What are Ecosystem Services and Natural Capital, and how does this apply to Soil Science?

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Summary

Ecosystem services and natural capital have become prominent terminology in the ecological and wider literature, and yet convey different meanings to different communities. No single consistent definition of ecosystem services has yet been adopted, but many follow the framework laid down in the 2005 Millennium Ecosystem Assessment that considers; supporting, provisioning, regulating and cultural services. In this article we review the concept of ecosystem goods and services in the context of green accounting. If the ecosystems approach is widely adopted it is important from the perspective of soil science that the contribution of soils to any green accounting system is fully realized.

Introduction

Society exploits nature to produce goods and services that are of benefit to our well-being. If we wish to remain a sustainable and viable society then we must account for the utilization of nature and ensure that societal economic growth does not depreciate our natural resources to the point of collapse, but manages our resources by cycling and replenishing the resources appropriately. Westman (1977) suggested that society could make more informed decisions and policy by incorporating the idea that ecosystems offered benefits of social value. This idea has grown into the concept of what we term 'ecosystem services'. Since then an increasing body of interdisciplinary work has developed that embodies ecology, earthscience, economics and social science. The books, Nature's Services (Daily, 1997) and an Introduction to Ecological Economics (Costanza,et al., 1997a) have helped to shape this field of research. In 2005, the Millennium Ecosystem Assessment, (MEA, 2005) made a huge global impact at a political level by reporting on the state of the earth's ecosystems. The report identified that many ecosystems were in serious decline or at the point of collapse. Stark reading has moved many Governments to move towards adopting a 'green' approach to policy development by endeavoring to account for the goods and services we obtain from nature, and protect and enhance these by making decisions that incorporate nature's value. These overall concepts are embodied in what is termed the 'ecosystems approach' which forms the context of this paper, especially with regard to how soil science can contribute to this.

The ecosystems approach often refers to 'natural capital' and 'ecosystem goods and services'. Costanza et al. (1997b) defined natural capital as, "the stock of materials or information contained within an ecosystem". Whereas ecosystem goods and services have been defined in a number of ways, but many people commonly refer to the definition provided by the MA, "the benefits people obtain from ecosystems" (MA, 2005). The typology used by the MA identifies four main services, supporting, regulating, provisioning and cultural (Table 1.); this has since been modified by various workers but provides a starting framework and overview.

The importance of the ecosystems approach is that it works to link ecosystem goods and services to economic value for human and societal well-being. The valuing of nature is central to the concept, though this doesn't necessarily mean assigning monetary value. What is important is recognizing that nature provides inputs to society, and that if, at the very least, sustainability is to be achieved the exploitation of natural resources must not degrade stocks beyond critical thresholds. Maintaining the rich diversity of life should be our goal, maintaining thriving biodiverse ecosystems. One approach to achieving this is the idea of an ecosystem index that complements welfare indicators such as Gross Domestic Product, GDP. GDP is a well-known national accounting term that has, rightly or wrongly, become politically and socially accepted as a measure of a country's standard of living. GDP and similar such economic terms, though imperfect serve a purpose in helping us to understand national output and national economic well-being. As a result, if the ecosystems approach is widely adopted it is important from the perspective of soil science that the contribution of soils to any green accounting system is fully realized. Often soils are overlooked, or at least felt to be by many working in the discipline, but the ecosystems approach offers the opportunity for the value of soils to societal well-being to be fully recognized. In order for functional ecosystem accounts to be developed there are three general requirements for developing welfare accounts that must be recognized, 1) defining and measuring accounting units, 2) Indexing the units, and 3) valuation (Boyd and Banzhaf, 2007). Therefore, the first of these requires that we have clear definitions in order to implement the subsequent steps.

Table 1. Ecosystem services as reported and classified in the Millennium Ecosystem assessment (adapted from, MA, 2005).

ECOSYSTEM SERVICES	
	Provisioning
	FOOD
	FRESH WATER
	WOOD AND FIBER
	FUEL
	Regulating
Supporting	CLIMATE REGULATION
NUTRIENT CYCLING	FLOOD REGULATION
SOIL FORMATION	DISEASE REGULATION
PRIMARY PRODUCTION	WATER PURIFICATION
	Cultural
	AESTHETIC
	SPIRITUAL
	EDUCATIONAL
	RECREATIONAL

Clarifying definitions used in the ecosystems approach

The sequence of steps in the ecosystems approach can be summarized as starting with nature, describing its components, and how goods and services are derived from these to benefit society. This simple statement belies a scientific and philosophical minefield, crossing from the disciplines of earth science and ecology, to economics and social science. As a result it seems appropriate to consider some basic definitions:

Goods, services and benefits

A good can be defined as, "*a physical or tangible item, a product that can be seen, tasted, felt, heard, or smelled before it is purchased; that can be owned, that satisfies some human want or need, or something which people find useful or desirable and who make an effort to acquire it*." Whereas, a service is by definition intangible, "*A type of economic activity that is intangible and insubstantial, it cannot be touched, gripped, handled, looked at, smelled, tasted or heard. It is not stored and does not result in* *ownership; a service is consumed at the point of sale*." The characteristics of a service are its intangibility, perishability, inseparability, simultaneity, and variability. Common examples of services are storage, maintenance, delivery and cleaning. We might consider that the independent concept of goods and services has a long history, but Cook et al. (1999) points out that it was 1940 when Clark (1940) identified a service sector, and 1964 when Judd (1964) defined services introducing a typology. Fisk et al. (1993) suggested that it wasn't until the 1980's that the difference between goods and services was broadly assumed. Hence the ecosystems approach is now seeking to embrace a relatively recent concept by identifying, and accounting for, ecosystem services.

With regard to benefits, Wallace (2007) and the MA (2005) broadly considered services and benefits to be the same. However, as pointed out by Boyd and Banzhaf (2007) a benefit is not a service. A benefit is in general defined as an '*advantage*', more specifically in the marketing context it is, "*a desirable attribute of a good or service, which a customer perceives he or she will get from purchasing*." Fisher and Turner (2008) point out that by treating benefits and services as the same it also creates a potential pitfall of double counting in valuation.

Defining ecosystem services

Fisher et al. (2009) provide a recent overview of how ecosystem services are defined, indicating that the literature has no commonly accepted consistent definition, something that they, and others (Boyd and Banzhof, 2007; Wallace, 2007), argue is required to turn a conceptual framework into an operationalizable system of accounting. Fisher et al. (2009) indicate that the three following definitions are most commonly cited:

- the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life (Daily, 1997).
- the benefits human populations derive, directly or indirectly, from ecosystem functions (Costanza et al., 1997b).
- the benefits people obtain from ecosystems (MEA, 2005).

They go on the state, "These definitions suggest that while there is broad agreement on the general idea of ecosystem services, important differences can be highlighted. In Daily (1997) ecosystem services are the "conditions and processes," as well as the "actual life-support functions." In Costanza et al. (1997b) ecosystem services represent the goods and services derived from the functions and utilized by humanity. In the MEA, services are benefits, writ large." As a result, there is often confusion as to what is meant when the term is used, the mixing of benefits and processes with services also adds to this.

In response to this confusion of terms, Boyd and Banzhaf (2007) wrote an article with the aim of clarifying the definition of services to develop an operationaizable green accounting definition, "*Final ecosystem services are components of nature, directly enjoyed, consumed or used to yield human well-being*". They argue that an ecosystem index must be developed along similar lines to the existing labor and capital indexes contributing to GDP. To avoid 'double counting' these indexes only count final products that are consumed by humans; for instance, cars and trucks are counted, but the parts, such as, tyres, glass, headlamps, radios, etc that they are made from are not. This leads Boyd and Banzhaf (2007) to distinguish between final and intermediate ecosystem goods and services. Based on this definition, benefits resulting in human well-being include, harvests, damage avoidance, waste assimilation, amenities and fulfillment, provision of water etc. Final ecosystem services that result in these benefits may include, delivery and storage of clean drinking water, or delivery of clean air, avoiding damage to health. Within this definition, water purification, often described as a service (MA, 2005) is now seen more appropriately as a process, whereas the service is the 'delivery' of clean water, which could be measured in cubic meters and valued accordingly. This approach consigns a myriad of identified ecosystem goods and services into the 'intermediate' category, as they act within ecosystems to contribute to final commodities. As a result, the ecosystem may be considered to be composed of different sectors e.g. soils, plants, animals, that through a combination of intermediate goods and services result in final ecosystem level goods and services; for instance, the benefit of clean water consumption results from the action of all three sectors to provide the final service of clean water delivery. It is important to point out that just because these intermediate goods and services would not be used in the final assessment of ecosystem GDP, it doesn't mean that they don't have value.

Ecosystem services and natural capital as applied to soil science

Given the previous discussion, where are we with regard to soils? Daily et al. (1997) was perhaps the first to attempt to classify the ecosystem services of soils, which has been followed by other classifications (Wall et al., 2004; Andrews et al., 2004), especially a number for the purposes of agriculture (Swinton et al., 2006). In addition a few attempts have been made to add value to soil ecosystem services (soil organisms; Clothier). Recently, Robinson et al. (2009) attempted to firm up the definition of soil natural capital. Dominati et al. (2010) attempted to provide a combined soil natural capital and ecosystem services framework, which Robinson and Lebron (2010) argued led to equivocation. All of which confirms that much of what has been written about soils contains many of the confusions with regard to definitions outlined by Fisher et al. (2009).

If soil science is to adopt the ecosystem services definition proposed by Boyd and Banzhaf (2007), soils could be considered to be relegated to a sector that contributes to the overall ecosystem services, as most of what soils produce are intermediate services. However, this is probably true of the other sectors in the ecosystem and is perhaps the most appropriate way to deal with the disciplines that contribute to the overall ecosystem goods and services that contribute to human well-being. Table 2 is an attempt to identify what might be considered final goods and services that soils contribute. The rest of what soils contribute, such as carbon storage, and nutrient and water delivery to

Table 2. Goods and services from soils that contribute to 'final' ecosystem goods and services as defined by Boyd and Banzhaf (2007).

Final Soil Goods	Final Soil Services
Biomaterials, peat, humus	Storage of heritage artifacts
Materials, clay, sand, for lubricants and cosmetics	Maintenance of support for infrastructure
Soil organism, e.g. worms used for fishing or gardening, or microbes used in pharmaceuticals	Maintenance of plant growth medium
Dyes and colors	Genetic and biodiversity store
Dietary mineral supplements	

plants would be intermediate services.

As pointed out by Boyd and Banzhaf (2007), intermediate services have value; it's just that the value is not counted directly in a Green GDP. A major challenge is then, how do we value the intermediate goods and services so that these can be incorporated in decision making schemes other than welfare accounting? One might decide to take a similar approach but for the soils level; from the top down, arguing that soil goods and services might be best captured through equating 'emergent properties' to final commodities. This would mean that properties such as soil horizonation, bulk density or soil structure/architecture etc. become the defining characteristics to value? An alternative approach from the bottom up might be to recognize soil stocks and try to value these as soil natural capital. Both of these approaches are likely to require monitoring and biophysical modeling approaches to help with accounting. They may also link with the concurrent efforts to define and classify soil quality and health (Karlen et al., 1997), which act as performance indicators for soil use. What is clear is that no agreed, consistent framework for soils yet exists, and this perhaps forms a demanding challenge for soil science for the coming decades.

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