



# What are the benefits of strictly protected nature reserves? Rapid assessment of ecosystem service values in Wanglang Nature Reserve, China



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## ABSTRACT

Despite broad recognition that nature reserves protect local biodiversity and rare species effectively, the wider benefits and costs provided by this conservation approach relative to alternative approaches are not well understood. This study addressed this research gap by quantifying differences in ecosystem services provision of two alternative conservation management approaches in a strictly protected nature reserve in China based on (1) existing strict regulations versus (2) extrapolation of those in an adjacent Natural Forest Protection Project (NFPP) allowing the use of natural resources by local communities. Using a new Toolkit for Ecosystem Services Site-based Assessment (TESSA), we demonstrated the nature reserve provides more valuable ecosystem services than it would have done if managed like the adjacent NFPP. In comparison, the nature reserve provides greater benefits in terms of carbon stock, carbon sequestration, and recreation, at the national and global scale. The monetary benefits of the nature reserve could cover all conservation management costs, making it a more worthwhile approach for conservation and beneficiaries. Thus, our study highlights the importance of strictly protected nature reserves in China, demonstrating the importance of balancing conservation and development to governmental managers and local residents, and could be used to guide eco-compensation for local beneficiaries.

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## 1. Introduction

China contains several nature reserves designed to conserve rare wildlife, like the giant panda *Ailuropoda melanoleuca* and the golden snub-nosed monkey *Rhinopithecus roxellanae* (Zhang, 2015), which act as umbrella species, protecting many other endangered plant and wildlife. These reserves are strictly regulated, with only a few economic activities being permitted outside their buffer zones. National and local governments invest much labor and money every year to ensure strict conservation measures are maintained. As a result, local residents complain because certain traditional livelihoods are forbidden in nature reserves. However, many of the benefits of this approach are not monetary, making quantification complicated. Thus, it is difficult to demonstrate how much one benefits from nature reserves and whether

the benefits actually cover the costs (Turner et al., 2003). Few assessments were made before the value of different ecosystem services was defined (Costanza et al., 1997, 2010).

Ecosystem services are the benefits that people derive from functioning ecosystems, ecological characteristics, functions, or processes that directly or indirectly contribute to human well-being (Costanza et al., 1997, 2010). The Millennium Ecosystem Assessment delineated four types of ecosystem services; namely, provisioning, regulating, cultural, and supporting services (MA, 2005). Bringing ecosystem services into the real world allows us to determine their benefits and costs in different environments. This information allows us to make trade-offs between development and conservation, as well as develop better policies and plans to manage them (Balmford et al., 2011; Kremen and Ostfeld, 2005). In China, ecosystem services are a new concept, with many studies on this subject being preliminary, focusing on static ecosystems (Bao et al., 2007; Xie et al., 2003). However, by applying the results of these studies to policy development, scientists realized that this approach does not aim to put a price tag on the total or particular

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ecosystem services, rather, it asks how changes to the quantity or quality of various types of ecosystem services might impact on human welfare (Bao et al., 2007; Costanza et al., 1997).

Several methods are currently used to estimate or measure ecosystem services, such as InVEST (Nelson et al., 2009), benefit transfer (Kubiszewski et al., 2013), ARIES (Bagstad et al., 2013), ESR (Hanson et al., 2012). Differences exist in the performance of these methods, with certain methods being more appropriate in distinct geographical or decision-making contexts. A toolkit for an ecosystem service sited based assessment (TESSA) was developed in 2013, which considers the changes in ecosystem service values for different scenarios at a high resolution. This toolkit does not require substantial resources or existing data, but is relatively low cost and requires low effort (Peh et al., 2013). Several assessments have been conducted in different landscapes and scenarios using this method (Birch et al., 2014; Blaen et al., 2015; Peh et al., 2014a, 2014b), demonstrating changes in values, with the assimilated information being fed into governmental decision-making processes effectively.

The assessment of ecosystem service values helps identify the priorities of ecological conservation in heterogeneous regions, as well as providing information on the distribution of benefits from different types of ecosystem services. In fact, resolving benefit disputes represents a major challenge for ecological conservation. Possible mediation strategies have been sought in China after the implementation of the National Forest Protection Project in 1998 and the Grain to Green program in 1999 (Cai et al., 2007; Zhang et al., 2005).

This study aimed to quantify the benefits of the ecosystem services provided by two different types of conservation practices in China; specifically, a strictly regulated nature reserve (Wanglang National Nature Reserve) versus a protected area in which human use of resources is permitted (Natural Forest Protection Project area). We completed a preliminary appraisal of the two sites at a workshop of local managers to understand the relevant services, pressures and contexts, assessments, and comparison of the ecosystem services provided by the two sites. In addition, we determined the affected stakeholders (beneficiaries) due to state conversion. Our results are expected to provide useful information for policy makers on the planning of nature reserves, persuasive publicity materials to local stakeholders on ecosystem services, and feasible approaches to resolve the distribution of benefits.

## 2. Materials and methods

### 2.1. Study area

Wanglang National Nature Reserve (WL) was founded in 1965, and is listed as one of earliest founded giant panda nature reserves in China. WL is located in the north of Sichuan Province and is situated on the southeast part of the Tibet Plateau (Fig. 1). The whole reserve covers 32,297 ha. The elevation of WL is 2300–4980 m, and it is surrounded by mountains. It has an average temperature of 2.9 °C.

As well as the giant panda *Ailuropoda melanoleuca*, many endangered animals are protected within WL, including the golden snub-nosed monkey *Rhinopithecus roxellanae*, the snow leopard *Panthera uncia*, and the takin *Budorcas taxicolor*. Dark conifer forest composed of the fir *Abies faxoniana* and the spruce *Picea purpurea* are also protected within the reserve. There are no local residents inside the reserve; however, the area outside the reserve supports the Baima people, who have lived in this region for centuries, grazing livestock, hunting animals and collecting natural resources.

Since its establishment, the WL has been subject to strict protection by the local government. Hunting, logging, and collection

are forbidden, while only some grazing is allowed, which supports the residents living outside the reserve. Nature-based tourism was started in the experiment zone after 2014. The tour route was controlled to allow access to just three scenic spots to prevent the human disturbance.

An alternative state was hypothesized for WL based on an actual site, Huangtuliang (HTL), which is adjacent to WL. HTL covers 13,855 ha and has similar geographic conditions. Compared with the status “strict conservation without exploitation” in WL, HTL is under the status of “general conservation after exploitation.” Before HTL was protected, it was managed by a local logging company and was subject to intense deforestation before 1998. After the Natural Forest Protection Project was implemented, HTL was protected and restored. HTL is subject to weaker conservation than the nature reserve (WL), with some human activities still occurring. The Baima people herd cattle and horses, collect fuelwood and some edible wildlife from this region. Furthermore, no tourism has been developed in HTL. As an actual reference site, the value of ecosystem services provided by HTL could be transferred proportionally to that provided by WL in an alternative state.

### 2.2. Assessing ecosystem services

#### 2.2.1. Preliminary appraisal

Before the field assessment, a small workshop was conducted with local experts and managers from WL and HTL to learn about the policy and environmental context of the two sites. The participants came from the Management Bureau of WL National Reserve (4 persons), the Forestry Development Corporation of Pingwu County (4 persons), the Forestry Bureau of Pingwu County (2 persons). Ten participants all have worked in this region for more than 10 years so that they were very familiar with the environmental and political context of WL and HTL. Detailed information was presented in Supporting information Table S1. All participants were asked to discuss and describe the policy and habitat status of HTL, consider the possible activities and threats affecting the habitats and biodiversity if WL was converted to an alternative state (i.e., reflecting HTL), and grade the various activities and threats with respect to time, space, and strength scales (i.e., low, medium, and high). We introduced the concept of ecosystem services to participants; namely, 18 specific services from 5 service categories (global climate regulation, water-related services, harvested wild goods, cultivated goods, and nature-based creation). We then invited the participants to predict and evaluate the importance of each service in both the current and alternative state for WL, scoring from 0 to 5 (5 = the most important). Based on this preliminary appraisal, the field assessment and interviews were structured based on the local contexts and differences in the importance of services and disturbances.

#### 2.2.2. Village interview

Based on the description from the workshop, local human disturbance mostly originated from a single Baima village, including grazing, cutting fuelwood, and collecting plants and medicine in HTL, but only grazing in WL. The village contained 113 families, and we conducted interviews with 43 families in January and May, 2016. The interviewed families were chosen at random unless the interviewee was too elder or too less-educated to answer our questions (young generations maybe go out for herding, collecting or other works). Data were collected using questionnaires (see Supporting information S2) on grazing, fuelwood, and collection activity.

#### 2.2.3. Global climate regulation

A land use/land cover map of WL from the 300 m MERIS sensor on board the ENVISAT satellite mission was derived from the

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