Can payments for watershed services help save biodiversity? A spatial analysis of highland Guatemala

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Abstract

Payments for environmental services (PES) are a promising mechanism for conservation. PES could either provide additional funding for protected areas, pay land users to conserve biodiversity outside protected areas, or both. For PES to work, it requires a secure long-term source of financing. Obtaining payments directly for biodiversity conservation is difficult, however. In most cases, water users are the most likely such source, either directly or indirectly. Thus the potential for PES to help conserve biodiversity depends, in a large measure, on the degree to which areas of interest for conservation of water services overlap with areas of interest for conservation of biodiversity. This paper examines the extent of such overlap in the case of highland Guatemala. The results show that this potential varies substantially within the country, with some biodiversity conservation priority areas having very good potential for receiving payments, and others little or none. Overall, about a quarter of all biodiversity conservation priority areas have potential for receiving payments. Thus PES is far from being a silver bullet for biodiversity conservation, but it can make a meaningful contribution to this objective.

Keywords

Payments for environmental services (PES), biodiversity conservation, Guatemala

5,500 words

1. Introduction

The global threat to biodiversity has been well documented, most recently by the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005). Traditionally, the main approach to biodiversity conservation has been the creation of protected areas (PAs). However, there has been considerable debate over the effectiveness of PAs as a conservation tool (Brandon *et al*., 1998; Dudley and Stolton, 1999; Bruner *et al*., 2001). For lack of sufficient funding, many PAs are little more than 'paper parks'. Whatever their effectiveness, further expansion of PAs is simply not financially or socially feasible in many areas.

Payments for environmental services (PES) have been identified as a promising mechanism for conservation (Pagiola *et al*., 2002; Wunder, 2005; Pagiola and Platais, 2007; Engel *et al*., 2008). PES could either provide additional funding for protected areas, pay land users to conserve biodiversity outside protected areas, or both. For PES to work, it requires a secure long-term source of financing. Obtaining payments directly for biodiversity conservation is difficult, however. In most cases, water users are the most likely such source, either directly or indirectly, as discussed in section 2. Thus the potential for PES to help conserve biodiversity depends, in a large measure, on the degree to which areas of interest for conservation of water services overlap with areas of interest for conservation of biodiversity, as discussed in section 3. This paper examines the extent of such overlap in the case of highland Guatemala.[1]

Guatemala is the twenty-second most bio-diverse country in the world (section 4). However, with an annual deforestation rate of 1.3% (more than seven times the world average), Guatemala's biodiversity is under severe threat. Although efforts to develop PES in Guatemala are still embryonic, the country is thought to have considerable potential in this regard. To assess the degree to which payments for water services might help conserve biodiversity in highland Guatemala, we conduct a spatial mapping exercise for highland Guatemala to identify the major water users and their corresponding water supply areas – areas where PES could potentially be implemented (section 5). We conduct a corresponding spatial mapping exercise to identify areas of importance for biodiversity conservation (section 6). We then use these two datasets to assess the spatial concordance between the identified water supply areas and biodiversity priority areas,

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[1] Highland Guatemala is defined as the part of the country that excludes the Petén region.

and explore how the concordance varies across categories of water use value and biodiversity importance (section 7).

2. Payments for environmental services

PES is a market-based approach to conservation financing based on the twin principles that those who benefit from environmental services (such as users of clean water) should pay for them, and that those who contribute to generating these services (such as upstream land users) should be compensated for providing them (Wunder, 2005; Pagiola and Platais, 2007; Engel *et al*., 2008). The approach thus seeks to create mechanisms to arrange for transactions between service users and service providers that are in both parties' interests, internalizing what would otherwise be an externality. The PES approach is attractive in that it (i) generates new financing, which would not otherwise be available for conservation; (ii) is likely to be sustainable, as it depends on the mutual self-interest of service users and providers and not on the whims of government or donor financing; (iii) is likely to be efficient, in that it conserves services whose benefits exceed the cost of providing them, and does not conserve services when the opposite is true.

Two main types of PES programs can be identified (Pagiola and Platais, 2007; Engel *et al*., 2008). The ideal case is that of *user-financed* programs, in which payments to service providers depend on payments made by service users. Such PES programs are most likely to be efficient as service users provide not only financing but also information on what services are most valuable, and have a strong incentive to ensure that payments are used effectively. Conversely, *government-financed* PES programs depend on financing from a third party, usually the national government. Government-financed program typically cover much larger areas, but are less likely to be efficient (Pagiola and Platais, 2007; Wunder *et al*., 2008).

User-financed PES programs have had notable success in the case of water services, where users are easy to identify and receive well defined benefits (Pagiola and Platais, 2007). They are also common in the case of carbon sequestration, where demand is created by cap-and-trade mechanisms. We return to the potential for carbon payments to contribute to biodiversity conservation in the conclusions.

Although biodiversity conservation can be considered a service in itself, basing PES programs on payments by biodiversity 'users' has not been possible so far. Significant hopes have been placed on biodiversity prospecting ('bioprospecting') as a means of generating income for biodiversity conservation (Farnsworth and Soejarto, 1985; Principe, 1989; McAllister, 1991; Pearce and Puroshothaman, 1992; Reid and others, 1993). Despite some individual success stories, such as Merck's agreement with Costa Rica, to date these hopes have largely been disappointed (Barbier and Aylward, 1996; Simpson *et al*., 1996; Simpson, 1997; Southgate, 1997; Laird and ten Kate, 2002). Although pharmaceutical companies remain interested in genetic material from natural ecosystems, their willingness to pay is far lower than the optimistic forecasts of the early 1990s.

The tourism industry is, of course, a major source of financing for PAs through entrance fees. Such fees are paying for direct uses such as recreational services, however, and not for the indirect uses that PES focuses on. As a source of financing for PES, the tourism industry is still largely untapped. Even in Costa Rica, efforts to generate financing from the local tourism industry have not yet borne fruit.[2] To our knowledge, the only PES program in which tourism operators are paying for environmental services other than direct recreational services is a program in Tanzania in which several tourism operators are paying Maasai villages to protect the calving grounds of animals which are later seen in the Tarangire National Park (Foley, 2006).

As a result, payments for biodiversity conservation have come primarily from the Global Environment Facility (GEF) and from some international non-governmental organizations (NGOs) like The Nature Conservancy (TNC) or Conservation International (CI). None of these sources is able to commit to long-term financing, however. CI has made some of the longest-term agreements, through its Conservation Incentive Agreements (CIA) program (Rice *et al*., 2003), but they are an exception. To convert the short-term financing provided by such buyers into long-term financing streams, endowment funds are often used (Pagiola *et al*., forthcoming). This approach is only viable for high-value cases such as Mexico's Monarch Butterfly reserve, however (Missrie and Nelson, 2005).

In contrast, direct payments by water users have been common, from a variety of water users, at a variety of scales. In Ecuador, Quito's water utility and electric power company pay to conserve the watersheds from which they draw their water (Echavarría, 2002a). In Costa Rica, Heredia's public service utility pays for watershed conservation with funds from a special fee on consumers (Barrantes and Gámez, forthcoming). Many small towns have similar schemes,

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[2] A hotel in the Guanacaste area is paying for watershed conservation, but it is doing so to protect its water supplies, as it is a major water user (Pagiola, 2008). To date, no tourism sector company is paying specifically for scenic beauty or biodiversity conservation.

including Pimampiro, Ecuador (Wunder and Albán, 2007); San Francisco de Menéndez, El Salvador (Herrador *et al.,* 2002); and Jesús de Otoro, Honduras (Mejía and Barrantes, 2003). Several small communities along the edge of the Pico Bonito National Park in Honduras are paying to conserve their water sources (EcoLogic, 2006). Hydroelectric power (HEP) producers are also well represented in current PES mechanisms. In Costa Rica, for example, many public-sector and private sector HEP producers are paying for conservation of the watersheds from which they draw their water through the country's PSA Program, generating payments of about US$0.5 million and conserving about 18,000 ha annually (Pagiola, 2008). In Venezuela, power company CVG-Edelca will be paying 0.6% of its revenue (about US$2 million annually) to conserve the watershed of the Río Caroní, where 70% of the country's HEP is generated (World Bank, 2007). Some irrigation systems, such as those in Colombia's Cauca Valley, also participate in PES programs (Echavarría, 2002).

Government-financed programs depend on financing from the government, either by annual appropriations from the government budget (as in the case of Mexico's PSAB program) or by using revenues from earmarked taxes (as in the case of Costa Rica's PSA program). Government-financed programs can, in principle, target any environmental service deemed to be of social importance. In practice, government-financed programs have also tended to focus primarily on water services. The main window of Mexico's PSAB program focuses on areas that are important for water services (Muñoz *et al*., 2008). Costa Rica's PSA program currently defines its eligible areas primarily on the basis of biodiversity services, due to early GEF support to the program, but is evolving towards a greater focus on water services (Pagiola, 2008). China's Sloping Lands Development Program (SLCP) focuses exclusively on areas thought to be at risk of erosion (Bennett, 2008). Some governments do use public resources for PES programs aimed at biodiversity conservation, notably in Mexico. Such funding is very limited, however. At the end of 2007, the area enrolled under the biodiversity window of Mexico's PSAB program was less than one tenth that enrolled under the water services window. The dearth of spending on PAs is another indication of the inability or unwillingness of most developing countries of devoting significant resources to biodiversity conservation. PAs in developing countries receive an average of less than 30% of the funding necessary for basic conservation management (James *et al*., 1999).

Thus both user-financed and government-financed PES programs have tended to focus primarily, if not exclusively, on water services. This is unlikely to change in the future; the very nature of the services involved mean that PES programs are much easier to implement for water services than for biodiversity services (Pagiola and Platais, 2007). The question then becomes, to what extent might payments for water services help conserve biodiversity?

3. Using water payments to preserve biodiversity

Several authors have argued that payments for water services (PWS) can play a major role in protecting biodiversity.[3] Turpie *et al.* (2008), for example, argue that water can serve as an 'umbrella service' whose conservation will also bring substantial biodiversity benefits. The potential synergies between PWS and biodiversity have already been explicitly exploited in many cases. In many GEF-financed PES projects, GEF funding is used to pay the start-up costs of establishing PWS mechanisms, with the expectation that payments by water users will also help protect valuable biodiversity over the long term. Similarly, the US Fish and Wildlife Service supported the development of a local PWS program in Los Negros, Bolivia, so as to protect bird habitat (Asquith *et al.*, 2008).

Water services have specific characteristics, however, that have a very strong impact on the nature of PWS programs. Water flows downhill, making water use and the potential for payments for water services highly watershed-specific (Pagiola and Platais, 2007). While water users often have strong incentives to pay for conservation of their water supply areas, they have no incentive to pay for conservation of areas outside them. The extent to which PWS might contribute to biodiversity conservation thus depends to a large extent on the extent to which areas of biodiversity value overlap with water supply areas (spatial correlation), and the extent to which land uses that provide water services are compatible with biodiversity conservation (ecological correlation). We focus here on spatial correlation, and return to the issue of ecological correlation in the conclusions.

Numerous examples can be cited to support the proposition that areas of high biodiversity can be important for water supplies. Dudley and Stolton (2005), for example, find that 33 of the world's 105 largest cities obtain a significant proportion of their drinking water from protected

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[3] In this paper, we use the abbreviation PWS to indicate PES programs that are financed by water users and focus on water services, to distinguish them from more general PES programs that may receive financing from several sources and focus on a variety of services.

areas. Indeed, several PES programs that help protect PAs already draw financing from domestic water users, at a variety of scales. While such specific examples are suggestive, however, they do not tell us the overall potential for PWS to contribute to biodiversity conservation on a large scale.

4. Biodiversity in Guatemala

Like much of mesoamerica, Guatemala has some of the world's most biodiverse ecosystems as a result of its unique location as a land bridge between two continental land masses. Moreover, mountain ranges running through the length of the region have created distinct ecosystems on the Atlantic and Pacific sides, as well as a multitude of micro-ecosystems. Mesoamerica has both a great variety of species and a high level of endemism. It is also an important habitat for migratory species. The region has been named one of the world's biodiversity hotspots – areas of very high biodiversity that are under severe threat (Mittermeier and others, 1999). Guatemala itself is one of the eight main sources of origin for cultivated plants, and despite its small size is the twenty-second most biodiverse country in the world (World Bank, 2006).

With an annual deforestation rate of 1.7% (more than three times the average rate in Latin America and the Caribbean), Guatemala's biodiversity is under severe threat. Currently, 13% of plant species and 34% of animal species (not including insects and mollusks) are considered threatened (World Bank, 2006).

Guatemala's national PA system had 120 official PAs in 2003, covering over 3 million ha, or 29% of total land area (CONAP, 2003), well above the 8.6% average in the Central America and Caribbean region, or the 10.8% average worldwide (UNEP-WCMC, 2003).[4] Most of the largest PAs are located in the lowland Petén region. About 1 million ha are protected in highland Guatemala, covering about 13% of the area. Financing for Guatemala's PA system is limited, however, and many PAs are 'paper parks' (CONAP, 2002; Bonham *et al.*, 2008). In 2003, for example, the National Council for Protected Areas (CONAP) received budgetary appropriation of US$4.4 million, or about US$1.4/ha (CONAP, 2003) – well below the world or even the developing country average levels (James *et al.*, 1999). Moreover, PAs managed by CONAP do not charge any visitor fees. Management responsibility for some PAs has been

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[4] Some sources give different numbers of PAs. The discrepancy arises from whether PA complexes that include a core zone, various multiple use zones, and a buffer zones are counted as a single PA or several separate ones.

delegated to NGOs. The Sierra de las Minas Biosphere Reserve, for example, is managed by *Defensores de la Naturaleza*, a Guatemalan NGO (Secaira *et al*., 2000). Some of these PAs do charge entrance fees.

5. Mapping water supply areas

Efforts to map water services have usually focused on locating water users. Such efforts are important, but they give little direct information on which areas are important for water service provisions, as these areas can be at some distance from where water is used. We mapped the areas that provide water services ('water supply areas', WSAs) first by identifying the location of the intakes from which individual users obtain their water. This required collecting and collating information from several disparate sources. In many cases, we contacted water users directly to ask for the location of their water intakes. We then delineated the portions of the watershed that contribute to those intakes using the closest 100m contour line up to the limit of the watershed.[5] We used the watershed map of Guatemala developed by Nelson and Chomitz (2007). They generated a 100-meter hydrologically correct elevation surface by interpolating contour lines and spot heights in combination data on rivers and lakes.[6]

We focused on the larger, formal sector water users. There is also a considerable amount of direct use of water by rural households. Transaction costs make it difficult in most cases to base PES programs on such dispersed users. We focused solely on users of surface water, as groundwater flows are insufficiently understood to allow the recharge areas of specific wells to be mapped with confidence. We limited our analysis to the highland areas of Guatemala, omitting the northern Petén department. Petén accounts for about a third of Guatemala's land area, but only 3% of its population. For each user, we also collected information on the nature and magnitude of their water use. This information allowed us to construct indices of the relative importance or "value" of water supply areas. At present these indices are use-specific, due to the very different nature of the uses. These indices give a broad sense of the extent to which payments might be made.

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[5] See Pagiola *et al*., 2007 for additional details.

[6] This map differs slightly from the watershed map produced by the Ministry of Agriculture, Livestock, and Nutrition (MAGA), but the differences are too small to materially affect the results of this analysis. Neither the MAGA map nor Nelson and Chomitz's map would be detailed enough to allow planning of specific mechanisms.

HEP producers are the easiest water users to map, as their location and installed generating capacity is well documented. Moreover, the number of such users is small – 17 in all, in highland Guatemala. The mean size of HEP WSAs is 70,000 ha, but there is considerable variation. The largest WSA, at over 0.5 million ha, serves the 300MW Chixoy plant. Three other WSAs cluster at about 100,000 ha, with one at just under 40,000 ha and all others smaller than 25,000 ha.

There are large number of domestic water supply systems in Guatemala, with as much as 70% of households having access to piped water (World Bank, 2004). These systems are operated by a wide variety of agencies, as Guatemala is the only Central American country that does not have a national public corporation that manages domestic water supply in most urban areas (Walker and Velásquez, 1999). Water service to the Guatemala City metropolitan area is provided mainly by the Municipal Water Firm of Guatemala City (EMPAGUA), while other urban areas are served by municipal governments, either directly or through public corporations, and rural areas are served by community based organizations (Foster and Araujo, 2004). We focused on urban water supply systems, using a cut-off of 1,000 households served, mainly due to data availability constraints. Data on the location of water intakes were obtained by contacting EMPAGUA and municipal governments directly. Usable data were obtained for EMPAGUA and for 47 municipal water supply systems. The WSAs serving domestic water supply systems tend to be small, with an average size of less than 11,000 ha. On average, these WSAs serve 1.08 households per hectare. The WSAs serving EMPAGUA are even smaller, with a mean size of 4,100 ha, but they serve 11.53 households per hectare on average.

Guatemala has a relatively small irrigated area of 130,000 ha (FAO, 2007) divided into private, state, and small-scale 'minirriego' systems. Documentation of water withdrawal and intake location of irrigation systems was even more limited than for domestic water supply. We focused on larger systems, with a minimum of 500 ha under irrigation. As with municipal water systems, most information was obtained by contacting water users directly. The WSAs serving large irrigation systems vary widely in size, with an average area of about 64,000 ha. On average, these WSAs serve 0.14 ha of irrigated area per upstream hectare.

Use of water by industrial users is very poorly documented. Moreover, these users were very reticent to provide information. Because of this, we were only able to gather data on a small proportion of all users, primarily coffee mills. The WSAs serving these mills have an average area of about 21,000 ha.

About 1.9 million ha in highland Guatemala have significant potential for development of PES mechanisms through the presence of significant downstream water uses, as shown in Figure 1. This area is under-estimated as we could only obtain data for a subset of all users. Individual water users would not willingly make conservation payments outside this area, as they would not benefit from them; likewise, a well-designed government-financed program that focused on water services would limit eligibility for payments to this area.

The potential for PWS within these areas varies, depending on factors such as the nature of the WSAs and the land use within them; the nature of the downstream users and their infrastructure; and the relative size of the use and its supply area. It is interesting to note that the highest value WSAs are not necessarily those with the largest downstream users, as these often have very large WSAs. The 300MW Chixoy HEP plant, for example, has a 545,000 ha WSA, which generates only 0.55KW/ha. The value of areas serving middle-sized users is often higher. Thus the highest-value HEP WSA, at 3.45KW/ha, is the 13,100 ha upper watershed of Río Las Vacas, which provides water to the 45MW Las Vacas plant. These differences are likely to have important effects on willingness to pay for conservation

6. Mapping biodiversity conservation priority areas

As a first approximation of the areas that are important for biodiversity conservation, we used the country's PA system. We combined maps of (a) formally declared protected areas; (b) areas of high biodiversity that are in the process of being declared protected areas (known as "areas of special protection"); and (c) a proposed extension of the PA system, including new PAs and biological corridors, developed by the Regional Environmental Program for Central America (PROARCA) based on a gap analysis of the existing PAs in the Mesoamerican Biological Corridor (MBC) (CCAD, 2005). We use the 2000 map of Guatemala's PAs prepared by PROARCA, which includes 94 PAs and 12 areas of special protection.[7] We also added a 3km buffer zone around all PAs that did not have a formal buffer zone. The resulting map of

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[7] PROARCA's map provides a more comprehensive coverage of Guatemala's PA system than the map currently available from the World Conservation Monitoring Centre's (UNEP-WCMC) World Database on Protected Areas (WDPA). There are minor discrepancies in the management categories of different PAs given in the PROARCA and WCMC maps. For instance, Laguna Lachuá national park is shown as a category I area in the PROARCA map but as a category II area in the WCMC map. Whenever such discrepancies arise, we use the PROARCA classification.

biodiversity conservation priority areas is shown in Figure 2. Formally declared PAs and areas of special protection cover just under 1 million ha. The additional PAs proposed by PROARCA cover 821,000 ha and their proposed biological corridors another 514,000 ha. Finally, the 3km buffer zone adds another 637,000 ha, for a total of 2.97 million ha.

There is no obvious value index for land that is of biodiversity importance. Here we use the World Conservation Union (IUCN)'s classification of protected areas as a crude ranking of importance (IUCN, 1994). IUCN has defined a series of six protected area management categories, based on primary management objective.[8] There are 5 category I areas covering 27,700 ha (3% of current PA area) in highland Guatemala, 5 category II areas covering 10,000 ha (1%), 6 category III areas covering 320,000 ha (32%), 7 category IV areas covering 24,100 ha (2%), 6 category V areas covering 4,300 ha (0.5%), 2 category VI areas covering 181,400 ha (18%), 25 areas categorized as buffer zones covering 158,000 ha (16%), and 38 areas without any category information (including the areas of special protection) covering 272,000 ha (27%).

7. Potential for payments for watershed services to contribute to biodiversity conservation

A comparison of Figures 1 and 2 shows that the overlap between WSAs and biodiversity conservation priority areas in highland Guatemala is only partial. Table 1 quantifies the extent of this overlap. Among the 998,000 ha of PAs, 246,000 ha (25%) are located inside WSAs. The PAs in the highest protection categories have relatively small shares of their area inside WSAs (10%). Category III areas have the largest area inside WSAs, 59,000 ha, although this accounts for only 19% of their area. Category IV areas have the greatest share of their area inside WSAs (65%). Unsurprisingly, the coastal category V areas have the smallest proportion of their area inside WSAs (6%). Thirteen PAs and their buffer zones covering 25,000 ha are fully or almost fully inside WSAs (Table 2). In addition, 153,000 ha (19%) of proposed PAs are located inside WSAs, as are 124,000 ha (24%) of the PROARCA corridor areas and 123,000 ha (19%) of buffer zones. In total, 523,000 ha (22%), of the total area of biodiversity conservation priority are located inside WSAs. Thus between a fifth and a quarter of biodiversity conservation priority areas are located inside areas with potential for receiving PWS.

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[8] IUCN's protected area categories are: Ia: Strict Nature Reserve (managed mainly for science); Ib: Wilderness Area (managed mainly for wilderness protection); II: National Park (managed mainly for ecosystem protection and recreation); III: Natural Monument (managed mainly for conservation of specific natural features); IV: Habitat/Species Management Area (managed mainly for conservation through management intervention); V: Protected Landscape/Seascape (managed mainly for landscape/seascape conservation and recreation); and VI: Managed Resource Protected Area (managed mainly for the sustainable use of natural ecosystems).

Figure 2 extends the analysis by examining the distribution of PA areas that are inside WSAs according to their relative potential for payments. As mentioned above, for each WSA we constructed an index of value by dividing a measure of the downstream use (such as installed capacity for HEP, or households served for domestic supply systems) by the area of the WSA. We then divided the WSAs into three groups, according to whether they are in the lowest, middle, or highest tercile in terms of value per hectare to their respective users. All else equal, the potential for payments is likely to be higher, in terms of both interest in participating in a PWS program and in the amounts of payment offered, in high-value than in low-value WSAs.[9] Figure 3 shows what proportion of each category of biodiversity conservation priority area is located in high, medium, and low-value WSAs. In general, most categories are located in a mix of areas, except for the small terrestrial segment of the category V (coastal and marine) PAs, which by chance happen to be located fully inside high-value WSAs. Category III PAs have the greatest share of their area inside high-value WSAs, and category VI the lowest. Overall, about a third of the biodiversity conservation priority area is located inside high value WSAs, and about a quarter inside low value WSAs, with the remainder in medium value WSAs.

The area of the Sierra de las Minas Biosphere Reserve illustrates the potential and limitations of PWS support to biodiversity conservation (Figure 4). The Reserve, which covers 236,000 ha, lies atop the Sierra de las Minas mountain range. It includes a variety of ecosystems, including the largest remaining area of cloud forest in Central America, and is home to many endemic species (Lenhoff and Núñez, 1998; Secaira *et al*., 2000). To the south of the mountain range, the Motagua River valley has a large concentration of high-value water users, including several HEP plants (with more planned), large commercial irrigation systems, agro-industrial producers, and several bottlers (including Coca Cola, Pepsi Cola, and several beer and rum producers). These users draw their water either from surface sources flowing south from the Sierra de las Minas, or from groundwater fed from the same area. There is clearly substantial potential to develop PWS mechanisms in this area, although problems of collective action are likely to arise. Indeed, Worldwide Fund for Nature (WWF) is working with *Defensores de la Naturaleza* to develop a Water Fund in the Motagua and Polochic valleys that drain from the Sierra de las Minas Biosphere Reserve. Conversely, the northern slope of the Sierra, which

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[9] As can be seen in Figure 1, WSAs for different water uses sometimes overlap. When the two WSAs are of different value, we use the higher-value category.

drains to the Río Polochic, has a much lower potential for PES, as the only water user of any size is a coffee mill, which draws its water from a small water supply area. Although there is a sizable population on this slope, their use is dispersed, making them relatively poor prospects for the development of PES mechanisms. The Water Fund being developed, therefore, would likely be only a partial solution to the conservation financing problems of the Reserve.[10]

8. Discussion

The research presented in this paper represents the first systematic attempt to assess the potential for payments for water services at close to national scale. By comparing the results of this assessment to areas of biodiversity conservation priority, we are able to assess the potential for PWS to contribute to protecting biodiversity. Overall, the results show that this potential varies substantially within the country, with some biodiversity conservation priority areas having very good potential for receiving PWS, and others little or none. Overall, about a quarter of all biodiversity conservation priority areas have potential for receiving PWS. Thus PWS is far from being a silver bullet for biodiversity conservation, but it can make a meaningful contribution to this objective.

Several caveats are in order. First, the estimate of potential for PWS is high, as it is unlikely that mechanism can be developed in all cases in which there is a potential to do so. PWS mechanisms may not emerge in any given case for a variety of reasons (Pagiola and Platais, 2007): there may be insufficient understanding of land use-water service relationships; the expected benefits of conservation activities may be insufficient relative to their cost (either because costs are high of because benefits are low); transaction costs may be excessive (for example, because of dispersion and small size of individual providers); it may prove impossible to arrive at an agreement for water users to pay for conservation (for example, when the presence of multiple users creates incentive to free ride); or it may not be possible to enter into conservation contracts with upstream land users (for example, if land tenure is insecure or conflictual). Even with a vigorous program to develop PWS mechanisms, therefore, the contribution to biodiversity conservation will remain below its potential.

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[10] Fortunately, the area's high profile has enabled it to attract other support, including a share of a US$24 million debt-for-nature swap with the US government that was facilitated by The Nature Conservancy in 2006. Other areas may not be so fortunate.

Second, even where PWS mechanisms can be established, they will not necessarily provide a high level of biodiversity conservation benefits. The degree of biodiversity benefits will depend on the specific land uses being supported by PWS. In most cases, PWS programs support land uses such as forest protection and reforestation, which can be expected to be benign with respect to biodiversity. In some cases, however, a PWS program may encourage land uses which do not have large biodiversity benefits. In Yamabal, in northwestern El Salvador, for example, payments finance the maintenance of conservation structures in an agricultural landscape, so as to facilitate infiltration to the source that serves that community (Pagiola and Platais, 2007). These measures probably provide no significant biodiversity benefits; though at least they are also unlikely to make things worse. In general, PWS programs that preserve existing ecosystems are likely to have the greatest positive impact on biodiversity, along with those which restore ecosystems that have been degraded. PWS programs that encourage the substitution of one agricultural land use by another are likely to have lower benefits, although it is hard to imagine a situation in which they could make things worse.[11]

Thus even if PES mechanisms are developed in all WSAs, substantial gaps will remain in funding for biodiversity conservation, either because no payments are possible in a given area, or because of a local mismatch between the activities required to preserve water services and those required to preserve biodiversity.

Carbon finance may help fill some of this finacing gap in some instances. Most demand for carbon sequestration services comes from firms needing to comply with obligations under the Kyoto Protocol or national laws (Capoor and Ambrosi, 2008). This market is subject to substantial restrictions. Under the Kyoto Protocol's Clean Development Mechanism (CDM), for example, only reforestation and afforestation are eligible, and even then under complex rules. Other programs, such as the European Union's Emissions Trading Scheme (ETS), bar land use based activities entirely. There is also growing demand from firms and individuals seeking to reduce their carbon footprint for ethical or other reasons. This second ('voluntary' or 'retail') market has no restrictions, but generally pays substantially less. It has grown substantially in recent years, although it remains to be seen whether this trend persists under current economic

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[11] In theory, it is possible that some PWS could endanger biodiversity. If the over-riding objective in a particular case were to increase total water yield from a watershed, then reducing forest cover might be one way of achieving this (Bruijnzeel, 2004). Total water yield is rarely the main concern, however; dry season flow or water quality are much more common concerns (Pagiola and Platais, 2007). In any case, as deforestation is illegal in most countries, such a PWS mechanism is unlikely to be implemented.

conditions. In the short term, the voluntary market is the only realistic outlet for land use based emissions reductions, as it is too late to begin new CDM-eligible projects. In terms of biodiversity impact, the greatest potential would come if reduced emissions from avoided deforestation (REDD) were to be accepted as a form of carbon sequestration eligible to participate in carbon markets.

Finally, one should be aware of the potential for leakage, for conservation efforts at one site to displace damaging activities to other sites, either directly (for example, a PWS recipient clearing one plot of land to substitute for another under conservation contract), or indirectly (for example, if maintaining forest results in higher crop prices due to the reduced availability of cropland, which induces additional deforestation elsewhere). Should leakage occur, the biodiversity benefits from PWS sites may be offset by increased damage at other, non-PWS sites. How big a problem depends on where the adverse land uses are displaced to; if they are displaced to areas of low biodiversity conservation priority, the benefit might still be substantial even if leakage occurs. The limited available evidence collected to date, however, indicates that leakage has not been a significant problem in most existing PES programs (Wunder *et al.*, 2008).

Even bearing these caveats in mind, watershed payments can make an significant contribution to biodiversity conservation in areas like highland Guatemala. Mapping exercises such as those we conducted can help to realize this potential by identifying areas that are important for biodiversity conservation and have a high potential for PWS, thus allowing conservation efforts to be targeted. About a third of the biodiversity conservation priority area is within WSAs with particularly high potential for PWS; these areas would be natural targets for such efforts.[12]

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[12] The converse situation of WSAs being fully or almost fully contained within a PA is also potentially interesting. Although in this situation water payments could help conserve only part of the PA, they might be especially easy to arrange as the transaction costs of negotiating and then implementing payments would be low, given that a single ‘provider’ is involved (the PA itself). This does not apply, however, to cases in which there are substantial populations living within the PA.

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Table 1: Overlap between biodiversity conservation priority areas and water supply areas in highland Guatemala

	Inside water supply areas		*Outside water supply areas*		*Total*
Type of biodiversity priority areas	*('000 ha)*	*(%)*	*('000 ha)*	*(%)*	*(ha)*
Protected areas					
Category I	2.5	9.2	25.1	90.8	**27.7**
Category II	1.2	11.6	8.9	88.4	**10.0**
Category III	59.2	18.5	261.0	81.5	**320.1**
Category IV	15.6	64.7	8.5	35.3	**24.1**
Category V[a]	0.3	6.0	4.1	94.0	**4.3**
Category VI	50.3	27.7	131.1	72.3	**181.4**
Formal buffer zone	152.9	18.6	668.2	81.4	**821.1**
Uncategorized and special protection	62.8	23.1	209.2	76.9	**272.0**
Total protected areas	**246.0**	**24.6**	**752.1**	**75.4**	**998.1**
PROARCA proposed protected areas	54.2	34.2	104.3	65.8	**158.5**
PROARCA proposed corridors	122.6	19.3	514.1	80.7	**636.7**
3km buffer zone	124.3	24.2	389.6	75.8	**513.9**
Total biodiversity conservation priority	**645.8**	**21.7**	**2,324.0**	**78.3**	**2,969.8**

Notes: [a] includes only the terrestrial portion of coastal and marine protected areas.

Source: Authors' calculations.

Table 2: Protected areas fully or almost fully inside water supply areas

Protected area (IUCN category)	*Area (ha)*	*Value of WSA*
Fully inside WSA		
El Espino (V)	255	Low
Laguna de Ayarza (not defined)	1,408	Low
Laguna el Pino (I)	500	High
Los Altos de San Miguel Totonicapán (IV)	3	
Volcán Agua (not defined)		
Core zone	9,725	High
Buffer zone	3,747	High
Volcán Cerro Redondo (not defined)		
Core zone	39	High
Buffer zone	335	High
Volcán Coxliquel (not defined)		
Core zone	746	High
Buffer zone	943	High
Volcán Cruz Quemada (not defined)		
Core zone	146	Low
Buffer zone	731	Low
Volcán Jumaytepeque (not defined)		
Core zone	115	Medium
Buffer zone	732	Medium
Zunil (IV)	468	High
Partially inside WSA		
Mario Dary (II)	1,159	High
Parque Regional Municipal de Quetzaltenango (IV)	772	High
Volcán Santo Tomás (not defined)	3,150	High

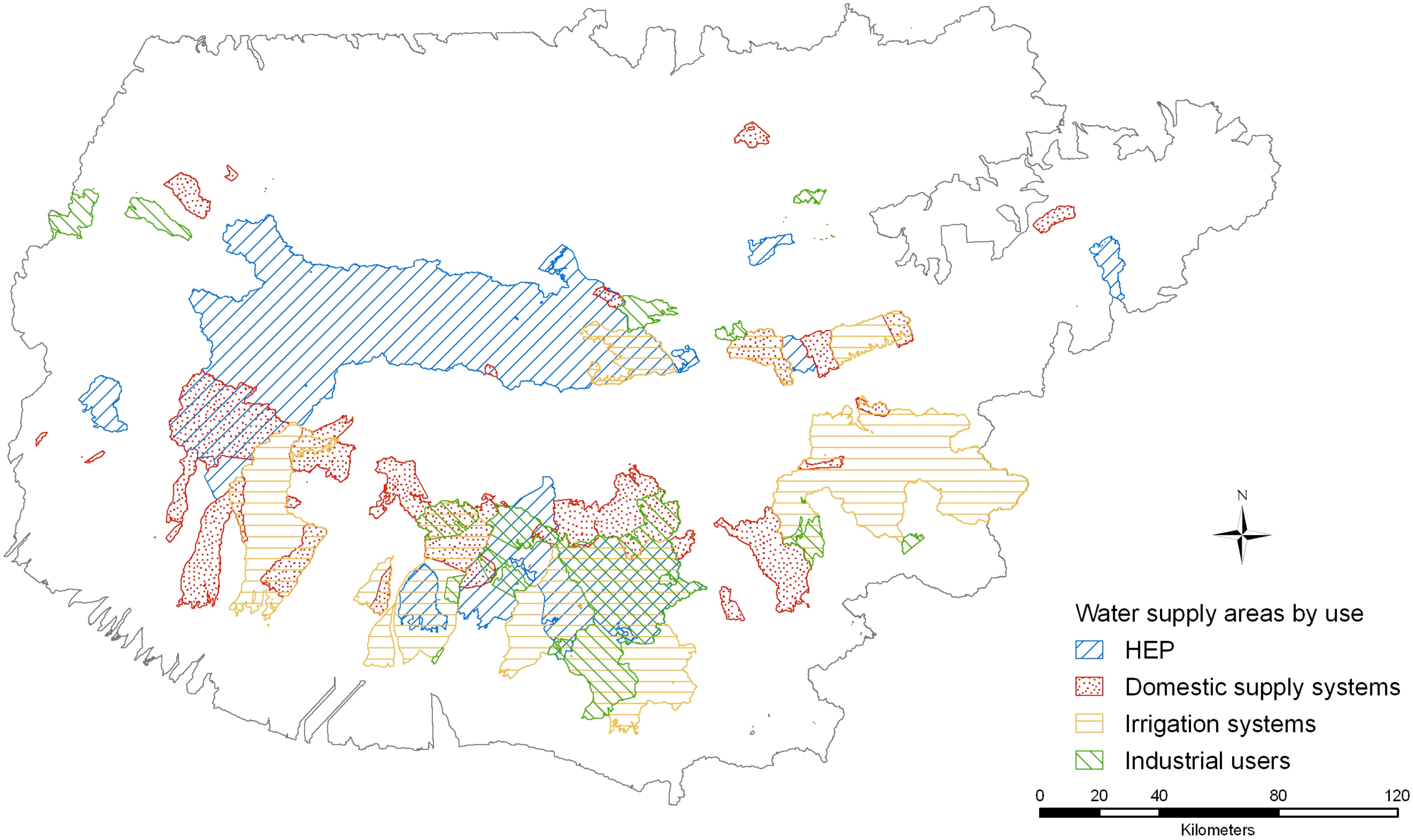

Figure 1: Water supply areas by major use

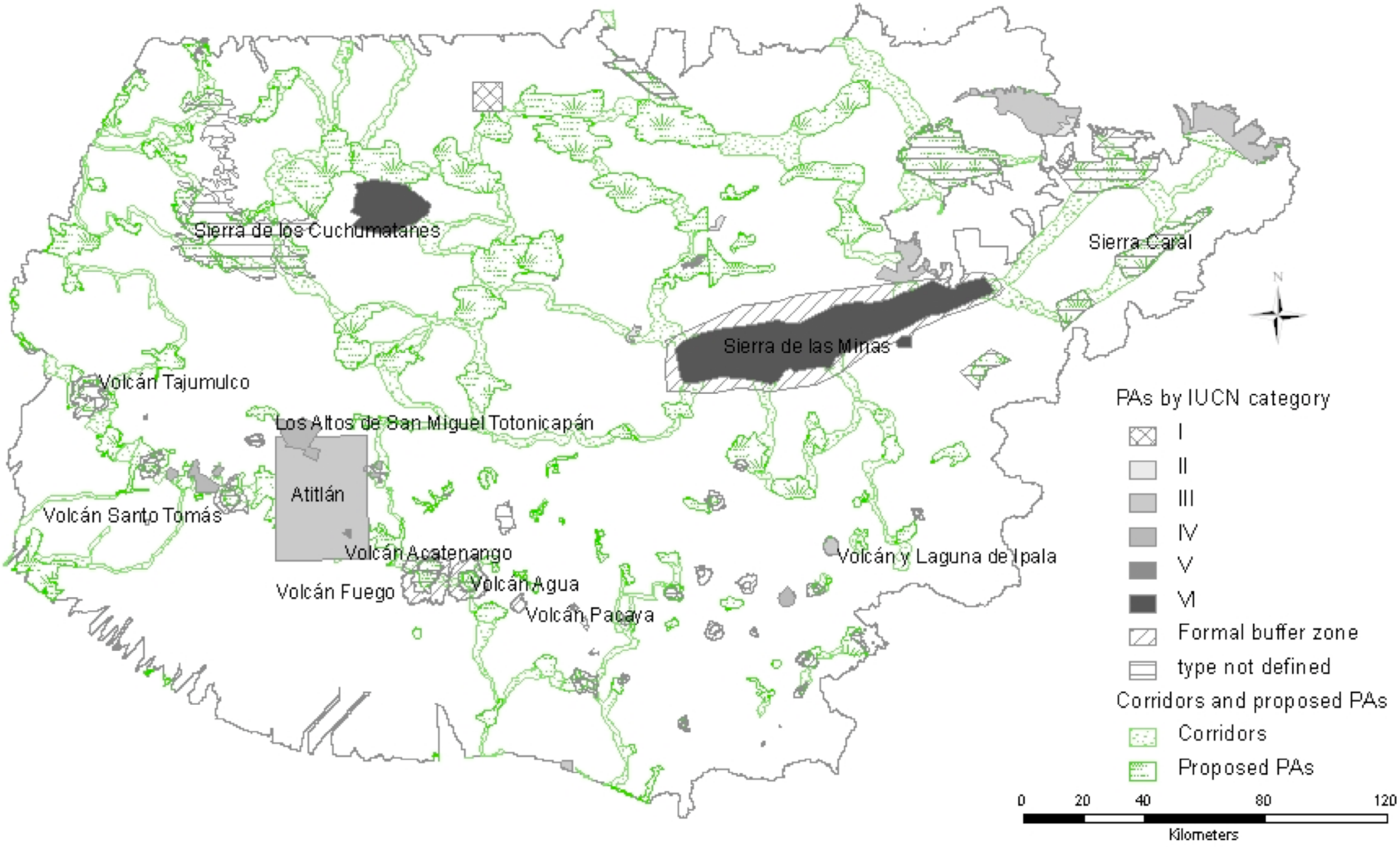

Figure 2: Biodiversity priority areas in Guatemala

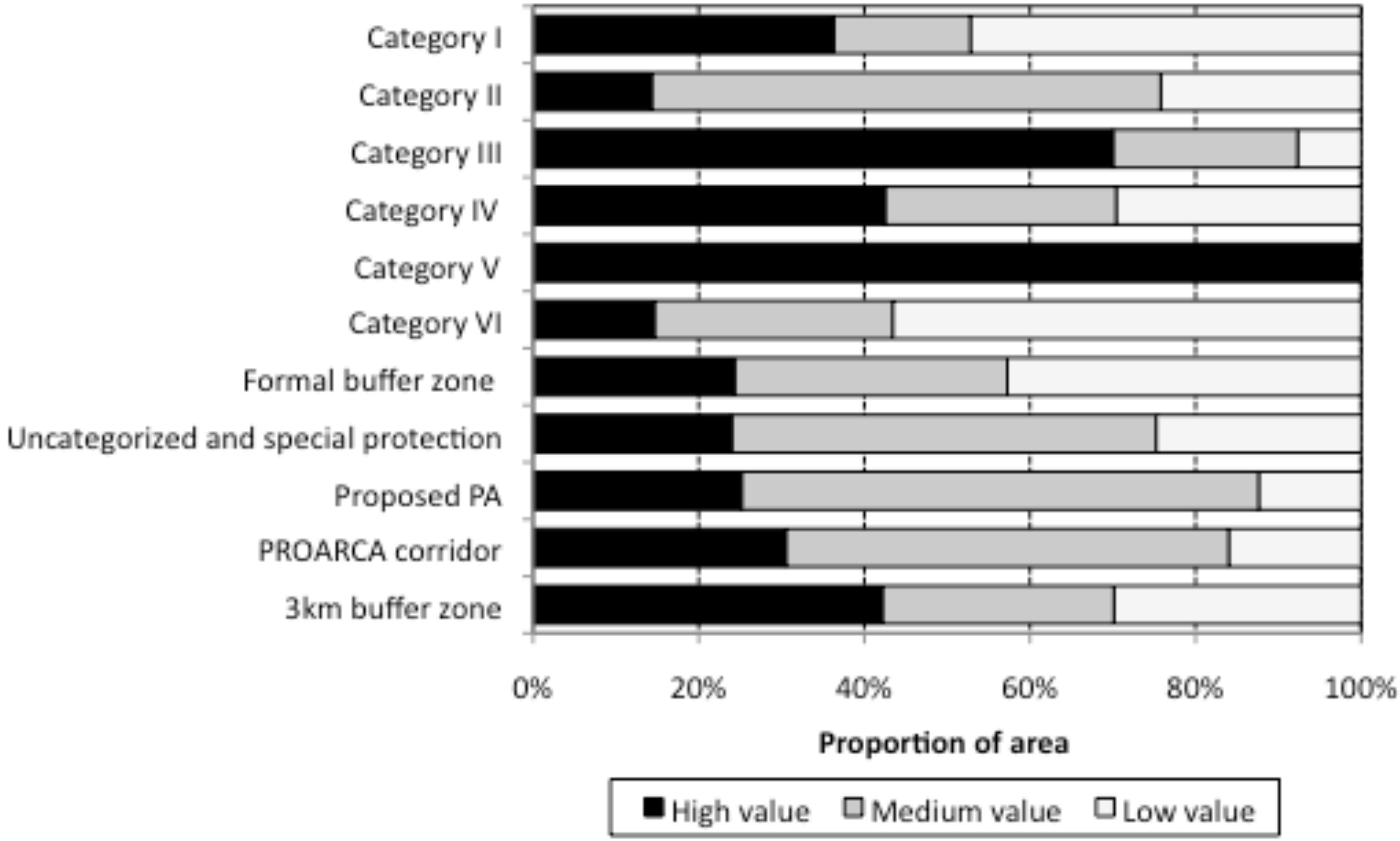

Figure 3: Distribution of biodiversity conservation priority area inside WSAs according to the relative value of WSAs

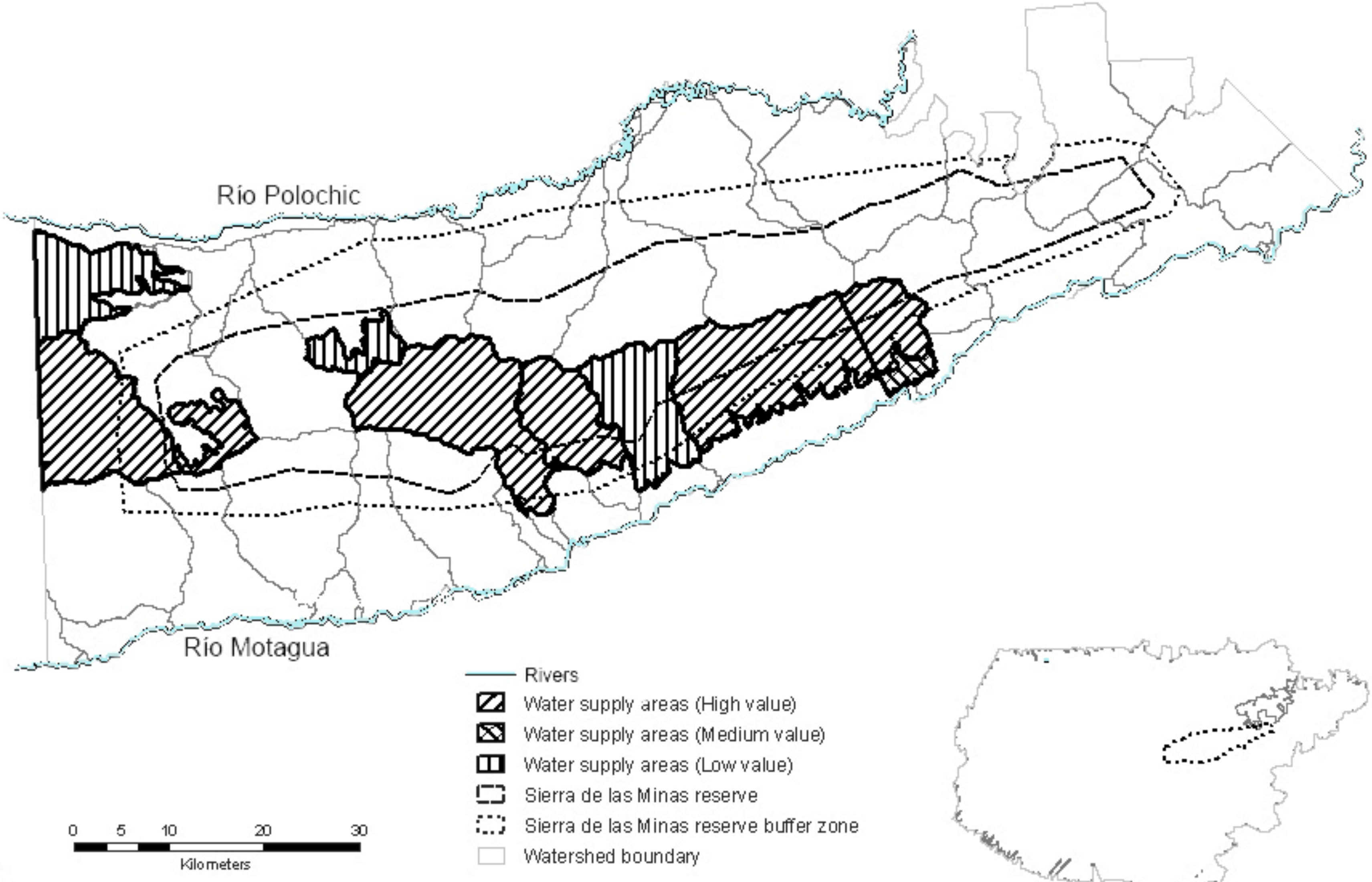

Figure 4: Water supply areas near the Sierra de las Minas Biosphere Reserve