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Accounting for ecosystem services in compensating for the costs of effective conservation in protected areas

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ABSTRACT

Protected areas are a major approach for conserving ecosystem services globally. Effective conservation in protected areas must integrate human livelihoods into the design and management of conservation. Although ecosystem services can contribute to reducing local people's costs of conservation, exploitation of ecosystem services often results in ecosystem degradation. One important ecosystem service is fuelwood, which is used by > 2.5 billion people worldwide. Conservation policy design needs information on the demand for and values of fuelwood that can be extracted without compromising conservation goals of protected areas. We estimated local people's willingness to pay (WTP) for access to fuelwood in China's Wolong Nature Reserve, which is undergoing a net increase in forest area. Forest recovery in Wolong resulted from both the protection of the reserve and conservation under China's Natural Forest Conservation Program (NFCP). The estimated mean WTP for access to fuelwood accounted for about 21% of the payment under the NFCP. Among household characteristics, the cultural practice of cooking pig fodder, for which there were poor substitutes, played a major role in driving the demand for fuelwood. Although fuelwood collection can be prevented through increased conservation payments, fuelwood collection under forest management that fulfills conservation goals of the reserve can substantially reduce the costs of conservation. In addition, many other ecosystem services are also important to local people's livelihoods, and the combined values of different ecosystem services can substantially lower the costs of effective conservation in Wolong and many other protected areas around the world.

1. Introduction

Protected areas are a major approach for conserving biodiversity and ecosystem services globally (Millennium Ecosystem Assessment, 2005). However, even protected areas are not exempt from human impacts (Curran et al., 2004; Liu et al., 2001). Protected areas often apply restrictions on human access to natural resources, resulting in the loss of fuel, food, and income that local people obtain from ecosystem services in these areas (Adams et al., 2004). Although billions of dollars have been invested by governments and conservation practitioners to create and maintain protected areas around the world, currently, the majority of conservation costs are borne by local people (Balmford and Whitten, 2003; Naughton-Treves et al., 2005; Watson et al., 2014). Due to conflicts between conservation and human livelihoods, command-and-control types of conservation often fail to achieve conservation goals (Adams et al., 2004; Watson et al., 2014). When human livelihoods are not well-integrated into the design and management of protected areas, the effectiveness of protected areas becomes an open question (Leverington et al., 2010; Watson et al., 2014).

Effective conservation through protected areas should address local people's concerns and embrace protected areas as coupled human-natural systems (Liu et al., 2015; Liu et al., 2007; Naughton-Treves et al., 2005). Conservation efforts, such as Integrated Conservation and Development Projects (ICDPs) and Payments for Ecosystem Services (PES), have been implemented to integrate human livelihoods into conservation through promoting socioeconomic development and reducing human pressure (Chen et al., 2010; Naughton-Treves et al., 2005; Wunder, 2007). However, conservation funds are scarce globally and far below the requirements for compensating local people's costs of conservation (Balmford and Whitten, 2003). As a result, many of these conservation efforts have not been effective (Sanchez-Azofeifa et al., 2007).

Protected areas generate a variety of ecosystem services (Daily, 1997; Xu et al., 2017), and local people can utilize these services for both subsistence use and income generation (Bray et al., 2008; Putz et al., 2012). Studies have reported that the opportunity costs of local

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people for forgoing access to ecosystem services in protected areas can account for 18% to 54% of household income (Bush et al., 2013; Shrestha et al., 2007; Shyamsundar and Kramer, 1996). Even without logging, the economic values of Non-Timber Forest Products (NTFPs) such as fuelwood, fruits and medicines can contribute between 14% and 44% of household income (Kalaba et al., 2013; Kar and Jacobson, 2012; Schaafsma et al., 2014). Although these case studies are site specific and may represent areas where the opportunity costs of conservation were relatively high, accommodating some local exploitation of ecosystem services can substantially reduce the costs of conservation. In order to avoid undermining conservation, any exploitation of ecosystem services needs to be done within the conservation goals of protected areas (Rands et al., 2010). Further, conservation policies that ensure sustainable use of ecosystem services may increase transaction costs of conservation. Therefore, management of ecosystem service use without compromising conservation goals of protected areas is still a challenge.

One of the important ecosystem services is fuelwood, which is a primary energy source for > 2.5 billion people worldwide (Global Energy Assessment, 2012). A meta-analysis of 51 case studies from 17 countries found that the value of fuelwood accounts for an average of about 7% of household income (Vedeld et al., 2007). However, fuelwood collection has been considered one of the major drivers of forest degradation globally and deforestation in some areas (Geist and Lambin, 2002; McNally et al., 2011), including in protected areas (Naughton-Treves et al., 2005). Therefore, many protected areas have enforced restrictions on local people's fuelwood collection, which often resulted in increased conflicts between human livelihoods and conservation (He et al., 2009; Weladji and Tchamba, 2003). However, fuelwood is also harvested in many places where forest regrowth exceeds the demand for fuelwood (Arnold et al., 2006; Bailis et al., 2015). Studies have found that allowing access to fuelwood can positively affect local people's attitudes toward conservation (Allendorf et al., 2006; Bajracharya et al., 2006).

Because fuelwood provides a valuable ecosystem service, conservation policy design can benefit from information on the demand for and value of fuelwood that local people utilize in and around protected areas. Although there is a substantial literature on the economic valuation of ecosystem services, including fuelwood, most studies within protected areas have estimated either the costs for keeping protected areas intact, or the values of exploiting NTFPs at levels that often lead to ecosystem degradation (Kusters et al., 2006; Peres et al., 2003). Little is known about the value of exploiting ecosystem services in protected areas without compromising conservation goals. Further, most NTFP valuation studies have relied on self-reported monetary values, or physical quantities and applied a price based on a market value or the price of substitutes of the NTFPs (Mamo et al., 2007; McElwee, 2008; Uberhuaga et al., 2012). However, in many areas market access or substitutes for fuelwood in local markets are lacking or non-existent, making valuation difficult. In addition to economic market values, fuelwood may also contain non-market values such as social and cultural values, so that even where they exist, market prices for substitutes often cannot capture the full value of the ecosystem services to local people.

The contingent valuation method (CVM) is a non-market valuation approach that can capture the full range of values of ecosystem services to the individual households, though it would not capture externalities a household's actions may have on other households. CVM has been widely used in the economic valuation of ecosystem services (Carson, 2000), including evaluation of the opportunity costs for forgoing access to resources in protected areas (Bush et al., 2013; Shyamsundar and Kramer, 1996). These studies estimate people's willingness to pay (WTP) for forest conservation (Amirnejad et al., 2006; Mill et al., 2007; Pouta, 2005), air regulation (Banzhaf et al., 2006), ecosystem management (Gurluk, 2006), conservation in protected areas (Adams et al., 2008; Hadker et al., 1997), and the implementation of conservation programs (Moreno-Sanchez et al., 2012; Ortega-Pacheco et al., 2009; Sattout et al., 2007; Shultz and Soliz, 2007). To our knowledge, CVM has not been applied to the valuation of fuelwood. In most CVM studies for the valuation of ecosystem services, a dichotomous choice method (also known as discrete choice method) is preferred over open-ended responses mainly because of its incentive compatibility and the reduction of protest bids. Dichotomous choice method was also endorsed by the National Oceanic and Atmospheric Administration (NOAA) Panel on Contingent Valuation (Haab and McConnell, 2002).

Studies on the WTP for forest ecosystem services have found mixed relationships between income and WTP. Some studies have found significant positive correlations between income and WTP (Adams et al., 2008; Amirnejad et al., 2006; Ortega-Pacheco et al., 2009; Vincent et al., 2014), but other studies did not find such a correlation (Pouta, 2005; Shultz and Soliz, 2007). Younger people and people with higher education tended to have higher WTP for ecosystem services (Amirnejad et al., 2006; Banzhaf et al., 2006; Hadker et al., 1997). Findings on the relationship between household size and WTP are mixed (Gurluk, 2006; Kramer and Mercer, 1997). Studies have also found significantly higher WTP for ecosystem services among people who perceived more frequent use of the ecosystem services (Kramer and Mercer, 1997; Sattout et al., 2007). In addition, the geographic location of people was also a significant determinant of WTP for ecosystem services (Banzhaf et al., 2006; Moreno-Sanchez et al., 2012).

The goal of the present study is to estimate local people's WTP for fuelwood services under forest management that fulfills conservation goals. A household survey was conducted to elicit WTP for access to fuelwood. Statistical analyses of stakeholders' responses also allowed us to identify household characteristics and respondents' features that drive demand for fuelwood collection. We chose China's Wolong Nature Reserve as our demonstration site for this study because we can draw on our two-decade research experience in the reserve (e.g., An et al., 2006; Chen et al., 2012b; Chen et al., 2010; Linderman et al., 2006; Liu et al., 1999; Liu et al., 2012; Tuanmu et al., 2011; Yang et al., 2015). Many results and methods developed in the reserve have been applied to studies at regional, national, and global levels (e.g., An et al., 2014; Bawa et al., 2010; Bradbury et al., 2014; Liu et al., 2003; Liu and Raven, 2010; Liu et al., 2016b; Vina et al., 2010; Xu et al., 2006; Yu and Liu, 2007).

2. Material and methods

2.1. Background and study site

Wolong Nature Reserve is located in Sichuan Province of China (Fig. 1). It was designated as a national nature reserve in 1963 with a size of about 200 km^2, and was expanded to about 2000 km^2 in 1975. This reserve is within one of the top 25 global biodiversity hotspots (Myers et al., 2000), and supports > 6000 plant and animal species. In addition, the reserve also contains about 4500 human residents (Liu et al., 2007). Most local residents are farmers and are involved in a variety of activities such as fuelwood collection, cultivating maize and vegetables, grazing, and support for tourism (Chen et al., 2009a, 2009b). Although the reserve banned commercial logging, the establishment of the reserve alone did not effectively prevent illegal timber harvesting (though subsequent policies described below did). Previous studies in this reserve have demonstrated that these human activities resulted in past deforestation (Liu et al., 2001; Viña et al., 2007).

Even though it takes substantial effort to collect fuelwood (men did most of fuelwood collection) in the extremely rugged terrain, local residents have traditionally used fuelwood as their main energy source for heating and for cooking human food and pig fodder. Fuelwood was not sold in the local market. The only main alternative energy source to fuelwood is electricity. Although local residents preferred electricity to fuelwood because electricity is more convenient and cleaner without indoor air pollution (Chen et al., 2012a), electricity was mainly used for lighting and electronic appliances because electricity was more