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Sustainability of Ecosystem Services in a Changing World

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Ecosystem services are the benefits that humans derive from ecosystems [1]. Recently, the importance of research into ecosystem services has been widely recognized, and many advances are being made in the field [1]. Additionally, in recent decades, humans have been changing the world's ecosystems more than ever before to satisfy growing demands for food, freshwater, timber, fiber, fuel and minerals [2,3]. Ecosystems are being degraded and depleted, especially in urbanizing areas and other regions in which nature is being disturbed, such as where land with natural uses is being converted rapidly to human-dominated land uses [4]. Therefore, research interest in the field of ecosystem services is rapidly increasing, and is likely to contribute significantly to the sustainable management of natural resources [1]. A wide range of ecosystem services is required to satisfy current demands and changes. Some of can be delivered by highly transformed ecosystems (such as fertile soil for intensive agriculture) while others depend on the maintenance of quasi-natural ecosystems (such as to ensure the steady supply of high-quality water) [3].

The dynamics of an ecosystem are strongly affected by natural and human disturbances, and such changes can have direct and cascading effects on the spatial and temporal variations in the composition, structure, and processes of ecosystems [5]. In developing countries, where short-term economic growth and social delivery are more important than conservation, placing a monetary value on ecosystem services is the only way to ensure intervention [5]. The challenge is to ensure that these interventions are ecologically sustainability and fair, and efficient. Many assessment methods (both single-species and community-based methods) have been developed in the last century to quantify many ecological responses to disturbances. The concept of ecosystem services was introduced to promote a quantitative understanding of the use and management of natural resources. The Millennium Ecosystem Assessment Report (2005a) divides ecosystem services into four categories, which are supporting services (ecosystem and population processes), provisioning services (food, water, wood, fuel), regulating services (regulation of climate, water, disease and disturbance regimes) and cultural services (aesthetic and spiritual benefits, cultural identity, and recreation/tourism). This classification of ecosystem services can be used to develop a method for quantifying the responses of an ecosystem to various disturbances as well as the post-disturbance resilience. The results thus obtained will help in designing management policies and evaluating the effectiveness of management. Therefore, the critical objective of studies of ecosystem services is to improve our understanding of the sensitivities, response regimes and resilience of various categories of ecosystem services to a changing world, and thereby support the prediction and management of ecosystem change. Recently, the Global Land project report (GLP) (2005) mentioned that special attention must be paid to identify critical non-linearities (such as thresholds) and feedback loops in ecosystem responses that influence the resilience of ecosystems and their sustained capacity to deliver critical services [6]. Understanding of the embedded nature of trade-offs of ecosystem services is lacking [6]. Assessments need to support efforts to resolve dilemmas and conflicts concerning ecosystem services, while promoting ecological sustainability and social fairness [6].

Sustainability science is motivated by fundamental questions about interactions between nature and society as well as compelling and urgent social needs [7,8]. The purpose of sustainable development is to create and maintain prosperous social, economic and ecological systems. These systems are intimately linked with each other: humanity depends on services that are provided by ecosystems for wealth and security. Humanity receives various ecosystem services, including clean water and air, food, fuel, and others [9]. Additionally, human beings can transform ecosystems to make their living conditions comfortable. Therefore, the concept of ecosystem service and their value can be a useful guide when distinguishing and measuring where trade-offs between society and the rest of nature are possible and where they can be made to enhance human welfare in a sustainable manner [10].

Many researchers have provided agendas for studying ecosystem services studies and implementing their findings. Kremen [11] discussed essential questions and critical in four areas, which were (1) identifying the providers of important ecosystem services; (2) determining the various aspects of community structure that influence (the function of ecosystems in real landscapes, and especially compensatory community responses that stabilize that function, or non-random extinction sequences that rapidly erode it; (3) evaluating the effect of key environmental factors on the provision of services, and (4) measuring the spatio-temporal scale over which providers and services operate.

Egoh et al. [12] noted that ecosystem services affect the implementation of conservation plans in many ways:

(1) Payments for ecosystem services are potentially an effective means of ensuring that important aspects of the ecosystem are preserved.

(2) Services have beneficiaries, facilitating the implementation of conservation plans.

(3) Targeting services in conservation evaluations may help to meet many biodiversity targets in an easy-to-sell manner while simultaneously improving the connection between conservation plans and human well-being.

Recently, Nicholoson et al. [1] proposed the following research agenda in some detail and identified four priority areas in which further research in ecosystem services is urgently required.

(1) Agendas: the ethical and economic frameworks for defining

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the values those are derived from ecosystem services and for evaluating trade-offs among those values [1].

(2) Processes: the interactions between socio-economic and ecological systems, among multiple ecosystem services, and among the ecological processes that underlie the provision of ecosystem services [1].

(3) Metrics: the quantification of the value that is provided by ecosystem services and processes for evaluating those services and detecting trends [1].

(4) Uncertainty: identifying sources of uncertainty, reducing uncertainty, and making decisions in the face of uncertainty [1].

Concepts associated with ecosystem services should be integrated into land use planning for maintaining sustainable ecosystem services in a changing world. Recently, de Groot et al. [13] showed that important research questions must be answered to improve the consideration of ecosystem services in landscape planning, management and decision-making.

For understanding how ecosystems provide services and quantifying relevant variables have listed as following [13].

(1) What is the state-of-the art typology of ecosystem services?

(2) How can the relationships between the characteristics of a landscape and ecosystem and their associated functions and services be quantified?

(3) What are the main indicators and benchmarks for measuring the capacity of an ecosystem to provide services (and what are the maximum sustainable levels of use)?

(4) How can ecosystem/landscape functions and services be spatially defined (mapped) and visualized?

(5) How can relationships between the characteristics of, and services provided by, the ecosystem and landscape, as well as their relevant dynamic interactions, be modeled?

(6) What are the effects of (changes in) the (temporal and spatial) dynamic conditions of landscape functions on services, in terms of both sustainability and resilience? Do critical thresholds exist?

The world is changing rapidly, and current trends do not point to a clear future. Ecosystem services, which are the benefits that people gain from ecosystems, are essential to human existence, but demands for those services often surpass the capacity of ecosystems to provide them [14]. Addressing ecosystem services is essential for sustainable development. However, a lack of ecological information frequently precludes informed decision-making that involves ecosystem services [14]. Therefore, to help in management efforts, ecological information about the dynamics of these systems must be made available to decision-makers in a usable form and in a timely manner [14]. Additionally, important areas of ecosystem services that are important to maintaining the components and functions of ecosystems that provide ecosystem services in a changing world must be carefully managed to secure the current and future provision of ecosystem services [4,12,15,16]. Therefore, a major research effort is now being undertaken to quantify, value and manage ecosystem services that may inform fundamental changes in society's approach to the environment [1]. Additionally, research to quantify ecosystem services to support decision-makers and stakeholders may also provide useful and fundamental knowledge that will support the maintenance of the sustainability of those services, as well as further planning and management of natural resources to deliver sustainable benefits to human beings. However, a major challenge for future research remains the incorporation of dynamic processes in the model, including potential regime shifts of ecosystems. For the purposes of policy-making and planning, information on the degree of sustainability of management systems is important. Sustainability refers to the use of desired ecosystem services without a long-term decline in biodiversity, supporting the future use of the ecosystem) [13]. Nature-conservation and conservation management strategies are now widely recognized not necessarily to involve a trade-off between "the environment" and "development" but to require investments in the conservation, restoration and sustainable use of ecosystems to provide substantial ecological, social and economic benefits [13].

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