

EEB 2208: LECTURE TOPIC 12

ECOSYSTEM SERVICES

Reading for this lecture

Millennium Ecosystem Assessment: Much of this lecture is based on information in, or related to, the MEA, so it would be worth taking a look at its content, here: <http://www.maweb.org/en/index.aspx>. Probably the best summary document is the synthesis chapter of “Volume 1: Current State & Trends”, available here: <http://www.maweb.org/documents/document.297.aspx.pdf>.

Discussion reading: Wolkovich et al. 2012. Warming experiments underpredict plant phenological responses to climate change. *Nature* 485:494-497. On-line at: http://www.people.fas.harvard.edu/~eebutler/Homepage/2011-2012_files/Wolkovitch_etal_2012.pdf

1. What are services?

A) DEFINITIONS

- i) “Ecosystem services are the benefits people obtain from ecosystems” (definition from the **Millennium Ecosystem Assessment**).
- ii) This definition is very broad and encompasses a wide variety of different things.
- iii) Sometimes services are discussed in monetary terms, but often their value is hard to quantify in this way.

B) MILLENNIUM ECOSYSTEM ASSESSMENT

- i) This global project sought to assess the state of the world’s ecosystems and was completed in 2005. It is notable, because it paid particular attention to the value that ecosystems have for human well-being.
- ii) The assessment divided services into four categories: provisioning, regulating, cultural, and supporting services.
- iii) **Provisioning services** include things like food, fresh water, wood, and fuel – things that provide the basics for life.
- iv) **Regulating services** include all the things that regulate process such as climate, flooding, disease, and water purity. Many of these are things that keep us safe in one way or another.
- v) **Cultural services** include things that provide aesthetic, spiritual, educational, recreational, etc. values to humans. You could (perhaps) think of these as the things that make life worth living.
- vi) **Supporting services** include the underlying processes that ensure that all the other services persist. These include things like nutrient cycling, soil formation, primary production, etc.
- vii) These different services collectively benefit humans by providing security (e.g., from natural disasters), material goods, health, and strong societal relationships. Without them there would be no human society.

C) EXAMPLES

- i) Because all that we do relies on services provided by ecosystems, there is a multitude of examples. But, I will focus on just a couple.
- ii) One of the most widely cited is pollination. Animal pollinators (mostly insects, and especially bees) are responsible for pollinating 87 of 115 leading crops around the world. Collectively this represents at least 35% of global crop production. Many crops are entirely dependent on imported

- honey bees – which are shipped around from state to state to provide pollination services wherever they are needed. Wild bees can also provide important pollination services, and the amount of pollination has been linked to the proximity of a field to natural habitat – fields closer to natural habitat receive more pollination and hence produce fruit more easily.
- iii) Another example is the protection from storm surges provided by vegetated habitats in coastal areas. Mangrove forest, for example, has been shown to reduce the impact of cyclones with, in one study of >400 villages in India, few human deaths in villages protected by large expanses of mangrove and many in those without mangrove.

2. Where are they?

A) EVERYWHERE, BUT NOT EQUALLY SO

- i) Services can be found everywhere, but there is considerable spatial variation in where particular services are greatest.
- ii) For example, carbon sequestration services (removing carbon from the atmosphere) are greatest in areas of extensive forest (especially tropical forest).
- iii) Areas of greatest carbon storage overlap a lot with areas of carbon sequestration, but the overlap is not complete, and the places that provide the greatest storage services are not always those that sequester the most carbon. E.g., there is lots of storage in the forests of northwestern North America, but not so much sequestration.
- iv) In contrast to these two services, the places that provide the greatest livestock grazing services are completely different.
- v) As with biodiversity, there is not a nice tidy overlap such that it is easy to say which places are best – and therefore the best places to protect. Consequently, any assessment has to take into account the relative values of different services.

B) MUCH IS UNKNOWN

- i) Complicating matters further, the one study that has attempted to map services globally concluded that there was only adequate data to map four services (the three mentioned above, and a fourth related to water use).
- ii) Consequently, any decisions about how to protect services must be done with very limited information.

3. Services and biodiversity

A) DOES HIGH BIODIVERSITY = LOTS OF SERVICES?

- i) In some cases there are clear connections. For example, areas of tropical forest that are rich in biodiversity (e.g., the Amazon Basin, west-central Africa) also provide considerable services in terms of carbon storage and sequestration.
- ii) But, in other cases, things are not so straightforward. For example, there has been a dramatic global increase in fertilizer use, which has resulted in dramatically increased levels of nitrogen and other chemicals throughout much of the world. This change has provided considerable services to humans, including increased total food production, increased per capita food production, reduced food costs, and reduced malnutrition (although, there has been a recent reversal in the last of these).
- iii) Increased nitrogen has not, however, had such clear benefits for biodiversity. **Eutrophication** has been seen in many ecosystems, for

example, with the result that biodiversity has declined. In coastal marine ecosystems, the runoff of fertilizer into the ocean has often resulted in greatly increased productivity, which in turn leads to oxygen depletion, which in turn leads to large “dead zones” where nothing can live.

B) VERY POOR CORRELATIONS

- i) When sites are ranked in terms of their species conservation value vs. their ecosystem services value there is very little correlation.
- ii) Nonetheless, it is possible to prioritize sites for overall value across these two axes.

C) TRADE-OFFS ARE INEVITABLE

- i) Because some services are closely tied to biodiversity protection, while others (e.g., agriculture) often require the exact opposite, there are always likely to be trade-offs between protecting land and using it.
- ii) Typically, however, society tends to see only one side of a problem. For example, converting an area of mangrove into shrimp farms has economic benefits because money can be made off of shrimp aquaculture. This is a clear service for those who farm the shrimp (and those who eat them). But, the mangrove conversion also “costs” something because there is a loss of value through reduced flood protection, fish habitat, availability of wood (e.g., for burning), etc. To truly evaluate whether shrimp farming is a good idea, the costs and the benefits need to be compared. The best solution might be a mixture – some shrimp farming, but not so much that the other benefits are greatly impacted.
- iii) Notice that in the mangrove-shrimp example, only monetary values of the mangrove are considered – trying to incorporate aspects of biodiversity that it is hard to put a \$ value on makes it even harder to evaluate the trade-offs. More on this in the economics lecture later in the course.

4. State of the world’s ecosystem services

A) HOW HAVE THINGS CHANGED?

- i) Over the past few decades, the provisioning services of ecosystems have clearly increased – humans are receiving more food, more clean water, more fuel, etc.
- ii) But, the cost has been a decline in some regulating, supporting, and perhaps also (depending on your point of view) cultural services.
- iii) A key conclusion of the Millennium Ecosystem Assessment is that the ability to support some services has clearly declined at a global scale. Two in particular are the provisioning services provided by marine fisheries and the range of services provided by biodiversity. Other services are also beginning to decline at regional scales.
- iv) The question is: will these declines continue? (probably); what will they mean for biodiversity? (probably not good); and what will they mean for us? (you can draw your own conclusions)