# Ecosystem Services

Humans live among ecosystems that provide innumerable benefits to our lives: ranging from the pollination of our crops to providing spiritual values, and everything in between. Collectively, these benefits that people obtain from ecosystems are **Ecosystem Services (ES)** (Millenium Ecosystem Assessment 2005) . ES can refer to both goods (i.e. timber) and services (i.e. water filtration). They have been discussed in related scientific fields since the 1960's (De Groot et al. 2002)[1] . However, in the last decade the amount of research on the topic, and its applicability to decision-making, has increased dramatically.

### Types of ES

The Millennium Ecosystem Assessment (2005)[2] divides ES into four distinct categories:

- provisioning services (that provide food, water, timber, and fiber),
- regulating services (that affect climate [i.e. carbon sequestration ], floods, disease, wastes, and water quality [i.e. surface water filtration]),
- cultural services (that provide recreational, aesthetic, and spiritual benefits), and
- supporting services (such as soil formation, photosynthesis, and nutrient cycling that support all other ES).

This is the most commonly accepted framework for understanding different types of ES. As our understanding of ES continues to grow, finding ways to explicitly identify and account for each one is an important step to implementing ES in decision-making. To assess these different types of ES, indicators are used for quantifying their flows.

### Importance of ES

The applied value of the ES concept, and research about specific ES, is that such information can be used to bolster sustainable, place-based decision making (Villamagna et al. 2013)[3] . Natural resource planning, infrastructure development, natural area management, tourism development, and more, are interconnected with ES. These sectors both depend, and exert pressures, upon the effective provision of ES. Research in the area of ES is making these interconnections explicit. For example, one can estimate the amount of water that is purified by a wetland area and subsequently used by the local population. The value of this service is an important counterbalance to the economic factors that would push for its development into, say, housing. Oftentimes, ES help present natural values in a way that they can be effectively quantified, and thus compared, with traditional economic values (Chan et al. 2012)[4] . By studying ES, the trade-offs, ES values, and relationships between actions and outcomes become more clear, enabling decision-makers to better address the issues they face.

Ecosystem Services include such a diverse range of goods and services that consistently defining ways to identify, characterize, and value them is incredibly important for effective application. Unfortunately, the research on ES is anything but consistent, using different terminology, definitions, and frameworks (Villamagna et al. 2013)[5] . This creates an ongoing challenge for practitioners. Some methods for categorizing, assessing, and valuing ES are reviewed below.

## Ecosystem Service Initiatives

There are several large scale attempts to frame and evaluate ES across the Alpine Space, Europe, and the globe. Some important examples of such initiatives are:

1. *The AlpES Project* , which examines and integrates ecosystem services and policy in the Alpine Space. Further details about the AlpES project may be found on the project website.
2. *The Millennium Ecosystem Assessment*, which assesses the worldwide impacts of ecosystem changes on human well-being. Please sea the Millennium Assessment website for more.
3. *The Economics of Ecosystems and Biodiversity*, which is a global initiative focused on “making nature's values visible”. More information can be found at the TEEB website

## AlpES Framework for Ecosystem Services

For the purposes of the ES evaluation in the AlpES Project, each ES is split into three aspects: *supply*, *flow*, and *demand*. The indicators used to assess ES are often different depending upon the category one is hoping to assess. Some notes on specific indicators are thus also included below.

### ES Supply

*Supply* is the amount of an ES that can be delivered by an ecosystem. The supply of ecosystem services is strongly linked to natural conditions, e. g. land cover (vegetation), hydrology, soil conditions, fauna, elevation, slope and climate (Burkhard et al. 2010)[6] . In order to better quantify the distinct pieces of supply, it is further broken down into 1.) *potential* and 2.) *stock*. This differentiation can aid in decision making.

1. *Potential* refers to the hypothetical maximum yield of selected ES that can be used or gained from an explicit portion of an ecosystem (Burkhard et al. 2012, Albert et al. 2016)[7] [8] . This term focuses on natural yields only, and thus does not consider the ways in which human activities can boost or diminish these yields. This means that it can be thought of without respect to current condition. Furthermore, the actual usage of the ES is irrelevant to its potential. Indicators for potential are often modeled based on the natural characteristics of an area.
2. *Stock* refers to the share of currently usable ES provided by an ecosystem. This characteristic can be thought of as the sum the natural potential and any human alterations, which can be either positive or negative. For example, the addition of fertilizer induces stocks that are greater than potential. Thus, stocks may either fall below or above the potential and are the actual maximum yield of a selected ES for the existing conditions on the landscape. Indicators for stock are ideally, especially for provisioning ES, simply direct ecosystem properties (Villamagna et al. 2013)[9] .

### ES Flow

Ecosystem Service *Flow* is the de facto, or actual, amount of an ES (or bundles of ES) that is utilized from an ecosystem in a given time period (Burkhard et al. 2014, Albert et al. 2016)[10] . Flow is easiest to conceptualize in provisioning ES; for example, the amount of fire wood taken out of a forest would be equal to the flow of the fuel wood provision ES. In other words, it is the amount or rate of an ES that is supplied to some beneficiary (Potschin et al. 2016)[11] . Indicators for flow are thus often simply

measurements of the amount of an ES used from a particular area in a given period.

#### ES Demand

*Demand* for an Ecosystem Service is the amount of the good or service that is currently consumed or used in a particular area over a given period, regardless of where the ES are derived from (Burkhard et al. 2012)[12] . For example, the amount of firewood burned in a village over a year, even if the majority of this wood is imported. Demand is a characteristic that can be measured across a multitude of scales, ranging from local demand for recreation opportunities, to global demand for carbon sequestration.

### Ecosystem Services in the Alpine Space

As part of the AlpES project, eight ES services have been selected for evaluation and mapping across the Alpine Space:

1. Surface water for drinking, with minor or no treatment
2. Biomass production from grasslands
3. Fuel wood
4. Filtration of surface water by ecosystem types
5. Protection of areas against avalanches, mudslides, and rockfall
6. CO2 sequestration by forests and bogs
7. Outdoor recreation activities (including enjoyment and willingness to preserve)
8. Symbolic plants, animals, and landscapes.

Now that the ES have been selected, indicators for each will be developed. They will then be evaluated and mapped for the Alpine Space as part of the AlpES project.For each ES indicator, metadata are available here.

natural resource management, ecosystem services, AlpES project, indicator

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