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ANALYSIS

Poverty and biodiversity: Measuring the overlap of human poverty and the biodiversity hotspots

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ABSTRACT

In an effort to prioritize conservation efforts, scientists have developed the concept of biodiversity hotspots. Since most hotspots occur in countries where poverty is widespread, the success of conservation efforts depends upon the recognition that poverty can be a significant constraint on conservation, and at the same time conservation is an important component to the alleviation of long-term poverty. In this paper we present five key socio-economic poverty indicators (access to water, undernourishment, potential population pressure, number living below poverty line and debt service) and integrate them with an ecologically based hotspots analysis in order to illustrate magnitude of the overlap between biological conservation and poverty. The analysis here suggests that the overlap between severe, multifaceted poverty and key areas of global biodiversity is great and needs to be acknowledged. Understanding the magnitude of overlap and interactions among poverty, conservation and macroeconomic processes is crucial for identifying illusive, yet possible, win–win solutions.

1. Introduction

The need for an interdisciplinary approach to science has become obvious in recent years and is perhaps most pertinent in the fields of conservation and sustainable development. Due to the linkages between socio-economic systems and ecological systems, issues such as development, poverty eradication, and biodiversity conservation need to be addressed not as individual phenomena but rather as complex dynamic systems. Addressing these systems will require input from social and natural scientists, as well as policy makers and practitioners (Sanderson, 2005). In this paper we address the interconnectivity of global biodiversity conservation priorities with human poverty issues. These issues represent key areas of focus for major global initiatives such as the United Nation's Millennium Development Goals, the Convention on Biological Diversity and Make Poverty History campaign.

The starting point for this analysis is the 2000 Nature article by Myers et al. entitled "Biodiversity hotspots for conservation priorities". In this landmark paper, Myers et al. developed a strategy for prioritizing areas of biodiversity by providing a ranking of hotspots in order to assist planners in the face of insufficient funding. The authors focused their analysis on and defined 'hotspots' as areas having "exceptional concentrations of endemic species and experiencing exceptional loss of habitat". They defined 25 original hotspots, but this list was recently expanded to 34 hotspots and has become the major focus of Conservation International's (CI) work. By focusing on these hotspots, the authors estimate it may be possible to protect 44% of all vascular plant species and 35% of 4 major vertebrate group in only 1.4% of the earth's surface (Myers et

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al., 2000). This was, and continues to be, an important and timely effort due to the growing evidence of human driven ecosystem degradation and species loss (Vitousek, 1997). While an excellent endeavor to help prioritize funding for conservation, their paper does not address the fact that the success of conservation initiatives is largely dependent on the socio-economic conditions of the areas where these hotspots occur.

Adams et al. (2004) recently reviewed the controversy surrounding the link between biodiversity conservation and poverty alleviation. In their article they developed a typology for this relationship, which spanned the range of opinions. The four categories they developed are:

1. Poverty and conservation are separate policy realms.
2. Poverty is a constraint on conservation.
3. Conservation should not compromise poverty reduction.
4. Poverty reduction depends on living resource conservation.

These categories do not preclude the necessity of both poverty alleviation and conservation, but rather express different viewpoints (or prioritizations) of these complex systems. The Myers et al. (2000) endeavor was excellent for identifying hotspots, but it is a *category 1* strategy of maintaining the separation between conservation priorities and poverty alleviation. While conservation and poverty data have seldom been fully integrated (Snel, 2004), Cincotta et al. (2000) have expanded the analysis of hotspots by including the interactions with population densities and growth rates. Smith et al. (2003) have examined governance corruption with respect to hotspots. There have also been several attempts at integrating socio-economic data into conservation prioritization in an effort to move away from this *category 1* framework (Sisk et al. 1994; Balmford et al., 2003; Veech, 2003; O'connor et al., 2003). These papers all base their priority setting on conservation costs and threats, and their analysis would generally fall in Adams et al.'s *categories 2–3*.

While the socio-economic indicators we use could support viewpoints in categories 2–4, the function of this paper is to provide analysis for practitioners to show the geographic overlap of key areas for both poverty alleviation and biodiversity conservation. This analysis could be useful to any of the typology viewpoints, but the discussion that follows the analysis focuses primarily on the category four viewpoint, which is becoming increasingly common in the literature.

Previous attempts are laudable calls to the conservation community to prioritize initiatives based on possible success in light of socio-economic conditions. Our work on the other hand uses vital poverty statistics, such as access to clean water, food scarcity and national debt service, in acknowledgment of the fact that organizations working on poverty issues face critical constraints but continue to work on literally life and death issues. In doing this, we move beyond conservation prioritization, and point to the large scale at which poverty alleviation and biodiversity conservation concerns overlap. We highlight the innate linkages between conservation and poverty by assessing socio-economic poverty indicators that have an impact on, and feedback into, conservation. We also provide a ranking of the critical hotspots and countries based on these indicators. This work recognizes the fact that conservation in general does not automatically translate to protection of high levels of biodiversity, but the linkage between these two is in recognition of the strong and well documented link that ecosystem destruction leads to species loss (Ehrlich and Ehrlich, 1981; Tilman et al., 1994; Czech et al., 2000).

2. Methods

We disaggregated CI's 34 hotspots into their constituent countries within a Geographic Information System. Hotspots (obtained from Conservation International's website at: http://www.biodiversityhotspots.org/xp/Hotspots/resources/maps.xml) were clipped to a map of the world's countries (obtained from USGS VMap, Level 0 Project). These files were combined in order to determine which hotspots overlapped with which country and to select all countries with at least 100,000 ha of overlapping hotspots. This resulted in 125 countries for further analysis. We chose the minimum area somewhat arbitrarily but felt that such a large area was needed because of the coarseness of the political boundaries and because the actual hotspots only comprise between 3% and 30% of the ecoregions to which they are assigned (Myers et al., 2000). (See Table 1A in the Appendix for a list of these 125 countries and their associated hotspot area.)

We chose critical socio-economic indicators relating to poverty that show this *category 4* interaction between poverty and conservation threats. We used traditional economic metrics of poverty: *national debt service* and *percentage of people living below the national poverty line*. We also included a broader range of poverty indicators (*undernourishment*, *access to clean water* and *potential population pressure*) not based solely on market-identified poverty. Due to their innate connection with life-supporting ecosystems, we call these *ecological poverty* indicators.

3. Ecological poverty indicators

3.1. *Undernourishment*

According to the 2003 State of Food Insecurity (SOFI) report of the Food and Agriculture Organization (FAO) there are 842 million people considered 'food insecure' in our world. Three-fourths of these people live in rural areas, the overwhelming majority in the developing world. The rural poor rely heavily on local ecosystems for primary goods and services and therefore the importance of biodiversity to food security in the developing world cannot be overstated (Snel, 2004). In the other direction, growing rural populations in the developing world may further burden already degraded food production systems (FAO, 2003). In light of this it is important to recognize how food security may affect and be affected by conservation initiatives.

We used figures from the SOFI 2003 report on the percentage of the population considered 'undernourished' to integrate this problem with biodiversity conservation. Table 1 (column A) shows the hotspot countries with the largest percentage of their populations considered undernourished. Where data was

Table 1 – The top 25 hotspot countries for each of the socio-economic indicators

Rank	A		B		C		D		E	
	Undernourished population (%)		Population without access to water (%)		Population growth rate*Population density		Population living below poverty line (%)		Debt service as % of exports	
1	Somalia [a]	75.00	Malawi	67	Hong Kong	59.41	Zambia	86	Brazil	68.9
2	Eritrea	71.79	Cameroon	63	Bangladesh	17.30	Liberia	80	Burundi	59
3	Democratic Republic of Congo	71.14	Bhutan	62	Rwanda	9.26	Haiti	80	Lebanon	51
4	Burundi	68.75	Kenya	62	Comoros	8.49	Guatemala	75	Turkey	46.5
5	Tajikistan	60.66	Liberia	62	Mauritius	6.01	Madagascar	71	Colombia	40
6	Afghanistan [a]	58.00	Vanuatu	60	Haiti	5.75	Bolivia	70	Sierra Leone [c]	39
7	Comoros [b]	49.06	Nigeria	60	Philippines	5.56	Mozambique	70	Somalia [c]	39
8	Sierra Leone	46.91	Tajikistan	58	Lebanon	5.46	Zimbabwe	70	Vanuatu [c]	37
9	Zambia	46.70	Eritrea	57	El Salvador	5.30	Burundi	68	Belize	36.5
10	Haiti	46.51	Sierra Leone	57	India	5.16	Sierra Leone	68	Kazakhstan	34.4
11	Mozambique	46.70	Uganda	56	Burundi	4.99	Ecuador	65	Chile	32.8
12	Ethiopia	46.51	Zambia	55	Israel	4.54	Comoros	60	Peru	32.8
13	Liberia	45.16	Swaziland	52	Reunion	4.28	Rwanda	60	Ecuador	28.7
14	Zimbabwe	44.09	Guinea	51	Pakistan	3.99	Nigeria	60	Bolivia	27.7
15	Tanzania	43.82	Togo	51	Nepal	3.71	Tajikistan	60	Zambia	27.1
16	Rwanda	37.50	Zaire	46	Sri Lanka	3.57	Malawi	55	Croatia	25.9
17	Madagascar	36.59	Madagascar	45	Nigeria	3.24	Colombia	55	Venezuela	25.6
18	Yemen	35.83	Equatorial Guinea	44	Puerto Rico	3.22	Peru	54	Kyrgyzstan	25.3
19	Armenia	35.48	Laos	43	Martinique	3.16	Honduras	53	Indonesia	24.8
20	Djibouti [b]	34.37	Mozambique	42	Cape Verde	3.00	Eritrea	53	Uzbekistan	23.3
21	Kenya	33.12	Papua New Guinea	39	Guatemala	2.87	Argentina	51.7	Morocco	23.9
22	Malawi	32.76	Cambodia	34	Vietnam	2.85	Armenia	50	Thailand	23.2
23	Cambodia	32.59	Somalia	29	Uganda	2.83	Kyrgyzstan	50	Mexico	23.2
24	Bangladesh	30.16	Ethiopia	22	Dominican Republic	2.70	Namibia	50	Philippines	20.2
25	Solomon Islands [b]	29.34	Afghanistan	13	Guadeloupe	2.40	South Africa	50	Panama	19.5
	Bhutan	[d]	Saudi Arabia	[e]			Somalia	[d]	Afghanistan	[d]
	Equatorial Guinea	[d]					Sudan	[d]	Myanmar	[f]
							Zaire	[d]	Nigeria	[f]
							Bhutan	[d]	Papua New Guinea	[f]
							Equatorial Guinea	[d]		
							Solomon Islands	[d]		
							Vanuatu	[d]		

[a] SOFI 2001.
[b] Percentage derived from caloric intake (see text).
[c] Latest data from L.C.D., Report, 2002.
[d] Least developed country status.
[e] Water scarce country (see text).
[f] WB severely indebted status.

missing we used per capita caloric intake figures from the United Nations *Least Developed Countries Report* (2002), and regressed them against figures we had for undernourishment. This model gave us an Adj. R^2=.76 (n=23, p<.0001). With this relationship we were able to fill in the undernourishment values for the missing countries. Bhutan and Equatorial Guinea, for which no data were available, were added to the list due to their status as least developed countries (LDCs).

3.2. *Access to water*

The UNDP with their human poverty index (HPI) have broadened the idea of poverty to include non-monetary indicators such as access to clean water. Currently, there are at least 1 billion people who lack daily access to safe drinking water globally (Gleick, 1999). Among these many are the rural poor who rely directly on ecosystem services for availability and quality of local water supplies (Scherr, 2003). Where conservation fails the loss of local ecosystem goods and services can inhibit long-term local health as well as food and water security (Perrings and Gadgil, 2003). Conversely, populations without adequate access to water face either urban migration, or further marginalization, either option is likely to stress proximate ecological systems.

The access to clean water data comes from the Millennium Indicators Database (UN, 2005) and the UN's (2002) *Least*

Developed Countries Report (UN, 2002). This data represents the percentage of the population with access to a clean water source. For the few countries for which there was no data we checked Gardner-Outlaw and Engelman's (1997) work on future water scarcity. This forced us to consider Saudi Arabia for analysis, and although water scarcity and access to water are different indicators it seemed prudently conservative to include it. Table 1 (column B) shows the hotspot countries with the poorest access to water.

3.3. *Potential population pressure*

Populations in areas of high biodiversity will continue to increase globally and these populations will be heavily reliant upon local food production and resource extraction (Scherr, 2003). Population growth in areas of high resource extraction has an obvious pressure effect on ecosystems, like increased fuelwood extraction (McNeely and Scherr, 2003). Deacon (1994) found deforestation rates to be positively affected by population growth (with some lag effects). The 'proximate' causes of ecological degradation are often local pressures such as wood extraction and land clearing for agriculture (Geist and Lambin, 2002). However, it has been well argued that population effects are secondary and driven by macro-scale economic processes (Shiva, 1993; Geist and Lambin, 2002). Further, in some systems, like dryland farming systems, population increases have had little to no causal effects on degradation (Adams, 2001). The population growth–ecosystem degradation debate is much more nuanced, however even if local pressure is a secondary effect of larger scale processes it still makes a useful proxy to 'potential pressure'. In light of this, it is essential that conservation strategies consider population dynamics (Cincotta et al., 2000). Cincotta et al. (2000) show that within the biodiversity hotspots, population growth and population densities are well above the world average.

In this analysis we define *potential population pressure* as the population growth rate multiplied by the population density (population/ha of country) as in Cincotta et al. (2000). This indicator is in recognition that a high population growth rate may not have a huge effect on local ecosystems if the initial population density is low. Where Myers et al.'s analysis used past habitat destruction as a factor, this figure attempts to get at the possible future pressures. We used population and population growth rates from the WB's World Development Indicators (2005). Missing data was incorporated from the CIA World Factbook (CIA, 2005).

Table 1 (column C) shows the hotspot countries with the greatest potential population pressure.

4. Economic indicators

4.1. *Poverty line*

Currently 40% of the global population lives in low-income countries; roughly 3 billion people live on less than \$2 a day; and 1.2 billion live below The World Bank's (2003) "extreme" poverty line of less than \$1 per day. The often-studied relationship between poverty and environmental degradation cuts both ways, where conservation affects local livelihoods and local livelihoods affect conservation efforts. This "bi-directional" relationship can have positive feedback effects, often described as a 'vicious cycle' where degradation and species loss affects local livelihoods in a negative way which leads to further degradation and so on (Boyce, 1994). To this, local ecosystem services are critical to those mired in poverty (Dasgupta, 2002), and where broad scale ecological degradation exists the poor suffer a large proportion of the costs incurred (Munasinghe, 1993).

Those who directly utilize biodiversity resources do so because they are displaced, marginalized and are likely to not have alternatives (Pimm et al., 2001). This is a case where the short-term incentives (food, materials) outweigh long-term stability (conservation). To avoid this social trap, economic poverty must be considered in conservation schemes.

For this indicator we used the Millennium Indicators Database (UN, 2005). The figure used represents the number of people living below the national poverty line. We found data for 91 of the 125 countries. We attempted to regress WB categorical status (e.g. Highly Indebted Poor Country) with poverty data to find a relationship to fill in for missing data points, but this attempt yielded no significant results. Of the missing 34 data points, seven countries were on the UN's Least Developed Countries list (2002). These seven were added to Table 1 (column D), which shows the countries with the greatest number of people living below the poverty line.

4.2. *Debt service*

Debt service is considered a key macro-economic variable when examining development issues. This statistic is usually measured in the amount of money spent to service loans as a percentage of gross domestic product or exports. The state of a country's indebtedness can have serious consequences for conservation and poverty reduction initiatives.

For example, several studies have looked at how indebtedness affects tropical deforestation. Capistrano and Kiker (1995) looked at deforestation in 45 tropical countries and concluded that indirectly, through currency devaluation, debt service was linked to deforestation. Owusu (1998) also found debt obligation to be a major driver in Ghana's increased deforestation. And in countries considered 'medium deforesting countries' debt service was found to be one of the main causes of deforestation (Mahapatra and Kant, 2005). In light of studies like these, the debt service – environmental degradation relationship was considered to be important for this analysis.

Data came from the WB's World Development Indicators (2005) and the UN's *Least Developed Countries Report* (UN, 2002), where debt service was measured as a percentage of total exports. If a country for which we did not have numerical data was categorically considered *severely indebted* by the WB it was added to the table. These additions were Afghanistan, Burma, Nigeria, and Papua New Guinea. Table 1 (column E) shows the hotspot countries with the poorest debt service status.

5. Re-ranking the hotspots

Table 1 shows the 25 poorest performers in each category. We also added some countries to this list when these countries

Table 2 – The poorest performing hotspots and countries according to this analysis

Country	No. of times found in top 25	Hotspot	No. of times found in top 25
Burundi	4	Eastern Afromontane	5
Nigeria	4	Guinean Forest of West Africa	5
Sierra Leone	4	Himalaya	5
Somalia	4	Coastal Forests of Eastern Africa	4
Zambia	4	East Melanesian Islands	4
Afghanistan	3	Horn of Africa	4
Bhutan	3	Indo-Burma	4
Comoros	3	Madagascar and the Indian Ocean Islands	4
Equatorial Guinea	3	Mountains of Central Asia	4
Eritrea	3	Caribbean Islands	3
Haiti	3	Caucasus	3
Liberia	3	Irano-Anatolian	3
Madagascar	3	Maputaland–Pondoland–Albany	3
Malawi	3	Mesoamerica	3
Mozambique	3		
Rwanda	3		
Tajikistan	3		
Vanuatu	3		

had missing data but were obviously in bad shape with respect to a criteria, as commented on in the above text. From this we ranked the poorest performers for both countries and hotspots. For the country list, we ranked countries based on the number of times (0 to 5) each of them appeared in the top 25 of the socio-economic categories. For the hotspots we analyzed the data two ways. One, we carried out the same exercise as with the countries, simply counting up the number of categories a hotspot occurred in the top 25. We also ranked the hotspots according to poverty-effected area. For this we took the total area of the biodiversity hotspot from each country that appeared in the top 25 categories and summed them to their associated hotspot. Tables 2 and 3 show the poorest aggregate performers for the countries and hotspots according to this analysis. Fig. 1 depicts how each of the 34 hotspots fared in this exercise.

6. Results

For undernourishment, the top five countries all have greater than 60% of their populations without adequate caloric intake. Four of the five are African countries, with Somalia as the country with the highest percentage of its population undernourished at 75%. There are 15 countries where greater than 50% of their population do not have access to clean water. Twelve of these countries are on the African continent.

For potential population pressure, Hong Kong is clearly in a league of its own. Bangladesh ranks second in this indicator with double the threat of any other country save Hong Kong. This means that in these countries, the Indo-Burma hotspot will continue to face serious conservation challenges due to population growth. All top 25 countries in the poverty line indicator have greater than 50% of their populace living below their national poverty line. Debt service, in relation to biodiversity hotspots, has seemed to hit Central and South America the hardest with ten countries in the top 25.

6.1. *Hottest spots*

By looking at all five socio-economic indicators we can get a sense of, to use the Myers–Mittermeier terminology, the ‘hottest hotspots’, meaning the biologically important areas most affected by poverty issues. Of the 125 countries considered in this analysis 18 countries ended up in the top 25 lists at least three times (Table 2). Five countries appear in four of the top 25 lists. They are Burundi, Nigeria, Sierra Leone, Somalia and Zambia.

Table 3 – Hotspots ranked according to the total hotspot area affected by the socio-economic conditions in the countries that comprise the hotspot

Rank	Hotspot	Affected area ($\times 10^3$ ha)
1	Horn of Africa	413932
2	Tropical Andes	277072
3	Indo-Burma	220250
4	Eastern Afromontane	213069
5	Cerrado	202251
6	Madagascar and the Indian Ocean Islands	178205
7	Sundaland	115869
8	Atlantic Forest	114421
9	Mountains of Central Asia	109898
10	Guinean Forests of West Africa	109830
11	Mesoamerica	105465
12	Coastal Forests of Eastern Africa	70781
13	Mediterranean Basin	64466
14	Himalaya	64417
15	Philippines	59029
16	Tumbes–Choco–Magdalena	52829
17	Madrean Pine–Oak Woodlands	44888
18	Chilean Winter Rainfall and Valdivian Forests	39612
19	Maputaland–Pondoland–Albany	33504
20	Wallacea	33462
21	Irano-Anatolian	33270
22	East-Melanesian Islands	20715
23	Western Ghats and Sri Lanka	18884
24	Caribbean Islands	14098
25	Caucasus	12559
26	Succulent Karoo	10237
27	Cape Floristic Region	7822
28	California Floristic Province	1184
29	Mountains of Southwest China	453
30	Polynesia–Micronesia	284
31	Japan	0
32	New Caledonia	0
33	New Zealand	0
34	Southwest Australia	0

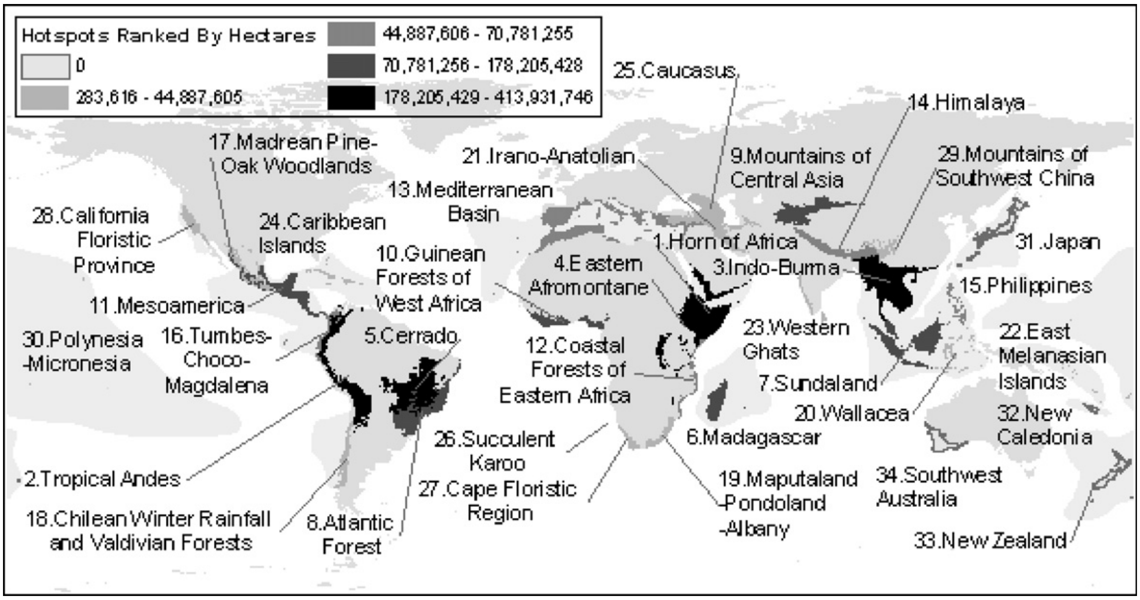

Fig. 1 – Darker shades show the more imperiled of CI's 34 biodiversity hotspots according to this multifactor assessment, based on aggregate area of hotspot affected by conditions of socio-economic poverty.

By re-aggregating the countries back to the biodiversity hotspots we can get a sense of the hottest areas as based on ecoregion (Table 2). Through this lens we see that 14 hotspots appeared in Table 1 at least three times. Of these only three hotspots made the top 25 five times. They are Eastern Afromontane, Guinean Forests of West Africa, and the Himalaya. Six hotspots appeared in the top 25 four times. They are the Coastal Forests of Eastern Africa, East Melanesian Islands, Horn of Africa, Indo-Burma, Madagascar and the India Ocean Islands, and Mountains of Central Asia. Of special note are the Coastal Forests of Eastern Africa, Indo-Burma and Madagascar and the India Ocean Islands. These three also appeared in the hottest hotspots list based solely on ecological indicators in the original Myers et al. Nature article. When re-ranked by area affected, we get a different ordering, with the Horn of Africa well above the rest. Again the Indo-Burma, Madagascar and the India Ocean Islands, and the Eastern Afromontane hotspots rank highly. But with this ranking they are joined by the Tropical Andes and Cerrado hotspots (Table 3).

7. Limitations

Our examination of the socio-economic landscape in the countries where CI's hotspots lie has a number of limitations:

1) The biodiversity hotspots are aggregated based on similar ecological characteristics, ignoring political boundaries, while most socio-economic data, including all used in this analysis, are available only for national boundaries. As global datasets improve and become more closely linked with geographical information systems, this analysis could focus directly on hotspots rather than through nations. At the same time much important initiative funding is channeled and tied to political boundaries i.e. countries (Balmford et al., 2000).
2) With analysis on 125 countries multiple data sources were used. While all attempts were made to standardize the data, deficiencies may still exist. One example is that each country determines its own poverty line, and therefore there are inherent methodological and precision errors.
3) Population density and growth figures are only proxies for human impact on ecological systems (Cincotta et al., 2000). For example, low density slash and burn populations can have large ecological effects. Also, proximity to urban areas may also provide a link to the impact of poverty on ecosystems.
4) The indicators used were picked from available global datasets. Sufficient datasets for additional appropriate socio-economic indicators do not exist. For example, primary fuel source data would be an appropriate indicator for population pressure on local forest resources. Extensive data on the nutritional sources of a country would also be an important indicator to flesh out the human dependence on local resources. On the economic side some figure on national wealth as adjusted by a distribution index (such as the Gini Index) would also be of great value for this analysis.
5) Due to its recent political history there is no data on the state of Western Sahara. This country, which contains part of the West African Forests hotspot, is likely to have poor socio-economic statistics and therefore although it is not included in the analysis both the country and hotspot should be given careful consideration.
6) Myers et al.'s analysis created ecoregion sized biodiversity hotspots, where only 3–30% of their extent would truly be considered a ‘hotspot’. In this analysis we utilized the entire *defined* hotspot (ecoregion) for analysis.

8. Discussion

Much work has been done on prioritization of global conservation efforts based on ecosystem characteristics such as endemism (Myers et al., 2000), habitat type (Olson and Dinerstein, 1998), adaptive variation (Smith et al., 2001), and/or threats to success like governance (Smith et al., 2003), cost (Balmford et al., 2000) and population (Cincotta et al., 2000). Our approach includes key social and economic poverty indicators that have been shown to drive land use change in the ecologically sensitive areas of the world (Lambin et al., 2001; Geist and Lambin, 2002). These social and economic poverty indicators provide metrics of human suffering all of which have strong connections to conservation issues (as shown above).

The main result of the analysis shows which of the globally important ecoregions for biodiversity are faced with deep and multifaceted poverty. It demonstrates the magnitude of this overlap and points to the possibility of a vicious cycle between poverty and biodiversity loss. This analysis does not imply that poverty is the underlying driver of the ecosystem degradation that leads to biodiversity loss. Others have made strong arguments for the connections between the macro-economic processes and policies of the developed world as being the underlying drivers of ecosystem change in the developing world (Shiva, 1993; Geist and Lambin, 2002; Martinez-Alier, 2002).

Despite these large-scale drivers there have been many attempts to integrate poverty alleviation and conservation projects. Integrated Conservation and Development Projects (ICDPs) have tried multiple general goals like sustaining ecosystems while simultaneously creating livelihoods for local people through projects like community forestry programs and ecotourism initiatives. These projects have generally been expensive, slow to show results and highly dependant upon local politics and perceptions (Adams, 345). It has been argued that these projects are rarely effective in achieving their multiple goals (Ferraro and Kiss, 2002). Likewise, straight conservation projects have hindered the economic development of local people (Naidoo and Adamowicz, 2005). The creation of national park and reserves has been shown to generate social and economic dislocations in Kenya, Uganda, Tanzania and Sri Lanka among others (NortonGriffiths and Southey, 1995; Harper, 2002). However, the impacts of reserve creation on local livelihoods needs to be studied further (Brockington et al., 2006; Wilkie et al., 2006).

Although projects attempting to incorporate poverty alleviation and conservation have had many failures, there are also examples of successful multiple goal initiatives (Scherr, 2003; Adams et al., 2004). The POEMA (Poverty and Environment in Amazonia) project provides farmers with high (local) income through farming a multilayer agroforestry system that is biodiversity friendly (McNeely and Scherr, 2003). Likewise, villagers near Chitwan National Park in Nepal are entitled to park entrance fees, and funding for park-buffering community forest systems (McNeely and Scherr, 2003).

Such indirect approaches to conservation and development are currently being complimented by direct payments for conservation efforts. Ferraro and Kiss (2002) argue that direct payments for conserving biodiversity benefit poor by "improving cash flows, providing a fungible store of wealth and diversifying sources of household income". The most established direct payments initiative is Costa Rica's Payments for Ecosystem Services (PES) in which landowners are compensated for providing ecosystem services such as water regulation and carbon sequestration. Mexico's payment scheme pays landowners to conserve forests in hydrologically important catchments, and similar systems are in place in Ecuador and Colombia (Pagiola et al., 2005).

It has been argued that PES systems help to diversify rural livelihood strategies while providing conservation successes (Rosa et al., 2004). Evidence from Costa Rica supports this as payments attend to short-term cash constraints, as debt has been shown to be a strong predictor for participation (Zbinden and Lee, 2005). At the same time, it is too early to make any strong conclusions about the impact such systems have on poverty alleviation (Pagiola et al., 2005). Such systems may in fact intensify poverty in certain locals due to tentative property rights, land take and exclusion and by ignoring traditional lands uses (Rosa et al., 2004; Pagiola et al., 2005). Participants in Costa Rica's payment system tend to have larger properties, higher institutional education, and live off-farm (Zbinden and Lee, 2005). This suggests that there may already exist market power and information asymmetries in the PES system, which would hinder the appropriate allocation of costs and benefits. On the other hand this may simply be a function of the goal of the program, which is ecologically based, rather than socially based (poverty alleviation).

Both direct and indirect conservation–development initiatives have their strengths and weaknesses. Empirically based evaluations of these programs are increasing, and continue to offer guiding insight for integrated solutions. While conservation of ecosystems is not identical to the goal of protecting biodiversity, ecosystem destruction is strongly and clearly linked to species loss (Ehrlich and Ehrlich, 1981; Tilman et al., 1994; Czech et al., 2000).

9. Conclusion

Adam et al.'s typology demonstrates the range of viewpoints surrounding the conservation–poverty alleviation issue. The analysis here suggests that regardless of which viewpoint you hold, the overlap between severe, multifaceted poverty and key areas of global biodiversity is great, and needs to be acknowledged. The goals of any project will dictate the approach, but as pointed out here, biodiversity hotspot conservation (or poverty alleviation in and surrounding the hotspots) must consider the large interaction effects between conservation and poverty. These interactions are beginning to be acknowledged more widely and currently many countries are using poverty maps to prioritize projects, by examining where impoverished areas overlap with degraded ecosystems (FAO, 2003).

This type of integration is crucial for identifying illusive, yet possible, win–win solutions. Paul Farmer's (2001) "Infections and Inequalities" was a watershed work for moving the AIDS discourse from its focus on blaming individual behavior to a more holistic view linking AIDS to inequality, poverty and political marginalization. The conservation–poverty issue is approaching a similar revolution in perception. Understanding the magnitude of overlap and interactions among poverty, conservation and macroeconomic processes is an absolute necessity for human wellbeing and ecological sustainability.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ecolecon.2006.05.020.

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