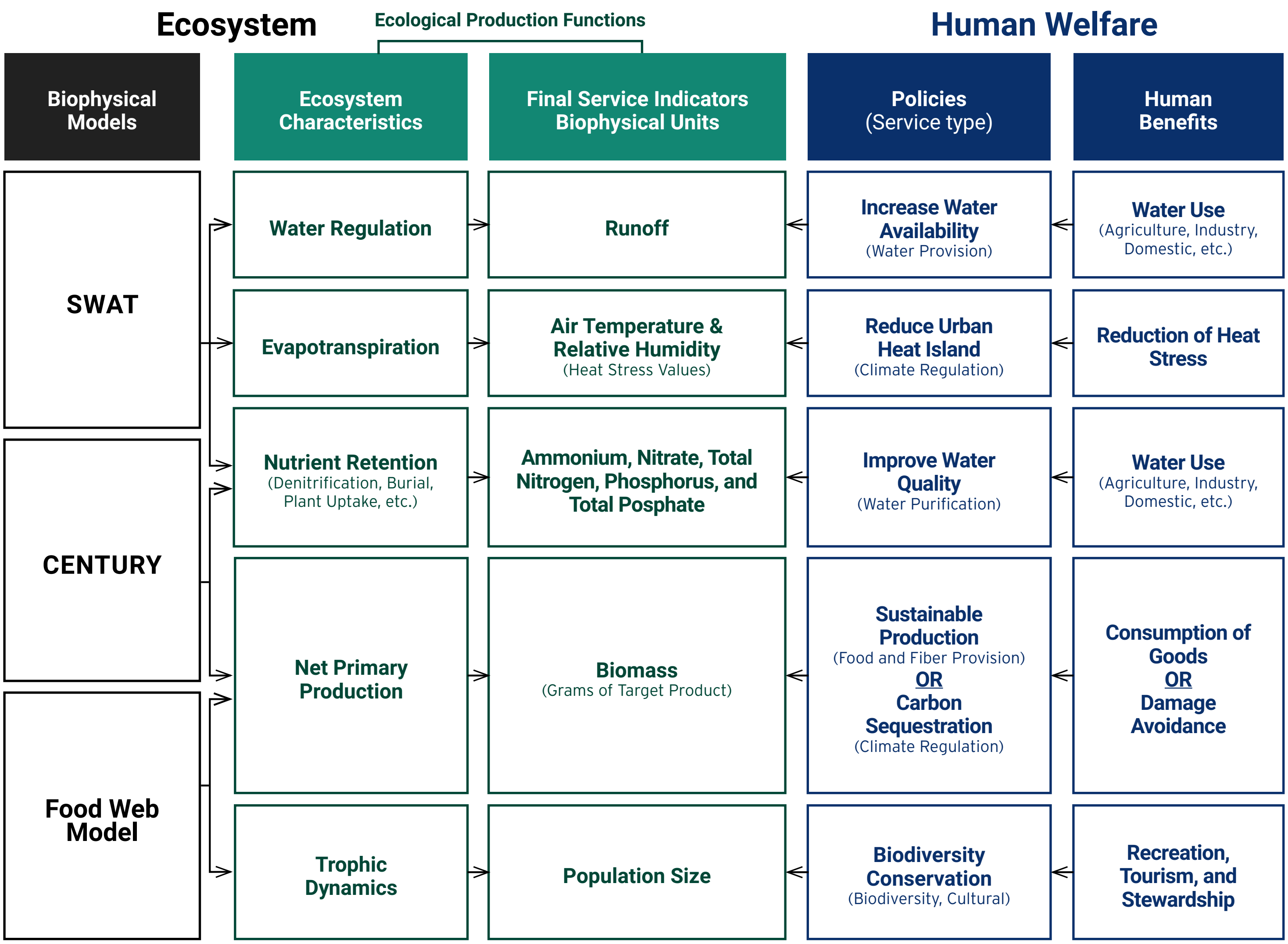
For More Information:

Center for Ocean Solutions. 2011. Decision Guide: Selecting Decision Support Tools for Marine Spatial Planning. Stanford, California: The Woods Institute for the Environment, Stanford University.

Ecosystem-Based Management Tools Network (www.ebmtools.org)

Waite *et al*., (2014). Coastal capital: ecosystem valuation for decision making in the Caribbean. Washington, DC: World Resource Institute. Retrieved from www.wri.org/coastal-capital.

Figure 8: Linking ecosystem characteristics to final ecosystem services for public policy
(Source: Wong, 2015)



Choose valuation method(s): After characterizing the ecosystem service changes, the next step is to value the changes in ecosystem services. An economic approach to valuation considers if a change in ecosystem services is beneficial or costly to people's well-being.[15] Ecosystem service changes can impact well-being by (Freeman, 1993):

- Changing the prices people pay for market goods and services.
- Changing the prices people get paid for production inputs.
- Changing the quantity and quality of nonmarket goods and services enjoyed by people.
- Changing the risks people are exposed to (uncertainty).

15 If the change is beneficial, then gain in value is estimated, alternately, if the change is costly, making the individual worse off, the loss in value is estimated. Gains and losses to individuals are measured in dollars, which is one type of measurement of value.

One of the primary considerations is whether the ecosystem service is a market goods or service (bought and sold in markets in which market prices are observable) or nonmarket goods or services (not bought and sold in markets, and so prices are not revealed in markets). In addition, certain methods are appropriate depending on whether use value, non-use value, or both, are estimated. The travel cost method for example, cannot be used to measure non-use value since data comes from actual visitors to the recreation site. A description of some valuation methods is contained in the Appendix. Examples of selected valuation methods as applied to ecosystem services is presented in **Table 4**.

Questions to consider in choosing the valuation method include (Natural Resource Defense Council, 2004):

- Are the ecosystem services valued those that support the decision making task at hand?
- Is there sufficient knowledge of the ecological production function for these services (to link the change in ecosystem condition to the change in ecosystem services)?
- Are there ecosystem services important to stakeholders that are excluded from the analysis due to lack of available ecological and economic science?

Choosing a valuation method therefore depends on how the ecosystem service change is impacting well-being, as well as the policy framing of these changes, for example, who has the property right to the impacted resource. The next section discusses valuation method implementation, including data requirements of some valuation methods.

Table 4. Primary Valuation Methods Applied to Ecosystem Service Values

Adapted from Turner *et al*., (2008), Table 4.8.

Valuation Method	*Description*	*Examples of Ecosystem Services Valued*
MARKET VALUATION		
Market Analysis and Transactions	Derives value from household or firm's inverse demand function based on observations of use	Fish Timber Water
Production Function	Derives value based on the contribution of an ecosystem to the production of marketed goods	Crop production (contributions from pollination, natural pest control) Fish production (contributions from wetlands, seagrass, coral)
REVEALED PREFERENCES		
Hedonic Price Method	Derives an implicit value from market prices of goods	Aesthetics (from air and water quality, natural lands) Health benefits (from air quality)
Travel Cost	Derives an implicit value of an on-site activity based on observed travel behavior	Recreation value (contributions from: Water quality and quantity Fish and bird communities Landscape, configuration, Air quality)
DEFENSIVE AND DAMAGE COSTS AVOIDED		
Damage Costs Avoided	Value is inferred from the direct and indirect expenses incurred as a result of damage to the built environment or to people.	Flood protection (costs of rebuilding homes) Health and safety benefits (treatment costs)
Averting Behavior or Defensive Expenditures	Value is inferred from costs and expenditures incurred in mitigating or avoiding damages	Health and safety benefits (e.g., cost of an installed air filtration system suggests a minimum willingness-to-pay to avoid discomfort or illness from polluted air)

Replacement or Restoration Cost	Value is inferred from potential expenditures incurred from replacing or restoring an ecosystem service.	Drinking water quality (treatment costs avoided) Fire management
Public Pricing	Public investment serves as a surrogate for market transactions (e.g., government money spent on purchasing easements).	Non-use values (species and ecosystem protection) Open space Recreation
STATED PREFERENCE		
Contingent Valuation (open-ended and discrete choice)	Creates a hypothetical market by asking survey respondents to state their willingness-to-pay or willingness-to-accept payment for an outcome	Non-use values (species and ecosystem protection) Recreation Aesthetics

Implement the valuation study: The data and modeling requirements vary according to the valuation method used. **Table 5** illustrates some examples of data requirements for some commonly-used economic valuation methods. When the ecosystem service under consideration is a marketed good or service, data on market prices can be used to indicate value. Ecosystem services, however, are typically non-marketed, and so, prices are not directly available and undertaking a valuation study means finding alternative data.

The travel cost method is commonly used to estimate recreational use values. Implementing a travel cost study involves developing and administering a survey questionnaire. This is commonly administered at the recreation site itself. Information gathered includes miles travelled to reach the site, expenditures made during the trip, length and frequency of the trip, preference information (for example, opinions about the site and substitute sites), and socioeconomic questions. One of the more controversial issues in implementing the travel cost method is estimating the value of time.

Implementing a hedonic pricing (HP) study involves inferring values for a non-marketed ecosystem service, based on the value of another service that has a market price. An example of this is a hedonic property value study, where variations in property values are used to estimate the value of property characteristics, including an ecosystem service such as the water quality of an abutting lake.

Implementing a contingent valuation method (CVM) study involves developing a survey questionnaire. The questionnaire must be designed by someone with expertise not only in survey research, but also in economic valuation. Key components to include in a CVM are: a description of the environmental good being valued, an explanation in the change in the level of provision of this good, a payment scenario (payment vehicle, such as taxes, fees, donations, etc., as well as who will pay – everyone, property owners, resource users, etc.), socioeconomic questions, and preference information (for example, opinions about the environment).

For More Information:

On the Ecological Production Function

EPA Ecological Production Function Library:
www.epa.gov/research/environmental-tools-support-sustainable-decision-making

Environmental Benefits Analysis Program by the U.S. Army Corps of Engineers:
http://cw-environment.usace.army.mil/eba/index.cfm

Select online libraries and databases of ecosystem valuation studies

Environmental Valuation Reference Inventory (EVRI) https://www.evri.ca/

Marine Ecosystem Services Partnership (MESP)
http://www.marineecosystemservices.org/

National Ocean Economics Program (NOEP)
http://www.oceaneconomics.org/

Ecosystem Service Valuation Database (ESVD)
http://www.es-partnership.org/esp/80763/5/0/50

Table 5: Examples of Data Requirements for Selected Economic Valuation Methods[16]

Estimation Method	*Approach*	*Data Requirements*	*Limitations*	*Example Study and Data Used*
Market price (MP)	Observe prices directly in markets	Use either market prices of goods and services (e.g., for fish or boating trips) and/or operating costs (e.g., equipment, tools, fuel and supplies)	Market prices can be distorted (e.g., by subsidies) Environmental services often not traded in markets	Henry *et al.*, (1991) State Highway Agency Questionnaire
Replacement Cost (RC)	Estimate cost of replacing environmental service with man-made service	Market prices for man-made equivalent (e.g., replacing wetlands with diversion canals)	Replacement cost is not recommended by economists because it is not an economic value measure.	Hansen and Hellerstein, (2007) National Inventory of Dams database, data from dredging contractors, state and local government data
Hedonic pricing (HP)	Estimate influence of environmental characteristics on price of marketed goods	Environmental characteristics that vary across goods (e.g., houses and hotels), data on property amenities (e.g., number of bedrooms, bathrooms, size)	Requires economic expertise High data requirements	Sander & Haight (2012) Local and state government datasets, GIS floodway data from Minnesota Department of Natural Resources, National Land Cover Database

16 Source: Waite *et al.*, (2014).

Estimation Method	Approach	Data Requirements	Limitations	Example Study and Data Used
Travel cost (TC)	Travel costs to access a resource indicate its value	Maps, market prices of costs to travel site, number of visitors	Requires economic expertise High data requirements	Englin & Shonkwiler (1995) General population survey
Contingent valuation (CV)	Ask survey respondents directly for value of environmental service	Population information, preference data	Expensive to implement Requires economic expertise	Rollins & Dumitras (2005) Questionnaires and surveys
Choice modeling (CM)	Ask survey respondents to trade environmental and other goods to elicit value	Population information, preference data, biophysical data (e.g., types of products; biophysical structure; harvest, yield or use rates; rates of biological productivity)	Expensive to implement Requires economic expertise	Cadavid & Ando (2013) Questionnaires and surveys

For More Information:

The Measurement of Environmental and Resource Values: Theory and Methods by Freeman, A. M. III.

Valuing Environmental and Natural Resources:
The Econometrics of Non-Market Valuations by J.C. Haab and K.E. McConnell

A Primer on Nonmarket Valuation by Patricia A. Champ, Kevin J. Boyle, and Tomas C. Brown

Case Study 3: Submerged Maritime Cultural Resources (Whitehead *et al.* 2003)

This study uses the contingent valuation method to examine the nonmarket value of maintaining shipwrecks in their submerged state. Non-market value includes both use value (benefits to recreational divers) and non-use value (benefits to people who derive utility from learning and knowing about shipwrecks without actually visiting the wreck in person). Regarding maritime cultural resource policy, estimates of the economic value of shipwrecks can be used to ascertain the appropriate level of social resources to allocate to shipwreck protection. The study finds that households are willing to pay (WTP) about $35 in a one-time increase in state taxes to maintain shipwrecks. Given a population of 650,000 in the study sampling region, the aggregate WTP is over $21 million. Given that residents outside of the study area value shipwreck protection, this is a lower-bound (conservative) estimate.

Photo: Figurehead of an old wooden schooner in Lake Michigan

Step 3: Outreach

Target Audience: As research ends and outreach begins, revisiting the original purpose of the ecosystem services valuation is recommended. Characterizing the target audience is important in ensuring outreach products enforce the intended valuation purposes. Including representatives of the target audience in developing outreach materials is instrumental in keeping valuation results simple and easy to understand, and encourages use of the final results in decision-making. Social and traditional media, workshops, meetings, and conferences can be used to share results, raise awareness, and drive conversations. Outreach products can include policy briefs, videos, brochures, toolkits, maps, and presentations.

Develop Tools and Products: Practitioners should keep in mind[17]:

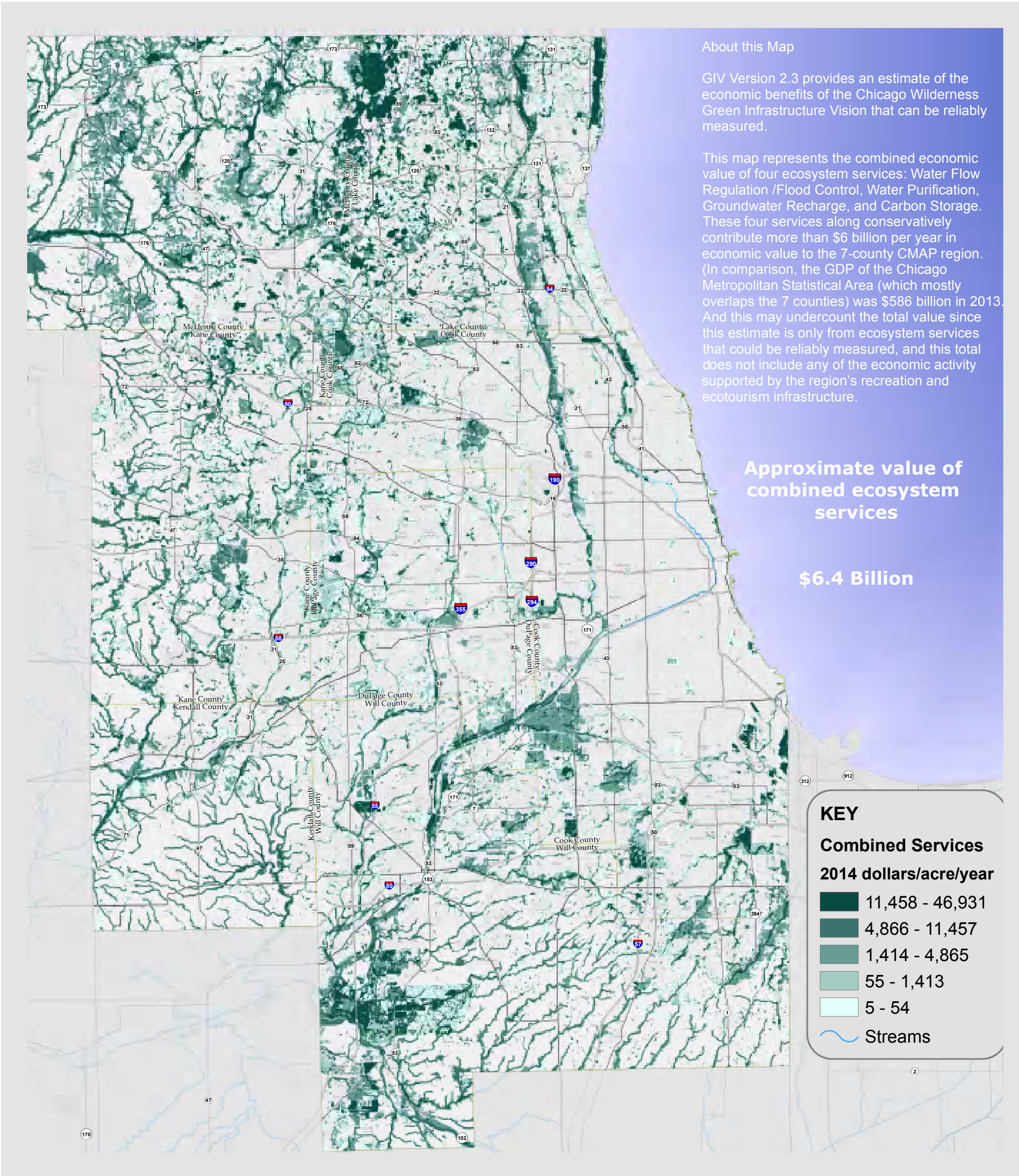
- The action they would like the audience to take.
- The need to maintain credibility and communicate the quality of the research.
- The benefits of working with partners, stakeholders, and local champions.

One example of public outreach using ecosystem service values is the Arbor Day Tree Tag Project led by the Morton Arboretum. Through the Tree Tag outreach campaign, over a dozen cultural and private sector institutions distributed over 5,000 educational and awareness tree tags. These tags show the value of trees – providing services such as cleaner air and cooler homes during the summer.

Photo: Ramon Gonzalez

17 Waite *et al*., (2014). Coastal capital: ecosystem valuation for decision making in the Caribbean. Washington, DC: World Resource Institute. Retrieved from http://www.wri.org/coastal-capital

Another example of an outreach product is the Chicago Wilderness Green Infrastructure Vision (GIV) [18] project maps, which spatialize benefits transfer results to communicate the value of implementing the GIV to local decision-makers:



18 http://www.cmap.illinois.gov/livability/sustainability/open-space/green-infrastructure-vision

Communicate Values Clearly: One concern with developing outreach products is making clear the value of benefits provided by ecosystem services. What is important to communicate is that monetary valuation does not mean that any payments have taken place. Just because values are expressed in dollars, it does not mean any dollars have actually changed hands. For example, in the tree tag outreach effort above, the tags do not represent the cost of installing the tree, or the price for people to buy or sell the tree, but is a monetary representation of value of ecosystem services provided by the tree (such as, carbon sequestration benefits). In the GIV example above, communities do not receive payments for the economic value of ecosystem services, rather, the value is experienced indirectly. For example, the water purification numbers used in the GIV represent reductions in costs of providing water treatment. Since these values are transferred from other studies (the study site – for example, water purification services provided by a 2000-square-mile watershed in New York), follow up evaluation is needed to determine if cost reductions are actually achieved as a result of green infrastructure implementation at the policy site (in this case, downscaled one acre watershed parcels in the Chicago region), given differences in geography, water treatment costs, and technology between the study site and the policy site. Nevertheless, the values serve to increase awareness of ecosystem services provided by green infrastructure and help drive conversations in communities.

For More Information:

Introduction to Stakeholder Participation: http://www.coast.noaa.gov/publications/stakeholder_ participation.pdf

Strengthening the Social Impacts of Sustainable Landscapes Programs: A Practitioner's Guidebook to Strengthen and Monitor Human Well-Being Outcomes: http://www.conservationgateway.org/ConservationPractices/PeopleConservation/SocialScience/Pages/strengthening-social-impacts.aspx#sthash.qML9nPyJ.dpuf

Stakeholder Participation for Environmental Management: A Literature Review: http://sustainable-learning.org/wp-content/uploads/2012/01/Stakeholderparticipation-for-environmental-management-aliterature-review.pdf

Step 4: Stakeholder Engagement

Stakeholders are an important part of any ecosystem service valuation or project. They are the people in the project location that are impacted directly by the study, people who can impact decisions and policies, and people who have concerns or support for the project, based on their interests and beliefs. Stakeholders involved in the process can be divided into three categories: primary, secondary, and external (Waite et al., 2014). Primary stakeholders are community members who are directly impacted by any decision or outcome from a project but do not have any major influence in the process. They are people who work in the area of the project sites and are highly dependent on the coastline, such as farmers, tourism business owners, and small coastal communities. Secondary stakeholders, such as local, state, and federal officials and resource managers, are people who have influence over the decision-making process. Finally, external stakeholders are people who are not directly impacted by the project but have concerns or support based on their interests. These stakeholders include land developers, tourists, lobbyists, and representatives or members of environmental non-governmental organizations, Native American tribes, universities, and natural resource industries, such as oil facilities and shipping yards.

Photo: Leslie Dorworth Facilitating a Coastal Services Ecosystem Valuation Workshop

In the beginning of a project, the group of involved stakeholders should consist of natural resource managers, such as city planners, local government officials, and representatives from a geologic survey (federal or state representation), the U.S. Fish and Wildlife Service, land trusts, and other conservation groups. This group should determine the scope of the project: What is the context and purpose, geographic and temporal scale, and socioeconomic (i.e., benefit relevant indicator goals and metrics?) and What is already known or has already been done? From here, an outreach specialist (liaison to the research community) will identify who can answer these questions and will open communication lines between stakeholders and researchers. Researchers, such as economists, engineers, biologists, coastal geographers, and climatologists, will present information to the stakeholders group. Gathering initial input from the public about ecosystem services using social science methods (including for example, non-monetary valuation) can be conducted during this phase as well. Once current data is presented, stakeholders should reconvene and discuss whether they have sufficient information for a project decision. If more research is needed, stakeholders should identify any missing links or gaps in knowledge from the causal chain and determine next steps to fill these gaps. At this point, stakeholders choose whether or not to proceed from the scoping phase (step 1) to the analysis phase (step 2) based on resources, effort, and organizational capacity.

In step 2 (Analysis), reconfiguring the stakeholders group is needed to steer towards a more technical focus and to include more representation from the research community. Setting a conceptual causal-chain in motion requires modeling ecosystem services and benefits in different disciplines. For a best-practices ecosystem services approach, a model(s) needs to translate ecological metrics into benefit-relevant indicators. The models used are determined based on information gaps identified by the manager stakeholder group. Throughout this process, keeping the lines of communication open between different research disciplines and the larger group is important to allow for stakeholder feedback. When research is completed and the outreach phase begins, a third reconfiguring of the stakeholder group takes place, adding members from the manager stakeholder group and people who have a background in communication, marketing, and outreach.

Step 5: Evaluation

It is important to tailor the evaluation to the ecosystem valuation. When undertaking an evaluation, the purpose, expected outcomes, and intended benefits of the evaluation should be clearly stated. This provides direction for the evaluation so that the correct data will be collected. Evaluation involves reflection on questions such as (Taylor-Powell *et al*., 1996):

- What is the purpose of the evaluation?
- What do I want to know?
- What do I intend to do with the information?

Another consideration is the target audience for sharing the evaluation results. This can include, but is not limited to, people affected by the project, participants, elected officials or reporters. By knowing the target audience, it is easier to identify what types of information should be collected and questions that should be asked. Examples of questions to ask when collecting data include (Taylor-Powell *et al*., 1996):

- When will the data be collected?
- Will a sample be used?
- Who will collect the data?
- What is the schedule for data collection and will this work with respondents' schedules?

Another consideration is the ecosystem service is used to show forms of change, progress, and any evidence of accomplishments. Once the ecosystem service, questions, and needed information have been identified, an evaluation timeline should be created that is based on any deadlines, funding restrictions, or expectations that can influence the evaluation. It is important to note that unexpected situations may occur and can impact the timeline. It's worth spending time considering possible sources that can inform the evaluation and save time and effort. These sources can include printed material about the program, gathering information directly from people involved in the project and using observations about program participants. It is important to make sure that the identified sources can actually provide the necessary information. During this process, remember that economic valuation can be conducted independently of any knowledge of the ecosystem production function. But whether a project actually results in the intended impact requires integration and measurement of both the ecological and economic metrics.

Once data collection is complete, data analysis can start. Understanding the outcomes of the valuation is not only documenting the results but also being able to draw conclusions from those results. This presents an opportunity to work with stakeholders because "greater understanding usually results when we involve others or take time to hear how different people interpret the same information (Taylor-Powell *et al*., 1996)." This also encourages stakeholders to use the results from your evaluation and possible future collaboration.[19]

Finally, project creation can be effective initially, but if the project is not maintained, it cannot function to its fullest abilities and in turn, may not provide all the benefits originally valued. An example is a green infrastructure project that is initially valued as providing benefits over 20 years, but due to lack of maintenance, fails after 4–5 years.

Metric Selection: Causal chains that focus on ecosystem services require models from many different fields of study to properly represent the services provided. These models can be broken down into ecological and economic models. Ecological models, incorporating ecological production functions, quantify changes in ecosystem service conditions. They use changes in physical and biological conditions, such as nutrient retention, flood storage, and game species populations, to determine the ecosystem benefits that are useful and directly relevant to decision makers. To quantify these changes, each individual service and restoration technique requires a specific type of metric. Because of this, each will have a different type of model associated with it. When the quantification of ecosystem services is complete, these quantities can be used in economic models to determine the value of the benefits based on pre-determined metrics.

19 For more ideas about sharing results, refer to Step 3: Outreach

For More Information:

A Guide for Incorporating Ecosystem Service Valuation into Coastal Restoration Projects: http://www.nature.org/media/oceansandcoasts/ecosystem-service-valuation-coastal-restoration.pdf

Coastal Capital: Ecosystem Valuation for Decision Making in the Caribbean: www.wri.org/publication/coastal-capital-guidebook

Valuing Ecosystem Services: Toward Better Environmental Decision-Making: http://www.nap.edu/catalog/11139/valuing-ecosystem-services-toward-better-environmental-decision-making

Appendix: Valuation Methods

Economic Methods

Revealed Preferences: uses market-based information to derive the value of an ecosystem service

Actual Expenditure/Actual Price – Evaluating the full cost paid for environmental and ecosystems goods and services. Market data can be collected to find how much people are paying for a certain good and using that information to determine the overall economic benefit to consumers, whether it be positive or negative. This process helps to determine the economic value of factors such as the impacts of sustainable versus non-sustainable commercial fisheries and timber harvest practices.

Averting Behavior – Looking at the benefits and/or costs to human health through different environmental actions. After determining the risk to be evaluated, data is collected on the amount of products people bought that would help prevent the impacts on people from the chosen risk. For example, if people believe their municipal public water supply water quality is too poor to drink (thus presenting a risk to their health), they will purchase bottled water rather than drinking tap water. In this example bottled water is the product and the human health impacts from consuming tap water are the risk.

Hedonic Wage/Property – Using market pricing to estimate the economic value provided by ecosystem and environmental services. Through collecting residential property sales data or wage data, statistical analysis can be conducted to determine the influential value that certain factors can contribute to the overall price of a house or the price of a person's time. These factors may include air quality, water quality, or workplace morbidity/mortality risk.

Travel Cost – The number of trips taken to a specific location is used to help determine the value of the good. At the location, visitors are surveyed about how many times they visit, how far away they live from the location, how long the visit was, and other information such as income, age, and education. The travel cost value is determined from respondents' answers.

Stated Preferences: uses surveys as a tool to directly ask respondents about the values they hold for ecosystem services.

Contingent Valuation – Determining a person's value for environmental and ecosystem services by surveying people directly about how much they would pay for the service or be compensated for losing the service. These surveys include detailed explanations of the service or good in question, demographics questions (age, income, etc.), and value questions. To help get a more realistic estimate, a description of how an individual would pay for the service would be included, such as taxes, donations, or other types of fees.

Conjoint Analysis – Measuring how people value certain products or services provided by ecosystems and the environment over other products or services. Through surveys, individuals are asked to respond to or rank different options regarding environmental and ecosystem services and products. Their answers reflect preferences for certain products or services over others and reflect their economic value. For example, this ranking process can help determine what types of recreational opportunities should be made available in a certain park.

Combined Revealed/Stated Preference – Looking at both a person's trade-offs and value for environmental services. By using stated preference, data is collected on one's preferences about certain goods or services. These options are based on the calculated values from revealed preferences that determined people's value for a variety of environmental and ecosystem services. An example of this type of study is looking at what type of management strategy for deer population is most favored by the local community and how much an individual values strategy implementation.

Cost-Based Approaches[20]

Replacement Cost – Determining how much it would cost a person or community to replace ecosystem services. This is done by assessing the service supplied by the environment and determining the cost to provide this service if it is lost. One example is looking at possibly removing a wetland, identifying the services provided, such as flood control, and calculating the total cost of building new infrastructure to manage future needs of those lost services.

22 Replacement cost and cost of treatment methods are not recommended for use by most economists though some valuation practitioners use these as a last resort (Natural Resource Council, 2004). This is because replacement cost and cost of treatment methods are not measures of economic value, and should be considered costs of providing an ecosystem service, not benefits (value) of this service to people, so these estimates should be approached with caution.

Benefits Transfer

Benefits Transfer – Using existing, original economic valuation studies to estimate economic value. Because original economic valuation studies require a high level of expertise and can be costly to conduct, the benefit transfer approach has been advanced as a way to provide a less costly and time-consuming way of conducting an economic valuation. The credibility of benefits transfer, however, varies depending on the method used to conduct the transfer, with a credible benefit transfer typically requiring as much expertise as an original valuation study. The two types of benefit transfer include:

Benefits Value Transfer – Determining the value of an ecosystem service in one location (the policy site) by using existing values from another location (the original site or the study site), which has similar landscape and resources, and transferring the values of the original services to the new policy site.

Benefits Function Transfer – This method uses the estimated valuation equation, or function, to calculate a transfer equation that takes into consideration the policy-site conditions. This also includes the meta-analysis method.

Non-Monetizing Assessment

Civic Valuation – Determining the value people place on changes in ecosystem services when carrying out civic duties, such as citizen juries or voting. With a focus on communities, the goal is to determine the value an ecosystem service has on the well-being of the targeted group or community. An example of this is citizens voting for an initiative that promotes the use of renewable energy in the state.

Biophysical Ranking Methods – Using biophysical indicators, such as biodiversity, biomass production, energy use, and carbon sequestration to determine ecological change based on predetermined criteria. This method is unique because it is not focused on the value placed by humans but rather is a ranking based on the value placed by nature. An example of this ranking method is picking a fuel source defined by how much energy is required to retrieve it compared to the amount of energy provided by the fuel source.

Ecosystem benefit indicators – Creating a quantitative metric based on the contributions an ecosystem service provides to human well-being. This type of assessment is based on spatial data of a specific location and the amount of demand for a service compared to how much the service can provide. An example of this would be calculating the number of recreational users in one lake compared to the number of users in another. The lake with the larger number of recreational users would have a higher ranking because it provides the service to more people.

Measures of Attitudes and Preferences – Gauging people's attitudes and preferences for ecosystem services. Through surveys, individuals participate in choice experiments designed to gather information on attitude, values, and trade-offs for different environmental and ecosystem services. An example of this is determining people's attitudes about electric vehicles from real life experiences over a long period of time to find out any preferences or concerns regarding driving an electric vehicle.

Multiple Criteria Analysis – Examining different available options for making decisions related to ecosystem services. This approach is often used for picking a management approach for forest and water resources, conservation planning, and sustainability. An example of a multiple criteria analysis is determining regulations and policy for using a forest on public lands – whether logging or mining should be allowed, whether the forest should remain pristine for recreational purposes, or a combination of both.

Subjective Happiness Metrics – Using a person's self-rated happiness and their income along with current environmental conditions to show how much a person would need to be paid to adjust for a decline in environmental quality. An example of this would be using a person's well-being to determine the cost of water pollution and its economic impact on a person's quality of life.

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