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Designer ecosystems: A solution for the conservation-exploitation dilemma

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ABSTRACT

Increase in human population is accelerating the rate of land use change, biodiversity loss and habitat degradation, triggering a serious threat to life supporting ecosystem services. Existing strategies for biological conservation remain insufficient to achieve a sustainable human-nature relationship and this situation has fueled a debate on the conservation-exploitation dilemma. We need to devise novel strategies, in a mutually inclusive way, which can support biological conservation and secure economic development of deprived populations. Here we propose the use of designer ecosystems which can ensure ecological sustainability while providing ample and some new means of livelihood to local people. Such designer ecosystems may provide a solution to the conservation-exploitation dilemma through lessening population pressure on conserved ecosystems and remediating environmental pollution and ecosystem degradation to secure a broad range of ecosystem services of economic and cultural values.

1. Introduction

Regardless of the consequent deterioration of natural ecosystems, increasing population pressure will likely accelerate the processes of industrialization and agricultural intensification. Many ecosystems around the world have lost their original structures and functions and developed novel properties, frequently described as novel ecosystems (Hobbs et al., 2009). Both, conservation of invaluable biodiversity and utilization of ecosystem services for economic development, are essential but their accommodation in a common agenda is still under debate (Doak et al., 2014). We suggest shifting anthropogenic activities from a focus on nature reserves into wisely developed multifunctional Designer Ecosystems (DEs) on marginal lands outside of protected areas. DEs may remediate harmful dis-services and externalities of anthropogenic activities like environmental pollution, habitat change and lessen the reliance of local populations on conserved ecosystems through providing a broad range of ecosystem services of economic and cultural value. In this way, the dilemma of biodiversity conservation and extraction of ecosystem services may be solved through spatial separation of both types of activities.

2. The conservation-exploitation dilemma

Potentially irreversible changes in natural ecosystems such as biodiversity loss and habitat homogenization are serious threats to important life sustaining ecosystem processes. Natural ecosystems preserve outstanding wealth of genetic resources, tuned through continuous evolutionary forces, which may work as insurance policies for future improvements in our sustenance and well-being. Traditional conservation strategies remain insufficient and most ecosystems are experiencing substantial loss in their original diversity. The new conservation strategies based on ecosystem ser-

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Fig. 1. Conservation-exploitation dilemma.
Protected ecosystems near human settlements are being severely damaged under anthropogenic pressures. These forests (e.g. A) are intensively used for fuelwood collection, cattle grazing and dumping of non-degradable wastes. Development of designer ecosystems on marginal lands (e.g. B) may shift these activities out of protected areas and open up new economic possibilities for local people.

vices of biodiversity are easily graspable and widely supported by economists and politicians (Goldman et al., 2008). However, such strategies will accelerate management of nature for exploiting a few provisioning and cultural services, largely ignoring non-valued regulating and supporting ones. Our evolutionary shortsightedness and competitive instincts are exploited by electoral and commercial allurements and drive relatively more exploitation than investment in conservation (Penn, 2003).

Anthropogenic interference like agriculture, commercial forestry, environmental pollution, exotic invasions and climate change have become an integral part of most ecosystems which have lost their original ecological identity (Fig. 1). The intensity of these activities is going to be higher in time as a result of increasing population and decreasing land availability. Establishment of functional biodiversity for ecosystem services in these degraded ecosystems is the major objective of traditional ecological restoration (Suding, 2011). However, some workers have advocated that instead of struggling for the restoration of historical biodiversity, these ecosystems should be developed into multifunctional ecosystems that are well adapted to anthropogenic pressures and deliver multiple ecosystem services (Hobbs et al., 2009). If properly developed, these ecosystems may ensure sustainable delivery of biodiversity-based ecosystem services (Palmer et al., 2004; Montoya et al., 2012) and ease exploitation pressure on conserved habitats. We suggest that the wealth of multidisciplinary knowledge spanning ecology, economics and social science should be employed in the development of degraded lands in management-friendly ecosystems. These ecosystems will work as buffer zones between patches of conservation and intensive anthropogenic activities. In this way such ecosystems may accommodate further essential agricultural intensification and industrialization, because they will be able to remediate several externalities such as environmental pollution and land degradation. They will fulfill local ecological and economic demands reducing intact natural ecosystems' exposure to disturbance.

3. Introducing designer ecosystems

Here we define the designer ecosystems (DEs) which are intentionally created or managed through inclusion of selected species combinations for sustainable use of various ecosystem services. DEs should be developed outside of protected areas on slightly degraded ecosystems or created *de novo* on natural and management-driven barren lands like those set aside after mining, agriculture (Fig. 1) and hydroelectric projects, beside railway tracks, highways, riverbanks and industrial areas. Frequent floods and riverine erosion pose ecological and economic threats; development of perennial diversity rich plantations along riverbanks may support the livelihood of flood affected marginal farmers. Temporary and degraded wetlands should be managed for biomass, timber, fishing etc. Similarly, DEs in urban areas may support cultural activities and bioremediation of air, soil and water. Biodiversity enhances the amplitude and stability in ecosystem functioning and makes ecosystems more resistant to exotic invasions and abiotic disturbances (Fargione and Tilman 2005). Therefore, as much as possible, these ecosystems should be rich in biodiversity with emphasis on ecologically and economically appropriate biotic material e.g. timber and bioenergy crops. These ecosystems should be tolerant to persistent human disturbance and provide a package of ecosystem services such as soil reclamation, bioremediation, and bioenergy production which are being provided by historical biodiversity in conserved ecosystems.

Naturally, biotic communities develop from the historical regional species pool that is adapted to the local biotic and abiotic environment (HilleRisLambers et al., 2012). Desired biodiversity can be created in DEs through managing abiotic factors like water, fertilization and selection of appropriate biotic material through assisted migration (Marris, 2011), instead of relying only on the regional species pool. Besides, habitat heterogeneity, disturbance and the sequence of species immigration also affect the community assembly (Fukami and Morin 2003). Introduction of invasive plants, which otherwise provide important services, may also be considered in the later stages of the development of DEs. Non-native species included in the community after the native community has been established through restoration approaches were found to be substantially less invasive (Martin and Wilsey, 2012). Understanding the roles of these factors requires exploration of numerous combinations of biotic and abiotic factors and monitoring ecosystem function and human well-being until we obtain the desired diversity with the desired services. Government can support this concept through 'pay for ecosystem services' schemes (Naeem et al., 2015) to promote the participation of local people for sustainable management and extraction of ecosystem services ensuring biological conservation. This will further enhance the climate change adaptability and ecological resilience of whole landscape (Hobbs et al., 2014).

4. Ensuring ecological and economic sustainability through designer ecosystems

Sustainability of designer ecosystems will depend on two strict conditions. First, DEs should contribute to the economic well-being of local people through delivering important provisioning and cultural services and second, they should provide more regulating and controlling services than in the pre-existing ecosystem. For example, rural populations largely depend on natural resources for their daily life-support requirements such as fresh water, food, fibers, fodder, medicines and other controlling and regulating ecosystem services like soil fertility, pollination and pest control. The decline of biodiversity may trap such ill-equipped populations in permanent poverty and trigger ecological and socioeconomic challenges to the whole society (Barrett et al., 2011). A large section of these societies is engaged in subsistence agriculture on marginal lands which are at high risk of habitat degradation and biodiversity loss and make only a minor contribution to national agricultural production. Establishment of high-diversity perennial crops (Tilman et al., 2006) on agriculturally marginal lands may meet the goals of ecological restoration; bioenergy production and alleviation of the poor economic status of locals. Introduction of DE projects in global strategies such as Aichi targets 2020, sustainable development goals 2030 (Griggs et al., 2013) and national government programs like NREGAS in India (www.nrega.nic.in), will create possibilities for new jobs, good health and environmental sustainability.

Incentives like 'paying for ecosystem services' through subsidizing these systems may further increase their economic viability. Inclusion of species of cultural and aesthetic importance in DEs will strengthen the human-nature relationship through pedagogical activities and eco-tourism and promote social well-being via cultural pathways (Clark et al., 2014). In addition, DEs may also provide shelter to fauna, particularly birds and scavengers, which are being extirpated from rural landscapes due to habitat destruction through agricultural intensification and other anthropogenic activities. For example, several agri–environment schemes found to restore countryside fauna and support many cultural services (Sutherland, 2002).

In broad perspective, the designer ecosystems are likely to support international efforts toward strengthening human-nature interactions, such as, Aichi biodiversity targets 2020 (https://www.cbd.int/sp/targets/) and sustainable development goals 2030 (http://www.un.org/sustainabledevelopment/sustainable-development-goals/), set by United Nations to improve human livelihood and conserve biodiversity, in a common framework. Additionally, this framework is also capable of increasing the participation of local communities in minimizing habitat destruction, exotic invasions and pollution and in enhancing biodiversity conservation and restoration. Direct cooperation of restoration ecologists, nature conservationists, economists and policy makers is required to promote conservation of biodiversity in protected areas and extraction of maximum services from recreated diversity-rich designer ecosystems outside of protected areas.

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