Threats to China's Biodiversity by Contradictions Policy

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Abstract China has among the highest biodiversities in the world, but faces extreme biodiversity losses due to the country's huge population and its recent explosive socioeconomic development. Despite huge efforts and investments by the government and Chinese society to conserve biodiversity, especially in recent decades, biodiversity losses may not have been reversed, and may even have been exacerbated by unintended consequences resulting from these projects. China's centralized approach to biodiversity conservation, with limited local participation, creates an inflexible and inefficient approach because of conflicts between local communities and national administrators over the benefits. Although community-based conservation may be an imperfect approach, it is an essential component of a successful future national conservation plan. Biodiversity conservation should be considered from the perspective of systems engineering and a governance structure that combines centralization with community-level conservation. In this paper, we describe China's complex challenge: how to manage interactions between humans and nature to find win-win solutions that can ensure long-term biodiversity conservation without sacrificing human concerns.

Keywords Biodiversity conservation · Unintended consequences · Centralization · Community-based conservation · China

INTRODUCTION

China has one of the world's most biodiverse ecosystems and one of the richest species assemblages in the temperate and subtropical northern hemisphere (Liu and Diamond 2005). However, China's biodiversity is jeopardized by the

country's huge population, and the increasingly explosive intensity and extent of human activities caused by the booming economy. For example, 2140 of species listed in the CITES appendices (ESSC 2012) were in danger of extinction in 2011. From 15 to 20 % of China's species of higher plants are endangered; the country's genetic resources have decreased sharply in the past 60 years, and 233 vertebrate species are in danger of extinction (Liu and Diamond 2005; MEP 2010). This is even true for famous species such as the giant panda (*Ailuropoda melanoleuca*), whose population declined from an estimated 46 000 individuals in the 1950s to fewer than 1000 individuals in 2006 (MEP 2009a). In addition to species, the habitat loss caused by increasingly severe land degradation has been significant: 90 % of China's grasslands and 40 % of its wetlands have sustained significant degrees of deterioration, and the area of undisturbed primary forest has decreased by 50 000 km² annually (MEP 2009a; Yang and Zhu 2012). These changes will have a remarkable impact on both biodiversity and China's socioeconomic development. For instance, 13 % of China's land has become significantly polluted, and estimates of the economic losses caused by environmental damage range between 4.5 and 18 % of GDP (MEP 2009b).

Despite the government's huge investments to combat these problems, the worrying trends of declining biodiversity and degradation of ecological habitats have continued. The benefits of the government's large conservation projects appear to have been limited, and unintended consequences resulting from these interventions may have exacerbated the problems. The current biodiversity conservation strategy in China is based on a model in which the central authorities make the rules and local governments implement them. This approach is problematic because it creates overlapping duties and authority, poorly

defined responsibilities, and implementation gaps between the national and regional authorities and the local communities that must implement the plans and that should benefit from them (Guan et al. 2011). In particular, dilution of the authority for conservation measures among multiple levels of government weakens the participation by local communities and hinders the development of diversified indigenous institutions and governance that would allow adaptation of national programs to local constraints and opportunities.

The remainder of this paper is structured into the following sections: the evolution of China's biodiversity conservation since 1949, the unintended consequences that have resulted from centralization of conservation planning, and the barriers to community participation. Based on this description of the current situation, we propose several recommendations that should improve the effectiveness of China's biodiversity conservation efforts.

THE BUMPY ROAD FOLLOWED BY CHINA CONSERVATION PROGRAMS

Since the People Republic of China was established in 1949, China's government has conducted a program of intensive exploitation of natural resources to increase economic production and support the country's huge population. These efforts have seriously damaged the environment through unsustainable expansion of agriculture and forest exploitation (leading to deforestation), particularly in ecologically fragile areas. The Maoist ideology that humans should conquer nature dominated the structure of socioeconomic development. The Great Leap Forward movement (1958–1961) represents an extreme case. During this period, 10 % of China's forests were harvested to fuel the furnaces used for steel production (Liu 2010). Although such overexploitation of nature was pervasive throughout the country, a few laws or actions to protect nature were implemented during that era. These include the Plan for Natural Forest Nature Reserve Construction (1956), establishment of the first national nature reserve in 1958 (Dingshanhu Nature Reserve, Guangdong Province), and shortly after this period, development of the Regulations on Forest Conservation (1964). Nonetheless, these programs could not be effectively managed because of the overall focus on exploitation of nature and natural resources.

Efforts at environmental conservation remained severely hampered during the Cultural Revolution (1966–1976). However, international conservation concepts were gradually adopted in China after the country's participation in the UN Conference on the Human Environment in 1972, leading to development of the Temporary Regulations on

Nature Reserve Management, which provided the first legal requirement for the establishment and management of nature reserves (Xu et al. 2012). Since the 1970s, China's government has gradually realized the necessity of environmental conservation, and has established nature reserves, planned to take actions to combat the country's serious problems, and formulated laws or regulations to promote environmental conservation. Many different types of nature reserves have been established and increasingly developed at various levels of government, especially after China's economic reforms began in 1978.

These reforms have led environmental conservation into a new development phase. China's state council formally implemented the Three North Shelter Belt Program in 1978 with the goal of combating desertification, conserving soils and water, and promoting ecological restoration by means of large-scale afforestation in northern China. A symposium on agricultural and natural resources was held in 1979, and greatly promoted the construction of nature reserves. Critical environmental and natural resource laws were published and implemented in the 1980s, including the Forest Law (1984), the Grassland Law (1985), the Law on the Protection of Wildlife (1988), and the Environmental Protection Law (1989). These constituted China's primary environmental conservation frameworks and demonstrated a growing government recognition of the urgent need for environmental conservation.

In addition to these domestic efforts, China's government has increasingly forged new collaborations with international conservation efforts, including signing of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1980, and the Ramsar Convention and the Convention on Biological Diversity in 1992. Under the latter convention, participating governments have agreed to establish protected areas, and China's government published Agenda 21 and the Action Plan for Biological Diversity Protection in 1994 to accomplish this goal. These initiatives have led to rapid development of nature reserves; the number of nature reserves increased to more than 500 in 1991, from only 34 in 1978 (Fig. 1).

However, China's national policy still prioritizes economic development over the environment, and GDP growth remains the main criterion for selecting and promoting government officials (Guan et al. 2011). This has inevitably resulted in poor management of natural resources and the environment. After devastating floods in 1998 were attributed to the widespread deforestation and soil erosion that had occurred, China implemented the Natural Forest Conservation Program and the Green for Grain Program, which banned the logging of natural forests and focused on growing more forests and a shift from cultivation in marginal land to planting of forests and grassland vegetation to promote soil and water conservation. These

Fig. 1 China's system of nature reserves: number, area, and location (NBS 2000–2011). Although the number of reserves is still increasing, the area per reserve is decreasing. In addition, many reserves are becoming fragmented as a result of human disturbances that isolate the reserves, thereby eliminating dispersal corridors

programs were strictly implemented by China at multiple levels of government, simultaneously with the development of many new nature reserves (Wang et al. 2007).

During the twenty-first century, two additional ecological restoration projects have been implemented: the Sand Control Program and the Forest Industrial Base Development Program. Together with the four abovementioned projects, these Six Key Forestry Projects covered 97 % of China's territory and became the cornerstone of China's environmental conservation system (Cao 2011). The Nature Reserve Development Program has directly contributed to biodiversity conservation. From 2000 to 2010, the government invested around 680 billion RMB in implementation of the forestry system (NBS 2000–2011). In 2006, the government launched the Wetland Conservation Project and invested 4.24 billion RMB in the project from 2005 to 2010 (Xu et al. 2012). By the end of 2011, China had established 2640 nature reserves, which covered 14.9 % of China's territory, equal to twice the area covered

in 1991 (Fig. 1). Almost 55 % of China's ecological zones and 81 % of its natural vegetation communities are represented in these reserves (Wu et al. 2011).

However, despite these enormous efforts and the considerable progress that has been made, China still struggles with both environmental degradation and biodiversity loss, and some of the problems have resulted from these environmental management programs, as we will describe in the next section.

UNINTENDED CONSEQUENCES OF CENTRALIZED CONSERVATION PLANNING

There is no doubt that approaches mandated by the central government have allowed China to implement the massive environmental and biodiversity conservation projects described in the previous section. However, these programs have relied excessively on an overly simplistic centralized

command and control structure, which encourages an inflexible, top-down approach that has undermined the effectiveness of China's environmental management (Dietz et al. 2003; Wang et al. 2010). A diverse range of local ecological and socioeconomic needs cannot be properly met by these programs, and bureaucratic inertia has resulted from low administrative transparency, poorly defined responsibilities, and insufficient cooperation between levels of China's complex administrative system. This has increasingly led to an increased risk of failed governance (Guan et al. 2011).

Internal Risks: A Top-Down and One-Size-Fits-All Strategy

Centralized approaches to environmental conservation are often characterized by strong bureaucratic inertia and low implementation efficiency. Without careful scrutiny and critical evaluation by both experts and local communities, environmental projects are likely to fail or produce unintended consequences. Dramatic examples include the fate of the Eurasian tree sparrow (*Passer montanus*) in the 1950s and of the plateau pika (*Ochotona curzoniae*) and the zokor (*Myospalax baileyi*) since the 1960s. The sparrow was accused of eating crops or spreading contagion in 1958, and an estimated 210 million sparrows were subsequently killed during the government's "destroy the four pests" movement, leaving the species on the brink of extinction (Fig. 2). This program continued until 1959, when a large-scale plague of insects occurred as a result of removing the predator that kept the insects under control. The sparrow population has not yet recovered despite a policy that placed sparrows on the list of protected animals.

On the Qinghai–Tibetan Plateau, the plateau pika and the zokor have been exterminated on a large scale since the 1960s using rodenticides because they were blamed for the ongoing degradation of alpine meadows and were thought to compete with livestock for forage (Xin 2008). From 2005 to 2010 alone, 1.4×10^6 L of poison was distributed, and 157 million RMB was spent to kill these species in 5.4 million ha of rangeland on the plateau (Shi et al. 2012). However, there is much evidence that the charges against these species are unfounded (Pech et al. 2007; Arthur et al. 2008). Many researchers have found that grassland degradation has resulted primarily from overgrazing by livestock. Because the weeds that are the main food source of the pika and zokor have dramatically increased in abundance after elimination of the herbivores that controlled these plants, these weeds have come to dominate the species composition, thereby exacerbating the effects of grassland degradation (Liu et al. 2003b). Rather than destroying the grasslands, these animals appear to be keystone species that play important roles in maintaining

Fig. 2 An old photograph of people showing off their "spoils": dead sparrows that were killed under the "destroy the four pests" campaign. Thousands of civil servants, including policemen and soldiers, and the general public participated in the campaign

the plateau's ecological balance. For example, they are the main food source for large predators such as the Tibetan blue bear (*Ursus arctos pruinosus*), the saker falcon (*Falco cherrug*), the Eurasian black vulture (*Aegypius monachus*), and the fox (*Vulpes* spp.). In addition, pika burrows provide good habitat or shelter for a wide variety of species, including Hume's ground tit (*Pseudopodoces humilis*) and a species of snow finch (*Onychostruthus taczanowskii*), which use the burrows for breeding (Lai and Smith 2003; Arthur et al. 2008; Xin 2008). Because of their decreasing food supply, hungry predators have been forced to turn to the livestock of local communities.

Another series of problems has resulted from a focus on the establishment of forests rather than other vegetation that might be more suitable in some areas. Afforestation has been practiced as the primary method to combat desertification and to restore the ecological functions of China's dry northern and central regions. Large numbers of exotic, fast-growing pioneer tree species and large areas of forage crops have been chosen to restore infertile and degraded land under the Three Norths Shelterbelt project and the Grain to Green project. The species are being asked to survive under the constraints imposed by the local environment, which is often very different from their native environment. A particular problem is that the fast-growing trees that have been chosen for afforestation generally have low water-use efficiency. When grasslands are replaced by plantations of these trees or shrubs, their high water consumption initially removes water from the upper soil horizons, making it impossible for shallow-rooted native species to survive or become established; in the long term, the woody vegetation may lower the water table so far that not even the planted trees can survive (Sun et al. 2006; Cao et al. 2011). The selection of few tree species has also led to monocultures or ecosystems with severely reduced

Fig. 3 (Top) The impact of road construction and urbanization on China's nature reserves has compromised biodiversity conservation, often in favor of economic development (NBS 2000–2011). (Middle) The construction of mountain roads in ecologically fragile zones has caused extensive damage to habitats. (Bottom) The use of slash burning before afforestation removes the site's original vegetation, leading to serious deterioration of the ecosystem

biodiversity that are vulnerable to large-scale insect and disease problems (Stone 2009; Cao et al. 2011). In addition to the woody vegetation, the grass *Bromus inermis* and the legume *Astragalus adsurgens* have been planted widely in northern China to restore degraded grasslands. Unfortunately, these highly competitive pioneer species can exclude native species. Where they have been planted,

biodiversity has therefore decreased continuously (Duan et al. 2004).

Although these and other “one size fits all” policies have been implemented efficiently by the top-down approach to management, the resulting programs have often been inefficient and ineffective. Although Chinese government officials have claimed significant success in combating desertification and promoting ecological restoration, little evidence supports these claims in many areas. For example, the overall survival rate of trees planted during the afforestation project from 1952 to 2005 averaged only 24 % (Wang et al. 2007). Part of the problem is that China's environmental projects usually involve many administrative agencies. For example, nature reserves are co-managed by the Ministry of Environmental Protection, the State Forestry Administration, and the Minister of Education, among others. The lack of a clear division of responsibility among these government agencies has interfered with effective gathering of feedback that would provide warning of unexpected risks or consequences of these large-scale programs (Berkes 2007).

In addition, competition among the multiple ministries and bureaus involved in these projects creates difficulties as a result of their conflicting goals and independent decisionmaking that does not account for the impacts of one agency's decisions on the efforts of other government agencies. The high-level centralization of governance, which is decoupled from a recognition of the consequences that arise from interactions with other stakeholders, combined with a restricted role for nongovernmental organizations in China and limited participation by citizens in the form of environmental advocacy and fundraising, limits the ability of these two groups of environmental actors to contribute to finding solutions, as they have done in the West (Grumbine and Xu 2011).

External Challenges: Conflicts Among Conservation, Society, and Development

Because China's national environmental conservation policy has been decoupled from the local environment and society, environmental managers face great challenges that go beyond the complexity of the ecological context. The formulation and management of conservation projects has become the business of central and local governments. However, economic growth has been the core objective of Chinese policy, and has been given priority over environmental conservation for decades. Thus, despite the emphasis on sustainable development by the central government since 1994, environmental conservation has been relatively weak; in land-use conflicts between conservation and development, economic development has usually won.

Since the employees of environmental agencies and judges are hired or fired by local officials, corruption and cronyism have also undermined environmental efforts, particularly at a local level. Many environmental regulations are not enforced when they conflict with the local government's enthusiasm for economic development (Grumbine and Xu 2011). For example, although the number of nature reserves has increased continually, the mean area of each reserve has decreased since 2007, especially in southern and eastern China (the most developed regions). This suggests that the nature reserves are

being squeezed by economic forces. Combined with the intrusion of roads into protected areas and expanding urbanization (Fig. 3), fragmentation of these areas is increasing, thereby jeopardizing regional ecological functions, particularly in the most economically developed regions (Wu et al. 2011).

Another problem has arisen from efforts to meet China's growing demand for energy by implementing "green" energy sources. Hydroelectric power is one of the primary means of providing clean electricity, and combined with the need to preserve water for agricultural and domestic

Fig. 4 **a** Large-scale dam construction in China has flooded large areas, many of which had abundant biodiversity before dam construction (NBS 2000–2011). **b** The Baishiya reservoir in Guangxi Province is a typical medium-sized reservoir in China. The photos were taken in 2005 (*top* before impounding) and 2011 (*bottom* after impounding) (Fangchenggang Daily News Agency 2011). **c** The Wulagai wetland faces serious ecological risks due to inadequate inflows of water as a result of the construction of a reservoir upstream of the wetland. The photos of the wetland's core area were taken in 2005 (*left*) and in 2010 (*right*). *Source*: Past Grassland Organization (2010). Even before construction of the reservoir, the region's dry climate occasionally produced dust storms; after construction, severe drought has led to desertification of the wetland

use, China has embarked on an ambitious program of dam and reservoir construction. China now has almost 88 000 dams (NBS 2000–2011), more than any other country (Fig. 4a, b). Most of China's rivers have been dammed. The large-scale dam construction threatens biodiversity by eliminating large areas of plant and wildlife habitat and by preventing the movement of migratory organisms, including fish species that must travel upstream to spawn. For instance, the Three Gorges dam, the world's largest dam, has created immense economic benefits through electricity generation, transportation, and tourism. However, the large area of the reservoir has led to isolation of habitat patches and the creation of a powerful barrier to dispersal for many species, and has seriously damaged local biodiversity (Yeh 2009), especially for migratory fish (Wu et al. 2003). For instance, Chinese carp and sturgeon have been severely impacted by destruction of their spawning grounds and fragmentation of the river into isolated habitats above and below the dam (Duan et al. 2009).

Dam construction has also resulted in significant water shortages downstream of the dam, leading to artificial droughts and even desertification of wetlands in arid and semi-arid regions. The story of the Wulagai wetland, the largest wetland and key protected area in Inner Mongolia, illustrates this problem. After construction of a dam in the 1980s blocked the flow of the Wulagai River to provide water for the regional mining industry, downstream ecosystems suffered disastrous drought and desertification (Fig. 4c). The wetland mostly disappeared and wetland species such as the red-crowned crane (*Grus japonensis*) and golden eagle (*Aquila chrysaetos*) almost became extinct in this region (Li 2010).

Although the trade in endangered wildlife was prohibited by CITES, this ban is widely believed to have failed because it attempts to artificially restrict supply in the face of persistent and growing demand (Biggs et al. 2013). The illicit trade in wildlife is a booming industry in the expanding Asian market, and traditional Chinese medicine is a significant driver of the trade. Because the skyrocketing level of poaching is being driven by the growing retail price, a variety of flora and fauna with considerable medicinal value are endangered in China. For example, large numbers of Tibetan antelopes (*Pantholops hodgsonii*) are hunted each year, even in protected areas, for their valuable fur and particularly for their horns, which are considered to be a precious medicine (Fig. 5). As a result, their population decreased from 200 000 to 20 000 during the 1980s (Bianba 2011).

The risks to such large species are clear, but the damage to smaller species such as herbs may be more significant but difficult to detect (Nijman et al. 2012). The booming commercial demand for traditional Chinese medicine has placed almost 2000 wild Chinese herbs at risk of

Fig. 5 The Tibetan antelope (*Pantholops hodgsonii*) has valuable fur and horns with high perceived medical value. This has led to extensive poaching that decreased their population from 200 000 to 20 000 during the 1980s. Chinese police have confiscated more than 17 000 illegally obtained antelope skins and arrested 3000 criminals since the 1980s (Bianba 2011), but this may only hint at the severity of the problem. As a result of increasing protection efforts, the population has begun to recover in nature reserves (Photograph source: Xi 2010)

extinction, and has led to severe degradation of their natural habitat (e.g., soil erosion) due to intensive gathering, especially in fragile environments such as high-altitude mountain areas or arid regions (Wang et al. 2012b). China's government has attempted to develop a sustainable medicinal herbs industry through the establishment of artificial plantations that help to meet the demand for these products. However, due to the perceived lower quality compared with natural plants and the limited variety of herbs that are currently available, cultivation of these herbs cannot entirely replace harvesting of wild ones (Wang et al. 2012b).

China's government has established series of conservation breeding programs to rescue endangered wildlife, and some of the problems have achieved a measure of success,

such as the programs for the giant panda and the tiger. However, there is a risk of high losses of genetic diversity because of poor management of these programs (Guo 2007). Products that could be provided by breeding of captive animals have been banned from markets by CITES regulations, so the growing market for these products continues to threaten the survival of their wild counterparts. How to deal with these products in a way that might protect wild populations has become a new puzzle that faces breeders.

Land ownership represents yet another problem. The land technically belongs to the government, even where citizens have been granted usage rights to the land, but this situation has been evolving without a consistent national policy. As a result, user rights for activities such as harvesting, mining, and hunting are unclear. The government has the ability to extinguish use rights without due process, and has occasionally used this ability, particularly in the case of local governments (Grumbine and Xu 2011). For example, forestry land tenure reforms in the 2000s were aimed at privatizing natural resources, but lacked environmental safeguards, leading to problems for biodiversity conservation. Much of the primary forest in Xishuangbanna has been replaced by large-scale rubber plantations due to the soaring price of rubber since 1994. The total plantation area has increased to nearly 600 % of its 1988 value (770 km²), reaching 4100 km² in 2007, while the vegetation cover has decreased from 70 % in 1976 to less than 50 % (including the rubber trees) in 2003. Furthermore, because of inefficient water consumption, water shortages caused by large-scale implementation of rubber plantations may threaten shallow-rooted vegetation and the livelihood of local residents.

BARRIERS TO COMMUNITY-LEVEL PARTICIPATION

Many Chinese conservation projects, such as nature reserves, have been implemented in areas that formerly belonged to the local community, including villages and farms. However, large numbers of people live in or adjacent to these reserves, and depend greatly on the natural resources in the reserves for their food, fuel wood, and medical herbs. This means that conflicts have inevitably arisen in these communities. This problem exists because the government officials responsible for centralized management had no understanding of the local conditions and made no effort to account for these conditions. Many scholars have emphasized that an alliance between the central government and local resource users, who could serve as a potential force for conservation, would promote conservation while also producing

community benefits (Xu et al. 2005). Such participation would increase the likelihood that environmental decisions would account for the full diversity of local values and needs by recognizing the complexity of each region's human–environment relationships.

Although most major conservation projects are implemented from the top-down, with little participation from local people, some conservation plans have embraced the local community and encouraged different forms of participation (Plummer and Taylor 2004; Grumbine and Xu 2011). For example, the Laojun Mountain National Park in Yunnan Province mandates an active role in decisionmaking for the local community (Zhou and Grumbine 2011). The concept of community participation in China is still in an embryonic and experimental stage. Xu et al. (2012) surveyed 198 nature reserve managers in 2009, and found that 45.2 % had no community participation projects and 14.7 % did not incorporate local communities into their policy development or decisionmaking.

Global tourism has become an important way to meet the income needs of parks or reserves (Wang and Buckley 2010), while also improving local community income and reducing or eliminating poverty by providing jobs and allocating the park revenues within the community. Such tourism has been credited with raising more than 4654 villages above the poverty level during the last 20 years. However, national-level park management has created conflicts between national parks and the local community because of the different objectives of these two groups. Based on their research in Pudacuo National Park and Laojun Mountain National Park, Zhou and Grumbine (2011) suggested that local administration should devote more attention to establishing infrastructure for tourism to generate income that would improve the livelihood of local residents. Limited community participation eliminates this opportunity to improve the life of local people, and the local community often finds it difficult to demand their rights because low education levels prevent them from obtaining the necessary skills (Wang et al. 2012a). Although tourism in nature reserves can provide an opportunity for the local community to participate in management of the reserve, the right of decisionmaking has traditionally been monopolized by the state, thereby providing no model for local community involvement. It is easy to see how a national park could flourish, while marginalizing local residents and preventing them from the benefits of the park (Zinda 2012).

The traditional culture and indigenous knowledge of local residents often contains centuries or millennia of key ecological principles. This knowledge could clearly benefit conservation efforts, especially in regions populated by minority groups (Berkes et al. 2000). Rooted in

spiritual incentives and their local social network, the local community has often developed regulations on how to protect the ecosystems that sustain them and on what punishments should be applied to those who violate the regulations. Conservation efforts in such regions must therefore emphasize more than biodiversity and the environment; they must also protect and nurture the local culture and society. Xu and Melick (2007) described effective management and conservation of natural resources by indigenous people in Yunnan Province through their traditionally sophisticated agricultural systems. The sacred mountains in Tibet and Yunnan Province contributed to harmonious linkages between nature and society in the local Tibetan community (Xu et al. 2005; Xu and Melick 2007; Shen et al. 2012). Accounting for these linkages permitted a successful case of community-based conservation in the Sanjiangyuan Nature Reserve that integrated the local culture with the reserve's conservation projects. However, this model of successful cultural-based community conservation efforts has been threatened by China's overwhelmingly state-oriented conservation projects (Xu and Melick 2007).

It is generally believed that community-based approaches to conservation have arisen from the perceived failure of government-directed conservation efforts, particularly in parts of the world where socioeconomic factors are increasingly seen as the key to successful conservation (Berkes 2004). However, successes of community-based conservation have been rarely reported in the scientific literature, and community-based conservation depends on the unique local context. Solutions developed in one region cannot necessarily be transferred to other regions without considerable modification (Berkes 2007). It is also important to remember that some communities have also managed their resources poorly, so local management is not a panacea. "Community" is also an elusive and constantly changing concept because communities are neither static nor isolated groups of people (Berkes 2004; Reed 2008). Especially in rural China, the community composition has varied widely in response to external factors, such as the modern trend toward massive immigration of rural workers to cities in search of employment. Such phenomena make it difficult to develop community-based policies. In addition, the development of rural natural resources often diverts the economic benefits of these resources to groups from outside the region, as was observed at the Wolong Nature Reserve (Liu et al. 2003a). Although community-based conservation is potentially a powerful tool for improving China's conservation efforts, it lacks enough successful, well-publicized case studies that would lead governments to pay more attention to this approach. An additional problem is that China's strong bureaucracy would become

a significant barrier to decentralization and community participation if bureaucrats felt that their power and prestige were threatened by this change.

CONCLUSIONS AND RECOMMENDATIONS

China's current centralized approach to biodiversity conservation is a poorly integrated system that relies on state-oriented conservation plans that often fit poorly with local ecological conditions and the dynamics of the local society, leaving local residents vulnerable to commercial demands and compromising the sustainability of economic development. Unfortunately, prioritizing short-term economic growth makes it difficult to achieve a balance with the need for conservation. In addition, protecting ecosystems is expensive in terms of both funding and labor, but provides few obvious returns in many cases. Biodiversity conservation is complex because human and natural systems are both complex and poorly understood, and their potential interactions are even more complex. The governance issues described in this paper are not limited to China. For example, the Great Plan for the Transformation of Nature in the Soviet Union has many similarities with China's experience. Numerous examples of failures that resulted from excluding the local community in protected areas have occurred in Africa (Adams and Hutton 2007). Based on these and other examples, it has been increasingly recognized that the governance structure can profoundly affect biodiversity conservation, especially in developing countries (Rands et al. 2010).

Despite these challenges, there is considerable potential to identify win-win approaches that will benefit both humans and the environment. To find these approaches, it is necessary to recognize that the governance structure plays a crucial role in determining a project's success; in particular, national-scale projects must account for the need to include a local governance component to take advantage of local expertise and knowledge of local conditions. In addition, the administrative structure of these programs must be improved, so that authority and responsibility are not divided among multiple government departments, leading to overlapping and conflicting jurisdictions with contradictory goals. These approaches will lead to improved forms of management that take advantage of both the benefits of central planning (i.e., the ability to coordinate large projects across multiple scales) and the benefits of local knowledge (i.e., the ability to adapt national goals to the constraints of local conditions). Achieving this will require the implementation of new laws and revision of existing laws, the development of support technologies, management of economic markets, and wise political judgment that emphasizes cooperation and consensus rather than a top-down approach. In particular, it will be necessary to avoid extreme solutions and

one-size-fits-all solutions that may not be appropriate for all ecosystems, leading to inefficient and ineffective strategies that create unintended consequences.

One option would be to develop a multilevel approach to conservation that carefully considers the needs of all human stakeholders, from national to local scales, as well as ecological stakeholders such as specific ecosystems or important species. As well, government economic development strategies must be changed to focus on more than the short-term economic benefits; the long-term ecological benefits must also be considered through a rigorous evaluation of the potential environmental impacts, and government officials must be rewarded for more than just their economic performance. Community-based conservation is likely to be part of the solution, but there are also many problems that must be resolved, including finding a mechanism for community participation and establishing the necessary relationships. The multiple levels of natural resource and conservation management in national, provincial, and local governments lead to vertical and horizontal interactions among institutions at many levels of the government hierarchy should be not ignored. The international experience with nongovernmental organizations that create links between governments and local peoples may provide insights into how to develop such an implementation model. A proper governance structure that combines centralization with local communities should be developed based on patterns that have been demonstrated to be successful, and researchers should be encouraged to find these patterns, publicize them, and fill in gaps on our knowledge of the patterns.

Conservation strategies that account for economic, social, and ecological needs are urgently required. Such strategies will require participation by local communities. Insights may be obtained from the frameworks that have been developed for the carbon trade, for sustainable forest certification programs (ISO 14000), and for stock market regulations. However, the experience from implementing these frameworks must be supplemented by the development of techniques to evaluate the value of biodiversity and define both property rights and the boundaries between competing rights.

Although China faces a difficult task, it should be possible to greatly improve its protection of biodiversity by adopting the approaches described in this paper. The key to success lies in finding ways to meet human needs without sacrificing ecological needs by seeking win–win solutions that provide benefits to both humans and the environment.

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