Biological Conservation xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/bioc

Habitat conservation redlines for the giant pandas in China

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ARTICLE INFO

Article history:
Received 19 November 2015
Received in revised form 5 March 2016
Accepted 24 March 2016
Available online xxxx

Keywords:
Giant panda
Habitat
Conservation
Redline
Population
Connectivity

ABSTRACT

Considering the impossibility to cover the entire population of an endangered species in protected areas, a new approach (species conservation redlines) was recently been proposed in China. It constitutes the baseline space for species conservation but mapping and managing a species redline is not clear. In this study, a procedure on how to map habitat conservation redlines for the endangered giant panda was proposed. Panda habitat was first modeled based on field survey and remotely sensed data. Redline area was proposed after comparing three different scenarios, covering different proportions of panda habitat and populations. Results showed that the proposed redline area covered 9358 km^2. This area can protect more than 80% of the populations in all mountain regions in the study area, while keeping the connectivity of the habitat. The current nature reserves cover 60% of the redline area. Suggestions on how to manage redline areas inside and outside reserves are proposed, to limit human development activities in panda habitat. Our study provided a new approach for managing panda habitat, and would have implications for conservation of other endangered species in China and the world.

1. Introduction

Finding the balance between conservation and development is still a challenge globally, and even more serious in a country with a huge population such as China. A redline paradigm has evolved at the central government level in China in 2011 to set the ecological redline in the key ecological functioning regions, eco-sensitive regions and eco-fragile regions (Lü et al., 2013; Zheng and Ouyang, 2014). Through reasonable layout and minimum area constraint, the redline is delineated in the regions needing special protection to coordinate the ecological environment and economic development, and the regions must be strictly protected (Rao et al., 2012). Among different redline areas for ecological conservation, the redline for species conservation started to be named by the State Forestry Administration in 2013, and defined by the Environmental Protection Administration (Gao, 2015). The redline for species conservation is based on the establishment of key areas displaying a minimum habitat area to maintain viable populations. This redline constitutes the baseline space for species conservation, and long-termed survival of the populations will be threatened if the redline is occupied by human development. The redline does not only comprise the spatial boundary for controlling human activities but also contains quantitative conservation management requirements (Yang et al., 2014). Although the definition was proposed for two years, there are no readily available procedures to map species conservation redlines. Here we take the endangered giant panda (*Ailuropoda melanoleuca*) as an example to describe, for the first time, how to delineate a species conservation redline.

The giant panda is the symbol of species conservation in China. This species once ranged throughout most of China, northern Vietnam, and northern Myanmar (Pan et al., 2001). However, the geographic distribution of the species in China has sharply declined mainly due to human activities (Hu, 2001). Currently, the wild giant panda is distributed in the six mountain regions (Qinling, Minshan, Qionglai, Daxiangling, Xiaoxiangling and Liangshan) (State Forestry Administration, 2015). During the last 60 years, China has established 67 nature reserves specifically to protect panda habitat. The program of National Wildlife Protection and Nature Reserve Construction, which started in 2001, has promoted the conservation of the giant panda, while the National Forest Conservation Program (NFCP) and the Grain-to-Green Program (GTGP) have shown the potential for restoring and expanding the panda habitat (Xu et al., 2006). In addition, the State Forestry Administration in China has carried out four national surveys of giant pandas. Much research has been carried out on habitat mapping, habitat change (Linderman et al., 2005a; Viña et al., 2010; Vina et al., 2007; Zhang et al., 2014), impacts of climate change and/or natural disasters on the giant panda (Li et al., 2015a, 2015b; Xu et al., 2009; Zheng et al., 2012), design of nature reserves or corridors (Loucks et al., 2003; Xiao et al., 2011; Xu et al., 2006), and impacts of human factors (Bearer et al., 2008; Linderman et al., 2005b; Liu et al., 2001; Yiming et al., 2003). However, it is still difficult to establish nature reserves in some regions where the panda habitat is not under conservation because it will affect local economic development, while also it is difficult to manage the habitat outside reserves. In addition, different human activities (e.g., road construction,

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http://dx.doi.org/10.1016/j.biocon.2016.03.028
0006-3207/

tourism, large hydropower stations, agricultural expansion, residential development) cause reductions and fragmentation of the panda habitat, further threatening the current panda conservation system. Therefore, the development of effective management measures to restrict human activities within the panda distribution area is important for panda habitat conservation.

In this paper, the approach for delineating the panda habitat conservation redline described, generates effective panda habitat conservation measures. Specific aims included a habitat assessment across the entire giant panda geographic range, comparison of different strategies for identifying the redline area, analysis of the spatial relationship between the redline and the current conservation system, and discussion of management approaches.

2. Methods

2.1. Study area

The study area (172,150 km^2) was defined by the six mountain regions currently inhabited by the giant panda in Sichuan, Shanxi and Gansu provinces in China, which comprise 56 counties. The region includes the Southwest China hotspot, one of the world's top 25 Biodiversity Hotpots (Myers et al., 2000). Most areas are characterized by high mountains and deep valleys, with elevations between ca. 260 and 7140 m. This significant change in elevation with its associated high variation in climate and soils causes high biodiversity in the region. The major vegetation types in the region are evergreen and deciduous broadleaf forests at lower elevations and evergreen coniferous forests at higher elevations (Fig. 1). The understory of the forests is dominated by ca. 60 bamboo species, with approximately 35 of them being the preferred food of giant pandas (Hu and Wei, 2004; Li, 1997). There are more than 300 hydropower stations, about 470 mines and more than 20 scenic spots in the study area, while the length of the road network in the study area is about 1300 km (State Forestry Administration, 2015).

2.2. Habitat assessment

We used a conceptual model to assess potential panda habitat (Liu et al., 1999; Ouyang et al., 1995). This model is based on previous studies on giant panda (Ouyang et al., 2001; Xu et al., 2006; Xu et al., 2009), and national panda surveys, and considers biotic and abiotic factors (e.g., vegetation types, elevation, slope and bamboo distribution). Assessment criteria are listed in Table 1. Potential suitable habitat for the giant panda is considered to be a function of the four main criteria. The Vegetation data was obtained from the China Ecosystems assessment dataset in 2010 at a spatial resolution of 30 m (Wu et al., 2014), which used the Chinese HJ-1A/B satellites as the major data source and method of object oriented automatic classification, combined with ground investigation and radar data. The classes of the vegetation include three levels of classifications (e.g., forest, broadleaf forest, evergreen broadleaf forest), and the vegetation types suitable for the giant panda were listed in Table 1. Elevation and slope were obtained from Digital Elevation Model (DEM; 1:50,000) in 2011, produced by the National Geomatics Center of China, and the bamboo distribution map was obtained from the Fourth National Giant Panda Census (State Forestry Administration, 2015).

2.3. Identification of the panda habitat conservation redline

The distribution of the panda occurrence locations can spatially reflect the degree of utilization of the habitat by panda individuals. On the basis of the potential habitat described previously, we delineated the panda habitat conservation redline using the density of panda occurrence locations. Data on panda population distribution was then overlaid to judge the proportion of the population conserved in the redline. The panda occurrence data and the population data were obtained from the Fourth National Giant Panda Census (State Forestry Administration, 2015).

The procedure for delineating the redline is as follows: first, the potential habitat is divided into 3 km * 3 km grids, and the number of panda occurrence locations within each grid was calculated, as well as the number of occurrences within a buffer zone of 10 km around each grid. Second, the grids were sorted in descending order by the number of occurrence locations. Grids exhibiting the same number of occurrence locations were further sorted by the number of locations in the buffer zone. Finally, the grids are sorted into different levels based on the proportion of the occurrence locations (i.e. 0, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%). The grids with the top 10%

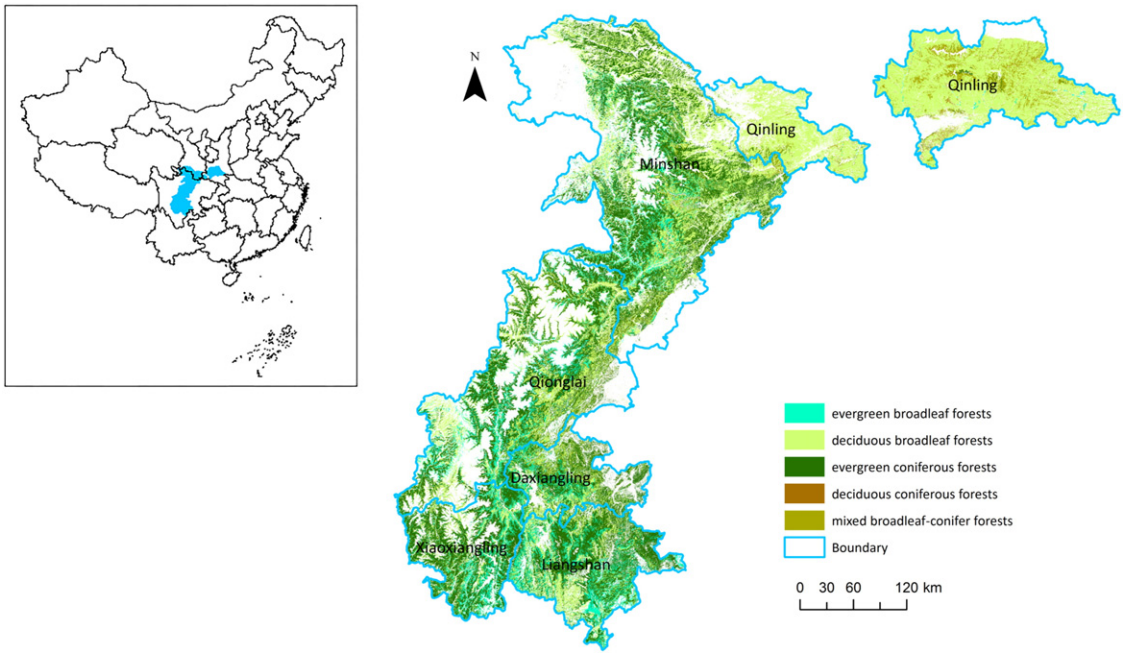

Fig. 1. Distribution of the different forest types in the study area (Wu et al., 2014).

Please cite this article as: Kong, L., et al., Habitat conservation redlines for the giant pandas in China, Biological Conservation (2016), http://dx.doi.org/10.1016/j.biocon.2016.03.028