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FORUM

Price of prosperity: economic development and biological conservation in China (财富的代价：中国的经济发展和生物保护)

Fangliang He

Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada T6G 2H1

Summary

1. In the past three decades China has experienced fundamental changes to its economy, which have transformed it from one of the poorest countries in the world to the third largest economic body. This gain in wealth has, however, been achieved at severe cost to the environment.
2. I review the current state of environmental protection and examine the effectiveness of the existing nature reserves for biological conservation in China.
3. *Synthesis and applications*. Proactive approaches to environmental management – including significant investment in science and technology, science-informed land-use policy making and international collaboration – are necessary for China to significantly slow down or reverse its current environmental problems.

Keywords: Baiji, Beshanzu fir, biodiversity conservation, China, economic growth, environmental protection, species extinction, invasive species, nature reserves

Introduction

Central to the conservation of biodiversity and environments is the relationship between man and nature. This relationship is not uniformly distributed across the globe but is of great geographical variation – a more balanced relationship is maintained in some regions than in others. In China, the relationship is out of balance. China is the most populous country in the world (1·3 billion people) and is also currently the most economically vibrant country, having enjoyed the highest economic growth over the past three decades, with an average annual gross domestic product (GDP) growth rate of around 10%. This growth has transformed China from one of the poorest countries in the world to the third largest economic body next only to the USA and Japan (http://en.wikipedia.org/wiki/Economy_of_the_People's_Republic_of_China).

This astonishing economic miracle does not, however, come without a price. The gain of wealth has been achieved at the expense of severe degradation of environments and ecosystem services. Over the past 30 years, China has lost millions of hectares of forests, croplands and grasslands to urbanization, desertification and industrial use (López-Pujol & Zhao 2004; Fu *et al*. 2007), contaminated 80% of surface water beyond human use, and heavily polluted the air, making blue skies a luxury (Fu 2008). This precipitous environmental decline has resulted in colossal economic loss and has significantly reduced the quality of life. To give an idea of the magnitude of the costs involved, the State Environmental Protection Administration of China (SEPA 2006) estimated that air and water pollution together in 2004 cost China 511·8 billion RMB (~$US75 billion), equivalent to 3·05% of the GDP of that year. Of this, water pollution alone accounted for the loss of 286·3 billion RMB. If other forms of environmental and ecological degradation are also considered, the cost could be much higher (7 to 20% of annual GDP, Fu 2008). In addition, water and air pollution has jeopardized the health of the population and is estimated by the World Health Organization to be responsible for over 300 000 premature deaths in China annually (Greenbaum & O'Keefe 2006).

Dust storms are another example of environmental calamity that is directly caused by unsustainable management of grassland ecosystems (e.g. overgrazing) and droughts induced by global climate change. Dust storms have resulted in enormous economic loss in China, with an annual loss estimated to be 470 billion RMB (http://env.people.com.cn/GB/1073/4307644.html). As an example, the dust storm on 15/16 April 2006 deposited 10·76 tons of dust per km^2 in Beijing. The impact of dust storms has crossed borders, reducing the primary productivity of the Pacific and affecting global climate (Zhuang *et al*. 2001). Another example of cross-border transmission of ecological hazards but in the opposite direction is biological invasion. China has seen a significant increase in biological invasions in the last three decades. At an average rate of 2·5 species per year, they have been driven by the rapid increase of international trade, transportation and economic growth (Lin *et al*. 2007). For example, in the first 10 months of 2006

*Correspondence author. E-mail: fhe@ualberta.ca

Fig. 1. *Abies beshanzuensis* M.H. Wu, a 'living fossil' and critically endangered species, only three trees grow in Qinyuan County, Zhejiang Province. The red arrow on the left bottom photo indicates the location of the species.

China Customs intercepted 104 000 attempts of introductions, resulting in the seizure of 2471 exotic species (http://news.xinhuanet.com/environment/200612/15/content_5491443.htm). Invasive species have cost China dearly, with a loss of 57·4 billion RMB to the 11 most harmful invasive species alone (Wan *et al.* 2002).

Loss of species

Above all the aforementioned problems caused by habitat loss and the degradation of ecosystems, the one with the most far-reaching impact is the loss of biodiversity. Species loss is irreversible and can profoundly jeopardize many ecosystem services. China is a country of mega-biodiversity. It is home to 33 000 higher plants and over 6350 vertebrate species. Many of them are endemic: about 52·5% of higher plants (~17 300 species) and 10·5% of vertebrates (~667 vertebrates) are only found in China. The demand for resources to meet continued economic growth has endangered the survival of a large number of species, pushing them to the brink of extinction. The declared extinction of the Yangtze River dolphin (*Lipotes vexillifer*; Baiji in Chinese) in 2007 is a vivid example of how irresponsible activities (e.g., harmful by-catch in local fisheries, the increasing number of container ships in the Yangtze River, boat collisions, sand/mud dredging, dam construction) can accelerate the extinction of an already critically endangered species (Turvey *et al.* 2007). The extinction of Baiji represents the wipe-out of an ancient mammalian family that was 20 million years old. I had an opportunity to see the charismatic Baiji in captivity in Wuhan in 1985 when the size of the wild population was still 300 (Turvey *et al.* 2007), but could not imagine it would be gone in just 20 years. Another endangered mammal, the Yangtze finless porpoise *Neophocaena phocaenoides asiaeorientalis*, living in the same habitat is facing the same doom as Baiji unless immediate protection is put in place (Zhao *et al.* 2008). While Baiji has now vanished, many other species of similar endangered status but less charismatic still have to struggle for their existence in the face of today's economic growth. For example, a dozen tree species in China are known to be represented by just a few individual trees (http://qzone.qq.com/blog/52005824-1216580452), for example *Carpinus putoensis* Cheng (Puto hornbeam, only one wild individual left), *Abies beshanzuensis* M.H. Wu (Beshanzu fir, three individuals; Fig. 1), and *Manglietiastrum sinicum* Law (Chinese manglietiastrum, six individuals).

As an example of the perilous state of these extremely rare species, Beshanzu fir had seven live trees when it was first discovered in 1976 by a local botanist, M-H. Wu, in Qingyuan County, Zhejiang Province, where I grew up. Only three trees are now left in the native site. The causes of the decline of the population are primarily due to human disturbance combined with poor regeneration. The species was listed as one of the 12 rarest and endangered plants by the International Species Security Committee in 1987. Unlike any other *Abies* in China which either live in high altitude (3000–4000 m) in southwestern China or high latitude in northern China, *A. beshanzuensis* grows in subtropical broad-leaf deciduous forest at an altitude of 1700 m. This site was a refuge of the Quaternary glaciation that had almost eliminated its entire population. This 'fossil' status makes the species important for understanding palaeoclimatic and palaeoendemic patterns and their influences on the modern distribution of species. To protect the species, Baishanzu Nature Reserve was established in 1985 and was designated as a national nature reserve in 1992 when a commemorative stamp illustrating this rare species was issued by

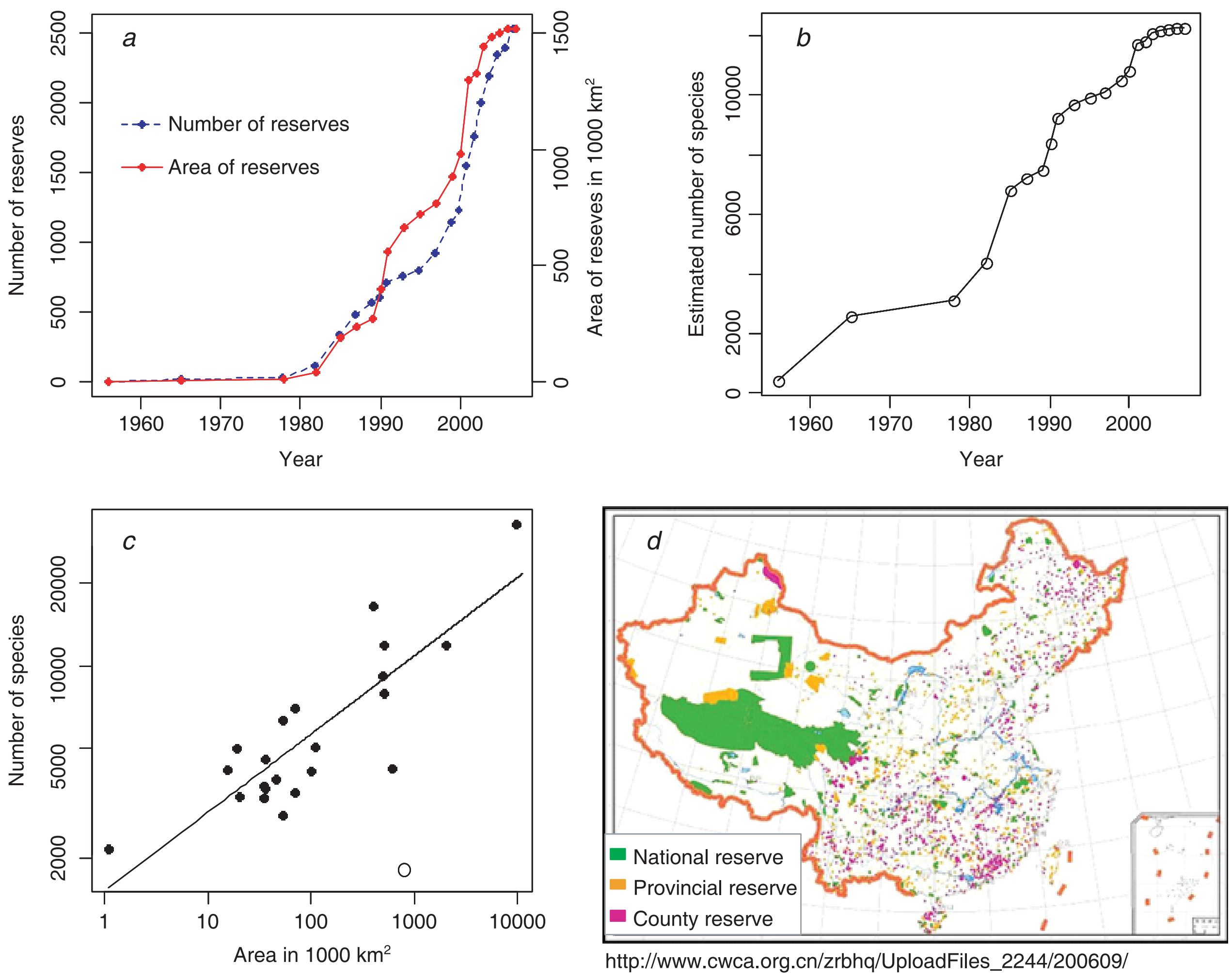

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Fig. 2. China's nature reserves (1956–2007; data: http://www.mep.gov.cn/plan/zkgb/). The first reserve, Dinghushan National Nature Reserve (area: 11 000 km^2), was established in 1956. The number of reserves has since increased to 2531 in 2007, totalling 1 518 820 km^2, accounting for 15·82% of China's 9·6 million km^2 terrestrial land base. (*a*) The number of reserves and the reserve area from 1956 to 2007. (*b*) The estimated number of plant species the nature reserves would protect. It increased from 415 species in 1956 to 12 287 in 2007. The estimation was based on the species-area curve shown in (*c*). The data in (*c*) are from López-Pujol & Zhao (2004; Table 3) and from Tang et al. (2006; Table 2), plus the whole country data point (9·6 million km^2 and 33 000 higher plants). The straight line is the log–log power law species–area curve, with intercept = 5·343 and slope z = 0·286. The open circle at the bottom of (*c*) is the number of species in the alpine Qinghai-Xizang Plateau where the floral diversity is excessively lower but highly endemic (Tang *et al.* 2006). This data point was excluded from fitting the species-area curve. (*d*) The distribution of the nature reserves in 2005.

China Post to heighten public awareness for conservation in the country (Fig. 1).

The loss of biodiversity is not just limited to rare species but occurs at a much larger scale. China has so far conducted three major species endangerment assessments. The first species red list was completed in 1992 using the modified 1960s IUCN criteria but only included 308 plant species (Fu 1992). The second was conducted in 1998 by a joint effort of 20 government departments (SEPA 1998) to fulfil China's commitment to the 1992 Rio Convention on Biological Diversity and included both plants and animals. The latest assessment was conducted in 2004 by the China Council for International Cooperation on Environment and Development (CCICED, http://www.cciced.org/). The new CCICED red list was compiled based on the 2001 IUCN criteria and included 10 211 species, of which 2208 were plants (Wang & Xie 2004). The new red list represents the improved knowledge and assessment criteria and reveals that few species are immune to threats. For example, the 1998 SEPA assessment reported that 13% of gymnosperms and 28% of angiosperms were endangered, while the percentages for these two groups were, respectively, 69·9% and 86·8% in the 2004 CCICED report (Wang & Xie 2004). In addition to this, a large number of extremely rare species were omitted from the CCICED assessment (Zhou *et al.* 2007). The driving factors that endanger or threaten the red list species include the loss of habitats, environmental pollution, unsustainable use of biological resources, introduction of exotic species, climate change, and lack of legislation and law enforcement (López-Pujol & Zhao 2004; Fu *et al.* 2007; Tao *et al.* 2007).

The second version of the CCICED red list is scheduled to be released next year.

Protecting biodiversity

China well realizes the ecological and environmental challenges it faces today and has resolved to develop a sustainable economy. Over the past three decades, particularly in the recent 10 years, China has invested significant efforts to improve the quality of environments and ecosystem services (Fang & Kiang 2006; Fu *et al*. 2007). This includes the programmes of natural forest protection (http://www.tianbao.net/; Zhang *et al*. 2000) and restoring forests from farmlands (http://www.tghl.gov.cn/) through government subsidies. Another major undertaking is the establishment of a national network of protected areas designed to protect biodiversity (Fig. 2). This network consists of nature reserves at local (county), provincial and national levels. Although the degree of protection varies considerably from free access with management activities to complete closure prohibitive of human disturbances, nature reserves play a fundamental role in protecting the diverse ecosystems in China. I unfortunately cannot find relevant floristic and faunistic data from the reserves that would allow me to examine the effectiveness of the current 2531 reserves in biodiversity protection. Assuming that species diversity in nature reserves distributes in a similar way as in those hotspots identified by López-Pujol & Zhao (2004) and Tang *et al*. (2006) (see Fig. 2), I estimated the current reserve network (total area = 1 518 820 km^2) to contain 12 287 plant species, equivalent to 37·2% of the country's total flora. If the target is to protect 60% of the species, about 35% of land must be set aside for reserves, while 47% of land is required for protecting 70% of them. The actual percentage would surely be higher if the species–area curve were not calculated from the data of hotspots and if the buffer and transition zones of reserves (subject to economic activities) are considered of lower value for biodiversity protection (Ma *et al*. 2009). China has planned to protect 18% of its land for conservation by 2050 (SFA 2004). Based on the above calculation, this target is unlikely to meet the need of biodiversity conservation.

Looking at the future

China has made significant progress in legislating environmental and ecological laws/regulations. For example, only one law ('the Environmental Protection Law') was passed in the 1970s, while 11 and 10 laws/regulations were enacted in 1980s and 1990s, respectively (López-Pujol & Zhao 2004). A very promising development is the recent adoption of green GDP that proposes to discount GDP for the environmental costs lost to growing that GDP (SEPA 2006). Although there may be discordant voices in the government for the implementation of green GDP (Liu & Diamond 2008), the final adoption of the new way of calculating GDP will profoundly impact China's economy and environment. While promising, there are limitations in the approach of green GDP as it is largely a reactive approach that addresses problems only when they have occurred. Proactive and forward-looking approaches to environmental management are necessary if China is determined to significantly slow down or reverse the current environmental problems. Any proactive approach must be science-based, and the ability to predict environmental changes and the consequences of human activity is key to its success. This requires significant investment in scientific research and technology development and international collaboration. Although China's investment in science, when measured in dollars, is still very small, the country has recently seen a rapid increase in research funding. For example, from 2001 to 2008, the total research funding of the National Natural Science Foundation of China increased from 978 million to 3·67 billion RMB (a 34% annual increase), and the funding for the Ecology Section increased from 11·9 to 40·9 million RMB (data: http://www.nsfc.cn/nsfc2008/index.htm).

With awakening public awareness, changes in government policies, increasing investment in science and technology, and enhanced international collaboration, China will realize its prosperous and green dream, yet the journey may still be a long one.

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