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Strengthening protected areas for giant panda habitat and ecosystem services

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ABSTRACT

Biodiversity and ecosystem services are two main focuses in conservation planning. Considering both biodiversity and ecosystem services is beneficial when designing protected area networks. We demonstrated the relationship between these two concepts using the giant panda in China as a case study. We assessed the spatial relationship between giant panda habitat suitability and three key ecosystem services including carbon sequestration, water retention, and soil retention. We conducted spatial correlation and then used MARXAN to propose areas to target for new protected areas in the future that consider both goals. Results showed that the habitat suitability was positively correlated with ecosystem services in the entire study area. Panda habitats covered 77.7%, 72.0%, and 66.6% of carbon sequestration, water retention, and soil retention supplies, respectively. However, in nature reserves, which encompassed 31.0% of the whole study area and contained 33.6% of panda habitat, there was only 26.1–29.7% coverage of all ecosystem services. This result implied that nature reserves represented panda habitats well but did not adequately represent the three key ecosystem services. We identified conservation priority areas combining both panda habitat and ecosystem services and then proposed new protected areas. Our results inform conservation policies such as giant panda national park planning in this region. Our study also has implications for the role of protected area systems in the conservation of both flagship species and key ecosystem services in other places.

1. Introduction

It is broadly recognized that losses in biodiversity and ecosystem services are occurring daily and accelerating in the face of human population growth, climate change, and rampant development (Department of Economic and Social Affairs, 2016; IUCN, 2015; Sandifer et al., 2015). A central approach to halting these threats is establishing nature reserves and other types of protected areas (PAs) (Juffe-Bignoli et al., 2014). Biodiversity has historically been the dominant goal for protected area design implementation and management (Duran et al., 2013), and currently ecosystem services for human well-being are also being incorporated into goals for PA design (Grêt-Regamey et al., 2017; Lin et al., 2017; Varma et al., 2015; Wissen Hayek et al., 2016). Galvanized by the Millennium Ecosystem Assessment and the Aichi Biodiversity Targets, ecosystem services have begun to be considered in the practice of conservation planning by major international conservation institutions including the World Wildlife Fund (WWF), International Union for Conservation of Nature (IUCN) and the Convention on Biological Diversity (Arpin and Cosson, 2018). It is widely acknowledged that biodiversity and ecosystem services are linked (Balvanera et al., 2014; Mace et al., 2012). Although gaps still exist in our knowledge about their relationship (Mori et al., 2016), evidence shows that PAs not only secure biodiversity (Bruner et al., 2001), but also provide ecosystem services such as mitigating climate change (Soares-Filho et al., 2010), and enhancing ecosystem resilience (MacKinnon et al., 2011). Therefore, a PA network design that considers both biodiversity and ecosystem services will optimize the overall functions and benefits of PAs (Xiao et al., 2011). This can be achieved by a complementary approach, such as systematic conservation planning (SCP) (Cimon-Morin et al., 2013), a multicomponent stage-wise approach to identify conservation areas and devise management policies, with feedback, revision, and reiteration, where

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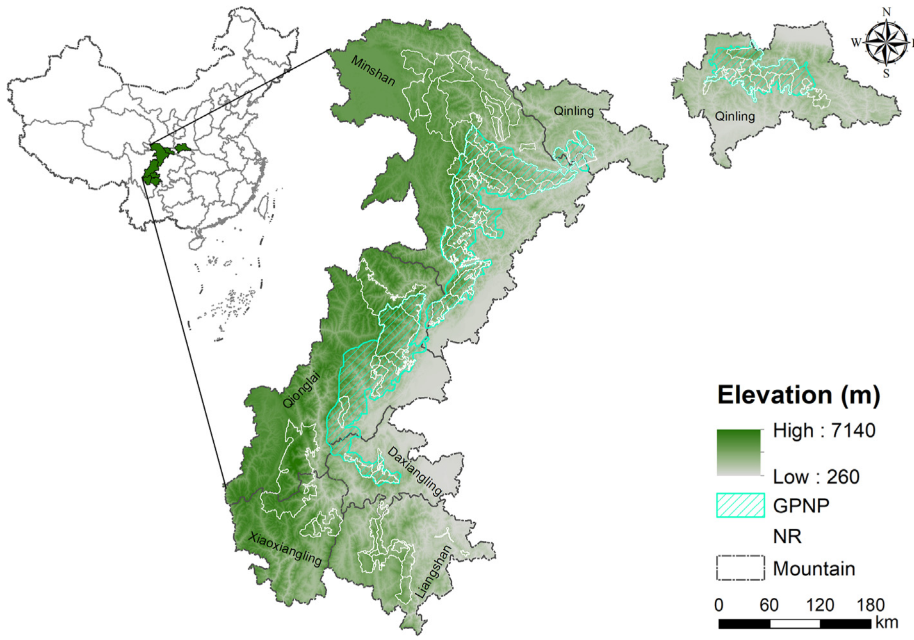

Fig. 1. Study area in giant panda habitat in south-central China.

needed, at any stage (Cowling and Pressey, 2003; Margules and Sarkar, 2007; Margules and Pressey, 2000; Sarkar and Illoldi-Rangel, 2010).

PAs are an important topic of study in China, a nation that contains high biodiversity and natural resources but also supports among the fastest growing human populations in the world. By the end of 2016, China established 2750 nature reserves (one of the major types of PAs) across 147 million ha, covering 14.9% of China's terrestrial land (Ministry of Ecology and Environment, 2017). A higher number of nature reserves have been built in the distribution areas of flagship species such as the giant panda (*Ailuropoda melanoleuca*), golden monkey (*Cercopithecus kandti*), Manchurian tiger (*Panthera tigris* ssp. *altaica*), Asian elephant (*Elephas maximus* Linnaeus), Tibetan antelope (*Pantholops hodgsonii*), and red-crowned crane (*Grus japonensis*) in order to conserve the flagship species in question, in addition to any sympatric species and the overall ecosystem (Kong et al., 2016; Li and Xiang, 2016; Lin et al., 2014; Liu, 2016; Xu et al., 2014). However, the necessity and rationale of flagship species conservation has been questioned, since gaps still exist in what is known about the relationships between important conservation areas of flagship species and ecosystem services, and even in the effectiveness of flagship species nature reserves in preserving ecosystem services (Kram et al., 2012).

A new initiative of establishing a national park system in China provides an unprecedented opportunity for optimization of PAs to consider both biodiversity and ecosystem services. This initiative was proposed in 2013, with the aim to resolve management conflicts between different administrations by combining all PAs into one national park system. The initiative aims to improve the effectiveness of protection of ecosystems, improve the capacity for ecosystem services provision for regional and national security, and provide a new mechanism for broadly achieving conservations (Wei, 2017). National parks will be established in areas of national significance for natural ecosystems conservation. To date, ten pilot national parks have been developed throughout China (Huang et al., 2018).

The Giant Panda National Park (GPNP) was proposed as one of the pilot parks in 2016 due to the national significance and ongoing threats to the giant panda. The giant panda is the global conservation icon (Loucks et al., 2001; Xu et al., 2017a). Although the giant panda was downgraded from endangered to vulnerable in 2016 (IUCN, 2016), panda conservation still needs to be strengthened, because panda habitat is heavily fragmented, and the extinction risk especially for small isolated populations is ongoing and increasing (Xu et al., 2017a). In addition, the distribution areas of the giant panda also contain ecological function zones that play a significant role in carbon sequestration (Wen, 2016), soil retention (Rao, 2015), water retention (Gong, 2016), and other ecosystem services (Zhou et al., 2015) that are important for regional ecological security and integrity. Therefore, establishment of GPNP will enhance the connectivity, co-ordination, and integrity of the giant panda habitat, and promote overall protection and habitat restoration (SCPRC, 2016). The design of panda PAs (including the GPNP) should also take ecosystem services into account (Xu et al., 2017a), but the relationship between giant panda habitats and ecosystem services is unclear, as is the effectiveness of existing nature reserves in the protection of giant panda habitats and ecosystem services.

In this paper we evaluated the effectiveness of giant panda nature reserves in covering major ecosystem services and designed PAs for protecting both giant panda habitats and ecosystem services by using one of the SCP method – MARXAN. The specific objectives are to: 1) explore the relationship between panda habitat suitability and the supply of the three ecosystem services: carbon sequestration, soil retention, and water retention; 2) evaluate the coverage of the three key ecosystem services in panda habitat; 3) assess the coverage of PAs in protecting giant panda habitat and ecosystem services; and 4) propose suggestions for policy making in the design of a protected area network and GPNP to enhance its effectiveness for preserving ecosystem services.

2. Methods

2.1. Study area

The study area (172,150 km^2) is comprised of six mountain ranges currently inhabited by the giant panda in Sichuan, Shaanxi, and Gansu provinces in south-central China. These include the Qinling, Minshan, Qionglai, Daxiangling, Xiaoxiangling, and Liangshan mountains. Most of this area is characterized by high mountains and deep valleys, with elevations between ca. 260 and 7140 m (Fig. 1). The area is one of the hotspots for global biodiversity conservation and priority areas for biodiversity conservation in China, supporting > 800 wild vertebrates and 4000 wild vascular plants (Ministry of Ecology and Environment and Chinese Academy of Sciences, 2014). In addition to giant pandas,