CHAPTER 24

COMPLEX FORCES AFFECT CHINA'S BIODIVERSITY

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SUMMARY

Enormous global efforts have been put into biodiversity conservation, but biodiversity loss continues rapidly in many parts of the world, including China. While China is one of the most biodiversity-rich countries, its biodiversity has been affected by numerous socioeconomic, demographic, technological, political, and biophysical forces both inside the country and elsewhere. The forces behind biodiversity maintenance or loss are complex – they occur at different times and with different strengths, have non-linear relationships and time-lag effects, and interact with each other directly and indirectly in many ways (e.g., enhance or offset). Over the past few decades, negative forces have become much stronger than positive ones. To fundamentally alter the trajectory of biodiversity loss, it is essential to explicitly analyze various forces as well as their interactive effects, recognize that biodiversity is part of coupled human and natural systems, and integrate natural and social sciences. China should also elevate its leadership role in biodiversity conservation to the global level and help protect biodiversity in other developing countries. The future of biodiversity in China (and elsewhere) will depend on the relative strengths of existing and emerging positive and negative forces.

INTRODUCTION

Global biodiversity continues along a trajectory of decline despite enormous conservation efforts (Rands *et al.*, 2010). This is also true in China, one of the most biodiversity-rich countries in the world (Liu and Raven, 2010; Ministry of Environmental Protection of China, 2010a). To fundamentally change this trajectory, it is essential to understand complex interactions among various forces affecting biodiversity, develop effective strategies to maintain it, and take bolder actions. This chapter outlines the overall status of China's biodiversity, highlights major forces behind biodiversity since the establishment of the People's Republic of China in 1949, and discusses strategies and actions that could lead to a brighter future for biodiversity.

OVERALL STATUS OF CHINA'S BIODIVERSITY

China's diverse ecosystems include forests, wetlands, lakes, oceans, meadows, shrublands, grasslands, and deserts. Although the tropical region, located in southern China, accounts for only 3.2% of China's territory, it includes one-quarter of the ecosystem types and

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one-third to half of the species found in China (Wang *et al.*, 2008). China is one of the richest countries in number of species and genetic resources, with about 32,500 vascular land plant species (third highest in the world; We, Raven and Hong, 2011), over 10,000 fungal species, and 6445 vertebrate species (13.7% of the global total) (Ministry of Environmental Protection of China, 2010a). China apparently has as much as 10% of the world's eukaryotic diversity, which would then amount to some 1.2 million species, the great majority of them unknown (Raven, personal communication).

Unfortunately, China's biodiversity has been declining at an alarming rate (Ministry of Environmental Protection of China, 2010a). Virtually all ecosystems are affected by human activities. For example, more than 90% of grasslands have been degraded to various extents (Ministry of Environmental Protection of China, 2010a), surface water has suffered quite severe pollution (Ministry of Environmental Protection of China, 2010b), wetlands have declined by 11.5% from 360,000 km^2 in 1990 to 324,000 km^2 in 2008 (Chen, 2010), and many species are disappearing in marine and coastal areas along with their habitats (Ministry of Environmental Protection of China, 2010a). Although forest cover has increased from 12% in 1981 to more than 20% in 2008 (Xinhua News Agency, 2009a), a large proportion of forests are single-species plantations, consequently with limited capacity to resist pests and diseases (Ministry of Environmental Protection of China, 2010a). China had the largest tree plantation area in the world, with a total of 62 million hectares (ha) as of 2008 (Xinhua News Agency, 2009a). This is also true in tropical regions. Plantations account for 48.3% (4.7 million ha) of woodland in China's tropical regions. In southern Yunnan Province, tropical forests declined by two-thirds over a period of 27 years (1976–2003), mainly because of the conversion of native forests to rubber plantations, a process that is still continuing (Li *et al.*, 2007).

At the species level, 15–20% of vascular plants (including more than 40% of gymnosperms and orchid species) are endangered, 233 vertebrate species are on the brink of extinction, and 44% of all wildlife species are declining. Many of these species are endemic, rare, and extremely local in distribution. Genetic resources for crops, trees, flowers, livestock, poultry, and fish are also being lost rapidly as their habitats are being destroyed (e.g., 60–70% of original habitat of wild rice has been lost) (Ministry of Environmental Protection of China, 2010a).

COMPLEXITY OF INTERACTING FORCES AFFECTING BIODIVERSITY

With the largest human population and second-largest gross domestic product in the world (Liu and Raven, 2010), China has experienced numerous positive and negative forces affecting biodiversity directly and indirectly (Figure 24.1). Positive forces are those whose impacts on biodiversity are positive or mostly positive, while negative forces have opposite impacts (e.g., Bearer *et al.*, 2008; Lepczyk *et al.*, 2008; Rutledge *et al.*, 2001; He *et al.*, 2008; Liu, Cubbage and Pulliam, 1994). Although many of these forces were created without biodiversity conservation or destruction in mind, their impacts have been enormous. Forces influencing China's biodiversity are complicated and have complex interactions.

Positive forces are largely remedies to earlier negative actions or inactions. For instance, the one-child policy was started in 1979 in response to inaction that had led to a population of 975 million, 80% higher than in 1949 (~541 million) (China Population and Development Research Center, 2011). The decline in birth rate resulting from the implementation of the one-child policy reduced human pressures on biodiversity. Other positive examples include the Natural Forest Conservation Program and the Grain-to-Green Program (Figure 24.2a), two of the world's largest conservation programs, both providing payments for ecosystem services (Liu *et al.*, 2008). The former aims to protect and restore natural forests through logging bans and plantations, and had an investment of 85.3 billion Yuan (US$13.3 billion) from the central government as of 2008 (Figure 24.2b). The latter project converts cropland on steep slopes to forests or grasslands, and had an investment of 189.4 billion Yuan ($US29.6 billion) as of 2009 (Figure 24.2c). These two programs have produced important ecological and socioeconomic outcomes nationwide (Liu *et al.*, 2008). They began in 1998 and 1999, respectively, in response to the devastating floods of 1998 that were widely believed to be the result of soil erosion related to the extensive deforestation nationwide that was greatly accelerated by certain national movements. During the "Great Leap Forward" in the 1950s, the clearing of forests to fuel backyard furnaces for steel production led to large-scale deforestation of at least 10% of China's forests (Liu, 2010a). Later, during the "Learn from Dazhai in Agriculture" movement in the 1960s and 1970s, the government promoted the agricultural model of ter-

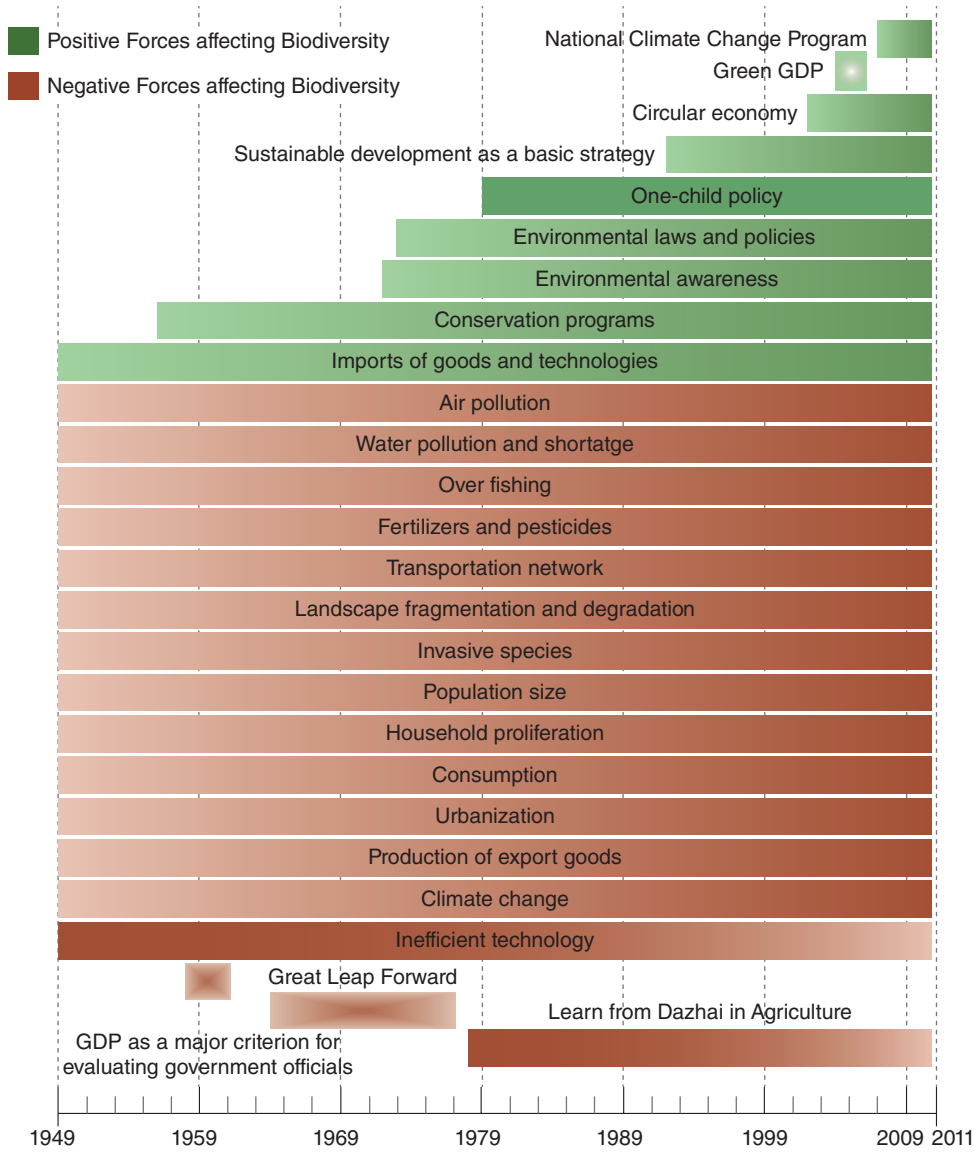

Figure 24.1 Examples of driving forces affecting the status of China's biodiversity. These particular forces were chosen for the following reasons: they are important at the national level; they represent different types of factors (socioeconomic, demographic, political, policy, technological, biophysical, international); they have different beginning and ending years; some of them become stronger while others become weaker over time; and they are useful to illustrate various interactions among them. Shaded gradients illustrate approximate general trends between starting and ending years. Lighter/heavier shades represent worse/better conditions and weaker/stronger forces, but the degrees of difference are not scaled. For the sake of simplicity, interactions among different forces are not shown.

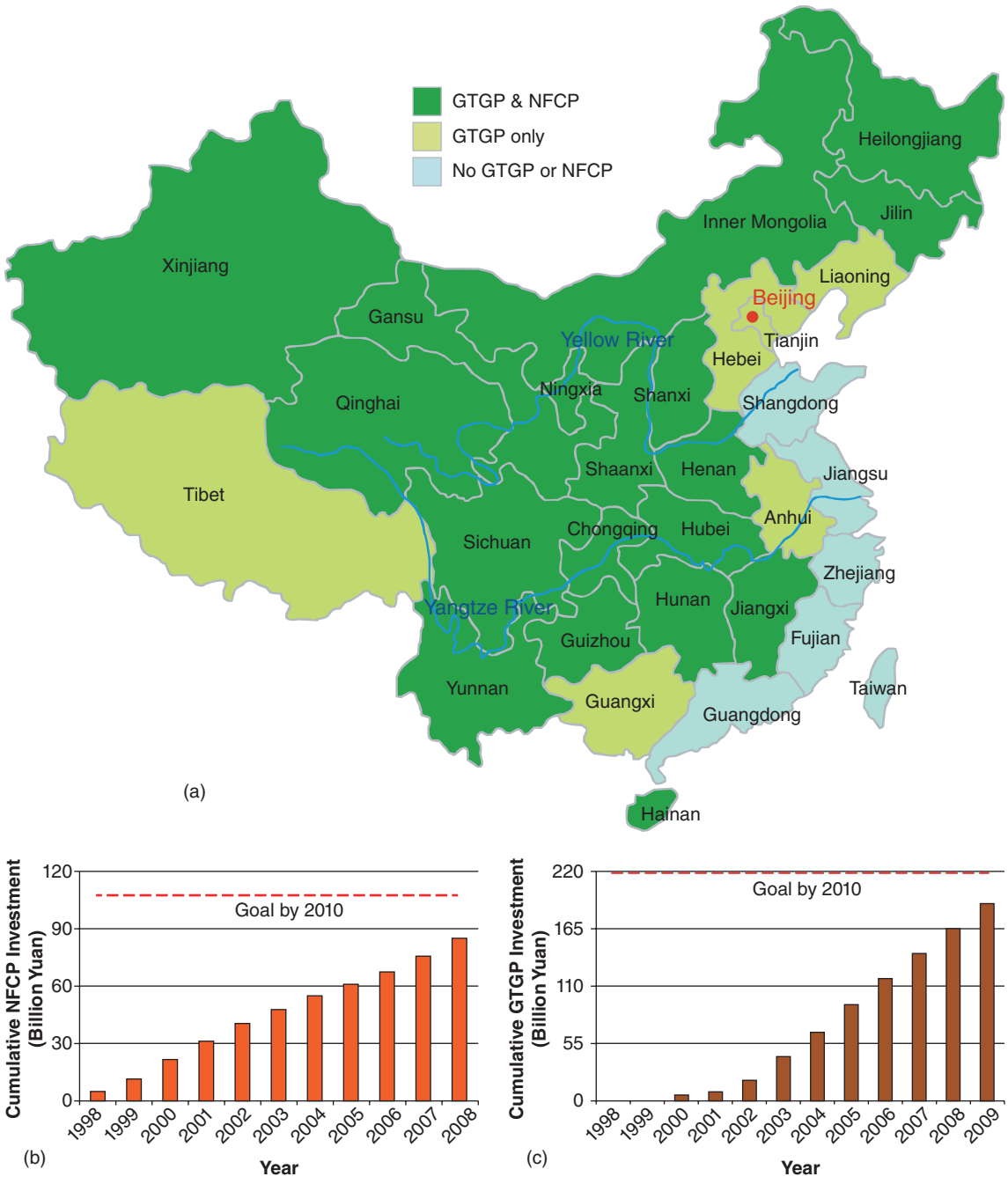

Figure 24.2 (a) Distribution of the Natural Forest Conservation Program (NFCP) and Grain-to-Green Program (GTGP) in China. Shown are names of provinces, autonomous regions, municipalities, and two major rivers (from Liu *et al.*, 2008. Proceedings of the National Academy of Sciences 105, 28). (b) Cumulative amount of investment in NFCP from 1998 to 2008. (c) Cumulative amount of investment in the GTGP from 1999 to 2009. Because data on separate investment in the GTGP for 1999 and 2000 are not available, the total amount of investment during 1999 and 2000 is shown in 2000 due to the lack of data on separate investment during these two years. In both (b) and (c), the dashed line indicates the goal for 2010 and data are from the State Forestry Administration. Reproduced from Annual Report of China's Forestry Development. State Forestry Administration, China.

racing mountains to grow grain in Dazhai Brigade of Shanxi Province, a policy that led to the transformation of numerous landscapes and filling of many lakes, wetlands, and coastal areas, disregarding local topographic, climatic, and socioeconomic conditions (Shapiro, 2001).

Some negative forces are weakening as positive ones emerge. Helping to stem biodiversity loss, the nature reserve system now includes 2541 reserves and occupies 1.47 million km^2, or 15.3% of China's territory (higher than the world average) (Liu and Raven, 2010). These figures are impressive given that China's first nature reserve was established in 1956; only 34 reserves existed in 1978 when China's economic reform started. Most of the reserves were established in the past decade to bring China's natural areas under increasing protection (Editorial Committee of Environmental Protection in China, 2000) (Liu and Raven 2010).

Unfortunately, many positive forces for conservation are offset by negative ones. For instance, while the one-child policy averted more than 300 million births by 2005 (National Development and Reform Commission of China, 2007), the number of households has increased much more rapidly than population since 1979. The rapid increase in household number has been related to factors including increasing numbers of divorces (Yu and Liu, 2007) and fewer traditional multigeneration households functioning (Liu *et al.*, 2003a). Reduction in *household size* alone added 80 million more households from 1985 to 2000 (Liu *et al.*, 2003a). More households consume more resources, release more waste, and destroy and fragment more habitat; smaller households lower the efficiency of resource use (Liu *et al.*, 2003a).

While environmental protection has been a basic national policy since 1983, GDP growth has been the major criterion for evaluating government officials. Many laws and policies have been enacted to protect biodiversity, but most of them have limited or ineffective implementation and enforcement (Ministry of Environmental Protection of China, 2010a). Although sustainable development has been a national strategy since 1994 (Zhu, 2007), short-term economic gain still receives priority. Despite increasing awareness about biodiversity, most biodiversity-friendly words and attitudes have not been translated into actions. Some positive actions, such as the calculation of green GDP (Chinese Academy for Environmental Planning 2006) (Figure 24.1), were short-lived due to much more powerful negative forces such as rapid economic development. In response to the Rio conference in 1992, China developed and released its biodiversity action plan (General Report Writing Group of the "China Biodiversity Conservation Action Plan," 1994) with a series of biodiversity conservation goals.

As part of economic globalization, production of many products for other countries has come at the expense of China's biodiversity, with natural resources consumed and pollution left behind, resulting in biodiversity loss and degradation. Although tropical areas cover only a small fraction of China's territory, the rising imports of resources (e.g., tropical timber, minerals, and soybeans grown on land converted from tropical forests) are compromising biodiversity in many other countries, especially tropical ones (Liu and Diamond, 2005). In this way, rapid development has put China in the position of an industrialized country, one that gathers resources worldwide to support its economy. After the implementation of the Natural Forest Conservation Program, which prohibits timber logging in natural forests, in the late 1990s and early 2000s (Liu *et al.*, 2008), China has become the world's largest timber importer (Yang, Nie and Ji, 2010). Many tropical countries, such as Malaysia, Papua New Guinea, New Zealand, and Gabon are among China's major timber suppliers (Yang, Nie and Ji, 2010). To minimize or avoid cutting down tropical forests, it is important that China increases its timber supply. It is encouraging that China has been planting more trees for timber production, but it may take several decades for these new plantations to become useful timber materials. Meanwhile the resources of other countries are being drained to support China's economic growth on a one-time basis, the supply being renewable neither in the source countries nor for China.

Interactions and consequences of various forces are often non-linear, yielding drastic changes when they reach thresholds. Also, their effects usually have time lags – effects of various forces might not show up until years or even decades later. In many instances, the government's intention is good, but surprises may then occur and upset calculations. For instance, in the early 1980s, the government and the World Food Program built a large apartment complex in Wolong Nature Reserve to relocate farmers away from habitat areas of the endangered giant panda, but no one moved because there was no land near the apartment complex for the farmers to grow crops (Liu *et al.*, 2003b). When the Natural Forest Conservation Program was introduced in Wolong in 2001, it led to a sudden large increase in the number of households, because subsidies were allocated at the household level and splitting one family into two could double the subsidies (Liu *et al.*, 2007).

STRATEGIES AND ACTIONS FOR BIODIVERSITY CONSERVATION

A wide range of strategies and actions for biodiversity conservation has been proposed (Liu *et al.*, 2003b; Xu *et al.*, 2009; Ministry of Environmental Protection of China, 2010a). The list is long and includes:

(a) improving biodiversity conservation law, policy, and regulations

(b) coordinating conservation efforts among government agencies and with non-governmental organizations

(c) incorporating biodiversity conservation into socioeconomic development planning

(d) enhancing the capacity of biodiversity conservation (e.g., obtaining baseline biodiversity information, monitoring biodiversity dynamics, and training research and conservation staff)

(e) strengthening conservation in priority areas and nature reserves

(f) establishing and improving preservation systems for genetic resources

(g) promoting sustainable use of biological resources

(h) restoring endangered ecosystems and species

(i) developing early-warning systems to prevent invasive species

(j) increasing the ability of addressing new threats (e.g., climate change and biofuel production) to biodiversity

(k) raising investment in conservation

(l) enhancing the public's awareness and participation in biodiversity conservation.

While these and other strategies and actions are necessary, they might not be sufficient to stop biodiversity loss. In other words, it is not clear whether biodiversity loss can be halted even if all strategies are implemented. Below are several complementary yet essential strategies to achieve biodiversity sustainability.

1. It is imperative to consider and explicitly analyze various forces as well as their interactive effects (e.g., enhancing or offsetting). China released a new strategic action plan in 2010 that aims to fully protect biodiversity by 2030 (Ministry of Environmental Protection of China, 2010a). However, without analyzing driving forces behind biodiversity, it is unknown whether this aim can actually be achieved. Furthermore, it is important to model, simulate, and track the long-term consequences of human activities to biodiversity and humans. Such analyses and simulations would help detect possible, important gaps in the 2010 action plan and avoid the outcome of the 1994 action plan (General Report Writing Group of the "China Biodiversity Conservation Action Plan," 1994), whose major strategies and planned actions were largely implemented but failed to maintain or improve biodiversity. For positive forces to overtake negative ones, the former must be stronger than the latter and be introduced before or right after the latter forces emerge. The relative strength needed will depend on the damages caused by negative forces and time lags between occurrences of positive and negative forces. More damages and longer time lags will require stronger positive forces. Unfortunately, positive forces usually do not occur until negative forces have already produced severe damages. Even if negative forces are eventually eliminated, their legacy effects are often enormous and long-lasting. For example, the absence of the one-child policy before 1979 increased China's population base by several hundred million, which will continue to have amplifying effects on population growth for a long time and create problems that will be increasingly difficult to solve in the future (Liu, 2010a).

Bolder actions are needed to weaken the negative forces and strengthen the positive ones (Liu and Diamond, 2008). Here are three examples. First, the success of their efforts to manage biodiversity sustainability should be a major criterion for evaluating government officials because strong leadership is critical to implement biodiversity actions effectively. This requires a fundamental shift from economic performances as the sole or major evaluation criterion. Second, because climate change is a major and rapidly increasing threat to biodiversity, China should reduce the absolute amount of CO_2 emissions by going beyond reducing CO_2 emissions per unit of GDP by 40–45% from the 2005 levels by 2020 (Xinhua News Agency, 2009b; Liu and Raven, 2010). This goal could be achieved by transforming the economic development model, using renewable energy, and reducing waste. Since climate change is a global problem, China should assume a leadership role in mitigating future increases of greenhouse gases. Third, biodiversity actions need also to take place at the household level. While global pressures for biodiversity conservation have been mainly on industry, households are basic socioeconomic units of consumption and production (Linderman *et al.*, 2005). Because most industrial products are manufactured to meet household needs, energy consumption is largely related directly or indirectly to the functioning of households. As households proliferate (Liu, 2010b), building more housing units converts more natural

land to residential use, and resource consumption, emissions of CO_2, and waste at the household level rise rapidly. There are many effective ways in which households can increase resource-use efficiency and reduce emissions (Dietz *et al.*, 2009), and these should be implemented to the extent possible in China and throughout the world.

2. It is important to explicitly recognize that biodiversity is a part of coupled human and natural systems (Liu *et al.*, 2007). A key characteristic of coupled human and natural systems is reciprocal interactions between nature and humans, such as how humans affect biodiversity and how changes in biodiversity in turn affect human well-being and behavior. While many biodiversity strategies and actions are proposed in the 2010 action plan (Ministry of Environmental Protection of China, 2010a), nothing is mentioned about reciprocal interactions – how these strategies and actions will affect biodiversity, how changes in biodiversity will affect people, how people will react to these changes in biodiversity, how people's reactions will affect biodiversity, and how impacts of people's reactions on biodiversity will and should change biodiversity strategies and actions in the future.

3. To untangle the complexity of positive and negative forces as well as the effects of their interactions on biodiversity, the integration of natural and social sciences is an important key. As in other countries, however, social sciences in China are largely isolated from natural sciences (Liu, 2008), even though their integration could provide crucial insights for promoting more effective policies for conservation. In the apartment complex case mentioned earlier, understanding farmers' needs for cropland would have avoided the construction of the complex and led to designing other solutions to the fundamental problem. In the case of distributing subsidies from the Natural Forest Conservation Program, understanding human behavior and basing the subsidies on amounts of land rather than households would have prevented the sudden formation of many households. Social norms also affect farmers' enrollment in conservation programs such as the Grain-to-Green Program (Chen *et al.*, 2009), thus influencing the efficiency and effectiveness of conservation investment. As a general principle, improving the efficiency and effectiveness of conservation investment requires not only new technology but also changes in human attitudes and behaviors.

4. As China continues to grow as an economic superpower and becomes increasingly interconnected with the rest of the world, it should increase its leadership role in biodiversity conservation at the global level, learn successful experience from other nations, and help protect biodiversity in developing countries. China's biodiversity has profound implications for the entire planet. It is not only a treasure to Chinese people but also crucial to human well-being in other parts of the world (Liu and Diamond, 2005; Millennium Ecosystem Assessment, 2005).

Since the early 1990s, China has begun participating in many international treaties (e.g., Convention on Biological Diversity) and has collaborated with a number of international organizations on biodiversity conservation. Sustaining large conservation programs such as the Natural Forest Conservation Program and Grain-to-Green Program (Liu *et al.*, 2008) would provide valuable lessons (e.g., large investment from the central government and transparency in distributing the investment) for other developing countries. Moreover, many forces affecting China's biodiversity also influence biodiversity elsewhere (Liu and Diamond, 2005). Protecting biodiversity at home should not be at the expense of biodiversity in other countries, especially in tropical countries that export timber, agricultural products, and other materials to China. Helping protect biodiversity in other countries will also benefit China in the long run, politically, economically, and environmentally.

THE FUTURE OF CHINA'S BIODIVERSITY

The future of China's biodiversity will depend on the relative strengths of existing and emerging positive and negative forces. On one hand, major existing positive forces (Figure 24.1) will continue at least for the foreseeable future. Some forces, such as many conservation programs and the public's awareness of them, will grow stronger. Other forces, although still supported, are getting weaker. The one-child policy seems to be an example of this trend, with increasing numbers of couples allowed to have more than one child and growing resistance to the limitations imposed. On the other hand, many negative forces (Figure 24.1) will also persist or even become stronger. There are also emerging negative forces. For instance, prompted by the global financial crisis, China is shifting its focus on exporting manufactured goods and raw materials to increasing domestic consumption. China will face more daunting challenges in achieving biodiversity

sustainability with rapid expansions in its economy and urbanization, continued population growth, even faster household proliferation and consumption, global climate change, and shrinking essential resources such as water (Figure 24.1).

Over the short term, the interactions between current positive and negative forces indicate that China's overall biodiversity conditions will continue to worsen. Over the long term, however, positive forces might eventually outweigh the negative ones and lead to biodiversity sustainability. If the strategies outlined in this chapter are adopted, the biodiversity in China and other tropical countries will be more likely to persist and flourish.

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