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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).

2.2. Ecosystem classification and biome assignment

The ecosystem shapefiles (Vreugdenhil et al., 2012) use the UNESCO (1973) classification system which heavily relies on vegetation structure and physiognomy, elevation, and hydric regime. We used de Groot et al.'s (2012) ecosystem service valuation that classifies land cover according to biomes, a higher level of organization than ecosystems, and assigns a corresponding ecosystem service value per ha per year ($/ha/year) to each biome. In order to estimate ecosystem service values in El Salvador, we first assigned each of El Salvador's ecosystems to one of de Groot et al.'s (2012) 8 recognized terrestrial biomes with the corresponding ecosystem service value ($/ha/year, 2007 price levels) (Supplementary Table S1.1). We also included cultivated land, urban areas, desert, and ice/rock/polar biomes which do not receive any value, since according to de Groot et al.'s (2012) valuation, these biomes have insufficient data for meaningful analysis. Assignment of ecosystems was done using the most representative biome as proxy of land cover (see de Groot et al., 2012, online supporting information). All 11 tropical forest ecosystems were grouped into the tropical forests biome, the mangrove forest ecosystem was regarded as the coastal wetlands biome, while savannahs and paramo ecosystems were grouped into the grasslands biome, and bodies of inland water were grouped into the rivers and lakes biome (see Supplementary Table S1.1). Only ecosystems that we designated to the desert biome (scarcely vegetated tropical dune and beaches, and tropical coastal vegetation in successional transition on very recent sediments) are not explicit in de Groot et al.'s (2012) biome definitions, but most closely meet the definition of barren lands for deserts even if not arid. We included cultivated land and urban areas in the land-use change analysis but excluded them from the ecosystem service evaluation. Although the contribution of urban areas and cultivated lands to ecosystem services has been valued (Constanza et al., 1997), we exclude them from the value transfer as our interest lies explicitly in the decapitalization of the value of ecosystem services provided by natural ecosystems in El Salvador.

2.3. ESV calculation

The total ecosystem service value provided by each biome was estimated using Troy and Wilson's (2006) formalized value transfer method introduced by Kreuter et al. (2001), which consists of using biome type as a proxy for ecosystem services and multiplying the area of each biome by the service value of one unit of area for each land use category, which we obtained from the de Groot et al. (2012) supplementary material, as:

$$\mathrm{ESV}_y = \sum (A_k \times \mathrm{VC}_k) \quad (1)$$

where ESV_y is the total estimated ecosystem service value for a single year in the sum of biome surface, A_k the area (ha) and VC_k the value coefficient ($/ha/year) for "$k$" biome. The change in ESV was estimated as the difference between the estimated values for each biome in 1998 and 2011. Although most studies upon which de Groot et al. (2012) base their values do not originate from Latin America, they represent a global average that grants them applicability while sacrificing precision.

We also calculated the change in ESV for each individual service after Kreuter et al. (2001), multiplying the area where that service is provided by the service value of each ecosystem service for each biome:

$$\mathrm{ESV}_y = \sum (A_k \times \mathrm{VC}_{sk}) \quad (2)$$

where A_k is the area of "k" biome (ha) and VC_{sk} the value coefficient of "s" service for "k" biome ($/ha/year). This allowed us to explore the effect of land use change on each service by itself.

Due to any uncertainty regarding the precision of de Groot et al.'s (2012) biomes as representations of El Salvador's grouped ecosystems, we determined how dependent our estimates are if the value coefficients change, and tested the robustness of the analysis by calculating elasticity; that is the percentage change in the output for a given percentage change in an input (Mansfield, 1985). Elasticity was assessed as:

$$\mathrm{CS} = \frac{(\mathrm{ESV}_j - \mathrm{ESV}_i)\,/\,\mathrm{ESV}_i}{(\mathrm{VC}_{jk} - \mathrm{VC}_{ik})\,/\,\mathrm{VC}_{ik}} \quad (3)$$

where CS is the coefficient of sensitivity, ESV is the estimated ecosystem service value, VC is the value coefficient ($/ha/year), '$i$' and '$j$' are the initial and adjusted values, respectively, and 'k' represents the land use category.

To be robust, we would expect the estimated ESVs to remain invariant when other variables change. When CS is greater than one, then the estimated value is elastic with respect to the changed coefficient, changing when other variables change. But if the ratio is less than one, then the estimated ecosystem value is considered to be inelastic, with smaller ratios implying values more resistant to change. We adjusted a change in magnitude of 50% for each coefficient, in case large enough shifts up to that magnitude occur that could affect the global average values for ecosystem services that de Groot et al. (2012) provide. Hence, if our ESVs are inelastic with respect to a variation of 50% we conclude the analysis to be robust. Using the minimum and maximum values of ecosystem services reported by de Groot et al. (2012) as VC_{jk} does not change the CS values. Also, using the same percent change as in other studies enables comparisons to be made (e.g. Kreuter et al., 2001).

2.4. Comparison to national income

Changes in land use in El Salvador have altered natural capital, here valued as economic changes in the provision of ecosystem services supplied by natural ecosystems at the national level. This in turn allows for a comparison between the value of services provided by natural capital and national economic indicators of production from manufactured and human capital, such as GDP. In order to render comparisons of El Salvador's GDP with the ESVs for both 1998 and 2011, we standardized currency to 2007 international dollars used by de Groot et al. (2012). We converted all data for GDP and all other values cited in this study from their original source in U.S. dollars to a constant 2007 price value using the Oregon State University inflation convertor (Sahr, 2015). We chose to standardize the common metric to 2007 U.S. dollars so that our values could be compared to any other study utilizing the database provided by de Groot et al. (2012).

2.5. Caveats and limitations

During our ESV estimation, we assumed that urban areas and cultivated lands do not contribute to the production of natural ecosystem services. This assumption conveys an underestimation of the total value of services provided by biodiversity, be it native or domesticated (Haase et al., 2014). The provision of food is a service, so the transformation of natural areas into cultivated land does not necessarily imply a net decline in ecosystem services. While we agree that urban areas and cultivated lands offer ecosystem services, we aim to highlight the loss of services provided by natural ecosystems as a way to stress the decapitalization processes facing El Salvador. We also emphasize that the entire Mesoamerican landscape is a human-modified environment with over 10,000 years of management (DeClerck et al., 2010); therefore to enable meaningful analysis, our definition of what is "natural" encompasses only native and nonurban or cultivated ecosystems.

Another caveat is in place. The dearth of local economic valuations for El Salvador forces us the use of generalized values, such as de Groot et al.'s (2012) valuation database: the TEEB Valuation Database (Van der Ploeg and de Groot, 2010). This work compiles ecosystem service values from different biogeographical regions and valuation methods from many case study locations each with individual societal needs, including entries from three different references in El Salvador and only for coastal wetlands. Widening the search to Central America, we find entries only for tropical forest and coastal wetlands biomes. Following Richardson et al. (2014) unit value transfer guidelines " …if there are no studies that meet all the criteria for an ideal benefit transfer, an average value may better reflect the criteria by at least partially canceling out biases in individual studies", the lack of local data pushes us to use the world values despite low precision.

Almost all of El Salvador's 19 terrestrial ecosystems qualify as threatened, 6 are endangered, 11 critically endangered, and 1 has already collapsed, placing the nation in dire straits with regard to the status of its environment (Crespin and Simonetti, 2015). Therefore, despite the drawbacks of a full value transfer, urgency warrants us to rely on available generalizations as the best alternative until local data is generated. The buildup of *in situ* ESV data would further delay the message. Beyond precision, we seek to stress the state of decapitalization of nature in El Salvador.

3. Results

3.1. Land use change

Cultivated land is the most common landscape category (82% of El Salvador´s total area), whose 2% increase alone from 1998 to 2011 is equal to nine times the remaining land area of grasslands and is nearly equal to the current extent of coastal wetlands (Table 1). In total, by 2011, 12% of terrestrial natural biome surface had been substituted by cultivated land and urban areas since 1998. Seven out of ten biomes exhibited changes in land use from 1998 to 2011. Tropical forests, grasslands and coastal wetlands decreased and respectively represent 93.5%, 6.2% and 0.3% of total biome reduction, while cultivated land, urban areas, inland wetlands and rivers and lakes respectively represent 74.4%, 25.0%, 0.5% and 0.1% of total biome increase. With regards to their initial surface area in 1998, in 2011 grasslands lost 42.7%, tropical forest suffered a 16.2% loss, and lastly coastal wetlands had a small decrease of 0.3%. In contrast, from 1998 to 2011, urban areas increased by 40.9%, while inland wetlands, cultivated land as well as rivers and lakes increased 4.06%, 2.07% and 0.16%, respectively. Ice/rock/polar, desert and coastal systems did not present detectable changes.

3.2. Ecosystem service sensitivity analysis

Adjusting coefficients used to estimate ESV by 50% produced generally low CS values, suggesting robustness (Supplementary Table S1.2). Changing the coefficient for coastal wetlands by 50% caused the highest change in value, followed by tropical forests, accounting for 38.3% and 7.3% of the applied 50% change (CS of 0.15 and 0.77, respectively) in 1998, and 39.2% and 6.3% of the applied 50% change (CS of 0.13 and 0.78, respectively) in 2011. Tropical forests comprise the largest extension of natural landscapes (66.7%), while coastal wetlands, formed mainly from mangrove forests, represent a much smaller extension (11.3%). However, coastal wetlands hold the largest ecosystem service coefficient, and any change in coastal wetlands will have a greater impact on ESV than other biomes.

3.3. Changes in ecosystem service value

Based on the de Groot et al. ecosystem service value coefficients, during the 1998 – 2011 period, ESV in El Salvador from natural ecosystems decreased by 2.6% from $9764.4 million per year to $9505.9 million per year (Table 2). Assuming a linear loss, this extends to an accumulative net loss of $1,809.35 million in ecosystem services between 1998 and 2011. Using maximum estimates of the value coefficients for each ecosystem service in all biomes decreased ESV by 2.5%, while minimum estimates trigger a decrease of 7% in ESV. The discrepancy between the decrease of ESV when employing maximum and minimum estimates is due to the fact that the minimum inland wetlands coefficient is so low that it fails to compensate for ESV lost from the other biomes at the same magnitude it does when using average or maximum estimates. These changes in magnitude of the decrease are a result of differences in the highly skewed distributions in de Groot et al.'s (2012) coefficients when using the registered maximum or minimum values.

Most individual ecosystem services tend to decline: 77% of the 22 service types present negative changes (Table 3). The three highest drops in value occurred in pollination and air quality regulation, both decreasing by 16.2%, and in climate regulation, declining 15.8%. As a whole, the greatest changes in magnitude occur in provisioning services (−11.27%), followed by cultural (−8.79%), regulating (−1.64%) and lastly habitat services (−0.98%). Changes in tropical forests are largely responsible for the loss of ecosystem service value, accounting for 90% of total ESV loss. For each biome's contribution to individual ecosystem services, refer to Supplementary information 2.

Table 1
Estimated areas and land use change in El Salvador from 1998 to 2011. Columns correspond to the absolute (ha) and relative (%) areas of each biome in 1998, 2011 and the difference in absolute and relative area.

	1998		2011		1998–2011	
Biome	ha	%	ha	%	ha	%
Urban areas	28751.54	1.36	40531.62	1.92	11780.07	40.97
Cultivated land	1694643.22	80.24	1729742.41	81.91	35099.19	2.07
Tropical forest	272049.00	12.88	227955.06	10.79	−44093.94	−16.21
Grasslands	6882.06	0.33	3942.58	0.19	−2939.48	−42.71
Inland wetlands	5326.82	0.25	5542.88	0.26	216.06	4.06
Coastal wetlands	38565.69	1.83	38443.00	1.82	−122.69	−0.32
Rivers and lakes	38302.38	1.81	38363.17	1.82	60.79	0.16
Ice/rock/polar	6323.08	0.30	6323.08	0.30	0.00	0.00
Desert	2432.21	0.12	2432.20	0.12	0.00	0.00
Coastal systems	18568.90	0.88	18568.90	0.88	0.00	0.00
Total	2111844.89	100.00	2111844.89	100.00		

Table 2
Total ecosystem service value (ESV in US$/yr, 2007 price levels) estimated for each biome in El Salvador using de Groot et al. coefficients, and the overall change and rate of change between 1998 and 2011.

		1998		2011		1998–2011		
Biome	ESV ($/ha/year)	$/year	%	$/year	%	$/year	%	%/year
Urban areas	0	0	0.00	0	0.00	0	0.00	0.00
Cultivated land	0	0	0.00	0	0.00	0	0.00	0.00
Tropical forest	5263	1,431,793,881	14.66	1,199,727,460	12.62	− 232,066,421	− 16.21	− 1.25
Grasslands	2872	19,765,273	0.20	11,323,096	0.12	− 8,442,178	− 42.71	− 3.29
Inland wetlands	25,681	136,798,130	1.40	142,346,676	1.50	5,548,546	4.06	0.31
Coastal wetlands	193,843	7,475,688,863	76.56	7,451,906,837	78.39	− 23,782,026	− 0.32	− 0.02
Rivers and lakes	4267	163,436,252	1.67	163,695,634	1.72	259,382	0.16	0.01
Ice/rock/polar	0	0	0.00	0	0.00	0	0.00	0.00
Desert	0	0	0.00	0	0.00	0	0.00	0.00
Coastal systems	28,916	536,938,190	5.50	536,938,168	5.65	− 22	0.00	0.00
Total		9,764,420,588	100.00	9,505,937,869	100.00	− 258,482,719	− 2.65	− 0.20

Table 3
Total ecosystem service value in El Salvador (ESV in US$/yr, 2007 price levels) estimated for each service, overall change between 1998 and 2011, and tendency to increase or decrease.

	1998	2011	1998–2011	
Service type	$/year	$/year	$/year	%
Provisioning services	748,519,262	664,183,885	− 84,335,378	− 11.27
Food provisioning	157,058,663	144,738,813	− 12,319,850	− 7.84
Water supply	126,116,735	124,798,575	− 1,318,160	− 1.05
Raw materials	39,510,108	35,698,327	− 3,811,781	− 9.65
Genetic resources	3,922,294	3,347,846	− 574,448	− 14.65
Medicinal resources	421,304,204	354,968,435	− 66,335,769	− 15.75
Ornamental resources	607,258	631,888	24,630	4.06
Regulating services	7,883,302,736	7,754,041,845	− 129,260,892	− 1.64
Air quality regulation	3,264,588	2,735,461	− 529,127	− 16.21
Climate regulation	570,344,196	480,196,059	− 90,148,138	− 15.81
Disturbance moderation	240,226,128	237,304,574	− 2,921,554	− 1.22
Regulation of water flows	122,902,925	109,034,009	− 13,868,916	− 11.28
Waste treatment/water purification	6,277,833,700	6,258,120,816	− 19,712,885	− 0.31
Erosion prevention	640,850,912	640,141,368	− 709,544	− 0.11
Nutrient cycling/soil fertility	11,676,450	11,908,752	232,302	1.99
Pollination	8,161,470	6,838,652	− 1,322,818	− 16.21
Biological control	8,042,367	7,762,155	− 280,212	− 3.48
Habitat services	699,925,626	693,065,245	− 6,860,381	− 0.98
Lifecycle maintenance	425,458,227	423,724,417	− 1,733,810	− 0.41
Genetic diversity	274,467,398	269,340,828	− 5,126,571	− 1.87
Cultural services	432,672,964	394,646,895	− 38,026,068	− 8.79
Esthetic information	8,031,559	7,819,811	− 211,748	− 2.64
Recreation	420,114,167	382,148,606	− 37,965,560	− 9.04
Inspiration	3,728,776	3,880,015	151,240	4.06
Spiritual experience	389,947	389,947	0	0.00
Cognitive development	408,516	408,516	0	0.00
Total	9,764,420,588	9,505,937,869	− 258,482,719	− 2.65

3.4. National economic importance of ecosystem services

The value of ecosystem services in 1998 (9764×10^6 $) is equivalent to 63% of the GDP (15,277 $\times 10^6$ $), decreasing to 44% (9505×10^6 $) of the GDP (21,606 $\times 10^6$ $) in 2011. Note that during this period, ESV declined by 2.6% and GDP increased by 41% (Supplementary Table S1.3).

4. Discussion

4.1. Limitations of value transfer

There is a difference between the biome classification analyzed by de Groot et al. (2012) and the classification used in El Salvador. Because El Salvador's classification included more categories, we aggregated them in de Groot et al.'s (2012) 8 terrestrial biomes. This aggregation immediately assumes uniformity among and within the aggregated categories (Eigenbrod et al., 2010). For example, we assigned the paramo to the grassland category following de Groot et al. (2012), however tropical grasslands and paramo systems carry inherently different values of ecosystem services, such as the regulation of water flows and water supply provided by paramos and minimally by grasslands. Accordingly, the results can present a subvaluation of ecosystem services of the paramos in El Salvador.

We warn that due to the ambiguity of the methodology used, all the estimated values should only be understood for academic, educational, or conservation purposes. We insist that in the event an accurate monetary value of natural capital for compensation

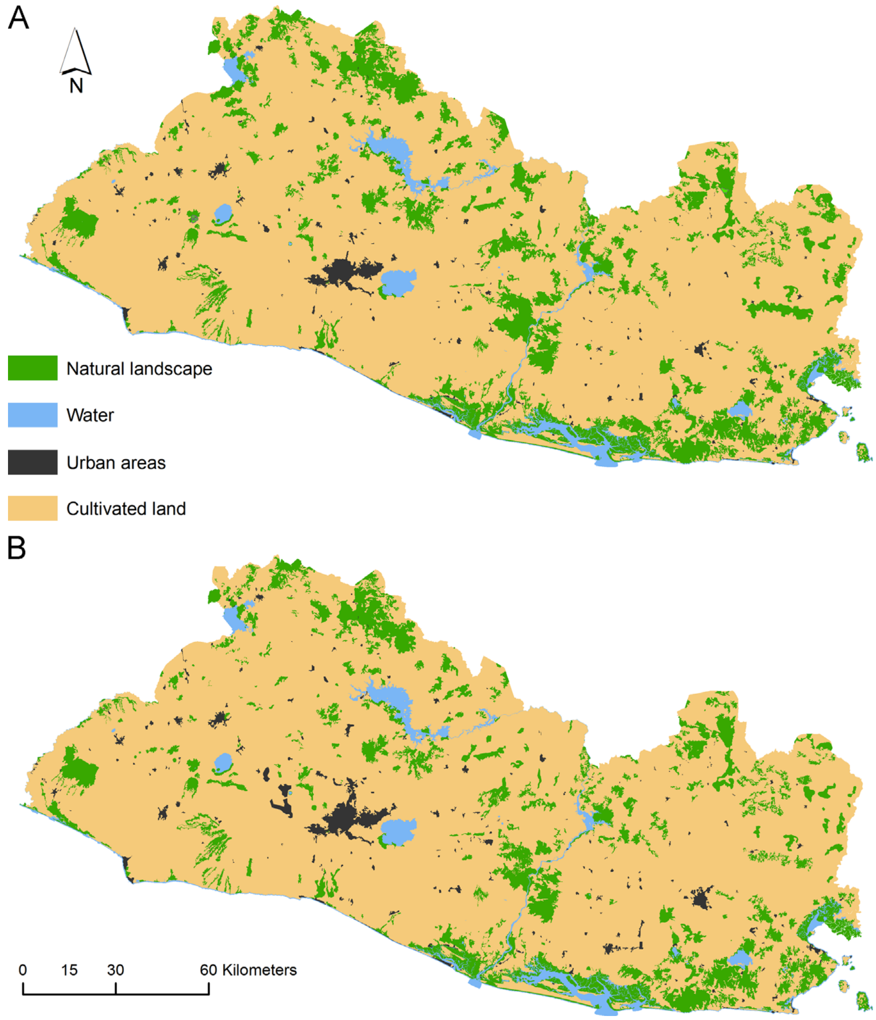

Fig. 2. Natural landscapes remaining in El Salvador c. 1998 (A) and 2011 (B). Green represents remaining natural landscape, blue areas represent water, orange and black represent cultivated land and urban areas, respectively.

purposes or for any purpose that has economic impacts is required, a specific study in the area of interest must be done.

4.2. Loss of ecosystem services and attendant economic and societal losses

Worldwide, avoiding depletion of natural capital is a priority (Millennium Ecosystem Assessment, 2005), while land use change is the major driver of changes in biodiversity (Sala et al., 2000). In El Salvador, the current trend in land use change is associated with a decrease in natural landscapes, accompanied with an increasing emphasis on urban area expansion (Fig. 2), evinced by the increase in population from 5.895 to 6.218 million in 1998 and 2010, respectively (United Nations, 2013), even when faced with massive international and urban migration (Hecht et al., 2006). Salvadoran population was evenly distributed between urban and rural areas in 1990 when the civil war was nearing its end (49.7% urban population), but by 2010 the population had shifted toward urban zones (60.2% urban population) (CELADE, 2012). In the span of 13 years, the decrease in the value of ecosystem services provided by natural ecosystems in El Salvador has translated to a loss of 2.6% in the yearly provision of services through the process of replacing 12% of natural landscapes with agro-productive systems and urban areas. This difference in value is not trivial; it represents 1.7% of El Salvador's GDP in 1998. While the decline in ESV per year for El Salvador is not high when compared to ecosystem service losses in the US, Laos and China (Table 4), for El Salvador the decline in the value of ecosystem services between 1998 and 2011 represents a loss equal to nearly 14% of the country's public debt of $12,951 million (BCR, 2012). This is a conservative estimate, for if we were to employ the maximum values for the ecosystem service coefficients reported by de Groot et al. (2012), then the loss of ESV would ascend to 11% of the GDP in 2011, while ESV increases to more than twice the GDP in 1998. Even using minimum coefficient values yield ESV equaling 6.5% and 4.3% of the GDP in 1998 and 2011, respectively, still a considerable amount of a nation's capital.

Among all values for the estimated ecosystem services, pollination is the most affected, critical when 11.6% of El Salvador's GDP comes from the agricultural sector (BCR, 2012), and 20.9% of El Salvador's employed population depends on agriculture as a way of life (World Bank, 2015). Although globally frequent pollinators consist of introduced species, in the tropics visits from stingless native bees produce significant increases in crop yield (Heard, 1999). If pollination services continue to drop, the agro-productive sector might need to compensate to pollinate crops (such as hiring beekeepers), and prices may increase in order to maintain revenue. Decrease in air quality regulation is also problematic, since annual particulate matter with diameter of 10 μm (PM10) in El Salvador is 52 μg/m^3, which exceeds the World Health Organization upper limit guideline of 20 μg/m^3 (World Health Organization,

Table 4
Previous ecosystem service valuations of land use change and percentage of decline reported in ESV.

Location	Study period	ΔESV %	ΔESV %/yr	References
Zoige Plateau, China	1975–2005	−4.6	−0.15	Li et al., 2010
NW Guangxi, China	1985–2005	−3.1	−0.15	Zhang et al., 2011
Taiyuan City, China	1990–2005	−2.7	−0.18	Liu et al., 2012
El Salvador	1998–2011	−2.6	−0.20	This study
San Antonio, Texas, USA	1976–1991	−3.6	−0.24	Kreuter et al., 2001
Northern Part of Lao PDR	1992–2002	−16.2	−1.62	Yoshida et al., 2010
Sanjiang Plain, Heilongjiang Province, China	1980–2000	−41.5	−2.08	Wang et al., 2006
HaDaQi industrial corridor, Heilongjiang Province, China	1990–2005	−29.0	−2.26	Zang et al., 2011
Chongming Island, China	1990–2000	−62.0	−6.20	Zhao et al., 2004

2011). This exemplifies that loss of natural capital is not only tied to the economy, but as it wanes, so does the life support system that we depend upon.

The consequences of other declining services such as climate regulation and water flow regulation may have already been felt: expenditures of up to $ 2715 million (EM-DAT, 2012) or ~1.1% of the GDP in damage costs from floods and hurricanes and a substantial amount of casualties during this same period (1998–2011). Considering costs per event, each disaster represents 3.6% of annual GDP, while the agricultural sector, which has eliminated native forests (Vreugdenhil et al., 2012), amounts to an average of 10% of a year's GDP during the same period. The fact that lakes increased 61 ha is possibly related to an increased rainfall from 2105 ml in 1998 to 2428 ml in 2011, the year with the second largest volume of rainfall registered in El Salvador (CEPAL, 2011). This illustrates that by losing ecosystem services there is not only a decline in environmental benefits but also the manifestation of adverse effects of increasing compensations for the aforementioned losses. Preventing further loss of ecosystem service provision then becomes a priority.

This loss of ecosystem service value is mostly attributable to a decreasing area of tropical forest, where a loss of 16% of its area is responsible for 90% of the total observed loss in ESV. Coastal wetlands account for 9% of the loss, even when only having decreased 0.3% in size. This result emphasizes the severity of impacts that further losses in coastal wetlands may incur. El Salvador's coastal wetlands, represented by mangrove forests, are the first barrier against flooding and tsunamis, preventing erosion and natural disasters, and maintaining lifecycles and nursery of stock upon which much of El Salvador's local and commercial fisheries sustain themselves. Had the mangrove forests lost the same percentage of area as tropical forests, the total loss of ecosystem services in El Salvador would have risen to 4.7 times its current amount. While woodland resurgence occurred from 1992 to 2001, mainly due to the lasting effects of the Salvadoran Civil War, such as the resulting international migration, the associated remittances and concomitant retraction of agricultural frontier (Hecht and Saatchi, 2007), the last decade (1998–2011) has seemingly reversed the trend.

Therefore, we suggest focusing funds in conservation towards tropical forests and coastal wetlands. Because tropical forests and coastal wetlands are the prime contributors towards ESV in El Salvador, protection of these biomes should now be a conservation priority. Whereas tropical forests have lost significant surface and coastal wetlands have not, they are both endangered (Crespin and Simonetti, 2015) and essential in slowing down the rate of decline in the provision of ecosystem services, therefore the former require reactive strategies to recuperate area while the latter need proactive strategies to prevent loss of area. However, public spending on protected areas in El Salvador in 2008 amounts to $395,404 (Bovarnick et al., 2010), equal to 0.004% of the ESV for 2011. In the 13 years since El Salvador first established its environmental law in 1998 (Diario Oficial, 1998), it has increased its protected area system from 0.4 to 0.8% of its land area, leaving 94% of natural land biomes susceptible to threats from land use change (IUCN and UNEP-WCMC, 2013).

The methodology of value transfer carries the typical uniformity error, the assumption that the values of ecosystem services are constant throughout the entire biome, however some places are more important in the provision of services than others (Eigenbrod et al., 2010). Consequently, prioritizing regions within tropical forests and coastal wetlands in decision making will require a localized study. Though if natural biomes are as limited as in El Salvador, where they represent 16% of land area, it should be an imperative that all natural area be protected.

Averting further loss of natural capital now becomes a question of not only how to prevent further shifts from natural to anthropic landscapes, but also of how to gain back lost ground. It is the agroproductive systems, whose increase of 2.1% is three times the expansion of urban areas in absolute terms, which represent the greatest threat to the biodiversity and natural landscapes of El Salvador, as they threaten 44.2% of El Salvador's threatened species (IUCN, 2015). However, cultivated land is not barren, since native species are known to use it (Vandermeer and Perfecto, 2007). Although it may not be the most suitable habitat, agro-productive systems can still be of use for biodiversity, and therefore, may have some ecosystem service value. In this context, a strategy that minimizes the contrast between the agricultural matrix and tropical forests should have the highest probability of succeeding in minimizing loss of service provision.

4.3. El Salvador and the forest transition model

The dominant narrative in the literature of Latin America regarding forest dynamics presents a "green revolution" based on increasing forest cover called the forest transition model (Hecht, 2014). Hecht and Saatchi (2007) show increasing tree cover taking place in El Salvador during the 1990s without discriminating between native forests and shaded coffee plantations. Shaded coffee certainly has potential for land-sharing conservation strategies such as increasing surface for canopy tree species and offering substitute habitat for animals, however caution must be taken when affirming forest transition has taken place when coupling native forests and exotic plantations. During the 2000s native forest ecosystems have become more endangered than ever (Crespin and Simonetti, 2015), and conflicting evidence for the 1990s report the clearing of 13% of shaded coffee areas (Blackman et al., 2007). Perhaps El Salvador did undergo forest transition during the 1990s, but uncoupling native forest and plantations during the 2000s reveals a different story. Our present work does not support the forest transition model in El Salvador for native forests during the 2000s and instead shows a decline in surface area that has consequences for society in the form of devalued natural capital.

5. Concluding remarks

To avoid further depletion of natural capital, both reactive and proactive strategies should be implemented. While protection of all natural biomes is certainly a necessary commitment, it would not be enough. A complementary strategy would require taking advantage of the dominant land use in El Salvador: the agro-productive systems. Payments for environmental services (PES), such as environmental certifications, can be extended as subsidies for maintaining current natural extensions, maintaining current agricultural frontiers or incentivizing crops that form an agricultural matrix that offers the least amount of contrast with native forests, such as the aforementioned shaded coffee plantations. Such agroforestry systems supported by PES might already have a niche within the existing Mesoamerican Biological Corridor, complementing the scarce protected areas in El Salvador (Crespin and García-Villalta, 2014). Implementation of PES will need identification and quantification of services present (Herrador and Dimas, 2000). Ready-to-use mechanisms for PES include the World Bank's BioCarbon Fund (http://wbcarbonfinance.org/BioCF; McDowell, 2002) and the newly designed REDD+ (http://www.un-redd.org; Groom and Palmer, 2012; Kettle, 2012) to stop deforestation, addressing the need felt for regulation of water flows during floods and hurricanes. The creation of markets for other environmental services may increase the viability of ecological restoration efforts. To achieve this, it is imperative for policy to not only consider effectively slowing down the rate of loss of natural landscapes, but to consider generating ecosystem services outside protected areas, through conservation strategies employing the agricultural matrix. Doing so will enable El Salvador to prevent further loss of natural capital and incorporate it into its development.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.ecoser.2015.10.020.

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