



# Framing local outcomes of biodiversity conservation through ecosystem services: A case study from Ranomafana, Madagascar

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## ABSTRACT

Conservation can have both positive and negative effects on human well-being by causing changes in ecosystem service flows and reallocation of the distribution of benefits. This can lead to different, sometimes contradictory, outcomes of conservation. We studied local perceptions of ecosystem service flows in the Ranomafana National Park area of Madagascar to examine the local outcomes of conservation. The Ranomafana forest area provides a variety of benefits that contribute considerably to local inhabitants' livelihoods and well-being. Changes in ecosystem service flows alter the provision of many important ecosystem services at the local level, which is likely to affect local livelihoods negatively and increase local vulnerability and inequality. The findings indicate the presence of trade-offs between types of ecosystem services and between different societal goals, namely conservation and development. Benefit trade-offs also occur within and between beneficiary groups and across spatial and temporal scales. Although conservation might prove beneficial for local people in the long run, its immediate local costs are high. The findings reveal the importance of integrating local perceptions of ecosystem services into conservation planning. In addition, there is a need for further negotiations of the trade-offs between ecosystem services, conservation and development in Ranomafana.

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## 1. Introduction

Ecosystems provide numerous resources and processes, collectively known as ecosystem services that contribute significantly to human well-being (Millennium Ecosystem Assessment, 2005). With growing recognition of the importance of biodiversity in providing these services (Mace et al., 2012), biodiversity conservation activities are often justified as being beneficial to people (e.g., Mooney (2010)). As a result, protected areas are increasingly being managed for conservation purposes to deliver continuous ecosystem service flows from ecosystems to beneficiaries (Egoh et al., 2007; Ten, 2011).

Ecosystems and their services are subject to diverse demands and meanings and thus are perceived and valued very differently from different perspectives and across different spatial and temporal scales (Hein et al., 2006; Rodríguez et al., 2006). Conservation activities can lead to changes in ecosystem service flows and reallocation of the benefits accrued from ecosystems (Daw et al., 2011; Roe and Walpole, 2010). Several researchers have criticized the poor performance of protected areas in

distributing the costs and benefits of conservation fairly (e.g., Adams et al. (2010)). This is especially true in developing countries where the local livelihood costs of protected areas can be significant while the benefits tend to be accrued globally.

Applications of the concept of ecosystem services provide novel tools for studying the outcomes of conservation, including both the trade-offs and synergies, as well as a means of addressing the multiple interests and values of biodiversity and ecosystem services (e.g., Daw et al. (2011)). By making the outcomes of conservation explicit, we can address and balance multiple needs and values (Hein et al., 2006; Tallis et al., 2008) and pursue equity in and sustainability of service provision (Daw et al., 2011; Dawson et al., 2010). Accordingly, the concept of ecosystem services can be applied not only as a new way to justify conservation (Mooney, 2010) but also as a tool for delivering ecosystem service flows fairly (e.g., Tallis et al., 2008). Local communities often depend heavily on ecosystems and are directly affected by changes in the flows of ecosystem services (Millennium Ecosystem Assessment, 2005). Failure to properly address trade-offs and adequately interpret or define people's perceptions can likely lead to conflicts (Adams et al., 2003). Therefore, it is essential to understand ecosystem service flows from the local perspective.

Ranomafana National Park in southeastern Madagascar harbors forest biodiversity of global importance, but conservation-induced

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changes in ecosystem service flows are affecting the lives and livelihoods of local residents. Drawing on data from Ranomafana, we evaluate the importance of locally perceived ecosystem services in biodiversity conservation and answer the following questions: (1) What are the main ecosystem services that the forest provides to local communities in the peripheral zone of the national park in Ranomafana? (2) How have the ecosystem service flows changed over time? (3) Given the findings, what can be said about local conservation outcomes in the area?

## 2. Ecosystem service flows and conservation outcomes

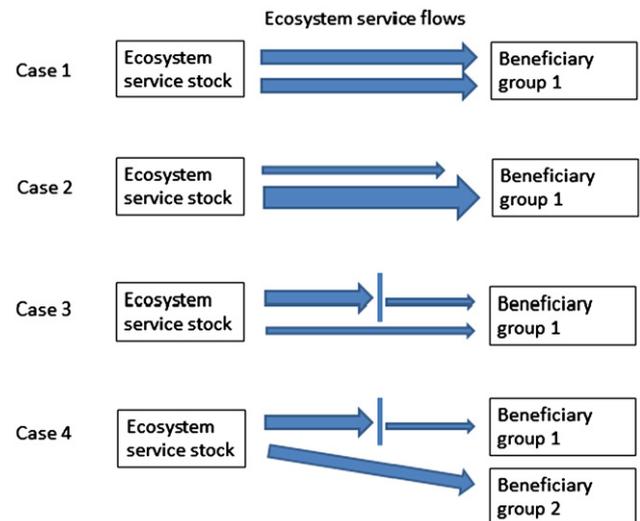
Ecosystem services are provided via ecosystem service flows from ecosystems to beneficiaries (Chan et al., 2006; Millennium Ecosystem Assessment, 2003, 2005). Ecosystem services are the benefits people actually receive from ecosystems, as opposed to the stock of ecosystem services, or the ecosystems' capacity to deliver these services (Layke, 2009).

Applications related to ecosystem service flows can serve as powerful tools and include the following:

- understanding the ecosystem service flows from ecosystems, especially the ecological processes underlying these flows (e.g., Boyd and Banzhaf (2007), Chan et al. (2006), Guariguata and Balvanera (2009));
- understanding the feedback between social and ecological environments and their effects on service flows and human well-being (e.g., Díaz et al. (2011), Maass et al. (2005), Millennium Ecosystem Assessment (2005));
- understanding and managing the trade-offs and other outcomes of the natural resource decisions that affect ecosystem service flows, including how such changes are valued and perceived (e.g., Daw et al. (2011), Goldman et al. (2010), Hein et al. (2006), Rodríguez et al. (2006), Tallis et al. (2008), Turner et al. (2012)).

Socio-ecological dynamics mean that ecosystem service flows are influenced by both their ecological underpinnings and their socioeconomic context (Díaz et al., 2011; Guariguata and Balvanera, 2009; Kremen and Ostfeld, 2005; Rodríguez et al., 2006). Whatever an ecosystem's capacity to provide services (protected areas tend to contain rich stocks of ecosystem services), societal drivers, such as access, are often stronger than biophysical factors in changing ecosystem service flows (Chan et al., 2006). Ribot and Peluso (2003) define access as "the ability to derive benefits from things", which aptly describes one major driver affecting the flow of ecosystem services in the context of protected areas. Access includes not only one's rights and restrictions but also abilities, such as social relationships. Ecosystem service flows are depicted in Fig. 1.

Conservation, mainly implemented through protected areas, has been criticized for achieving its goals at the expense of local communities (Adams et al., 2010). Problematically, protected areas represent a form of land use that generally rules out all other land uses, thus leading to the physical, economic and cultural exclusion of local people (Agrawal and Redford, 2009). Protected areas are also highly political in nature, with inequalities between actors in terms of power and distribution of benefits (Adams and Hutton, 2007). To overcome these challenges, many researchers have argued that conservation needs to acknowledge both trade-offs and synergies, i.e., the mutual gains and losses arising from certain choices and actions (Hirsch et al., 2011; McShane et al., 2011). Outcomes are also good indicators of conservation success (Kapos et al., 2009). Trade-offs seem inevitable in conservation but choices are rarely recognized or debated,



**Fig. 1.** Ecosystem service flows or the service provision from certain ecosystems to certain beneficiaries (cases 1–4). Multiple flows and different outcomes can occur simultaneously. Various direct and indirect drivers of change affect ecosystem service flows (case 3 and 4). Trade-offs occur between ecosystem services (case 2) and between beneficiary groups (case 4).

even though they often trigger obvious conflicts or have unfair consequences.

Despite the apparent importance of conservation in supporting the provision of ecosystem services in the long run (Turner et al., 2012), conservation goals can clash with the more immediate livelihood needs of local inhabitants, especially in developing countries (Fisher and Christopher, 2007; Roe and Walpole, 2010). As conservation measures often affect ecosystem service flows, conservation outcomes can be assessed by observing the resulting changes in service flows. Outcomes can be either intentional or unintentional, often take place over a long time and are likely evaluated differently depending on the social and cultural perspective and the time (Kapos et al., 2009; Skourtos et al., 2010). Trade-offs that are considered negative today may appear positive in the future. Similarly, beneficiary groups perceive changes in ecosystem service flows differently depending on what they have at stake. Furthermore, given coexisting objectives, different outcomes are likely to occur simultaneously (Persha et al., 2011; Rodríguez et al., 2006; Roe and Walpole, 2010; Tallis et al., 2008). Consequently, trade-offs in conservation take different forms and occur at multiple temporal and spatial scales. Following are three trade-offs relevant to our case study.

First, conservation of one service may take place at the expense of another (Fig. 1, case 2) (e.g., Fisher et al. (2009), Pereira et al. (2005), Rodríguez et al. (2006)). In particular, flows for provisioning services are often traded off against regulating services (Bennett et al., 2009; Fisher et al., 2011). Nevertheless, synergies also exist, as some services offer a means of delivering other services; for example, regulating and supporting services generally support provisioning or cultural services (Wallace, 2007). Second, there may be competition between resource use objectives or societal goals (Faith and Walker, 2002), most evidently between conservation and development (e.g., Campbell et al. (2010), Goldman et al. (2010), Kareiva et al. (2008)). Outcomes will thus be different in cases with such barriers to ecosystem service flows compared with cases without them (Fig. 1, case 3) (Daw et al., 2011). This is closely related to the third trade-off, where trade-offs occur between beneficiary groups—or individuals—when benefits are reallocated (Fig. 1, case 4). Roe and Walpole (2010) claim that this factor underlies the general conservation outcomes whereby production of global

well-being (through restrictions and exclusions as part of conservation efforts) can actually degrade the livelihood base and hence the well-being of local inhabitants. Benefit trade-offs may also take place between current and future generations (Hein et al., 2006).

### 3. Ranomafana national park and local communities

The tropical rainforests of Madagascar lie in a mountainous area in the eastern part of the country. Ranomafana National Park, in Fianarantsoa Province in southeastern Madagascar, contains 43,500 ha of mountainous rainforest (Fig. 2).

Functions of the Ranomafana forest area include resource production, livelihood support, conservation, research and ecotourism. The region is home to almost 2000 endemic species (Brooks et al., 2009). As part of the “Rainforests of the Atsinanana” UNESCO World Heritage Site, Ranomafana National Park and its ecosystem services have received global recognition. Besides biodiversity, the forest in Ranomafana is primarily recognized for its protection of the Namorona watershed for the hydroelectric power plant that produces all the electricity for the regions of Fianarantsoa, Ambositra and Antsirabe (Mogelgaard and Patterson, 2006). The ecosystem is based on this watershed, which was the founding rationale for the park’s conservation and law enforcement (Hanson, 1997).

Today, the park’s peripheral zone surrounds the protected area with a 5 km buffer. In 2008, there were 137 villages or village-like communities in the peripheral zone, with a total population of 52,449 (Madagascar National Parks, 2009). People living in the peripheral zone are generally divided into two ethnic groups: the Betsileo and the Tanala. The Betsileo inhabit the highlands west of the park and the Tanala live at lower elevations in the central and eastern areas. Although most people self-identify with one of

these groups (Hanson, 1997), Harper (2002) stresses that these classifications refer more to flexible culturally and economically adapted groups than to ethnic tribes.

As elsewhere in the region, the main livelihood activity for most households is subsistence farming. The main crop cultivated by Malagasy people is rice. Irrigated rice usually requires a flat field, whereas dry tavy rice can be cultivated on steep slopes. Tavy techniques frequently employ fire as an agricultural tool. Other crops include cassava, beans, peanuts, leafy vegetables, sugarcane, maize, taro, pineapple and sweet potatoes. Many households also rely on banana and coffee plantations as well as other wild or cultivated fruit trees, such as oranges and litchis. Some have cattle or other domestic animals such as chickens and pigs (Ferraro and Rakotondranjaona, 1991; Madagascar National Parks, 2009; Peters, 1992). Many people supplement their livelihood needs with forest resources, many of which have acquired commercial value and are sold at local markets. Wage labor also is increasingly important. The Ranomafana forest is also the site of family tombs and memorial stones, known as *vatoalahy* (Ferraro and Rakotondranjaona, 1991; Peters, 1999).

In Ranomafana, the land surrounding the park is owned by the government, agricultural land is owned by individual households and the village land base is determined by the state (Ferraro and Rakotondranjaona, 1991). People can obtain title deeds to land but the process is unaffordable for poorer residents (Hanson, 1997) and suffers from bureaucratic confusion (Peters, 1999). Ownership largely remains under customary rights, which are still of high value and are shaped by inheritance (Hanson, 1997). Furthermore, many villages in the peripheral zone have rights to use and manage their forest resources under community-conservation agreements (Jones et al., 2008).

Since the park was established in 1991, several development activities have taken place in its peripheral zone, and the growth of the tourism industry has led to improved infrastructure such as roads (in 2010–2011) and public water taps in the Ranomafana town center (in 2007) (Wright and Andriamihaja, 2011). In a system known as the *Droit d’Entrée dans les Aires Protégées* (DEAP), revenue raised from park entrance fees is divided between the national park system and small development projects proposed by local communities (Peters, 1998a). Under this system, groups of villagers apply to carry out projects, which have included building rice storehouses and dams and buying seeds. The number of these microprojects has risen from a few dozen per year in the 1990s to 44 in 2008 (Madagascar National Parks, 2009). As the economic returns are directly linked to tourism, the DEAP funds fluctuate from year to year. The number of visitors to the park rose from less than 1000 in 1992 to over 24,000 in 2008, but political turmoil in 2002 and 2009 decreased tourism substantially (Madagascar National Parks, 2009). However, the DEAP system is experiencing problems related to villagers’ ability and opportunity to apply for DEAP money for their projects. For many years, most of the DEAP money has not been allocated for local people’s projects (Korhonen, 2006; park director, personal communication, 2010).

### 4. Methodology

To study the ecosystem service flows and conservation outcomes in Ranomafana National Park, we adopted a case study method, the aim of which is to illustrate a phenomenon or theoretical frame in a context-specific setting (Stake, 2000). This study is based primarily on data collected through individual interviews conducted in September and October 2009 in 10 village communities in the peripheral zone of Ranomafana National Park. Each village was visited at least once.

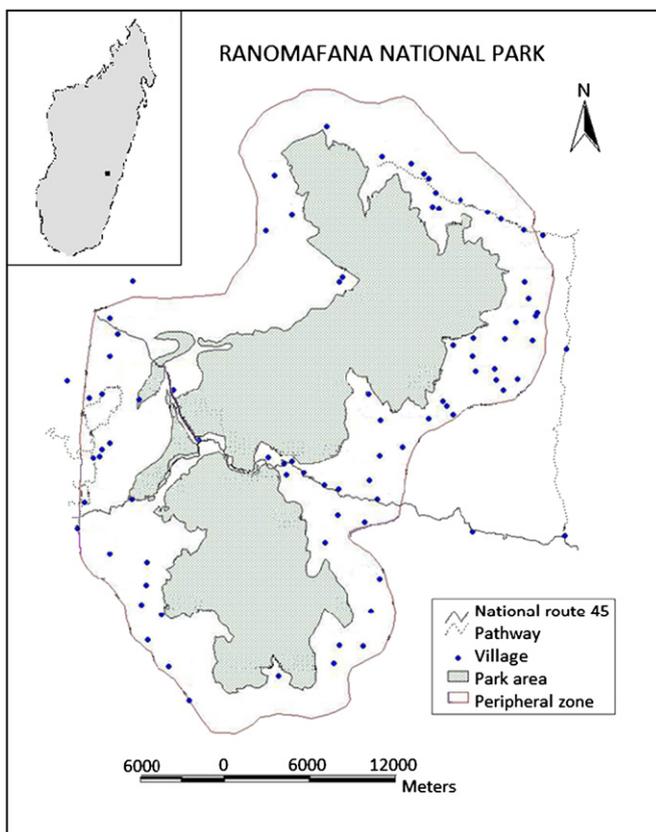


Fig. 2. Map of Ranomafana National Park, Madagascar.

The semi-structured thematic interviews consisted of open-ended questions, with additional inquiries occasionally made. The questionnaire employed the template on forest products and services taken from FAO (2004), which provides a standardized method for identifying forest benefits. The objective of the thematic interviews was not to examine exhaustively the ecosystem services used, but to allow respondents to mention them in an associative manner, because one of the aims was to detect the value attached to the ecosystem services.

In total, 66 individual interviews were conducted in Malagasy by a Malagasy research assistant. Different areas, genders and age groups were well represented among the interviewees. The researcher was able to partly follow the interviews because of intensive studies in the local language.

The interview data were analyzed according to the principles of theory-driven qualitative content analysis. This approach provides an efficient tool for identifying similarities and differences in the textual data, enabling the study phenomenon to be summarized and conceptualized in its context and connected both to the theoretical frame and to the broader discussion of conservation outcomes (Boyatzis, 1998). Ecosystem services were divided into four categories based on the Millennium Ecosystem Assessment (2005): provisioning, regulating, cultural and supporting services. We assumed that all services were of equal weight, and did not consider their relative market and nonmarket values. As indicators for ecosystem service flows, we used respondents' perceptions of the benefits gained from the forest, how they benefited from the services, whether they have access to the services, how benefit provisions have changed and their need for certain services (see Tables 1 and 2). The extent to

which conservation or other factors have affected the perceived outcomes, i.e., changes in ecosystem service flows, was estimated based on local perceptions. Responses were also compared with interview results in earlier studies on people's forest use, especially Ferraro and Rakotondranjaona (1991).

## 5. Results

### 5.1. Forest ecosystem services in Ranomafana

Local inhabitants recognized a wide range of ecosystem services (Tables 1 and 2). Provisioning services were most widely recognized; given the strong history of harvest and trade, provisioning services form tangible, direct benefits with visible economic impacts, and thus are usually perceived as the most important for well-being (Layke, 2009, Pereira et al., 2005).

Forest use has been highly restricted in the area since the park was established, and thus access—especially to provisioning services—is limited. Entry to the park is forbidden and forest patrols control illegal use. Many restrictions to control forest and land use are also in force outside the park limits. Although tavy—a form of slash-and-burn agriculture—was prohibited in Madagascar in the late 19th and early 20th centuries (Kull, 2002), fire regulations for the park have been reinforced. The local inhabitants regard these as laws set by the park authorities. Most hunting activities also are prohibited. Although firewood and medicinal plants can usually be collected freely from designated areas, the acquisition and use of many other provisioning services is strictly limited. Charcoal making is permitted only from planted trees, and crayfish collection and trade is forbidden. According to

**Table 1**

Perceived provisioning services provided by the Ranomafana forest area to local communities and the factors (access, demand, stock) affecting service flows.

Provisioning ecosystem service	Examples	Access	Demand <sup>a</sup>	Change in demand <sup>b</sup>	Stock <sup>c</sup>	Change in stock <sup>b</sup>
Timber and wood products	Construction of houses, fences, dams, animal enclosures, utensils	Tightly restricted	High	↗	– Community forest – Eucalyptus and other plantations	→/↘ →/↘
Arts and crafts materials	Mats, baskets	Tightly restricted	High	↘	– Cultivated – Wild	↗ ↘
Fuelwood	Firewood, charcoal for energy production	Controlled – Firewood: only deadwood – Charcoal: only planted trees	High	↗	– Community forest – Secondary forest, kapoka – Plantations	→ ↘ ↗/↘
Natural medicines	Treatment of illnesses	Generally available outside the park	Moderate	↘	– Community forest – Secondary forest	–
Food: Wild foods	Wild plants, wild animals	Restricted, partly forbidden	Low/moderate	↘	– Village – Secondary forest – Park forest	↘ ↘ ↗
Food: Crops	Cultivated crops (cassava, beans, etc.)	Land and practices tightly restricted	High	↗	– Fields in and outside forests	↘
Other plant materials	Flowers, flower pots, compost material	Partly restricted	Low	↘ ↗ (compost)	– Secondary forest	–
Water	Rice cultivation, other planting and agricultural uses, drinking	Free access	High	→	– Whole forest area	↗

<sup>a</sup> Demand is divided into three-step estimates based on comparison of one service to another: low, moderate and high.

<sup>b</sup> Estimated change, i.e., whether the demand/stock is perceived to be increasing, decreasing or stable, is marked only if detected. Due to variety in perceptions, more than one estimate may be indicated. Increasing ↗, decreasing ↘, stable →, no clear indication –.

<sup>c</sup> Stock indicates the supply in quantity and quality as well as the source of the service. Interviewee perceptions and the comparison of data over time (1991–2009) were used to estimate relative changes in demand or stock.

**Table 2**  
Perceived regulating, supporting and cultural services provided by the Ranomafana forest area.

Service category	Ecosystem service	Benefit definition	Trend in perceived importance and/or access <sup>a</sup>
Regulating services	Air quality	Health	↗
	Water quality and quantity	Agriculture, health	↗
	Soil fertility, stability, moisture	Agriculture	↗
	Weather+shade	Agriculture, human security	–
Supporting services	Habitat provision	For animals and plants to live	↗
	Pollination	Beekeeping, agriculture	↗
	Primary production	Forest functioning	–
	Air and water cycling	Agriculture, health	–
Cultural services	Sense of place and cultural affinity	Identity building, sense of well-being, pride	–
	Recreation and tourism	For tourists to enjoy	↗
	Heritage	Identity building	↗

<sup>a</sup> Estimated trends are based on interviewees' perceptions since the establishment of the park in 1991. Changes are marked only if detected. Increasing ↗, decreasing ↘, stable →, no clear indication –.

respondents, regulations seem to vary between villages, and new laws and regulations have appeared throughout the years.

Respondents stated that, before the park was established, the forest was a source of many products and most necessary resources were easy to find. Although the variety of provisioning services mentioned by respondents was similar to that in the study by Ferraro and Rakotonranjaona (1991), the available stock of provisioning services is now either prohibited (in the park forest) or exhausted. Although firewood is still easy to find, people are prohibited from using the wild stock of wood for construction, except for controlled housing construction. Consequently, many people invest in their own tree plantations to gain their own supply. Many villagers have also started growing raw materials for weaving. These initiatives have decreased people's dependence on the wild stock of forest resources. A few respondents stated that the pressure has shifted from the forest to areas outside the park and tree plantations.

By contrast, flows of many of the regulating and supporting services mentioned were described as good, thanks to the park. Many respondents perceive that the preservation of the forest has enabled and secured the supply of water and clean air and hence local people's health. The forest is also seen as heritage for children, who would experience difficulties if the forest was not there in the future.

## 5.2. Changes in ecosystem service flows at Ranomafana

Although the park is widely seen as the cause of changes in the flow of provisioning services, such changes have also been driven by other factors that affect forest use—not only the rules and regulations, but also the demand and supply dynamics of the current provision of ecosystem services. Perceptions of the park and resource sufficiency also are influenced by this interplay of supply and demand. The decrease in provisioning service flows is likely due to increasing demand for diminished stock, and future population growth is likely to further boost demand for forest products.

Local inhabitants affect the available stock and consequent ecosystem service flows through demand. Local residents' main activities in the forest were found to be affecting the forest in one way or another. Respondents expressed concerns over the degradation of the stock of many provisioning services: people pointed out that the forest area available for use has only small trees left and many of the resources have been exhausted or are more difficult and time-consuming to find because they are further away. Many interviewees reported seeing the impacts of their activities on resource provision due to overexploitation. However, many claimed that the degradation of the forest was not a new phenomenon but exhausted gradually by traditional gathering practices and farming methods that were seen most significant contributors to deforestation. Indeed, a decreasing trend in the

stock outside the intact park's forest area was reported by Ferraro and Rakotonranjaona (1991) already during the establishment of the park. Consequently, interviewees generally perceived the current local rules and restrictions for community forests as beneficial for sustaining stock, and people were eager to participate in the management of their own forest.

Many of the inhabitants recognized that the current resource availability and demand are threatening the sustainability of many livelihood strategies; increasing numbers of people depend on the same or decreased stock of resources compared with before. Respondents often raised the issue of the increasing importance of income-generating activities, as cash is more often needed in everyday life because of lower returns from agriculture and forest products. This same trend was reported by Hanson (1997). However, opportunities for income generation were said to be weakening because of decreased ability to exploit many of the forest resources that are also sources of income. Many resources, such as the raw materials for weaving or trees for charcoal, are restricted and the accessible stock being used by more people, thus leaving less surplus for selling. Previously, people could save money by meeting their needs with supplementary forest resources, for example, for food (see also Ferraro and Rakotonranjaona (1991)).

Because of the decline in the available resource stock, many people have chosen to abandon collecting activities in favor of alternative livelihood options. In particular, many are seeking to expand their livelihood activities by working for wages. Nevertheless, most households still rely on subsistence farming and locally available natural resources. With restrictions on forest use and shortages that can no longer be supplemented by the forest, dependence on cultivation is increasing, as are concerns over access to and quality of agricultural land.

With the decrease in the stock of provisioning services and the growth in demand, provisioning service flows are increasingly likely to be deemed insufficient. However, the subjective nature of views on sufficiency and variations in inhabitants' socioeconomic situations mean that perceptions of the sufficiency of the available forest resources will differ among respondents, even within the same villages. Three broad categories of views on the sufficiency of ecosystem services are observed:

- People who consider the community forest to be insufficient and tend to perceive conservation negatively. For people in this group, the harvest or agricultural land is not enough; they can rarely manage to supply themselves by, for example, their own tree plantations and thus they tend to need to collect more forest products for substitution and additional income. Restrictions are especially hard for these people.
- People who generally agree with the restrictions. People in this group think that, had use of the forest continued as before, the

forest resources would now be exhausted. They are generally satisfied with their ability to meet essential needs from the community forest. Many claim that the sources of money are not enough, but they accept the restrictions because they view them as the only option to ensure their children's heritage and future subsistence.

- People who support the restrictions. People in this group consider forest resources to be sufficient because the harvest from their own fields or tree plantations makes up for what they no longer obtain from the forest.

Most people were in the second group, with the remaining respondents evenly distributed between the first and third groups.

Respondents suggested that, before the park was established, people could use provisioning services according to their needs, whereas now access is restricted regardless of their needs. Current service flows are generally seen as insufficient especially when compared with the potential stock inside the park's borders. One respondent stated that having only enough to meet essential needs is not always satisfactory. He also noted that what is "sufficient" for locals was determined by restrictions imposed from outside, with most villagers wielding little influence. Consequently, as the supply is unsatisfactory and alternatives nonexistent, many respondents see few options for livelihood improvement. Our study thus indicates that local communities around Ranomafana National Park continue to depend heavily on forest resources for subsistence and safety net functions, in addition to their major occupation of farming.

Our study identified trends that reflect previous remarks made since the park was established, such as on the degradation of the stock of forest resources, lack of agricultural land, importance of income-generating activities and population growth (Ferraro and Rakotondranjaona, 1991; Hanson, 1997; Korhonen, 2006). Identifying the subtle fluctuations in overall trends and their causes has proved to be difficult. Nevertheless, although the variety of perceived forest benefits was quite similar to earlier studies, the use of the forest seems to have simplified and some services lowered in importance. Many services were mentioned only a few times or only after a specific inquiry. However, it is likely that respondents deliberately avoided talking about ecosystem services with restrictions and possible retributions, such as bush meat. Responses openly indicated that there is less acquisition of materials for arts and crafts because of increasing competition and decreasing supply, and hunting and other food collection are less common than in previous years.

In addition, monetary assets are now said to affect livelihood activities more than before. Money is also involved in the access to ecosystem services: some people asserted that it is possible to pay for a permit, for example, to sell wood or make charcoal. Despite the eagerness in villages to manage their community forests, legal arrangements for the transfer of resource use and control rights from the central government to local communities were described as expensive and hence impossible for the villagers to complete without outside help.

In contrast to negatively perceived changes in provisioning service flows, people acknowledged positively supporting and regulating service flows, as well as some cultural service flows. Many people could easily discuss benefits related to these services, most of which are important in supporting local agriculture (see Table 2).

## 6. Discussion: conservation outcomes at Ranomafana

The Ranomafana forest area provides a variety of benefits for its residents, which contribute considerably to their livelihoods and well-being, as they use forest resources on a regular basis or

during times of need (e.g., farming shocks). However, the flows of provisioning services have weakened, mainly because of restrictions on access, degradation of available stock and increased demand. Communities noted that many critical services are declining, and that they have to go further to find those that are available. In addition, the use of the forest is becoming less diverse. People expressed strong concerns over the sufficiency of agricultural land with the intensification of competition for land and its resources. Many of these changes affect local livelihoods negatively and increase local vulnerability and inequality. By contrast, in the context of increasing awareness of the value of other services, flows of regulating, supporting and some cultural services were perceived to be stronger.

The limited availability of important resources means they do not adequately support livelihoods and well-being, and poor people then tend to overharvest available resources (Butler and Oluoch-Kosura, 2006). However, local taboos (*fady*), such as taboos against the commercial harvesting of food, including tenrecs, honey, fish and crayfish (Jones et al., 2008), also serve to control forest resource use in the area and might prevent some resource-exhaustive practices in Ranomafana.

Limited sources of livelihoods and the lack of alternative income-generating opportunities are important drivers of dependence on forest resources despite expectations that growth in the local tourism industry will boost employment opportunities. Peters (1998b) documented that local inhabitants were able to capture only a very small fraction of the tourism benefits in the free market. Similarly, Korhonen (2006) noted the elite capture of tourism benefits, even though ordinary villagers are those most negatively affected by conservation restrictions. Lack of and restricted access to agricultural land, particularly land suitable for irrigated rice cultivation, constitutes a major part of the livelihood problem in Ranomafana and creates marked inequalities within communities.

The provision of cultural services, by contrast, is difficult to assess. Detecting cultural services is one of the most difficult and least accomplished tasks in ecosystem services research, and the inability to capture cultural services often results in underestimation of their importance (Daniel et al., 2012).

However, the forest is an important part of the local identity in Ranomafana, especially for those who identify as Tanala, "people of the forest" (Harper, 2002; Korhonen, 2006). For these people, the land is *tanin-drazana*, land of the ancestors that was given to them, making them its rightful owners (Ferraro and Rakotondranjaona, 1991). Likewise, the economic and cultural aspects of tavy, thoroughly connected to forest values, cannot be separated (Hanson, 1997; Harper, 2002); tavy is not only an important livelihood strategy but also a form of resistance (Hanson, 1997). For many inhabitants, these values and arguments continue to be relevant to their lives and their relationship with the forest. Therefore, cultural ecosystem services are likely to play a major role in perceived forest benefits and livelihood strategies. Understanding them and values attached would be highly beneficial for conservation planning and for building community support in Madagascar (Fritz-Vietta et al., 2011).

Ferraro (2008) points out the expected outcomes of establishing protected areas that restrict the supply of agricultural land and ecosystem material products but that maintain the flow of less tangible ecosystem services. That is, supporting and regulating services are generally trade-offs for provisioning services. In Ranomafana, the combination of restricted access, degraded stock and increasing demand has similarly affected the ecosystem service flows.

This describes a typical trade-off situation in conservation, where the production of some ecosystem services is traded off against others, an outcome judged quite differently from different perspectives. Our findings also support previous studies on Ranomafana National Park that found that conservation has been

costly for local inhabitants (Ferraro, 2002; Harper, 2002; Korhonen 2006). The respondents in this study found the current provisioning service flows to be insufficient to support their livelihoods, well-being and development. This finding reveals another apparent trade-off in Ranomafana between societal goals, namely conservation and development. Respondents also pointed out the importance of the forest for tourism, indicating a trade-off between beneficiary groups. Respondents understand that the park not only serves to protect the environment (an objective they may perceive in various ways; see, for example, Korhonen (2006) for local environmental interpretations), but also secures the availability of many of the regulating and supporting services both for themselves and for future generations; this view reveals a trade-off between current and future generations. At the same time, for some people, the perceived benefits provided by the park forest (other than provisioning services) either go unrecognized or inadequately compensate for the perceived loss of benefits. Opinions expressed in this regard indicate that the trade-offs are not easily accepted. All of these trade-offs work over various spatial and temporal scales.

The results of this study support the common assumption that local people tend to focus on the direct-use values of biodiversity and cultural associations, in contrast to conservationists' values of the continuation of threatened species, habitats and the flow of less tangible ecosystem services (Roe and Walpole, 2010). Locals might also emphasize their losses more than benefits (Liu et al., 2010), whereas conservationists are known for their sometimes false win-win declarations as conservation outcomes (McShane et al., 2011).

Carpenter et al. (2006) argue that, in trade-off decisions, people often prioritize provisioning services, then cultural, and after that regulating and supporting services, thereby tending to undervalue the ecosystem processes that create the services (see also Rodríguez et al., 2006). The respondents in this study were aware of their own role in the delivery of services and recognized the effects of their own resource use and practices; they were aware that, in the long run, the prevailing demand and supply dynamics could in practical terms degrade the whole service base. Hence, in the long term, conservation might prove to be more beneficial than costly at the local scale also, as regulating and supporting services are generally the means to achieving items listed under provisioning or cultural services (Wallace, 2007). Given this, the importance of Ranomafana National Park for conserving biodiversity and ecosystem services in the area is inescapable, even if the benefits accrue at very broad spatial and temporal scales. Nevertheless, for many of the poorest inhabitants the trade-off might appear unbearable and unjust in any case.

The concepts of ecosystem services and service flows are novel and essential tools for assessing the trade-offs and synergies of conservation in the socio-ecological setting of Ranomafana. These concepts integrate both the social and ecological dimensions of the landscape, which is an approach not previously adopted in studies of this area. Although the applicability of subjective perceptions as a tool in conservation can be contested (as opposed to the identification of "more objective" ecosystem service flows and trends), we argue that locally perceived ecosystem services constitute an integral part of the framework for conservation as it relates to local acceptance and social sustainability. With expanding social indicators of the success of conservation efforts and the need to measure the benefits of conservation, park management should be an ongoing, adaptive process with constant assessment and reevaluations.

## 7. Conclusion

Ranomafana National Park in southeastern Madagascar harbors forest biodiversity of global importance, but changing ecosystem

service flows are negatively affecting the lives and livelihoods of local inhabitants and increasing local vulnerability and inequality. This has resulted in important trade-offs, between types of ecosystem services and between conflicting societal goals, namely conservation and development. Benefit trade-offs also occur within and between beneficiary groups and across spatial and temporal scales.

Local residents of the park's peripheral zone do not seem to have fully accepted the trade-offs because they receive insufficient compensation and have few alternative livelihood options. Although local inhabitants are aware of the benefits from the forest, the costs are perceived as high. Consistent with earlier studies (e.g., Harper (2002), Korhonen (2006)), it is reasonable to say that the poor people living in the Ranomafana area are paying the price for global conservation benefits.

Conservation practitioners should properly address these trade-offs to ensure the equitable distribution of any benefits accrued. They must be willing to engage in a fair dialog to hear the various perceptions of residents in the Ranomafana forest area. This will involve recognition of the value that local people give to the forest and their land use objectives. Evidently, proper incentives for balancing the distribution of the benefits from ecosystem services and for making sustainable options more attractive than destructive resource use are needed. Compensation might include reinforcement of compensation mechanisms and the flow of benefits through an enforced system for sharing revenue from park entrance fees or the development of new mechanisms, such as payments for ecosystem services.

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