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Ecosystem services analysis: Mimicking ecosystem services for regenerative urban design

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Abstract

This paper proposes using an understanding of ecosystem services to determine measurable goals for urban regenerative design that are based on site specific ecological reality. This is termed ecosystem services analysis. The usability of the ecosystem services analysis concept is tested through a case study of an existing city. The case study demonstrates how the concept could be used as a tool to evaluate the performance of an existing built environment, and how it could reveal places to intervene in the built environment to create a more robust, adaptable and cohesive system. This is important because more than half of all people live in urban environments, cities have a large negative impact on ecosystems, humans are dependent on ecosystems for survival, and issues such as climate change and biodiversity loss are already impacting on the built environment and people, and continue to become more urgent.

Keywords: Climate change; Cities; Biomimicry; Ecology; Regeneration

1. Introduction

It is well documented that urban environments have a large negative effect on ecosystems and the services they provide freely to humans (see for example: Doughty and Hammond, 2004; Eigenbrod et al., 2011; Newman, 2006; Rees, 1999). One way to reduce or to reverse this is to create or re-design urban areas so that they provide, integrate with, or support ecosystem services, and therefore reduce pressure on ecosystems. This is important as cities continue to grow and as the climate continues to change (McKinney, 2002), and is crucial given that more than half of all humans now reside in urban areas, a figure predicted to rise to 60% by 2030 (Eigenbrod et al., 2011). If the built environment can provide some of its own ecosystem services, pressure is potentially decreased on local and distant ecosystems. This means these may be able to become healthier, or regenerate if they are currently degraded, and therefore be able to support more species. Healthier ecosystems more readily provide ecosystem services to humans that cannot be provided by the built environment and therefore enable humans to be better able to adapt to the impending impacts of climate change (MEA, 2005).

Ecosystem services are the benefits humans derive either directly or indirectly from ecosystems (Table 1). People are entirely dependent on ecosystem services for their wellbeing and economies and indeed survival (Díaz et al., 2006).

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Table 1
Ecosystem services.

Provisioning services	Regulating services (human time scale)	Supporting services (long time scale)
• Food - Human (land/fresh water/marine) - Forage • Biochemicals - Medicines - Other • Raw materials - Timber - Fibre - Stone - Minerals/ores • Fuel/energy - Biomass - Solar - Hydro - Other • Fresh water - Consumption - Irrigation - Industrial processes • Genetic information	• Pollination and seed dispersal • Biological control - Pest regulation - Invasive species resistance - Disease regulation • Climate regulation - GHG regulation - UV protection - Moderation of temperature • Prevention of disturbance and moderation of extremes - Wind/wave force modification - Mitigation of flood/drought - Erosion control • Decomposition - Waste removal • Purification - Water/air/soil	• Soil - Formation - Retention - Renewal of fertility - Quality control • Fixation of solar energy - Primary production/plant growth (above ground, below ground, marine, fresh water) • Nutrient cycling - Regulation of biogeochemical cycles - Retention of nutrients • Habitat provision - Shelter and resource - Reproduction space • Species maintenance - Biodiversity - Natural selection - Self organisation

Despite this, 60% of global ecosystem services are degraded or are being managed unsustainably (MEA, 2005). Ecosystem services can be divided into provisioning services, regulation services and supporting services. Many sources also list a fourth category named 'cultural services' which includes artistic inspiration, recreation, education etc. (Costanza et al., 1997). Ecosystems are the best known examples of effective organisation of life on Earth (Vincent, 2010). Mimicking ecosystem services enable design teams to know what the quantifiable ecological goals should be for a development in a given location and climate if it is to integrate with existing ecosystems and contribute to their health rather than depleting them.

Regenerative design seeks to address the continued degradation of ecosystems by developing the built environment to restore the capacity of ecosystems to function at optimal health for the mutual benefit of both human and non-human lives (Cole, 2012). Crucial to regenerative design is a systems-based approach. Rather than being conceived as stand-alone objects, buildings are thought of as nodes in a system, much as organisms form part of an ecosystem. The intention of this is that it may enable complex and mutually beneficial interactions to occur between the built environment, the living world, and human inhabitants.

Information about the negative environmental impact of the built environment is often relative to other human endeavours. For example, the United Nations Environment Program (UNEP, 2007) states that 40% of all global energy and material resources are used to build and operate buildings. Such a figure is useful in setting an agenda for future research and for establishing the urgency of the need to change urban environments and their use, but has no relationship to how much energy is available, what level of use would be sustainable, or what the environmental impact of this use is. A typical goal that fits into this way of thinking related to water consumption for a building might be 'to reduce water use by 10%'. This is based upon human defined goals related to economic, political or convenience factors. It does not give information relative to an example of a successful and sustainable system, nor does it relate to what could be physically possible at a given site. A common reaction to such information is to reduce, remove or stop certain behaviours or ways of constructing the built environment. Regenerative design aims to enable built environments to move into the realm of creating health and wellbeing rather than simply reducing damage (Reed, 2007). A goal, again related to water consumption but based on understanding ecosystem services in an urban context, might be to 'tailor water use within a given site to its annual rainfall budget'. This second kind of target is based upon the physical possibilities a specific site affords, can be clearly measured, and enables a development to be understood in the wider context of its ecosystem.

2. Key places for change in the urban built environment

While all aspects of ecosystem functioning are important to a system as a whole, this section investigates which ecosystem services are the most suitable for inclusion in an urban context. This process was important given that 17 distinct ecosystem services were initially identified (Table 1) and trying to use this long list proved to be too complicated in a design or evaluation context (Pedersen Zari, 2012). Determining which ecosystem services are the