Identifying priority areas for ecosystem services management in South Africa

Benis Egoh [A], Belinda Reyers [B], Mathieu Rouget [C], Patrick O'Farrel [B], David Le Maitre [B] and Richard Cowling [D]

[A] European Commission – Joint Research Centre, Water resources Unit, Institute for Environment and Sustainability, Via E. Fermi, 2749, I-21027 Ispra (VA), Italy
[B] The Council for Scientific and Industrial Research (CSIR) PO Box 320, Stellenbosch, 7599 South Africa
[C] University of KwaZulu-Natal. Private Bag X01, Scottsville 3209, South Africa
[D] Department of Botany, Nelson Mandela Metropolitan University, PO Box 77000, Port Elizabeth 6031, South Africa
Contact email: benis.egoh@jrc.ec.europa.eu

Abstract. Studies have highlighted the importance of managing ecosystem services to stop further degradation and transformation, yet very few studies have endeavored to identify priorities. The identification of priority areas for ecosystem services remains the least of objective for all studies that have mapped ecosystem services. Steps for identifying priority areas for management of ecosystem services include identifying features that supply ecosystem services, threats to service provision, potential actions to ensure future supply of service and cost of these actions as well as the availability of alternative means of providing benefits supplied by the service, the capacity to meet human demands and scale and site dependency of service. We present examples of the inclusion of ecosystem services in spatial planning in South Africa including quantifying conservation features and threats, as well as implementation issues. The prioritization of areas for ecosystem services management is still in its infancy. At present, spatial planning for ecosystem services is mostly coupled with biodiversity, but ecosystem services deserve to be conserved on their own right through conservation actions specifically designed for ecosystem services. The identification of priorities for such conservation action faces many challenges.

Keywords: Ecosystem management, priority areas, conservation features and threats.

Introduction

More than 60% of ecosystem services around the world have either been degraded or transformed according to the millennium assessment and report from the world resource institute (WRI 2001; MA 2005). Other studies have demonstrated substantial (20%–50%) declines across ecosystem services as a result of land-cover change (Reyers *et al.* 2009). These studies have highlighted the importance of managing ecosystem services to stop further degradation and transformation. Following the MA, scientific studies on ecosystem services have increased dramatically (Costanza and Kubiszewski 2012). Some of these studies have generated maps of biophysical quantities of ecosystem services at global (Tuner *et al.* 2007; Naidoo *et al.* 2008), national (Egoh *et al.* 2008) and local scale (Reyers *et al.* 2009). Others have looked at the impact of policies on ecosystem services using different scenarios (Swetnam *et al.* 2011) or congruence with biodiversity (Chan *et al.* 2006; Egoh *et al.* 2009). Although the ultimate aim of all these studies is to reduce degradation and transformation, very few studies have endeavored to identify priorities areas for conservation action (Egoh *et al.* 2012a; Luck *et al.* 2012) a major strategy employed in biodiversity conservation. The advantage of identifying such priorities is that conservation or management efforts could be focused in such areas to reduce degradation and maximize the production of ecosystem services.

Identification priority areas for ecosystem management is a common phenomenon in biodiversity conservation, used to direct funding or to implement other conservation actions such as the establishment of protected areas or restoration based on the fact that bringing an end to global biodiversity loss requires that limited available resources be guided to those regions that need it most (Margules and Pressey 2000; Mittermeier *et al.* 2011). Conservation planning, a sub-discipline of conservation biology which seeks to identify priority areas for conservation action is well developed (Sakar *et al.* 2006). Conservation planning has several steps and includes, the identification of conservation features, setting targets or goals, review the extent to which conservation areas meet goals and prioritize areas for conservation (Margules and Pressey 2000). Several conservation plans have been developed across the world (Egoh *et al.* 2007). The challenge in conservation planning is the implementation of identified priorities (Knight *et al.* 2008). Ecosystem services have been identified as having the potential to improve the implementation crisis if humans understood the importance of biodiversity in supporting human wellbeing (Chan *et al.* 2006; Reyers *et al.* 2005). Consequently, ecosystem services are now been included in many conservation policies, notably the CBD biodiversity strategy for 2020 (http://www.cbd.int/).

While much work has been done in generating biophysical information on ecosystem services, not much

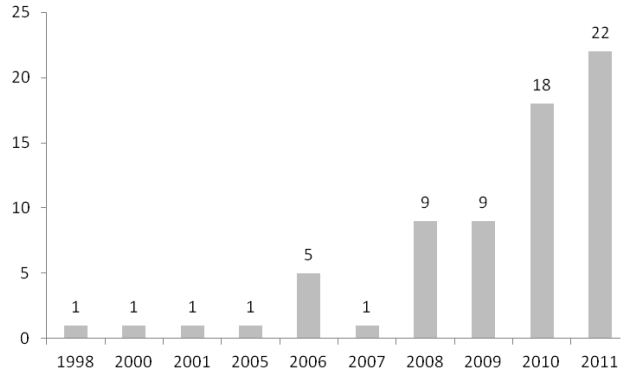

Figure 1. Number of publication per year that mapped ecosystem services (Egoh *et al.* 2012a).

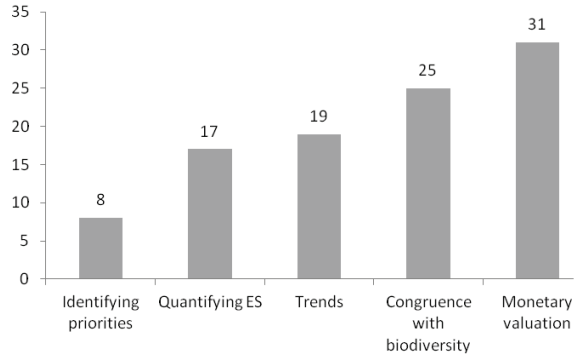

Figure 2. Rational for mapping ecosystem services between 1998 and 2011 (%) (Egoh *et al.* 2012a).

has been done in using this information to identify priorities for conservation action. A recent review by Egoh *et al.* (2012a) on studies that have mapped ecosystem services from 1998 until 2011 showed that research on ecosystem services has grown in the past decade (Fig. 1). However, the identification of priority areas for ecosystem services remains the least of objective for all studies that have mapped ecosystem services. Of the 68 studies included in the review, only 8% had as an objective to identify priority areas for ecosystem services whereas a third of the studies had as objective to assign monetary values and another 25% aimed at evaluating congruence with biodiversity (Fig. 2).

Luck *et al.* (2012) has identified the essential step for identifying priority areas for management of ecosystem services. These includes, identifying features that supply ecosystem services, threats to service provision, potential actions to ensure future supply of service and cost of these actions. Since ecosystem services has to do with human use, the authors included additional considerations such as the availability of alternative means of providing benefits supplied by the service, the capacity to meet human demands and scale and site dependency of service. The complexity of such a procedure is evident given limitation in data availability and methodology for generating such information. The few studies that have identified priority areas for management of ecosystem services, have mostly considered supply (Chan *et al.* 2006; Egoh *et al.* 2011; Luck *et al.* 2012) and or demand (*e.g.* see van Jaarsveld *et al.* 2005).

Examples of the inclusion of ecosystem services in spatial planning in South Africa

The inclusion of ecosystem services in spatial planning (*e.g.* conservation planning) depend in most instances on the rational of the study. In some cases, the inclusion of ecosystem services in biodiversity plans is being explored and congruence between the two is assessed. Typical examples of such studies include Egoh *et al.* (2010) and Chan *et al.* (2006). Egoh *et al.* (2010) used data on five ecosystem services to examine the extent to which ecosystem services could be included in a conservation plan in the little Karoo of South Africa. The authors found that at least 40% of the ecosystem services are captured by meeting only target for biodiversity. This study suggests that if the right ecosystem services are targeted, a substantial amount of ecosystem services could be captured in a conservation plan for biodiversity. However, ecosystem services deserved to be conserved by their own right and targets could be set for ecosystem services as well as biodiversity if included in one plan.

In other instances, priorities for ecosystem services are identified and overlaps with biodiversity priorities are assessed to find areas where ecosystem services could be used to make a case for biodiversity. Two examples here include O' Farrell *et al.* (2011) and Reyers *et al.* (2005) where priorities for ecosystem services were identified in the succulent Karoo and grasslands of South Africa, respectively. In both studies, priorities were identified for biodiversity separate from ecosystem services. In the grassland program, Reyers *et al.* (2005) identified priorities for fresh water biodiversity, terrestrial biodiversity and ecosystem services. The authors overlaid the biodiversity priorities and those of ecosystem services to evaluate where ecosystem services could be used to make a case for biodiversity. The ecosystem services included in this study were mostly those particularly produced by grasslands (*e.g.* water, grazing and soil services). In the second study, O' Farrell *et al.* (2011) identified ecosystem services that were important in the succulent Karoo and overlaid them with already identified biodiversity priorities. They then described for each biodiversity priority, which ecosystem services could be used to make a case for biodiversity. Here again, mainly ecosystem services that were important and provided in the Karoo were included (*e.g.* Tourism and ground water). In instances where the objective is to use ecosystem services to make a case for biodiversity conservation, simple overlap studies might suffice and ecosystem services particular to the area where biodiversity exist could be considered.

In the last example, priorities for ecosystem services are used together with human capital and poverty data to identify areas where payment for ecosystem services could be developed that would benefit local people and as a poverty alleviation strategy (Blignaut *et al.* 2008; Rouget *et al.* 2009). In the study, Blignaut *et al.* (2008) used ecosystem service maps developed by Egoh *et al.* (2008) and overlaid them with poverty and population data in South Africa. Areas with the highest priority are those with high ecosystem services provision, high population and high poverty. A quick look at the maps of population

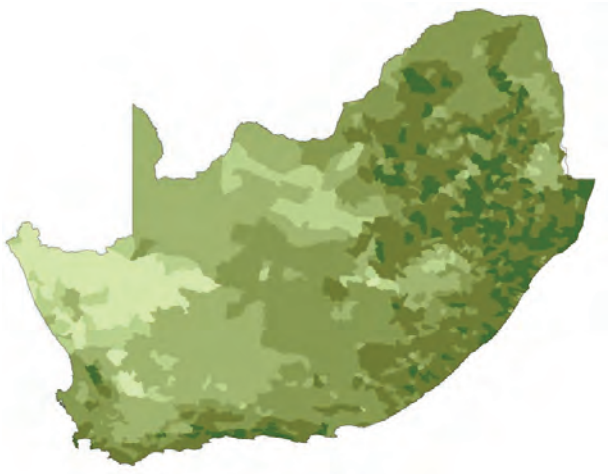

Figure 3. Map of ecosystem service richness in South Africa. The darker areas have the highest ecosystem services.

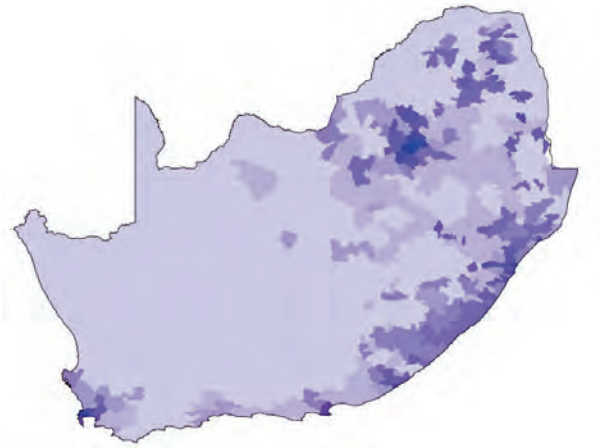

Figure 4. Number of people per Km^2 in South Africa. The darker areas are the most populated.

density and ecosystem service richness suggest that there could be some congruence between the two with the central northern, southern most areas and the eastern regions being high in both ecosystem services richness and population density.

Challenges in identifying priorities for ES

If the procedure for identifying priorities for ecosystem services proposed by Luck *et al.* (2012) is anything to go by, many challenges remain. Below we discuss three main challenges on prioritizing areas for ecosystem services management.

Quantifying conservation features: Processes and pattern

In identifying priority areas for biodiversity conservation, it is common practice to include both biodiversity features that represent pattern and process (Rouget *et al.* 2006). Ecological processes are the key to sustaining biodiversity and ensuring its long term existence. The need to include such processes in conservation plans, has been emphasized with ecological processes such as sand movement corridors (*e.g.* inland movement of marine sands and associated soil development) and micro climatic gradients (important for the geographic diversification of plant and animal lineages and the migration of biota) being mapped and included in plans (Rouget *et al.* 2003). It is also important to understand the ecological processes that underpin ecosystem service delivery and to capture these processes in conservation plans if possible. For example, if particular species of fish, birds or mammals, provide recreational services, focusing conservation efforts on the location where these organisms are found without understanding basic processes such as migration that underpin the existence of these animals, may not guarantee the continuous existence of these organisms for future recreational activities. In the same light, focusing conservation effort in locations where we have portable water may fail to continue to deliver water supply services, unless we understand the process by which such water is made available. Depending on the type of services included in the conservation plan, both the process and the pattern might be captured. For example, if water regulating services are included together with water supply or forest cover included together with soil fertility, it is possible that both the pattern and the process have been captured. While maps of ecosystem services have been produced, the distinction between pattern and processes in prioritization procedure still has to be made.

Quantifying threats

Most biodiversity conservation plans includes threats to biodiversity as a criteria for identifying priorities. Some threats include land use (*e.g.* agricultural expansion, mining and urbanization), climate change and invasive alien species. Interestingly, most of what we call ecosystem services today has often been treated as threats in biodiversity conservation plans. A typical example is grazing of animals (now coined as fodder provision) (Reyers *et al.* 2009). While threats to biodiversity have been immensely researched and are easy to identify and include in a conservation assessment, those for ecosystem services are not necessarily well researched. In many instances, threatened processes are the same as the ecosystem services themselves. In the example above, the grazing of animals is regarded as an ecosystem service because nature provides fodder to livestock which are used by humans as a source of protein. However, when there is an over exploitation of this resource, it becomes a threat to the service provided. Unsustainable grazing (*e.g.* overstocking of animals beyond recommended carrying capacity) is not considered an ecosystem service but a threat. The aspect of sustainability becomes very important. The challenge is identifying thresholds beyond which humans activities become a threat to the provision of the service. Examples include, to what extent does water abstraction becomes a threat or to what extent does recreational activities become a threat to the service provision. There has been some research on the effects of human use on biodiversity and there are many studies on the effect of tourism or some recreational activities on biodiversity (Pickering and Hill 2007). As ecosystem services are mostly provided by biodiversity, an important starting point is to understand the effects of know threats to biodiversity (*e.g.* climate change, land use changes, fragmentation or alien species) on various ecosystem services. Many threats exist for ecosystem services and include, climate change, poverty, and land tenure situation, just to name a few.

Implementation issues

The first challenge in implementing a conservation plan for ecosystem services is choosing the type of implementation procedures to follow. If, it is a large scale study with the sole aim of directing funding for management on the ground (as has been the case for some biodiversity plans; see Margules and Pressey 2000), then implementation could be straight forward. The areas with the most ecosystem services get the highest budget for managing those areas to prevent loss and to improve on service provision. However, if the aim is to implement management on the ground, it might need some thoughts. The majority of conservation plans are developed for the establishment of protected. In the case of ecosystem services, the establishment of protected areas might not be the appropriate implementation option. This is because the value of ecosystem services is in their use and protection may contradict the use aspect of ES. However, this challenge could be overcome depending on the type of ecosystem services and the type of protection. Egoh *et al.* (2012b) proposed the establishment of protected areas which allows some use such as conservancies. This type of protected areas could be useful especially for provisioning services such as fuel wood collection, grazing and even water supply.

The second major implementation challenge for an ecosystem services plans, is the fact that most ecosystem services are not congruent with each other. A single management plan may not benefit all services, since there are often tradeoffs between services (Maes *et al.* 2012; Reyers *et al.* 2009). It might be worth bundling services according to compatibility in management recommendations and having a separate plan for each bundle. For example, a few studies have shown positive correlation amongst water regulating services, soil protection and accumulation and carbon sequestration (Maes *et al.* 2012). These services mostly improved by maintaining vegetation in natural state, could be included in a single plan, while services that can tolerate some level of degradation (*e.g.* crop provision, fodder provision and other services associated with extractable resources) could be bundled together in one plan. Management plans can therefore be drawn for the two separate priorities and appropriate resources allocated. Nevertheless much research is needed in identifying appropriate bundles and examining each outcome from particular management practices. Such bundles could be based on ecosystem services relevant in the country or study area and the potential of managing them together. In South Africa, the ecosystem services relevant and of interest are mostly water, grazing and tourism.

A third implementation challenge may be the fact that different government organizations have responsibilities for different ecosystem service. For example, in South Africa, water resources are usually governed by the water sector while agricultural resources are under the responsibility of the agricultural sector. If priorities are identified for ecosystem services that cut across different governing bodies, it might be a challenge to get these bodies organized to implement the plan. In the case for biodiversity, the implementation is carried out by nature conservation organizations (*e.g.* Cape Nature for Western Cape, South Africa). In contrast, for ecosystem services, water is governed by Ministry of Water Affairs, agriculture by Ministry of Agriculture, Forestry and Fisheries, tourism by Ministry of Tourism. In many instances, these organizations manage these resources to maximize benefits without necessarily considering sustainable use.

Conclusion

The prioritization of areas for ecosystem services management is still in its infancy. At present, spatial planing for ecosystem services is mostly coupled with biodiversity by assessing congruence with biodiversity. However, ecosystem services deserve to be conserved on their own right through conservation actions specifically designed for ecosystem services. The identification of priorities for such conservation action faces many challenges.

References

Blignaut J, Marais C, Rouget M, Mander M, Turpie J, Preston G, Philip K, Du Plessis L, Klassen T, Tregurtha N (2008). Making markets work for people and the environment. Research paper commissioned by the Second Economy Strategy Project, an initiative of the Presidency.

Chan KMA, Shaw MR, Cameron DR, Underwood EC, Daily GC (2006) Conservation planning for ecosystem services. Public Library of Science Biology DOI:10.1371/journal. pbio. 0040379.

Costanza R, Kubiszewski I (2012) The authorship structure of "ecosystem services" as a transdisciplinary field of scholarship. *Ecosystem Services* **1**, 16-25.

Egoh BN, Drakou EG, Dunbar MB, Maes J, Willemen L (2012a).Indicators For Mapping Ecosystem Services: A Review. EUR 25456 EN. Publication Office of the European Union, Luxembourg JRC73016.

Egoh B, O'Farrell PJ, Koellner T, Charef A, Gurney LJ, Abi HN, Egoh M, Willemen L (2012b) An African account of ecosystem service provision: use, threats and policy options for sustainable livelihoods. *Ecosystem Services* **2**, 71-81

Egoh, BE, Reyers B, Carwardine J, Bode M, O'Farrell PJ, Wilson KA, Possingham HP, Rouget M, de Lange W, Richardson DM, Cowling RM (2010) Safeguarding biodiversity and ecosystem services in the Little Karoo, South Africa. *Conservation Biology* **24**, 1021-1030

Egoh B, Reyers B, Rouget M, Bode M, Richardson DM (2009) Spatial congruence between biodiversity and ecosystem services in South Africa. *Biological Conservation* **142**, 553–562.

Egoh B, Reyers B, Rouget M, Richardson DM, Le Maitre DC, Van Jaarsveld AS (2008) Mapping ecosystem services for planning and management. *Agriculture, Ecosystems and Environment* **127**, 135–140

Egoh B, Rouget M, Reyers B, Knight AT, Cowling MR, van Jaarsveld AS, Welz A (2007) Integrating ecosystem services into conservation assessments: a review. *Ecological Economics* **63**, 714–721.

Knight AT, Cowling RM, Rouget M, Balmford A, Lombard AT, Campbell BM (2008) Knowing but not doing: selecting priority conservation areas and the research-implementation gap. *Conservation Biology* **22**, 610–617

Luck GW, Chan KMA, Klein CJ. (2012).Identifying spatial priorities for protecting ecosystem services. *F1000Research* **1**, 17

Maes J, Paracchini ML, Zulian G, Dunbar MB, Alkemade R (2012) Synergies and trade-offs between ecosystem service supply, biodiversity, and habitat conservation status in Europe. *Biological Conservation* **155**, 1–12

Margules CR, Pressey RL (2000) Systematic conservation planning. *Nature* **405**, 243–253

Mittermeier R A, Turner W R, Larsen FW, Brooks TM, Gascon C, Zachos FE, *et al* (2011) Global biodiversity conservation: the critical role of hotspots. pp. 3–22. In: FE Zachos, JC Habel eds. Biodiversity hotspots: distribution and protection of conservation priority areas. Springer Berlin, Heidelberg.

Naidoo R, Balmford A, Costanza R, Fisher B, Green RE, Lehner B, Malcolm TR, Ricketts TH (2008) Global mapping of ecosystem services and conservation priorities. *Proceedings of the National Academy of Sciences of the USA* **105**, 9495–9500.

O'Farrell PJ, Reyers B, Le Maitre DC, Milton SJ, Egoh B, Maherry A, Colvin C, Atkinson D, De Lange W, Blignaut J, Cowling RM (2010) Multi-functional landscapes in semiarid environments: implications for biodiversity, ecosystem services, and beneficiaries. *Landscape Ecology* **25**, 1231–1246

Pickering CM, Hill W (2007) Impacts of recreation and tourism on plant biodiversity and vegetation in protected areas in Australia. *Journal of Environmental Management* **85**, 791–800

Reyers B, Nel J, Egoh B, Jonas Z, Rouget M (2005) National Grasslands Biodiversity Program: Grassland Biodiversity Profile and Spatial Biodiversity Priority Assessment CSIR Report Number: ENV-S-C e 102

Reyers B, O'Farrell PJ, Cowling RM., Egoh BN, Le Maitre D, Vlok JH (2009) Ecosystem services, land cover change, and stakeholders: finding a sustainable foothold for a semi-arid biodiversity hotspot. *Ecology and Society* **14**, 1-27.

Rouget M, Blignaut J, Egoh B (2010) Creating markets for ecosystem services. *South African Journal of Botany* **76**, 415

Rouget M, Cowling RM, Lombard AT, Knight AT, Kerley G H (2006) Designing large-scale conservation corridors for pattern and process. *Conservation Biology* **20**, 549–561.

Rouget M, Cowling, RM, Pressey RL, Richardson DM (2003) Identifying spatial components of ecological and evolutionary processes for regional conservation planning in the Cape Floristic Region, South Africa. *Diversity and Distributions* **9**, 191–210.

Sarkar S, Pressey RL, Faith DP, Margules CR, Fuller T, Stoms DM, Moffett A, Wilson KA, Williams KJ, Williams PH, Andelman S (2006) Biodiversity conservation planning tools: present status and challenges for the future. *Annual Review of Environment and Resources* **31**, 123–159

Swetnam RD, Fisher B, Mbilinyi BP, Munishi PKT, Willcock S, Ricketts T, Mwakalila S, Balmford A, Burgess ND, Marshall AR, Lewis SL(2011) Mapping socio-economic scenarios of land cover change: a GIS method to enable ecosystem service modeling. *Journal of Environmental Management* **92**, 563–574

Turner WR, Brandon K, Brooks TM, Costanza R, Fonseca GAB, Portela R (2007) Global conservation of biodiversity and ecosystem services. *BioScience* **57**, 868–873.

van Jaarsveld AS, Biggs R, Scholes R, Bohensky E, Reyers B, Lynam T, Musvoto C, Fabricius C (2005)Measuring conditions and trends in ecosystem services at multiple scales: the Southern African Millennium Ecosystem Assessment (SAfMA) experience. Phil. Trans. R. Soc. B **360**, 425–441

Wilson K, Pressey B, Newton A, Burgman M, Possingham H, Weston C (2005) Measuring and incorporating vulnerability into conservation planning. *Environmental Management* **35**, 527–543.