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Return on investment of the ecological infrastructure in a new forest frontier in Brazilian Amazonia

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ABSTRACT

Protected areas anchor the ecological infrastructure that societies need for long-term prosperity and provide benefits to local, national, and global stakeholders. However, these areas continue to go unfunded. In this paper, we have provided the first estimate of the return on investment for nine large protected areas that compose the core of the ecological infrastructure of the State of Amapá, which is located in a new forest frontier in Brazilian Amazonia. These nine protected areas will require US $147.2 million over five years in order to be established and then US $32.7 million in annual recurrent costs. If implemented, these nine protected areas have the potential to contribute at least US $362.4 million per year in benefits (timber, non-timber forest products, nature-based tourism, fisheries, and carbon) to the local economy. The return on investment (ROI) of these protected areas will be 1.6% during the first five years and 10% thereafter; however, ROI could reach 45.8% or more if option and non-use values are also included as benefits. Although the costs of establishing the protected area system in Amapá are higher (US $3.2–3.5 ha^{-1} y^{-1}) than the costs reported in other tropical forest regions (US $0.2–0.4 ha^{-1} y^{-1}), the investments required are within the reach of both state and national governments. Our study shows that if fully implemented, protected areas can become engines for socio-economic upliftment, making the conservation-centered development model a feasible option for most of the world's new forest frontiers.

1. Introduction

Infrastructure refers to the physical elements of interrelated systems that provide goods and services essential to enable, sustain, or enhance societal living conditions (Fulmer, 2009). There are two types of infrastructure: socio-economic and ecological. Socio-economic infrastructure is composed of the physical assets required by both social sectors (such as financial, educational, health, cultural, defense, and judicial) and economic sectors (such as energy, water and sewage, food and agriculture, transportation, and communications). Economic and social infrastructures are also known as "hard" or "soft" infrastructures, respectively. The ecological (or green or natural) infrastructure is an interconnected network of natural and semi-natural areas that is planned and managed for its natural resource values and for the associated benefits it confers to human populations (Benedict and McMahon, 2006). Both types of infrastructure are required for human development, but investments in ecological infrastructure are much smaller than investments in socio-economic infrastructure (Ruggeri, 2009).

Ecological infrastructure underpins human well-being by directly supplying ecosystem services that cannot be imported and by providing services that, through interaction with the socio-economic infrastructure, become valuable to humans (Collados and Duane, 1999; Costanza et al., 2014). To be effective, ecological infrastructures should: (a) be large and connected enough to protect all species existing in a territory, (b) provide all goods and services that people need, and (c) increase society's resilience against the negative impacts of global climate changes (Garda et al., 2010; Maes et al., 2015; Sussams et al., 2015). If societies want long-term prosperity, they must design and establish their ecological infrastructures, integrating them at several spatial scales (Yu, 2012).

The core of any ecological infrastructure is composed of protected areas, which are clearly defined geographical spaces that are recognized, dedicated, and managed through legal or other effective means to achieve the long-term conservation of nature with associated ecosystem services and cultural values (Dudley, 2008). Currently, the global ecological infrastructure is built around 155,584 terrestrial protected areas covering around 12.5% of the world's land surface as well as 7318 marine protected areas covering 3% of the world's marine ecosystems (Watson et al., 2014). Most of the existing protected areas have not been fully implemented because financial resources for building the core of a global ecological infrastructure have always been

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significantly smaller than what is needed (Jenkins and Joppa, 2009). Although the act of designating an area as protected by governments can halt ecosystem loss for some time, a protected area can only achieve the desired goals if it receives enough funds to be well-managed (Bruner et al., 2001).

In the last few years, there has been a trend in which key national governments have reduced their commitment to supporting protected areas (Watson et al., 2014). The lack of support by governments has traditionally been demonstrated by cuts in the operational budgets of the agencies responsible for protected area management. However, currently, governments are also reducing the strictness of the conservation status of protected areas, opening them to more intense human activities, reducing their sizes via boundary changes, and removing legal protection (Mascia et al., 2014; Bernard et al., 2014).

Watson et al. (2014) suggested that more studies documenting the return on investment (ROI) of protected areas for local societies could help to renew the interest of local and national governments in this particular component of the world's ecological infrastructure. Although the use of return on investment is not new in conservation (see review by Boyd et al., 2015), it has primarily been used to identify conservation gaps during systematic conservation planning or to guide future resource allocations across regions (Murdoch et al., 2007, 2010), rather than to provide evidence that existing protected areas are indeed good investments for local societies (Task Force on Economic Benefits of Protected Areas of the World Commission on Protected Areas (WCPA) of IUCN, in collaboration with the Economics Service Unit of IUCN, 1998).

In this paper, we present the return on investment of nine protected areas that compose the core of the ecological infrastructure of the State of Amapá, Brazilian Amazonia (hereafter referred to simply as "Amapá"). We calculate the costs of implementing these protected areas as well as some direct benefits they can generate for the local human population. We selected Amapá as a case study because it is a new forest frontier, i.e., it harbors large stocks of natural ecosystems, has low deforestation rates, and has low population density (Bryant et al., 1997; Becker, 2009). New forest frontiers are relevant because they cover around 5.8 million km^2 in South America, Africa, and Asia (Bryant et al., 1997) and are the places where conflicts regarding the fate of the world's largest stocks of pristine ecosystems will possibly emerge in the near future if sustainable land-use policies are not implemented at an appropriate pace.

2. Materials and methods

2.1. Study area

Amapá is located in northern Brazil and is bordered by French Guyana and Suriname (Fig. 1). Amapá has an area of 14,281,458 ha (Drummond et al., 2008) and a population of 669,526 (Instituto Brasileiro de Geografia e Estatística, 2014). Most of the population is urban, with 74.6% of the population living in the capital of Macapá and in Santana. Amapá's gross domestic product (GDP) for 2013 was US $5.5 billion, representing 0.2% of Brazil's GDP (Instituto Brasileiro de Geografia e Estatística, 2014). The state's public budget is around US $1.6 billion per year (Governo do Estado do Amapá, 2015); of this budget, around 68% comes from transferences from the federal government. Most of the economy is based on services and government spending, with a small portion coming from forestry, mining, hydroenergy and agriculture (Instituto Brasileiro de Geografia e Estatística, 2014).

Ninety-three percent of Amapá's territory is still covered by natural ecosystems. Dense upland forests of the Guiana Shield cover 75% of the territory (Instituto de Pesquisas Científicas e Tecnológicas do Estado do Amapá, 2008). Along the coast, Amapá harbors seasonally flooded grasslands (11%), upland savannas (7%), seasonally flooded forests (5%), and the Americas' most pristine mangroves (2%) (Instituto de Pesquisas Científicas e Tecnológicas do Estado do Amapá, 2008). Since 1995, the government of Amapá has implemented an ambitious socio-economic development agenda based on the sustainable use of its natural resources (Drummond et al., 2008). As a result, Amapá is the most protected state in Brazil, with 73% of its area covered by protected areas or indigenous lands. Together, these two types of areas compose the Amapá Biodiversity Corridor, an initiative launched in September 2003 during the World Park Congress in Durban, South Africa. The Amapá Biodiversity Corridor aims to integrate the management of protected areas and indigenous lands by creating synergies between them, reducing management costs, and leveraging resources from multiple partners.

Nine large public protected areas anchor the Amapá Biodiversity Corridor (Fig. 1). The national government manages seven of them and the state government manages two (Table 1). Three protected areas are strict nature reserves (IUCN's Category I), two are national parks (Category II), and four are protected areas with sustainable use of natural resources (Category VI). Five protected areas were declared during the 80s and two during the 90s. The two largest protected areas, encompassing 42.4% of the state, were not declared until 2002 (Montanhas do Tumucumaque National Park) and 2006 (Amapá State Forest).

2.2. Protected area costs

We classified the protected area costs into two categories: establishment costs and recurrent management costs. Establishment costs are start-up investments and include: (a) physical infrastructure (e.g., trails, visitor centers, and offices), (b) equipment (e.g., cars, boats, and communication), and (c) planning and demarcation (e.g., management plans, land tenure surveys, and boundary demarcation). Recurrent management costs are annual and include: (a) staff salaries, (b) operational costs (e.g., fuel, electricity, services, and meetings), (c) maintenance of infrastructure and equipment, and (d) priority projects (e.g., research, tourism, and environmental education) as defined by the management plan.

To estimate the costs of protected areas, four pieces of information are required: (a) an assessment of the current state of implementation of each protected area; (b) an estimate of the number of staff required for each protected area; (c) a list of minimum infrastructure and services required for each protected area; and (d) a table with standard reference costs for products and services that are required to implement the protected areas.

To assess the current state of implementation of each protected area, we interviewed the areas' managers. We used an open-ended questionnaire. We asked questions about: the number of staff, available assets, current expenses, existing funds and revenues, past and existing investments, status of the management plan and boundary demarcation, existence and status of essential infrastructure (such as visitor centers, management and surveillance offices, existence and extension of trails, and research laboratories), major needs, and potential number of visitors.

We used 1:3333 ha as the minimum acceptable density of field staff. We selected this value because it was the median density of guards in the 15 most effective parks studied by Bruner et al. (2001). Protected areas also need management staff to provide technical and administrative support for the field staff and to manage relationships with external stakeholders. To calculate the number of management staff required by each protected area, we used the following assumptions: (a) if the protected area requires 70 or less field staff, then it would require seven management staff; (b) if the protected area requires 70 or more field staff, then the required management staff should be 10% of this number.

The amount of equipment and number of offices were estimated based on the staff numbers required for each protected area. Other infrastructure needs (e.g., trails and visitor centers), planning and demarcation costs (management plan and boundary demarcation),