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Loss of ecosystem services and the decapitalization of nature in El Salvador

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ABSTRACT

Land use change can reduce the wealth and wellbeing of a nation by modifying its biodiversity. We used value transfer methodology to estimate changes in the value of ecosystem services provided by natural ecosystems in El Salvador, a country particularly impacted by natural disasters. Ecosystem services (1998–2011) provided annually only by natural ecosystems declined by 2.6%, and are equal to 44% of El Salvador's GDP in 2011. Changes in services provided by tropical forests account for 90% of those losses, followed by 9% for coastal wetlands. However, sensitivity analysis of changes per biome revealed that changes for coastal wetlands are much more elastic than for tropical forests, emphasizing the severity that further losses in coastal wetlands may incur. Forests reduce soil erosion and landslides while coastal wetlands reduce hurricane damages. Focusing conservation efforts towards these ecosystems could reduce the occurrence of natural disasters, but their services should be complemented by those generated in the agricultural matrix during forest and mangrove resurgence.

1. Introduction

Loss and modification of natural habitats brought about by land use activities are one of the leading threats to biodiversity (Foley et al., 2005). These changes reduce the provision of ecosystem services that benefit human society. Because the value of goods and services provided by ecosystems is rarely given weight in driving policy decisions (Daily et al., 2000; Balmford et al., 2002; NRC, 2005), neglecting society's dependence on these provisions and ignoring their importance effectively means ignoring society's life support system. However, the value of this life support system can be economically assessed, which allows a direct comparison to other components normally included in decision making (i.e. economic services, manufactured goods), and enables appropriate assignment of priorities (Daily et al., 2009).

Policy decisions often do not consider natural capital. The stock of materials at a given point in time and the manpower capable of functioning as cogs in national policy systems have historically taken precedence over natural capital (Costanza and Daly, 1992). Failure to include natural capital in policy-making is exemplified by the collapse of major global fisheries, where despite declining catch since 1989, it is still a heavily subsidized activity leading to overfishing and further depletion of the stock upon which marine fisheries depend upon (Myers and Kent, 2001; Robin et al., 2003).

Ecosystem services are the benefits that arise from ecological processes resulting from the interactions among the components of natural capital stocks that combine with manufactured and human capital to produce human welfare (Constanza et al., 1997). Decreases in the flow of natural goods and services resulting from anthropogenic impacts on ecosystems by economic activities may incur externalities. Ignoring the biophysical basis of ecological systems undermines the importance of natural capital and will likely reduce the wellbeing and possible survival of the human species in the biosphere (Constanza et al., 1997). Therefore, external effects, such as changes in the flow of ecosystem services, should be accounted for in economic analyses of national incomes and promote polices that support sustainability and future human wellbeing.

The Republic of El Salvador is the smallest nation (21,000 km^2) in Central America (Fig. 1), yet holds its highest population density (294 p/km^2) (UNSD, 2014). Like many other long-inhabited subregions of Mesoamerica, El Salvador has a history of ecological disturbance of over 4000 years by pre-Columbian farming leading into modern agricultural practices (Dull, 2008). As a consequence, presently less than 1% of land surface remains as old-growth forest (Kernan and Serrano, 2010). However, forest resurgence that occurred during the civil war that El Salvador suffered from 1980 to 1992 increased total forest cover to 14% until 2001 (UNSD, 2014),

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Fig. 1. Location of study area, the Republic of El Salvador.

due to a retraction of the agricultural frontier stemming from international migration (Hecht and Saatchi, 2007). El Salvador also stands out as particularly impacted by natural disasters, such as floods, tsunamis and landslides (Rose et al., 2004), potentially related to the fact that all but one of El Salvador's ecosystems are threatened by a high risk of collapse (Crespin and Simonetti, 2015). These attributes establish El Salvador as a nation whose government and policy-makers would benefit from having an estimated value of the nation's natural capital.

Change in land use has brought about changes in the flow of ecosystem services through habitat loss. Estimating the economic impact of this change allows us to ascertain if the increase of other kinds of capital in national incomes compensates for the loss of natural capital. Our aim was to determine how changes in land use have altered the value of ecosystem services solely provided by the remaining natural ecosystems of El Salvador, and to identify the importance that natural capital holds in a nation's income, measured as GDP. This assessment could support future Salvadoran policy making and decisions by granting an estimate of the services lost when converting natural ecosystems to productive or urban land uses.

2. Materials and methods

Ecosystem services can be mapped using Troy and Wilson's (2006) spatially explicit unit value transfer method. Changes in the provision of ecosystem services can be inferred from changes in the surface area of ecosystems, as assessed in Kreuter et al. (2001), Zhao et al. (2004), and Liu et al. (2012). A loss in the surface area of ecosystems can translate into monetary losses through the use of ecosystem service estimates of production per unit of area. This requires land cover data spanning at least two time periods to determine land use change, ecosystem service values per unit of area for each biome type, and a test of elasticity to determine the robustness of the estimated values.

2.1. Data collection

To estimate changes in the surface area of ecosystems in El Salvador, we used data from the Ministry of Environment and Natural Resources (MARN) consisting of two polygonal maps of El Salvador's ecosystems in 1998 and 2011 (Vreugdenhil et al., 2012). Remote sensing data for 1998 were derived from Landsat 7 bands 4, 5 and 3 at a 30×30 m resolution by a combination of paths 18 and 19 with rows 50 and 51 while data for 2011 were generated at a 15×15 m resolution from multiple ASTER tiles. Vegetation fieldwork was done to ground truth the data during 2011. We considered changes in the 25 land categories identified in the shapefiles, which consist of 23 terrestrial ecosystems that El Salvador hosts as well as the two major recognized land use categories: agro-productive systems and urban areas (Vreugdenhil et al., 2012).