Laojunshan National Park. Photo by Xu Jian

PART 1:
LAY OF THE LAND

I. Biodiversity

This part of the book provides context for land protection efforts in China aimed at protecting biodiversity. Chapter I, Biodiversity, provides an overview of the country's wealth of species and ecosystem values. Because ample existing literature thoroughly documents China's biodiversity resources, this chapter does not delve into great detail. Rather, it provides a brief overview of species diversity, and then describes the locations, types, and conservation issues associated with each major ecosystem. Chapter II, Land Use, identifies the locations and trends in land use across the country, such as urbanization, livestock grazing, forest uses, and energy development, which can affect multiple ecosystems. Not surprisingly, China's flora and fauna are experiencing ever-increasing impacts as a result of China's unprecedented economic growth and exploding demand for natural resources. Thus, new and strengthened land protection efforts are required to ensure the persistence of China's rich biodiversity heritage (see Part 3, Land Protection in Practice).

A. Species Diversity

Terrestrial biodiversity in China is among the highest in the world, and research and inventories of the distribution and status of the country's biodiversity are fairly comprehensive. China is home to 15% of the world's vertebrate species including wildlife such as the Yunnan golden monkey, black-necked crane, and the iconic giant panda. China also accounts for 12% of all plant species in the world, ranked third in the world for plant diversity with 30,000 species (Chinese Academy of Sciences, 1992) (Li et al., 2003). Of the vertebrates, 667 (11%) of genera are endemic, while 275 (7%) plant genera are endemic (Table 1–1). It is estimated that approximately 233 vertebrate species face extinction while 15%-20% of the wild higher plants in China are endangered (Ministry of Environmental Protection, 2011). The species richness of terrestrial mammals varies throughout the country (Figure 1–1).

With such a wealth of biodiversity, a disproportionate amount of conservation resources appear to be dedicated to single-species conservation efforts, particularly the giant panda, but also species such as the South China tiger and the baiji dolphin (Durnin, 2011). Pandas arguably warrant robust conservation action, given that their wild population is less than 2,500 mature individuals and their current habitat is confined to isolated patches on six mountain ranges (World Wildlife Fund). However, China's vast array of biodiversity values may suffer given that much conservation attention goes panda and other conservation efforts focusing on single species (Figures 1–2 and 1–3).

China's species diversity can be attributed to wide variations in climate, geomorphology, and ecosystems. Covering approximately 9.6 million km^2, China is bordered by the Pacific Ocean on the southeast and extends northwest to the center of the Eurasian continent. The country spans 5,500 km and 50 degrees of latitude from north to south, covering multiple temperature zones from cold temperate to tropical. Precipitation mainly comes from monsoons that originate in the Pacific and Indian oceans, respectively. As a result, the eastern and south central areas of

China are moist and wet, while the northwest is arid and bordered by a transitional semi-arid zone of steppe vegetation. The terrestrial ecosystems reflect the latitudinal distribution of these zones and climate.

Table 1–1. Plant and vertebrate species in China (Chinese Academy of Sciences, 1992) (Li, Song, & Ouyang, 2003)

	Known Species			Known Genera and Endemism		
	China	World	Percent of World Species	Number of Endemic Genera in China	Total Number of Known Genera in China	% of Known Genera that are Endemic
Mammals	500	4,000	12.5%	72	514	14.0%
Birds	1,244	9,040	13.8%	112	1,244	9.0%
Reptiles	376	6,300	6.0%	26	371	7.0%
Amphibians	284	4,184	6.8%	30	273	11.0%
Fishes	3,862	19,056	20.3%	427	3,882	11.0%
Subtotal, Vertebrates	**6,266**[1]	**42,580**	**14.7%**	**667**	**6,284**	**10.6%**
Bryophytes	2,200	16,600	13.3%	13	494	2.6%
Pteridophytes	2,600	10,000	26.0%	6	224	2.7%
Gymnosperms	200	520	38.5%	10	34	29.4%
Angiosperms	25,000	222,000	11.3%	246	3,123	7.9%
Subtotal, Plants	**30,000**[2]	**249,120**	**12.0%**	**275**	**3,875**	**7.1%**
GRAND TOTAL	**36,266**	**291,700**	**12.4%**	**942**	**10,159**	**9.3%**

[1] *The National Biodiversity Conservation Strategy and Action Plan*, issued in 2011, states that the number of vertebrates total 6,455 and comprise 13.7% of the world's vertebrate species (Ministry of Environmental Protection, 2011).

[2] *The National Biodiversity Conservation Strategy and Action Plan* identifies 34,984 plant species (Ministry of Environmental Protection, 2011).

Figure 1–1. Species richness of terrestrial mammals by county (Xie et al., 2009)

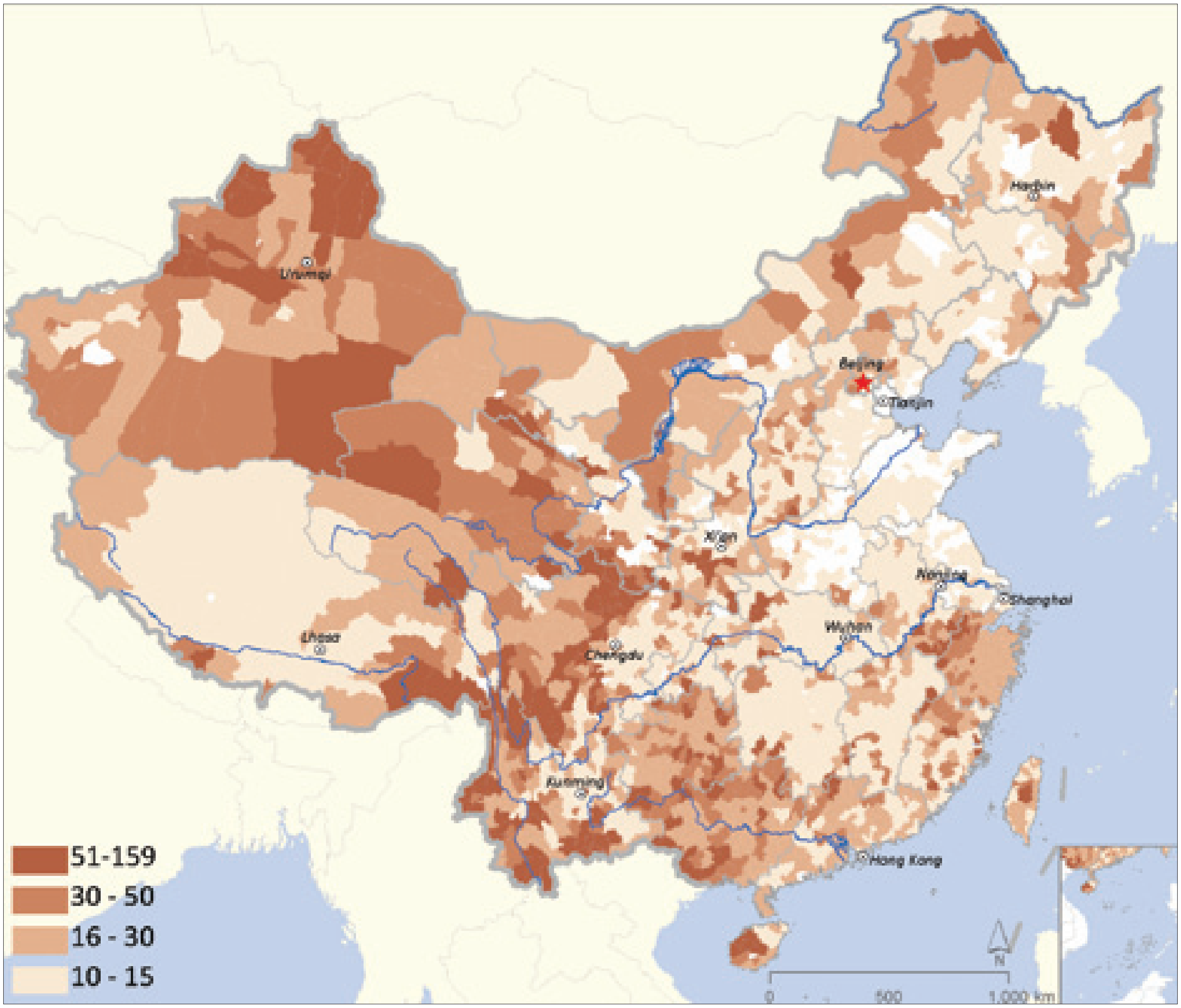
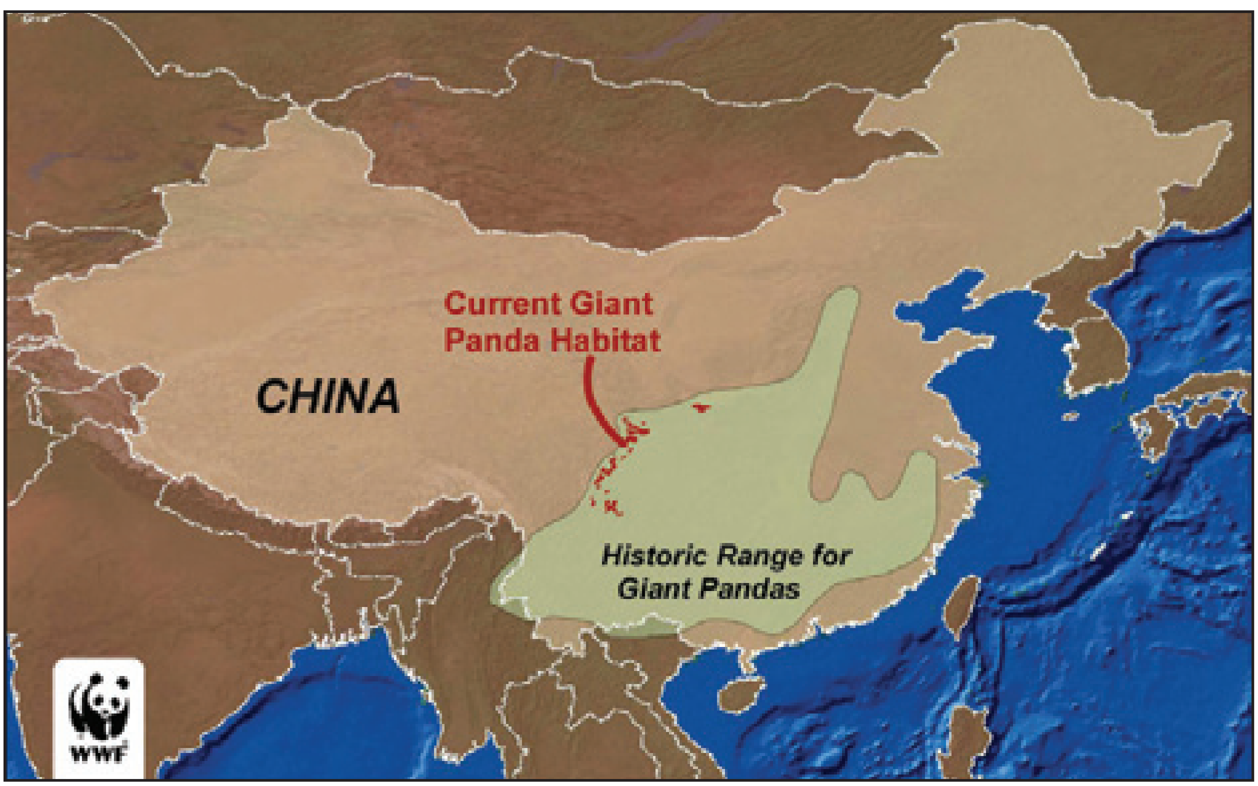


Figure 1–2. Significant resources are dedicated to single-species conservation efforts, such as the giant panda. Photo by Zhou Lulu

Figure 1–3. Current habitat and historic range of the giant panda in China (World Wildlife Fund)



B. Ecosystem Diversity

Terrestrial land cover includes, in descending order of percentage cover: grasslands; forests; deserts and salt flats; barren lands; shrublands; wetlands, rivers, and streams; and glaciers (Figures 1–4 and 1–5; Table 1–2). Most of these land covers include sub-categories, especially grassland, forest, desert, and wetland. This chapter describes the sub-categories and major conservation issues; Table 1–3 includes a summary.

This chapter does not describe one type of land cover—shrublands—due to limited information availability. In short, shrublands are widely distributed throughout China, from the tropics to temperature zones, and from sea level to 5,000 meters elevation. Given their wide range and distribution, there is great biodiversity within shrublands. They typically consist of vegetation less than 5 meters in height, with vegetative coverage exceeding 30-40% (Chinese Academy of Sciences, 2007).

Figure 1–4. Major land cover types of China (Chinese Academy of Surveying & Mapping, 2004)

Table 1–2. Land cover types and size

Ecosystems	Millions of hectares	Percent of China's land area
Grasslands	318	33.1%
Forests	198	20.6%
Desert & salt flats	191	19.9%
Barren lands	64	6.7%
Shrublands	39	4.1%
Wetlands, rivers, and streams	21	2.2%
Glaciers	5	0.5%
Other	124	12.9%
TOTAL	**960**	**100%**

Figure 1–5. Land cover as a percentage of China's land mass

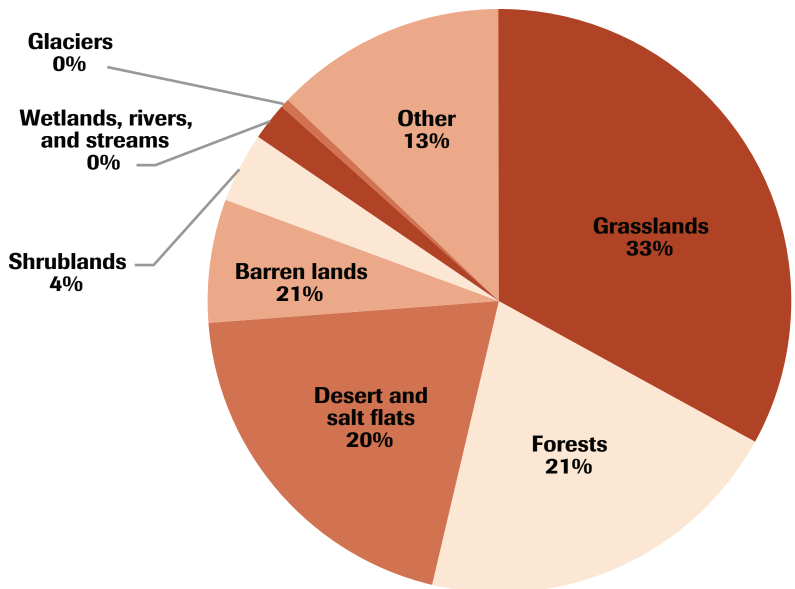


Table 1–3. Summary of sub-categories and major conservation issues for each land cover type

Land cover type	Sub-types	Conservation issues and threats
Grassland	• Meadow steppe • Typical steppe • Desert steppe • Alpine steppe	• Livestock grazing and demand for energy resources (e.g. coal, oil) • Global climate change • Overhunting
Forest	• Cold temperate coniferous forest • Temperate coniferous and broadleaf mixed forests • Deciduous broadleaf forests • Warm temperate coniferous forest • Sub-tropical and tropical evergreen broadleaf forests • Sub-tropical and tropical coniferous forests • Tropical rainforests	• Historic deforestation • Timber harvest • Harvest of non-timber forest products • Conversion to plantations
Desert & salt flat	• Sandy • Gravel (Gobi) • Loam (loess deposits) • Clay (saline desert) • Rocky (inselbergs)	• Gathering fuels and digging medicinal herbs • Overhunting and habitat destruction • Mining • Misuse of water resources and drought
Wetlands, rivers, and streams	• Lakes of the Qinghai-Tibetan Plateau & Xinjiang Basin • Freshwater marshes • Coastal wetlands • Rivers	• Land conversion • Unsustainable use • Dams • Pollution
Glaciers	• n/a	• Global climate change

1. Grasslands

DESCRIPTION

As the dominant land cover in China, grasslands account for approximately 33% of the land area (Figure 1–6, Table 1–2). Approximately 78% (318 million hectares) of the grasslands in China occur in the northern temperate zone (Kang et al., 2007). China's northern grassland ecosystems play a critical role both ecologically and socioeconomically, supporting diverse plant and animal species and traditional human uses such as livestock grazing to produce meat, milk, wool, and other animal products. These ecosystems are distributed across approximately 4,500 km, stretching from the northeastern plains adjacent to Mongolia to south of the Tibetan Plateau.

Figure 1–6. Grasslands and livestock on the Tibetan Plateau. Photo by Li Baoming

The grassland ecosystems in China can be classified as meadow steppe, typical steppe, desert steppe, and alpine steppe, as described below (Figure 1–7) (Kang et al., 2007):

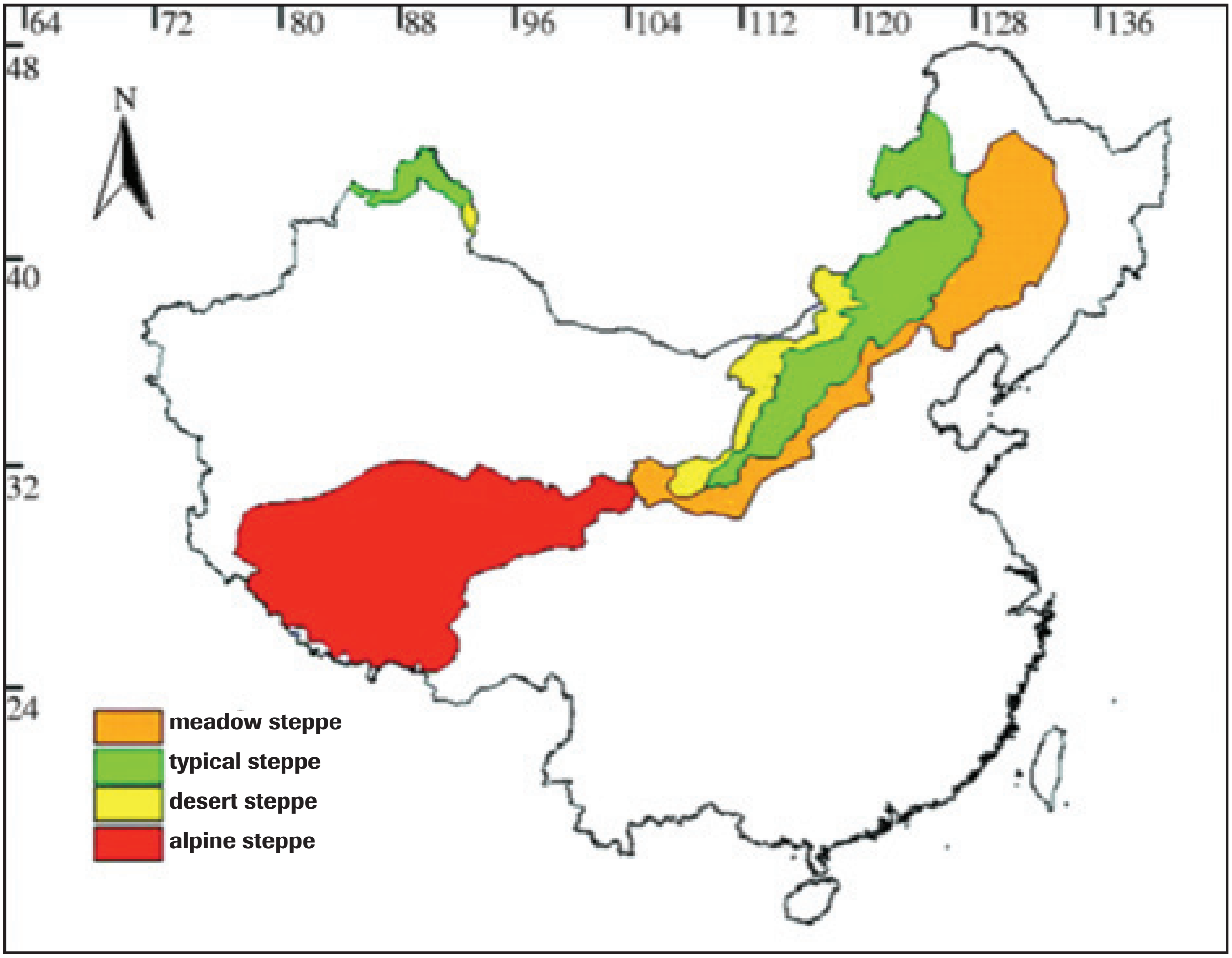
Meadow steppe occurs on the most moist and fertile sites in areas with annual precipitation around 450 mm and soils with high organic content (Kang et al., 2007). Typical species include *Stipa baicalensis, Bothriochloa ischaemum, Cleistogenes mucronata, Leymus chinensis, L. angustum,* and *Filifolium sibiricum*.

Typical steppe occurs in areas with semi-arid climates and annual precipitation of around 350 mm. Plant species are usually drought tolerant and typical species include *Stipa* sp., *Festuca* sp., *Leymus,* sp., and *Artemisia* sp.

Desert steppe occurs in the most arid regions with annual precipitation of between 150 and 250 mm. Typical species include *Allium polyrhizum* and several *Stipa* species.

Alpine steppe is typically found in southwest China (Qinghai and Tibet) between 2,300 and 5,300 m in elevation and is inhabited by cold- and drought-tolerant grasses and small shrubs. Typical species are purple feathergrass (*Stipa purpurea*), *S. subsessiliflora, Festuca olgae, Carex moorcroftii,* and *Artemisia salsoloides wellbyi.*

Figure 1–7. Distribution of grasslands in China by sub-type, adapted from (Kang et al., 2001)



CONSERVATION ISSUES AND THREATS

Nearly 90% of the grasslands in China are now degraded to varying degrees, with one-third of grasslands classified as severely degraded (SDPC, 1996) (SEPA, 1998) (Meyer, 2006). The situation is particularly grave in Inner Mongolia, where land degradation is generally believed to be a major reason for the increasing frequency of severe sandstorms and dust storms in northern China in recent decades. The environmental and economic future of the Inner Mongolia grasslands is at risk and in need of sound ecosystem management strategies for grassland sustainability. Primary causes of grassland degradation include the following:

Livestock grazing and demand for energy resources—An increasing demand for animal products and energy resources (e.g. oil and coal), in response to sharply rising human populations, has placed tremendous pressures on grassland ecosystems. For example, on the Tibetan Plateau, now accessible by rail, a growing human population and increasing numbers of cattle and sheep are putting pressure on the fragile alpine landscape and competing with wildlife. Grazing reduces vegetative cover and leaves grasslands more prone to erosion and dust storms, which can cause crop loss, human and livestock deaths, and other problems. Chinese experts estimate the number of livestock grazing on some grassland areas in China's "Middle West" exceeds sustainable limits by 50-150% (Waldron et al., 2008). New roads and railroads also open the possibility of mining. The threat of invasive species, while not an immediate issue, will become problematic as these lands become more accessible. See Chapter II, Land Use, for more information about livestock grazing and transportation construction.

Global climate change—Although overgrazing, mining, conversion to cropland, and development are the primary drivers of grassland degradation, in recent years, global climate change and droughts have exacerbated the problem. For example, Sanjiangyuan on the Qinghai-Tibet Plateau has witnessed unusual warming, and by some estimates temperatures in the region have increased by 0.88°C in the past 50 years and approximately 0.18°C per decade. This is greater than the global average temperature change, which increased by around 0.06°C per decade over last 100 years and to 0.16 -0.20°C in the last decade (European Environment Agency, 2010). Warming has caused glacial retreat, permafrost melting, and drainage and degradation of numerous lakes and wetlands critical to the region's rivers and grasslands. These trends pose significant challenges to conservation and herding communities. All grassland regions of East Asia are experiencing drying of rivers, wetlands, and the grasslands that provide sustenance to native animals and a livelihood for traditional herders. The thawing of permafrost and glaciers could have especially significant consequences downstream from Tibet, as major Chinese and Southeast Asia population centers depend upon river water coming from the plateau.

Overhunting—Finally, overhunting across the grasslands and poaching in protected areas is leading to widespread wildlife declines. For example, in the 1980s and into the mid-90s, international demand for fine wool led to the illegal taking of as many as 20,000 animals per year (Wildlife Conservation Society, 2010). Easier access to the grasslands could see this number increase.

2. Forests

DESCRIPTION

As the second largest land cover type in China, forest ecosystems encompass approximately 198 million hectares, or nearly 21% of the terrestrial land base (Table 1–2). For comparison, the forest cover of the U.S. was approximately 302 million hectares as of 1997 (Smith & Darr, 2004). China's forests are far less extensive today than they once were, due to conversion and unsustainable timber harvest. However, massive afforestation efforts are reversing that trend (see Land Use chapter). In fact, the Central Government has a goal of increasing forest coverage to 20% by 2010, 23% by 2020, and 26% by 2050 (State Forestry Administration, 2007)[3]. Nonetheless, China's forest resources are still relatively scarce on a per-capita basis; as of 2005 its per-capita forest cover was one-fifth of the world average, and its per-capita standing stock of timber was approximately one-seventh of the global average (Demurger et al., 2005).

[3] Official government estimates of forest cover range by at least 5%. In its Seventh National Forest Resource Inventory (2004-2008), the State Forestry Administration tallied 195 million ha or 20% of the country (Petry & Zhang, 2009). The Ministry of Land and Resources, by contrast, estimates 236 million ha of forest cover or 25% of the country (Table 1–5).

Little of China's original forest cover remains. According to one country-wide study of forest cover, approximately 53.1 million hectares of forest were lost or converted to other uses from 1700-2005. Forest loss was greatest in the northeast (Liaoning, Jilin, Heilongjiang) and southwest (Sichuan, Guizhou, Yunnan, Tibet) from 1700-2005, with total forest losses of 22.8 million hectares and 8.7 million hectares respectively. As examples of forest loss in specific areas, 70% of the natural forest cover was cleared from the three largest coniferous forest regions in China including Daxing'anling and the Changbai Mountains in northeastern China, and the Hengduan Mountains in the southwest (Li et al., 2003). In northern China, less than 10% of the original forest cover remains, and the western provinces of Ningxia, Xinjiang, Gansu and Qinghai have less than 4% forest cover (Zheng et al., 2001).

Currently, China's forests are concentrated in the northeastern, southwestern, and southeastern provinces (He et al., 2008) (Figure 1–9). As a result of the deforestation, secondary forests now form the majority of broadleaf forest cover and old-growth deciduous broadleaf forests are scarce. The largest forested area of 10 million hectares covers parts of Inner Mongolia and Heilongjiang provinces (Chen & Chen, 1991). There is nearly an equal distribution between coniferous forests (approximately 50%; Figure 1–8) and broadleaved forests (approximately 47%) across the country (Chen & Chen, 1991) (Wang, 2006).

Figure 1–8. Coniferous forests of Meili Snow Mountain, looking at Yubeng village, Yunnan Province. Photo by Xu Jian

China's forests can be broadly divided into seven sub-types (Figure 1–9):

Cold temperate coniferous forest dominated by larch (*Larix* spp.), spruce (*Picea* spp.), fir (*Abies* spp.), and pine (*Pinus* spp.). These forests are largely distributed in habitats dominated by cool-cold and humid conditions. Some 200 vertebrate species can be found in these forests, of which more than 40 are mammals and nearly 120 are birds.

Temperate coniferous and broadleaf mixed forests are dominated by Korean pine (*Pinus koraiensis*). This is a major forest type in the eastern part of northeastern China. Once an important timber base, this forest type today is severely limited. Well-conserved *P. koraiensis*-broadleaved deciduous forests occur mainly in nature reserves in the Xiao Xingan and Changbai mountains.

Deciduous broadleaf forests are widely distributed on hills and from mid-elevation to subalpine zones on mountains in the warm temperate and tropical zones. The diverse oak forests (*Quercus* spp.) and mixed oaks and deciduous broadleaved forests are typical of the warm temperate zone. There are approximately 11 types of oak forests extending from northern to southern China, each dominated by a different species of oak. Due to its extremely limited distribution, one of the more unique deciduous forests in China may be the beech (*Fagus* spp.) forests which occur only in mountains in the subtropical zone in the east central to south central part of the country (Chen & Chen, 1991). There are 9 types of birch forests in China, all distributed in mountainous regions. Three types of alder (*Alnus* spp.) forests occupy humid sites. Birch forests and poplar (*Populus* spp.) forests are typically secondary forests succeeding montane broadleaved forests and coniferous forests, under natural conditions. In subtropical regions, deciduous broadleaved forests are secondary forests that develop mainly after the original evergreen forests are damaged.

Warm temperate coniferous forest can be classified into four broad forest types by their dominant species as: Chinese red pine (*Pinus tabulaeformis*), Japanese red pine (*Pinus densiflora*), lacebark pine (*Pinus bungeana*), and Chinese arborvitae (*Platycladus orientalis*). Only the first is widely distributed. Most of the Pinus tabulaefonnis forests are concentrated in northern China. Pinus densiflora forests appear on the Shandong and Liaodong peninsulas. Platycladus orientalis forests are widely distributed, but restricted to small areas. The distribution of Pinus bungeana is limited to northern China the southern part of Shanxi, western Hubei, and northern Sichuan.

Sub-tropical and tropical evergreen broadleaf forests are widely distributed in the humid subtropical zone in China. The subtropical region occupies a quarter of the total area of the country. There is a very rich diversity of plant species distributed throughout the evergreen broadleaf forest area, including more than two-thirds of the genera (2,674) and one-half of the species (14,600) occurring in China (Li et al., 2003).

Forests in this region are typically mixed forests dominated by one or more evergreen species such as chinquapin (*Castanopsis* spp.), *Cyclobalanopsis* spp., *Machilus* spp., or *Schima* spp. There is a slight difference between the easternmost and westernmost evergreen forests within China´s subtropical zone (Chen & Chen, 1991). In the western part, the most widely distributed forests are *Castanopsis delavayi* forests. In the eastern part, there are more forest types, each with one of the following as the dominant species: *Castanopsis eyrei*, ring-cupped oak (*Cydobalanopsis glauca*), *Castanopsis carlesii*, *Castanopsis fargesii*, Tabu-No-Ki tree (*Machilus thunbergii*),and *Schima superba*.

Sub-tropical and tropical coniferous forests are abundant in China. Chinese red pine (*Pinus tabulaeformis*) forests from the warm temperate zone give way in the tropical and sub-tropical zones to Chinese red pine (*P. massoniana*) forests in the south and east, and to Yunnan pine (*P. yunnanensis*) and Chinese white pine (*P. armandi*) in the west (Li et al., 2003). A special note is required for another representative forest consisting of what are often referred to as "living fossils." This forest consists of species dating back to the Tertiary period such as *Cathaya argyrophylla*, golden larch (*Pseudolarix kaempferi*), dawn redwood (*Metasequoia glyptostroboides*), water pine (*Giyptostrobus pensilis*), taiwania (*Taiwania cryptomeriodes*), and *T. flousiana*. These species occur independently of each other, are dispersed in small isolated areas, and appear to be gradually declining (Chen & Chen, 1991) (Li et al., 2003).

Tropical rainforests in China are seasonally wet or dry rainforests occurring on the margins of the typical rainforest ecosystem range. Chinese tropical rainforests are an extension of the Indian and Malaysian rainforests, and are distributed in areas with sufficient year-round rainfall and heat. Rainforests dominated by Cotton tree (*Bombax malabaricum*), Chinese albizia (*Albizia chinensis*), and *Vatica astrotricha* are the most common and widely-distributed rainforest types in China. Sitting at the extreme northern edge of the south Asian tropical forest range, China has only a small area of tropical forest distributed in southern Guangdong, Hainan, southern Guangxi (Guangxi Zhuang Autonomous Region), southern Yunnan, and southeastern Tibet. Despite their relatively limited distribution (0.5% of China's land area) the tropical rainforest in China contains some of the country's highest biodiversity, with 25% of the country's species (Li et al., 2003). Hainan and southern Yunnan have more extensive rainforests than any other part of China, but with increasing human pressure for development, these forests are disappearing quickly. Rainforest coverage is also changing rapidly due to expanding human populations. For example, the rainforest on Hainan covered 25.7% of the total island area in the early 1950s, but within 30 years had decreased to 10.6%, of which just 6% is natural (Chen & Chen, 1991).

CONSERVATION ISSUES AND THREATS

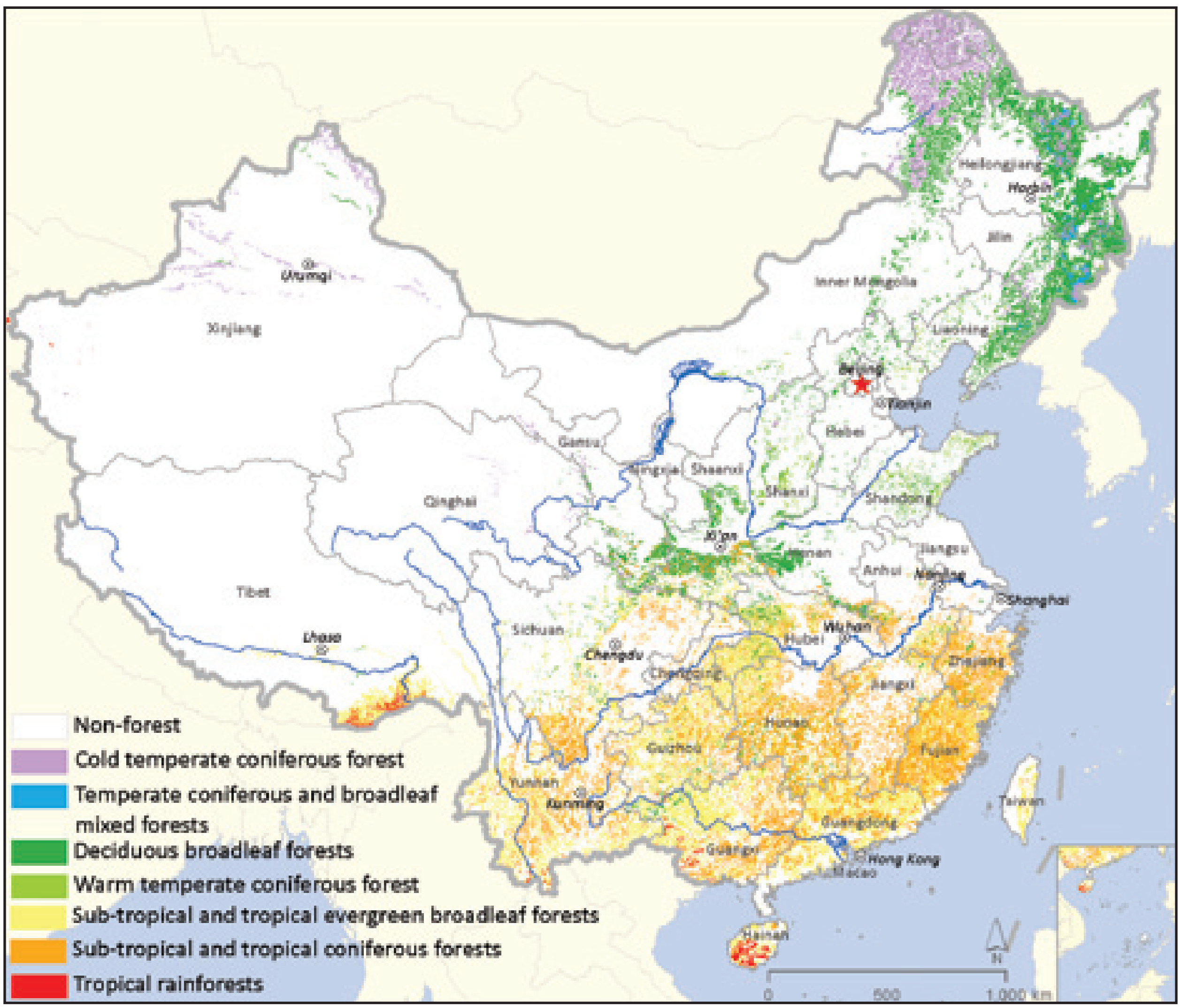
Historic deforestation—As mentioned, over the past several hundred years, forest cover declined greatly due to conversion to cropland, logging, and clearing for development. Forests are still recovering. Over the last 60 years, since the creation of the People's Republic of China in 1949, there have been several periods of intense deforestation. During the Great Leap Forward (1958-1961), citizens felled and burned thousands of hectares of trees for steel production, with only limited reforestation. Then, starting in the late 1960s, the government encouraged conversion of forests to agricultural land in order to increase grain self-sufficiency. Finally, in the 1980s, peasants were granted use rights to forests and many immediately harvested the trees for short-term profit, fearing that the use rights would be rescinded before they could reap the benefits (Demurger et al., 2005).

As deforestation escalated, so did ecological consequences including soil erosion, desertification, natural disasters, and loss of biodiversity. One of the most devastating results of deforestation was the flooding of the Yangtze River in 1998. The flood, China's worst in 44 years, drowned more than 4,000 people and rendered 14 million homeless (PBS.org). Deforestation was largely to blame; because 85% of the Yangtze River Basin had been logged, monsoon rainfalls coursed relatively freely toward the river.

Timber harvest and harvest of non-timber forest products—See Chapter II, Land Use.

Conversion to plantations—There has been a tendency toward replacing evergreen broadleaf forests with plantations of coniferous species such as Chinese red pine (*Pinus massoniana*) and Chinese fir (*Cunninghamia lanceolata*), leading to decreasing species diversity in these forests (Chen & Chen, 1991).

Figure 1–9. Major forest sub-types (Chinese Academy of Sciences)



3. Deserts and Salt Flats

DESCRIPTION

China boasts some of the world's largest and most extreme deserts such as the Taklamakan Desert just north of the Tibetan Plateau. They are expanding, due to desertification of grasslands and other ecosystems. The tallest sand dunes and highest elevation alluvial fan in the world are located in north-central China in the Badain Jaran desert. China's deserts are roughly distributed northwest of the Lang, Helan, and Burhan Budai mountain ranges and cover an area of approximately 191 million hectares, or approximately 20% of China's terrestrial area (Figure 1–11) (Li et al., 2003)(Alles, 2007).

The desert regions of China form the largest arid area in the temperate climate zone in the world (Warren-Rhodes et al., 2007). The distribution of China´s deserts is closely related to the pattern of rainfall, which is in turn strongly influenced by the East-Asian and Indian summer monsoon and the moisture sources from the South, Southwest and Southeast. Like most deserts, China's are characterized by strong continentality (large thermal variation), low precipitation, extreme climatic variations, intense sunshine, and strong winds and sandstorms in winter and spring (Warren-Rhodes et al., 2007). In winter, the desert regions are dominated by the Siberian high-pressure system, causing extremely dry and cold climates.

According to their substrata, deserts may be divided into **sandy, gravel (Gobi), loam (loess deposits), clay (saline desert) and rocky (inselbergs)**. The first two types cover the largest areas in China. In general, and in the classification in Figure 1–11, if more than 50% of an area is gravel or cobble plains it is considered Gobi desert.

Compared with other terrestrial ecosystems, the species composition of deserts is relatively poor. The total number of seed plants encountered in the vast desert areas of northwestern China is just a little more than 600. The Junggar Basin plain is considered to have the richest flora, yet, only about 500 species have been recorded. The flora of the Tarim Basin comprises less than 200 species (Ministry of Environmental Protection, 2004).

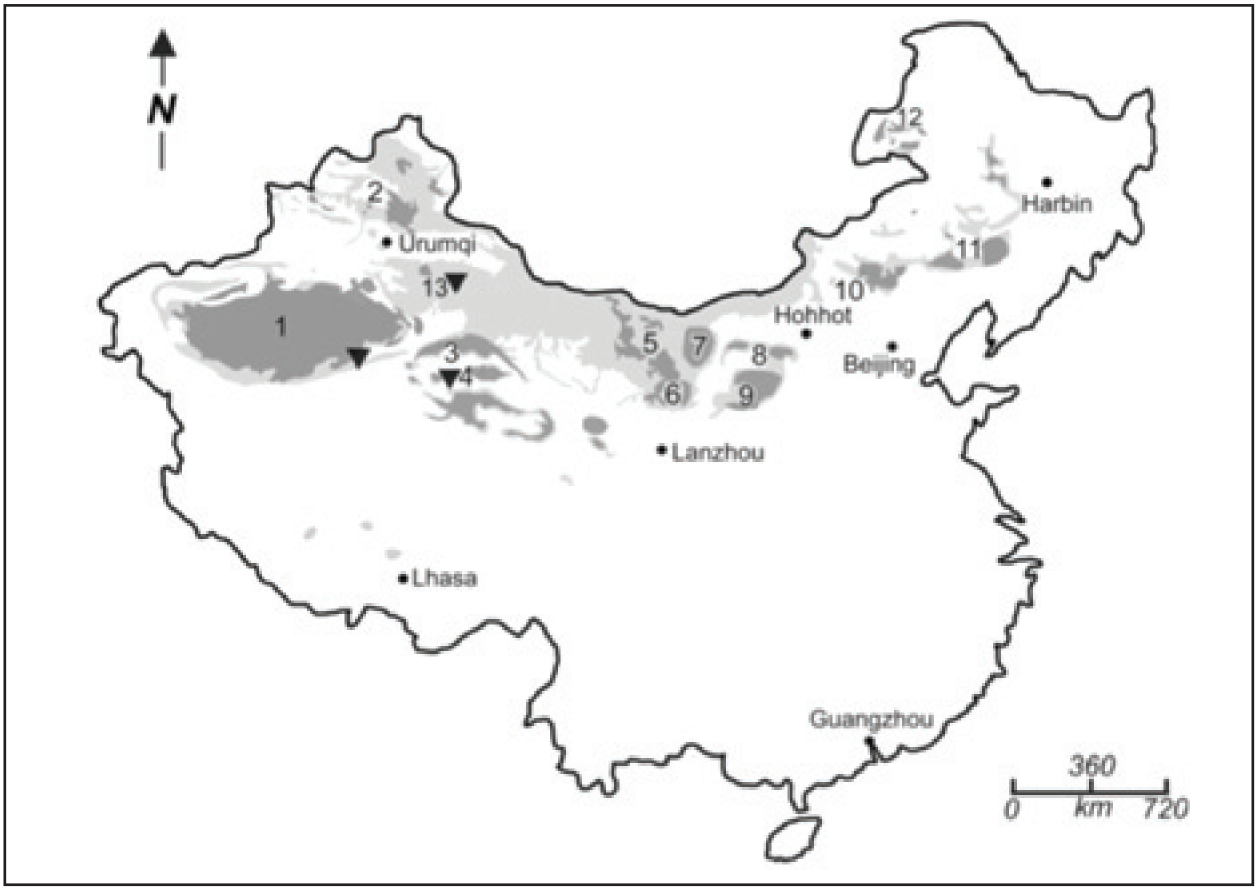
Despite the limited species composition, relatively unique ungulates developed in the deserts of China—including ancestors of its present livestock. These include, for example, Przewalskii's wild horse (*Equus przewalskii*), kulan (*E. hemionus*), bactrian camel (*Camelus bactrianus*), yarkland deer (*Cervus elaphus yarkandensis*), saiga antelope (*Saiga tatarica*), Przewalskii's gazelle (*Procapra przewalskii*), and gazelle (*Gazella subguttarosa*) (Figure 1–10). Other species that come down from the surrounding arid mountains to the borders of such deserts include alpine ibex (*Capra ibex*), mountain sheep (argali; *Ovis ammon*), and Himalayan blue sheep (*Pseudois nayaur*). Rodents, especially representatives of the Dipodidae (12 species) and Gerbillinae (*Cricetidae*) (7 species), are particularly conspicuous in desert ecosystems. Compared with adjacent humid regions, there is less bird and larger mammal diversity, though birds of prey are more numerous (12 species).

Reptiles are widely distributed in the desert ecosystems of northwest China, where both species and individuals are numerous. The most commonly seen are species of toadhead agamas (i.e., lizards; *Phrynocephalus*) and *Eremias*, a genus of wall lizards. In the western part of the deserts of Xinjiang lives a unique terrestrial tortoise, the Russian tortoise (*Testudo horsfieldi*).

Figure 1–10. Desert with Przewalskii's gazelle (Procapra przewalskii), Qinghai. Photo by Ge Yuxiu.

Figure 1–11. Map of sandy and Gobi deserts (*shamo*) and sandy lands (*shadi*) in China (Warren-Rhodes et al., 2007), redrawn from (Zhu et al., 1980)

Dark gray: sandy deserts and lands; **light gray**: Gobi desert. All of the light gray areas along China's border with Mongolia can collectively be referred to as the central Gobi Desert and cover over 100 million hectares (Li et al., 2003) (Warren-Rhodes et al., 2007).



1. Taklamakan Desert
2. Gurbantunggut Desert
3. Kumtag Sandy Desert
4. Qaidam Basin Desert;
5. Badain Jaran Desert
6. Tengger Sandy Desert
7. Ulan Buh Sandy Desert
8. Qubqi Sandy Desert
9. Mu Us Sandy Lands
10. Hunshandake Sandy Lands
11. Horqin Sandy Lands
12. Hulun Buir Sandy Lands and
13. Turpan Kumtag Sandy Desert.

CONSERVATION ISSUES AND THREATS

Due to harsh environments and relatively sparse human populations, it is generally thought that the impacts of human activities in deserts are relatively low. However, many of China's deserts, and particularly those in the northwest, have been severely damaged. Desert biological resources are being swiftly depleted. Primary threats include:

Gathering fuel and digging medicinal herbs—It is estimated that annually in desert areas of the Junggar Basin, on average, each inhabitant family utilizes at least two tons of saxoul (*Haloxylon ammodendron and H. persicum*), a tree common to Gobi deserts. For example, in the Alxa desert of Inner Mongolia, the saxoul forests were reduced by 60% from 1958-1978 (Ministry of Environmental Protection, 2004). In addition, valuable medicinal plants, such as licorice (*Glycyrrhiza* spp.), ephedra (*Ephedra przewalskii*), cynomorium (*Cynomorium songaricum*), and others have all decreased due to severe uprooting and collection. These species are all well-adapted to the harsh desert environment and play an important role in soil stabilization and hydrologic cycles. They also provide micro-habitats (e.g. cover and food) for many vertebrates and invertebrates. Their loss is leading to greater desertification and reduction of wildlife habitat.

Overhunting and habitat destruction—Przewalskii's horse (*Equus przewalskii*), saiga antelope (*Saiga tatarica*), Xinjiang tiger (*Panthera tigris lecoqi*), desert bear (*Ursus arctos pruinosus*), bactrian camel (*Camelus bactrianus*), onager (*Equus hemionus*), and Przewalskii's gazelle (*Procapra przewalskii*) are all desert dwellers, and were numerous in the deserts of Northwest China a few centuries ago. Przewalskii's horse disappeared from the wild in the 1960s mainly because of overhunting. The saiga antelope, originally widely distributed in Middle Asia, Mongolia, and the Junggar basin of China, has not been seen in China since the early 1950s.

Mining—Large scale prospecting and exploitation of petroleum and mineral ores, as well as the construction of roads and cities, threatens wild animals and plants through habitat destruction and disturbance, and by blocking the migration routes of wild animals.

Misuse of water resources and drought—Increasing the use of surface and groundwater resources in these arid regions for agriculture, mining, and other uses has lowered water tables in many areas of north and northwest China. This reduction in water availability has led to loss and degradation of desert plant ecosystems. Decreasing soil moisture can stop germination in many agricultural and natural plant species and lead to insect infestation, plant disease, and loss of plant cover.

Continued overuse and mismanagement of water resources in regions of northwest China, such as Gansu's Hexi corridor, have led to serious environmental problems such as reduced water flows in most rivers, drying up of terminal lakes, reduced water quality in the lower reaches of many rivers, increased soil salinity, and ultimately loss of plant cover. In 2004, severe drought and reduced water flow may have led to or compounded droughts in China's southern provinces, which were the worst droughts in 50 years. In the hardest-hit region of Guangxi Province, 1,100 reservoirs went dry and hydropower generation reduced dramatically (State Forestry Administration, 2002).

4. Wetlands, Rivers, and Streams

DESCRIPTION

The Convention on Wetlands recognizes 31 natural and 9 artificial wetland types, all of which are found in China (State Forestry Administration, 2002). Total wetland area is approximately 60 million hectares, including natural and artificial wetlands. Natural wetlands account for less than half of the total wetland area, covering 21-26 million hectares or between 2.2-2.7% of China's land area. Nearly half of China's natural wetlands disappeared from 1990–2008. Natural wetlands include peatland (approximately 11 million hectares), coastal wetlands (over 2 million hectares), and riverine and lacustrine wetlands (over 12 million hectares). By contrast, artificial wetland types account for approximately 36 million hectares and include paddy fields (34 million hectares) and saltpans and aquaculture areas (2 million hectares) (Mackinnon et al., 1996) (State Forestry Administration, 2002) (World Wildlife Fund, 2005) (The Nature Conservancy, 2007). (Cyranoski, 2009).

A significant diversity of plant and animal species inhabit and rely on healthy wetlands (Figure 1–12). Approximately 101 plant families, including 94 families of vascular plants, occur in China's wetland areas. Over 100 species are endangered. Of China's extensive bird species, its 31 wetland species comprise 54% of Asia's total of 57 endangered wetland bird species. The wetlands are particularly important to migrating waterfowl such as cranes; in fact, 9 of the world's 15 crane species have been recorded in China (State Forestry Administration, 2002).

Figure 1–12. Wetlands of the Chongming Dongtan Nature Reserve. Photo by nature reserve staff

Figure 1–13. Upper Yangtze River in Northwestern Yunnan. Photo by Ami Vitale

Wetlands and rivers are widely distributed throughout the country and are generally described as follows (Mackinnon et al., 1996) (State Forestry Administration, 2002) (Figure 1–14):

Lakes of the Qinghai-Tibetan Plateau and Xinjiang Basin are the sources of great rivers such as the Huang He, Chang Jiang, Mekong, and Nujiang (Salween) in the east; and the Indus, Ganges, and Brahmaputra in the south. These lakes, pools, and marshes are important for waterfowl such as the bar-headed Goose *(Anser indicus)* and black-necked crane *(Grus nigricollisi)*. Approximately half of China's lakes are saline and most are in northwest China and western Inner Mongolia. They support one of the largest breeding populations of the black stork *(Ciconia nigra)* in China (in the Tarim River Basin which lies in Xinjiang) and the relict gull *(Larus relictus)* in the Taolimiao Alashan Nur region of Inner Mongolia.

Freshwater marshes are primarily found in the northeastern provinces of Heilongjiang, Jilin, Liaoning, and Inner Mongolia. They are of great importance as breeding and stopover areas for large numbers of waterfowl and, in particular, four species of crane: red-crowned crane *(Grus japonensis)*, Siberian crane *(G. Leucogeranus)*, white-naped crane *(G. vipio)* and common crane *(G. grus)*. Peatlands are widely distributed throughout northeast China, the Qinahai-Tibetan Plateau in western China, and the Tian Shan and Altai Shan uplands in northwestern China.

Coastal wetlands include seven major types: deltas and bays, tidal mudflats, grassy and reed-bed salt marshes, mangrove swamps, sandy beaches, rocky sea coasts, and offshore islets. Some of the most important flyways in the world, such as the East Asian-Australasian Flyway, cross over China and wetland areas such as the Yellow Sea ecoregion between northeast China and the

Korean Peninsula. The entire global population of Saunders' Gull *(Larus saundersi)* breeds in the coastal wetlands of China. Many migratory waterfowl fly directly from Australia to China, using the coastal wetland areas as wintering and staging areas. The mangroves, fish ponds, and rice paddies along the coast also support large numbers of herons and egrets, as well as important species such as the black-faced spoonbill *(Platalea minor)* and the Saunders' Gull, which winter in Deep Bay, Guangdong/Hong Kong.

Rivers exceed 50,000 in total number and include some of the longest and most important freshwater resources in the world. More than 1,500 rivers each drain areas equal to or greater than 1,000 km². Many of China's and southeast Asia's largest and most valuable rivers begin high on the Qinghai-Tibetan Plateau, with significant elevation differences between their sources and mouths (State Forestry Administration 2002). Basins of rivers flowing to the ocean account for approximately 65% of China's land area, while basins of inland rivers emptying into lakes or other inland rivers account for approximately 35% of China's land area (State Forestry Administration, 2002).

The Yangtze, Yellow, Heilong, and Pearl River basins are the four largest and most ecologically and economically important to China's wildlife and people. The 6,300-km long Yangtze River is the longest in China and the third-longest in the world (Figure 1–13). It has eight major tributaries and a catchment area of 1.8 million square kilometers, which is equivalent to one-fifth of the total land of China. The Yellow (Huanghe) River is the second largest river in China with a length of 5,464 km. As one of the birthplaces of ancient Chinese civilization, the Yellow has lush pasturelands and abundant mineral deposits. The Heilong River in northern China covers a total length of 4,350 km, of which, 3,101 km are in China. The Pearl (Zhujiang) River covers 2,214 km in southern China.

One particularly important and unique area from an ecological perspective is the "Three Parallel Rivers" region. This region boasts China's most spectacular river canyons formed by the Nujiang (Salween) River, Lancang (Mekong) River, and the Yangtze River. In a remote corner of Yunnan Province, these three rivers run parallel to each other, coming within 70 km of each other before separating to water the plains of eastern China and Southeast Asia. The region is part of a 1.7 million hectare World Heritage Site: Three Parallel Rivers of Yunnan World Protected Areas (UNESCO).

CONSERVATION ISSUES AND THREATS

Land conversion—The largest threat to wetlands in China, as in many countries, is conversion to farmland and urban development. According to research by the Chinese Academy of Sciences, approximately 10 million hectares of wetlands were lost over a 30-year period, from 1978-2008 (Zhang, 2011). Specific to coastal wetlands, approximately 50% of China's have been lost to aquaculture and urban development. Reclamation and aquaculture have decreased mangrove forest cover by 72% since 1950, from 50,000 hectares in 1950 to approximately 14,000 hectares today (State Forestry Administration, 2002).

Figure 1–14. Major wetlands, rivers, and streams (National Foundational Geographic Data Center, 1994)

Unsustainable use—Wetlands in the low altitude southeast area of the Tibetan Plateau face local pressures due to drainage, peat mining, reservoir construction, pesticide use, and changes in agricultural practices. Also, waterfowl populations have declined due to overhunting, egg collection, and the destruction of fish stocks through illegal fishing. Over-extraction of water for urban and agricultural uses is also a major threat to many freshwater rivers and lakes. For example, flow records for the Yellow River show that there were 226 days without water flow in 1997 (State Forestry Administration, 2002).

Dams—Dams threaten many rivers in China and have fragmented and destroyed river ecosystems, thus preventing the reproduction or disrupting migration patterns of many fish and leading to their decline. Construction of hydropower stations typically results in flooding of riverbanks and, for larger projects, relocation of local residents. For example, the construction of the Three Gorges Dam, submerged 13 cities, 140 towns, and 1,450 villages, and resulted in the relocation of

1.3 million people to other locales (International Rivers, 2009) (news.163.com, 2009). It should be noted that small dams are arguably just as impactful (environmentally, if not socially) as larger dams in that they still fragment the river system and virtually never include fish passages (Harrison, 2011). There are approximately 85,000 dams across China at present (Wang & Zhao, 2010) (Guo et al., 2010). With increasing demand for electricity, flood control, and water supply, the number of dams will no doubt continue to increase (State Forestry Administration, 2002). See Chapter II, Land Use for more information about hydropower and dams.

Pollution—Pollution from domestic, industrial, and agricultural sources is another critical threat to wetlands, rivers, and lakes in China. Of the 15 reaches of the country's 7 largest rivers that are located near major cities, 13 have been seriously polluted (Mackinnon et al., 1996). Urban lakes have reached eutrophic status in Jinjiang, Hangzhou, and Huangshi and are hypertrophic in Nanjing, Whuan, Changchun, and Guangzhou. Pollution from agricultural and industrial runoff continues to be a major concern throughout China (Chang, 1993) (Zhang et al., 2008).

5. Glaciers

DESCRIPTION

Glaciers comprise the smallest ecosystem type, covering an area of approximately 5.5-5.9 million hectares or approximately 0.6% of China's land area. Yet, they are critically important to biodiversity because their meltwater supplies aquatic ecosystems. China's glaciers are primarily found in western China, in the mountains of Sichuan, Yunnan, Gansu, and Tibet. Many of Asia's major rivers, including the Jinsha (upper Yangtze), Lancang (upper Mekong), Nu (upper Salween), Dulong (tributary of the Irrawaddy), and Yarlung Tsangpo (upper Brahmaputra), originate from and rely on the meltwater of glaciers. These rivers are the source of water for hundreds of millions of people. Without them, the ecosystem services they provide, such as fish, drinking water, and irrigation, would be severely impacted.

CONSERVATION ISSUES AND THREATS

Global climate change—Unlike other ecosystem types, loss from direct human impact, such as land conversion, is not an issue with glaciers. The primary threat to glaciers is global climate change. Some estimates suggest that since the late 17th century, temperatures have risen in the western regions of China by as much as 1.3°C. This has led to a 20% decrease in glacial area (Shi & Liu, 2000). All told, approximately 1.2 million hectares of China's glaciers have disappeared in just over 300 years. Experts predict that temperatures will continue to rise in western China, and by the year 2100, glacial area losses could range from 30-60% (Shi & Liu, 2000). At this rate, some glaciers would likely disappear, and the rivers and streams that they supply would dry up as well. One study of the Hengduan Mountains in northwest Yunnan used repeat photos to show that the warming is in fact leading to a retreat of glaciers. Serious efforts to combat global climate change are these glaciers' only hope of survival (Baker & Moseley, 2007).

II. Land use

The Biodiversity chapter identified conservation issues and threats specific to individual ecosystems. This chapter describes trends in land uses across the country as a whole, since any one land use can affect multiple ecosystems and their associated biodiversity. It also describes the way that the Chinese government defines land use, which is important base knowledge for understanding various aspects of the land tenure system, such as land use planning (see Part 2, Land Tenure). And land use planning, in turn, affects the potential to implement land protection projects.

Overall, China is experiencing massive land use changes and impacts to the environment due to an unprecedented period of economic growth. Its growth has catapulted it from one of the world's poorest countries 30 years ago to the world's second largest economy today. Since the period of "economic reform and opening," initiated by Deng Xiaoping in 1978, China has moved from a closed, tightly-controlled, and centrally-planned economic system to one that is more market-oriented and showing signs of increasing liberalization. For example, the creation of a diversified banking system and stock markets, the emergence of a private sector, and increased receptiveness to foreign investment and trade all have contributed to China's remarkable GDP growth rate, which was estimated as 10.3% in 2010 (Central Intelligence Agency, 2011).

China's economy is heavily dependent upon industries with a large ecological footprint to sustain its extraordinary growth rate. Manufacturing, infrastructure construction, and heavy industry, for example, account for roughly 50% of China's GDP (Central Intelligence Agency, 2011). China is the world leader in the gross value of industrial output, and land-intensive extractive and agricultural industries are a major pillar of China's economy. China was also the leading global exporter in 2009 and the world's third largest importer in 2010. Looking forward, China's 12th Five-Year Guideline (2011-2015)[4], released in March 2011, indicates that Beijing seeks to change its growth model to focus on stabilizing prices, and turn the economic spotlight away from manufacturing and exports to service-based industries (Bloomberg News, 2010) (Central Government, 2011).

In the meantime, it is commonly said that China is not only the world's factory, but also its smokestack. A 2007 *New York Times* series entitled "Choking on Growth" described the way in which China's low-cost and high-impact economic strategy is heavily damaging the environment and public health (The New York Times, 2007). Furthermore, the environmental impacts of China's "red-hot" growth are readily apparent, with desertification, loss of arable land, and pollution of air, land, and water accounting for billions of dollars of lost economic productivity per year (The World Bank and State Environmental Protection Agency, 2007).

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[4] Five-year guidelines are major planning documents, which set priorities for socioeconomic development, growth targets, and land or other reforms for five-year (or so) blocks of time. See Part 2, Land Tenure.

Needless to say, based on trends in economic development, population growth, and land use, China's natural landscape will undoubtedly experience significant and increasing pressures well into the future, as this chapter explores. These trends are driving the need for effective land protection. Some natural landscapes will be converted to non-natural uses entirely. Urbanization will likely have the largest negative impact, while the construction of roads and railways, and the development of energy will cause further fragmentation (Figure 1–15). Other uses such as livestock grazing and the harvest of timber and other forest products may not entirely convert the natural landscape, but they too will have negative impacts. Fortunately, some positive changes are occurring too, in particular massive afforestation efforts and other management/conservation programs.

Note that in a variety of places throughout this chapter, comparisons are made between China and other countries. The U.S. provides a particularly useful comparator since the countries have approximately the same land area.

A. Government Definition

The Central Government identifies land use according to three major categories: agricultural land, construction land, and unused land. These trends are driving the need for effective land protection. As of 2008, agricultural lands covered 69% of China and included cultivated lands, forests, grasslands, orchards, and "other" lands. "Unused lands" such as deserts, alpine tundra, and swamps covered approximately 27% of the country, while construction lands such as residential areas and transportation corridors covered 3% (Table 1–4 and Figure 1–16). These statistics pertain to actual, on-the-ground uses as opposed to planned uses.

The Ministry of Land and Resources (MLR) collects and updates land use statistics on a regular basis. In 2000, the MLR published China's first national land use survey. This survey, which the State Council initiated in 1984, created a baseline of information about the amount, quality, and use of land in China, not including Hong Kong, Taiwan, or Macau (Yun & Wang, 2007). The MLR is in process of completing a second nationwide survey, initiated in 2007, to gauge changes in land use since the first survey. In addition to these major survey efforts, approximately once a year the MLR collects land use statistics from the provinces; Table 1–4 shows the results from the 2008 survey.

Figure 1–15. Cumulative land uses (The Nature Conservancy, 2008)

This map combines land uses including major roads and railways as of 1994; and cropland, urban settlements, and other developed areas as of 2004. The largest contiguous blocks of habitat exist in northern and western China.

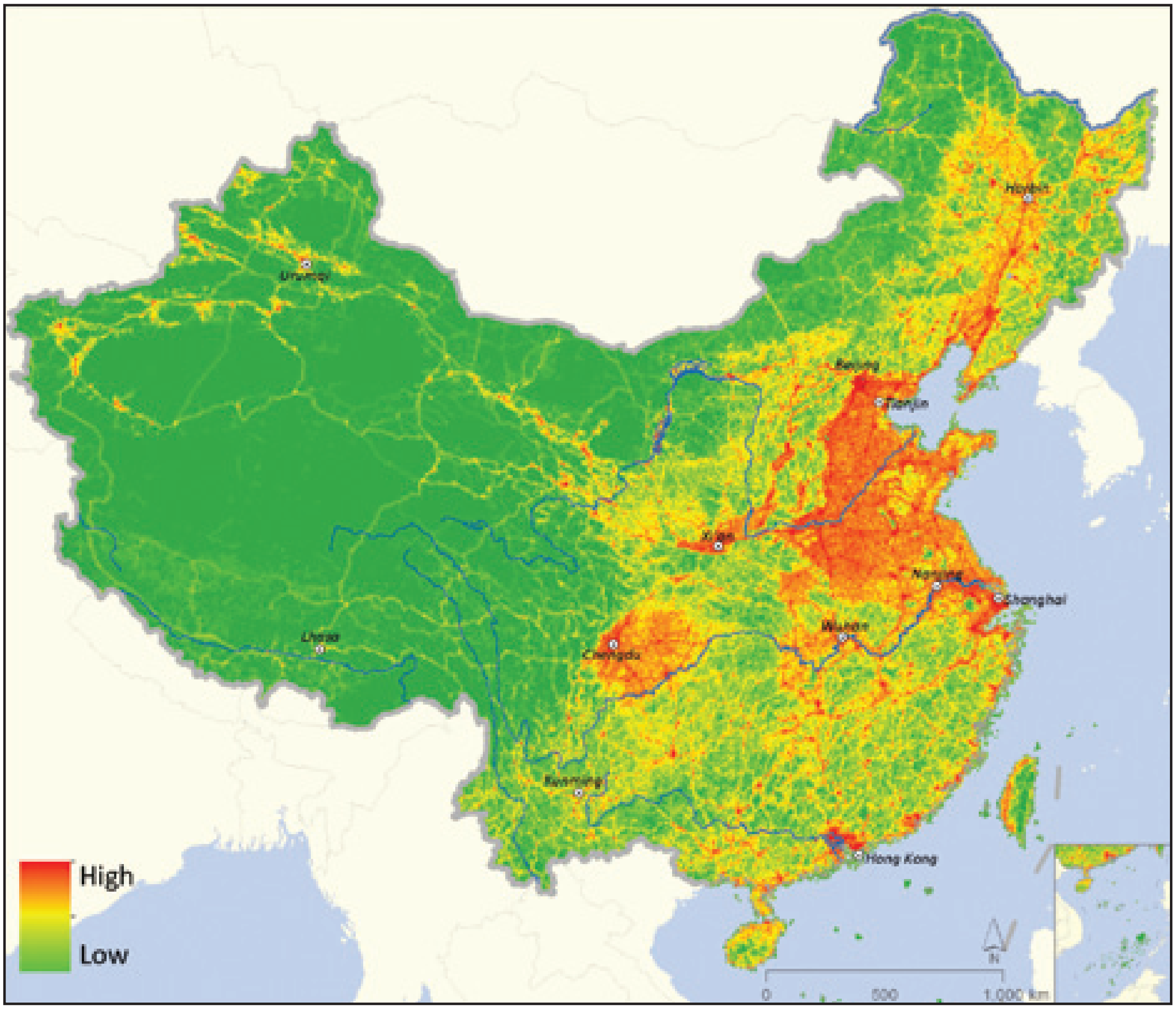
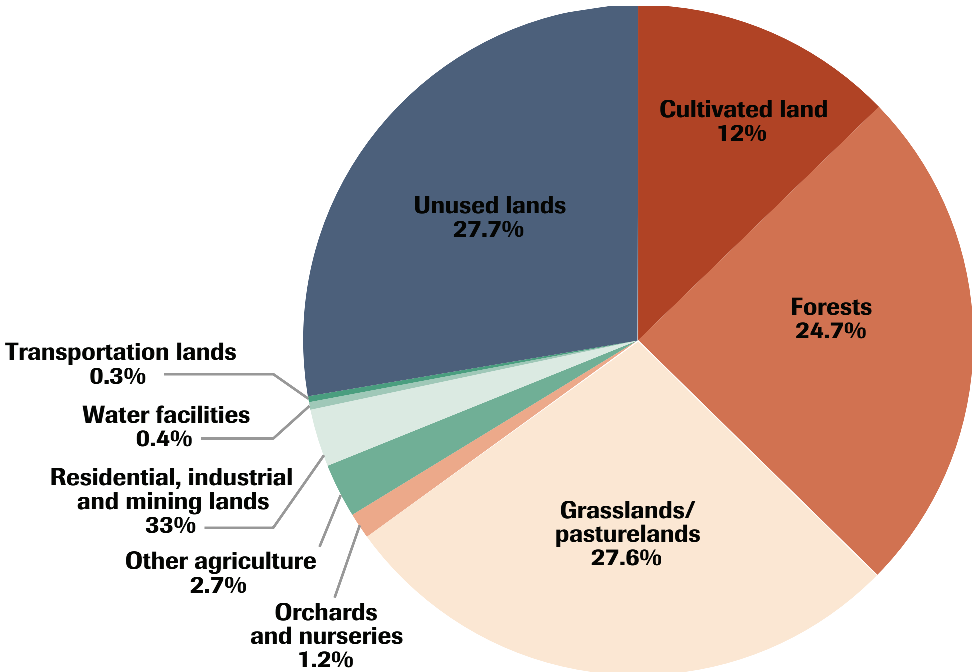


Table 1–4. Land use in China, 2008 (Ministry of Land and Resources, 2009)

Land use category	Hectares	Percent of all land in China	Description
AGRICULTURE			
Cultivated land	121,681,114	12.7%	Land that is currently cultivated or otherwise set aside for cultivation (e.g., fallow land).
Forests	236,126,436	24.7%	Lands covered by forest, regardless of species mix or usage (e.g., for timber harvest or other purposes). Does not include orchards and nurseries (see below).
Grassland	263,345,213	27.6%	Grassland land cover with at least 10% vegetative cover.
Orchards and nurseries	11,797,171	1.2%	Orchards and nurseries for the purpose of collecting fruit, seeds, tea, etc.
Other	25,480,060	2.7%	Other agricultural lands.
Subtotal	**658,429,994**	**68.9%**	
CONSTRUCTION			
Residential, industrial, and mining lands	26,912,673	2.8%	Broad category that encompasses a wide array of uses: Residential lands including the areas encompassed by cities, townships, and villages; industrial and mining lands including mines, factories, etc.; salt flats from which salt is harvested; and other places of special interest such as areas used for national defense, cemeteries, Scenic Areas, etc.
Transportation	2,401,032	0.3%	Land covered by roads, railroads, pipelines, airports, havens, docks, etc.
Water facilities	3,645,219	0.4%	Reservoirs, dams, hydropower stations, etc. Does not include irrigation facilities for cultivated land.
Subtotal	**32,958,924**	**3.4%**	
UNUSED			
Unused lands	264,400,658	27.7%	Lands that are not used or that are difficult to use, such as deserts, salt flats from which salt is not harvested, grassland with less than10% cover, swamps, alpine tundra, glaciers, beaches, etc. Also includes rivers, lakes, streams, etc.
Subtotal	**264,400,658**	**27.7%**	
GRAND TOTAL	**955,789,576**	**100.0%**	

Figure 1–16. Land use in China, 2008 (Ministry of Land and Resources, 2009)



B. Urbanization

China has four times the population of the U.S. and nearly seven times that of Brazil, within roughly the same area. With 1.3 billion inhabitants,[5] one out of every five people in the world lives in China. The rate of population growth has generally been declining for decades, but the overall number of inhabitants has been growing and is expected to do so at least through 2030 (Figures 1–17 and 1–18). The country has at least 125 cities (including Hong Kong) with metro area populations of more than 1 million people, the largest of which include Chongqing (29 million), Shanghai (23 million), and Beijing (people.com.cn, 2008) (National Bureau of Statistics, 2011). By comparison, Europe has 36 cities with over one million residents while the U.S. has 9. Nearly 600,000 people poured into the municipality of Shanghai every year from 2000-2010 (Cox, 2011)[6].

[5] The population of mainland China (not including Taiwan, Macao, or Hong Kong) is 1.3 billion. The population of China, including Taiwan, Macao, and Hong Kong, is 1.4 billion (National Bureau of Statistics, 2011).

[6] Calculated by subtracting Shanghai's 2000 population of 16.41 million from its 2010 population of 22.21 million and dividing by 10 years.

Figure 1–17. Population 1950-2050, U.S. and China (Population in thousands and projected from 2005-2050) (United Nations Population Division, 2010)

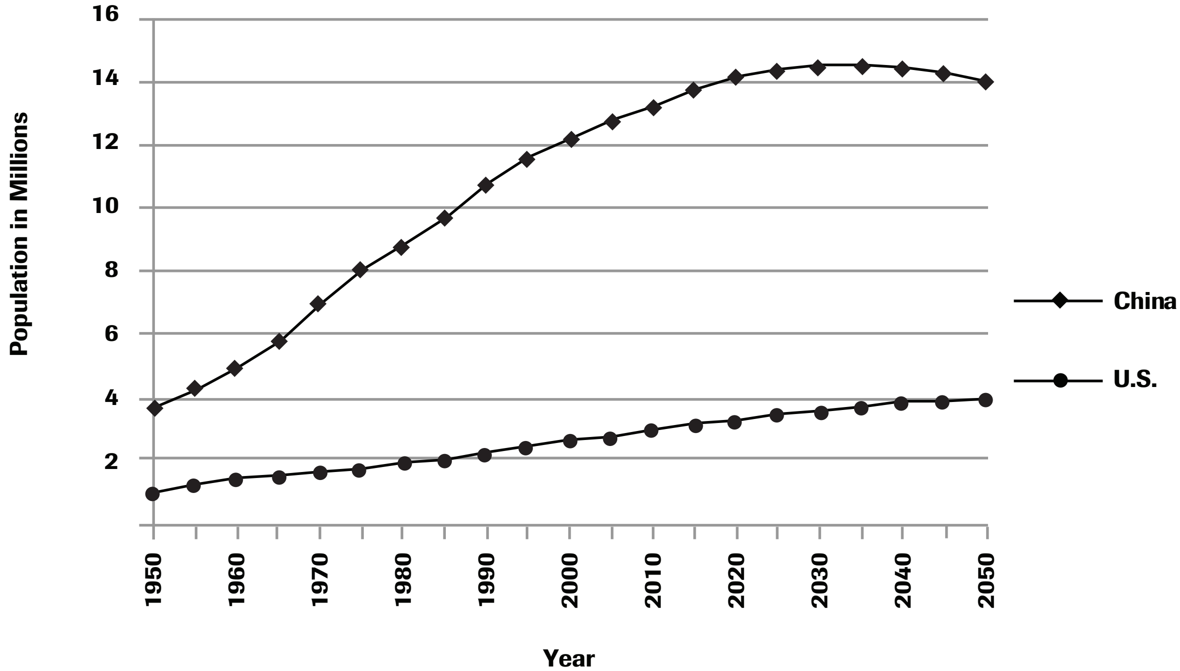
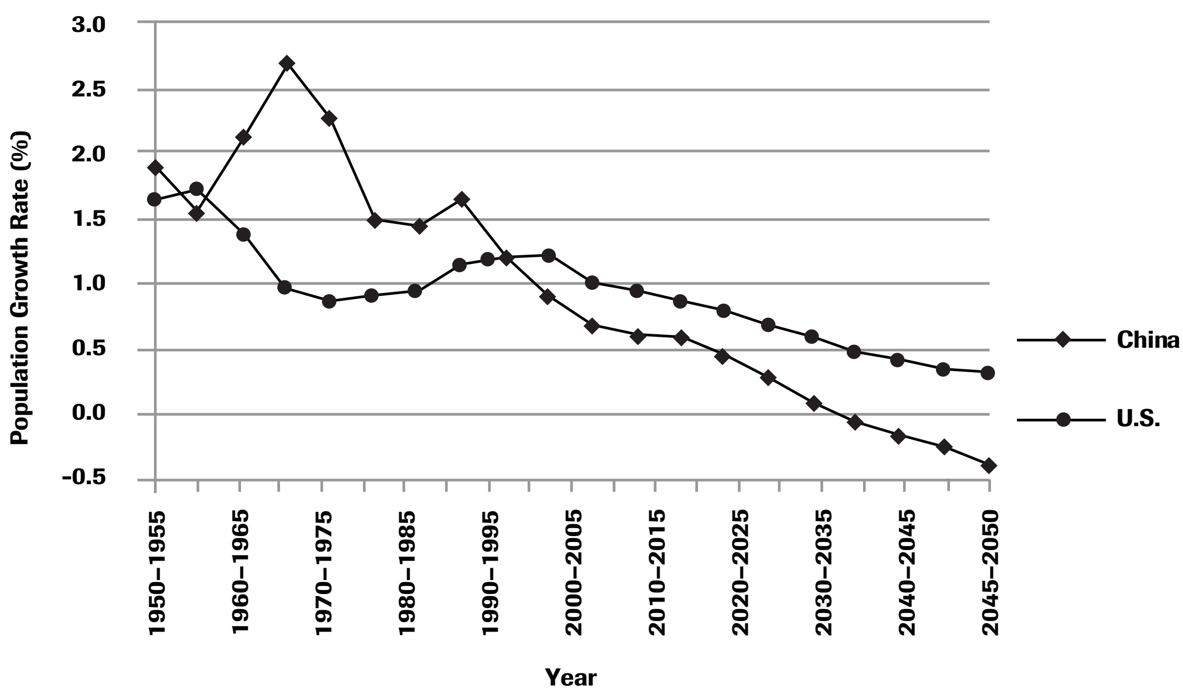


Figure 1–18. Population growth rate (%), U.S. and China, 1950-2050 (projected for 2005-2050) (United Nations Population Division, 2010)



The population is distributed unevenly throughout the country, with the major cities and most of the population lying in the east, where the natural resources are much more favorable for human habitation (Figure 1–19). The forests and agriculturally-productive landscapes of eastern China support far more people than do the grasslands, deserts, and high mountain regions of the west.

China's population is rapidly urbanizing as rural residents flock to cities to seek higher-paying jobs. Residents of eastern China generally migrate to cities in the east, while those of western China generally migrate to cities in the west. The west is also attracting some eastern migrants despite its harsh terrain, though as a proportion of total migration, the "going west" phenomenon is small (Bao, 2008). The Central Government encourages the "balanced development" of cities and towns in the *11th Five-Year Guideline (2006-2010)* and emphasizes the development of metropolitan regions (Kamal-Chaoui et al., 2009). This represents a shift in focus from the previous Five-Year Guideline (2001-2005), which emphasized the urbanization of rural townships. For information about Five-Year Guidelines, see Part 2, Land Tenure.

China's urban population is growing rapidly—much more quickly than that of the U.S., for example (Figure 1–20). Between 1950 and 2009, the percentage of the population living in urban areas quadrupled from 12% to 48% (People's Daily Online, 2009). According to the 2010 census, the urban-rural population is now evenly split, 50% and 50% (National Bureau of Statistics, 2011). Experts forecast that the country's urban population will grow steadily from more than 50% by 2015, to more than 60% by 2030, and to more than 70% by 2045 (Danlu, 2010) (United Nations Population Division, 2010) (Figure 1–20). By 2025, China could have 219 cities with more than 1 million inhabitants each, including 8 "megacities" with more than 10 million residents (McKinsey Global institute, 2008). China also has plans to create the largest megacity in the world with 42 million residents and covering an urban area that will be 26 times larger than greater London (Moore & Foster, 2011).

Figure 1–19. Cities with populations exceeding 100,000; 1994 data. The vast majority of cities with populations exceeding 100,000 lie in eastern China.

Figure 1–20. Percent of population in urban areas, 1950-2050 (projected for 2005–2050) (United Nations Population Division, 2010)

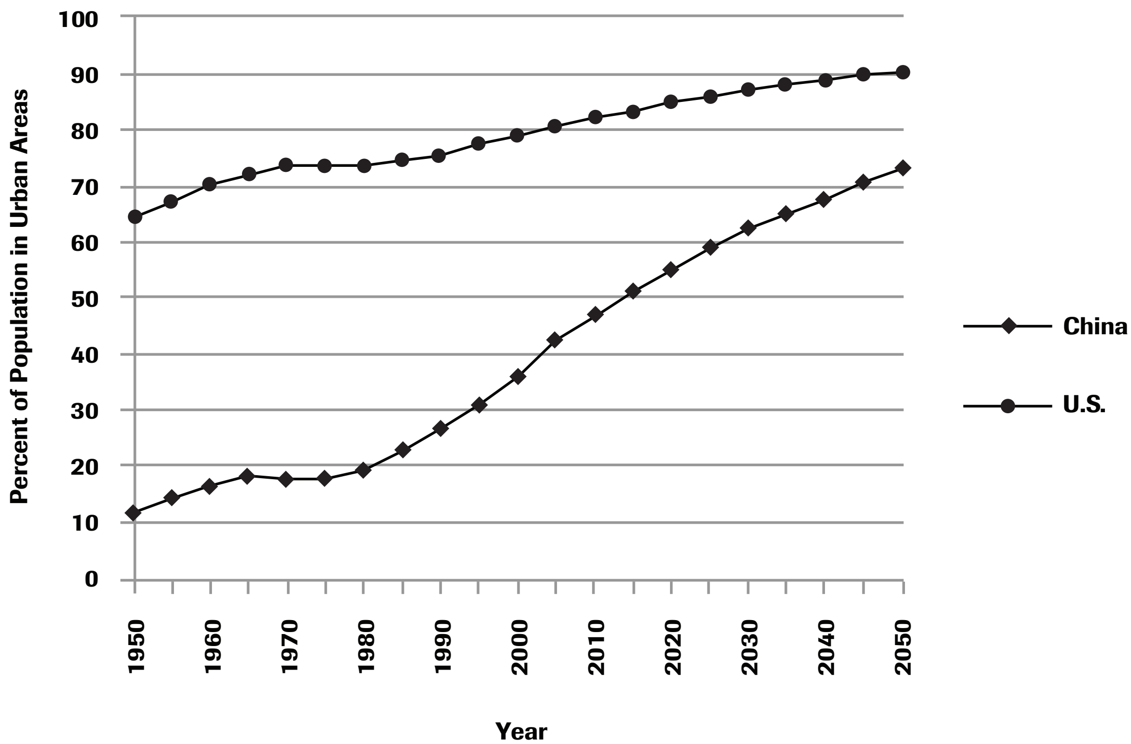
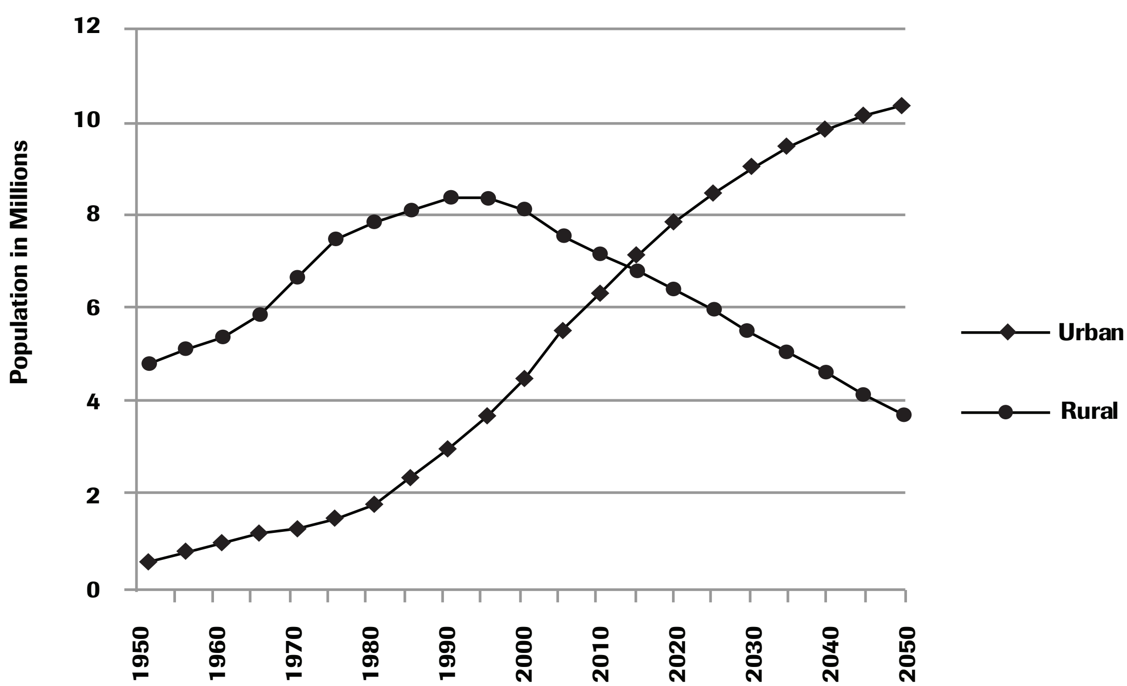


Figure 1–21. Urban and rural population in China, 1950-2050 (population projected for 2005–2050) (United Nations Population Division, 2010)



Cities are expanding both upward and outward. Endless city scenes of cranes, bulldozers, and high-rises sheathed in temporary netting confirm that China's construction industry is booming. Theoretically such construction should lead to higher density and reduce or preclude the need for spatial expansion, but real estate speculation has resulted in high vacancy rates in major cities such as Beijing, Shanghai, and Shenzhen. According to one estimate, there are 64.5 million vacant homes in China (Liu, 2010). Therefore, the influx of new urban dwellers is also causing cities to spread outward. In Beijing for example, since 1949 approximately two-thirds of the one-story hutongs, some dating back to the Yuan Dynasty (1206-1341), have been bulldozed to make way for high-rises and other uses (MacLeod, 2010). Meanwhile, Beijing's built area has been expanding, and increased by 11% from 2001-2005. This expansion is also common in other major cities throughout the country (Table 1–5). Although most Chinese would prefer to live in city centers, which enjoy better public services, many live on the outskirts where housing prices are more reasonable (Qi & Lu, 2008).

As people flock from rural to urban areas, the population of the rural landscape is declining, thereby opening up the landscape in the areas that are not "eaten up" by growing cities (Figure 1–21). Over time, this trend may provide more land protection opportunities in rural areas. Rural population peaked in 1990 at 840 million residents, and has declined by more than 120 million residents over the last 20 years. Villages are shrinking in size and may disappear completely as young people move to larger towns and cities (Hessler, 2010). By 2050, experts project that the rural population will have declined to 379 million (27% of the population). However, even as people relocate from rural villages to townships, pressures for other uses of rural land such as timber harvest, cultivation, and energy development will continue to grow to support the country's burgeoning total population. Some cities are increasing residential density in order to free up land for other purposes. For example, the prefecture-level city of Huzhou in northern Zhejiang Province became a model zone for rural development by merging 6,000 villages into 281 central rural communities in order to convert more land for agricultural purposes (Hu, 2010).

Table 1–5. Change in built area, population change, and change in population density of major Chinese cities, 2001-2005, recreated from (Qi & Lu, 2008)

Type of Change	Nanjing	Chongqing	Beijing	Shanghai	Shenzhen	Shenyang	Guangzhou	Tianjin	Hangzhou	Chengdu
Change in built area	25%	16%	11%	11%	11%	7%	9%	6%	8%	15%
Change in population	10%	15%	3%	3%	3%	1%	4%	1%	6%	13%
Change in population density	-12%	-10%	-8%	-6%	-6%	-6%	-5%	-4%	-2%	-1%

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C. Cultivated Land

The vast majority of China's cultivated land covers the eastern monsoonal plains and river basins, including the Northeast Plains, Northern China Plains, Middle & Lower Yangtze River Plains, the Pearl River Delta, and the Sichuan Basin. According to available statistics, nearly all of China's arable land, totaling 122 million hectares or 13% of the country is cultivated (Qiang, 2010). With 1.3 billion people to feed, the country places great emphasis on efficient and large-scale food production. This high rate of cultivation is not surprising given China's immense and growing population, and that China's per-capita average of arable land is less than 30% of the world's average (State Council, 2007).

The Central Government places a strong emphasis on food security through domestic production and, to a far lesser degree, grain imports. Since the 1960s, China has been a net importer of grain, though the annual portion of grain that is imported is only around 3–4% of all grain produced domestically (Chu et al., 2006). Since the mid-1950s, per-hectare domestic yields have increased while the area of cultivated land has decreased. To ensure adequate food production, the government has identified a minimum threshold or "redline" of 120 million hectares of cultivated land (Central Government, 2006). The law also requires a one-to-one replacement of any farmland that is converted to other uses, in terms of quantity and quality.[7] In the coming years, to feed its ever-growing population, the government will need to expand the area of farmland, increase farmland productivity, and/or increase grain imports.

These policies and realities, combined with development and other land use pressures, are shifting the location of farmland. Some cultivated lands are being newly created *from* other uses such as forestry, grasslands, and wetlands, while existing cultivated lands are being converted *to* other uses such as built up areas, forests, and grasslands. According to one nationwide study that assessed cultivated land changes from 1986-2000, land area converted from other uses to cultivation totaled 55% from grasslands, 28% from forests, and 20% from wetlands or other unused lands and other uses. Over this same time period, conversions of cultivated land area to other uses included 38% to built areas, 30% to grasslands, 17% to forests, and 16% to other land uses/land cover types. Overall, there was a net increase of cultivated land of 2.7 million hectares (1.9%) and a net decrease of grasslands, forests, and unused land as a result of their conversion to cultivated lands (Deng et al., 2005).

Although this study's data is already a decade old, the trend of converting cultivated lands to and from other uses has continued and will probably do so for the foreseeable future. For example, since 1999, a forest restoration program called Grain to Green has been converting 15 million hectares of cultivated land on steep slopes into forests (See Forest Uses section below). Conversely, though residential development has been exploding and pressures for other uses mounting, local governments must convert other uses into cultivation in order to honor the one-to-one farmland replacement requirement.

[7] Land Administration Law Article 31

D. Livestock Grazing

Livestock grazing occurs throughout China and is possibly the most common use of the grasslands in the Inner Mongolia Plateau, Xinjiang, Qinghai, and the Tibetan Plateau. Intensive grazing, beyond sustainable levels, reduces biodiversity and productivity, and also causes erosion and desertification. China is the world's largest livestock consumer (AgriFood Asia), and is likely to remain so as the country's population and income levels grow. In 2004, China supported approximately 375 million grazing livestock including cattle, sheep, goats, horses, mules, and camels. China is the world's largest producer of sheep and goats, and the fourth largest producer of cattle (Figure 1–22) (Food & Agriculture Organization, 2011). For comparison, China has approximately 11% fewer heads of cattle than the U.S. (a difference of 11 million), but over 30 times more sheep and goats. The number of sheep, goats, and cattle varied and remained relatively steady between 1999-2009, while the number of other livestock grazers decreased (Figures 1–23 and 1–24). The former are much more frequently used as food sources.

Figure 1–22. Top five global producers of goats, sheep, and cattle in 2009 (Food & Agriculture Organization, 2011)

Goats	
China	**149,376,747**
India	125,732,000
Pakistan	56,742,000
Bangladesh	56,400,000
Nigeria	53,800,400

Sheep	
China	**136,436,206**
Australia	79,937,577
India	64,989,000
Iran	53,800,000
Sudan	51,100,000

Cattle	
Brazil	202,287,191
India	174,510,000
U.S.	96,034,500
China	**82,623,951**
Argentina	50,750,000

As the Biodiversity chapter explains, livestock grazing is a major driver of grassland degradation in China. One source estimates that desertification costs China more than 40 billion RMB annually and affects more than 40 million people (Meyer, 2006). The accelerated and large-scale degradation and desertification of grassland ecosystems in areas with fragile environmental conditions and poor ecosystem structures have raised concerns within many organizations and institutions inside and outside of China.

As a result, the government has instituted a variety of programs to combat desertification. In the 1970s, the government created the Three-North Shelterbelt Project and the National Project for Prevention and Control of Sandification (see Forest section below). Then in 2002, the government launched the *National Action Plan to Combat Desertification* for northwestern China. This 10-year project received $8 billion of funding and included six main ecological restoration projects, aimed at controlling desertification over 22 million hectares by 2010. China also implemented a "Grassland Seed Base Program" from 2000-2002. Finally, China has also employed technical fixes to reduce desertification such as reducing livestock grazing pressure on grasslands through rodent and insect control, fencing, and improved livestock management (Su, 2006) (Waldron et al., 2008) (Wang et al., 2010).

Figure 1–23. Number of goats, sheep, and cattle in China, 1999-2009 (Food & Agriculture Organization, 2011)

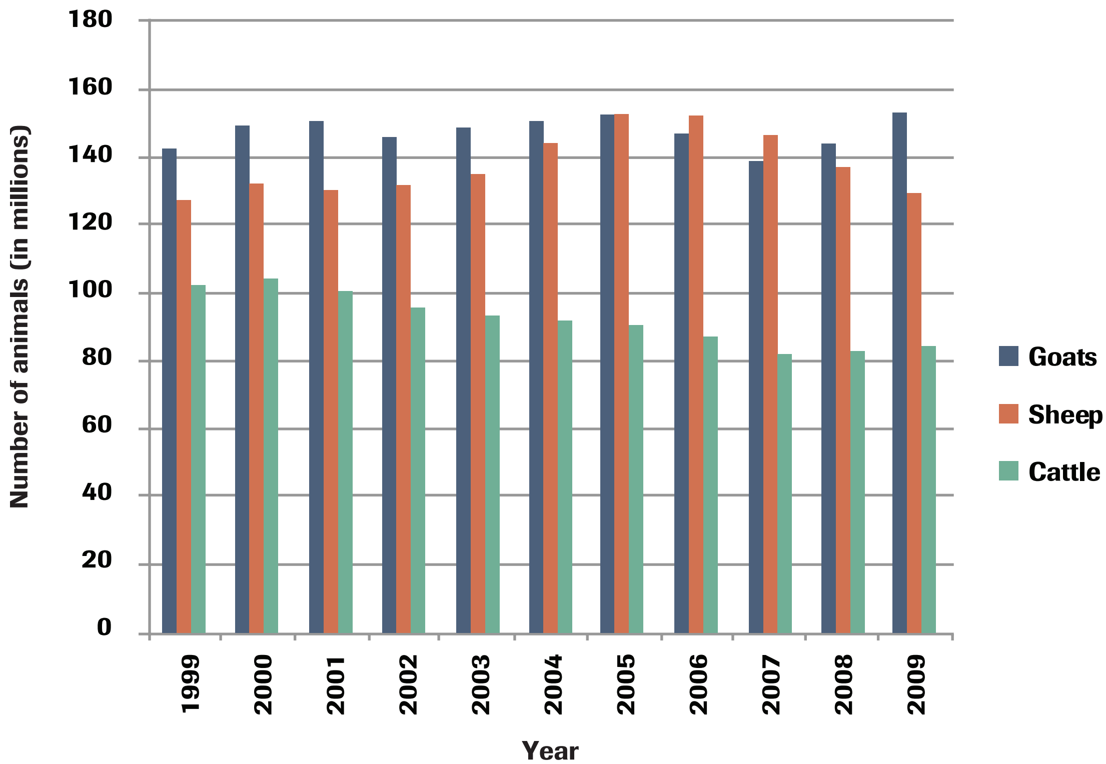
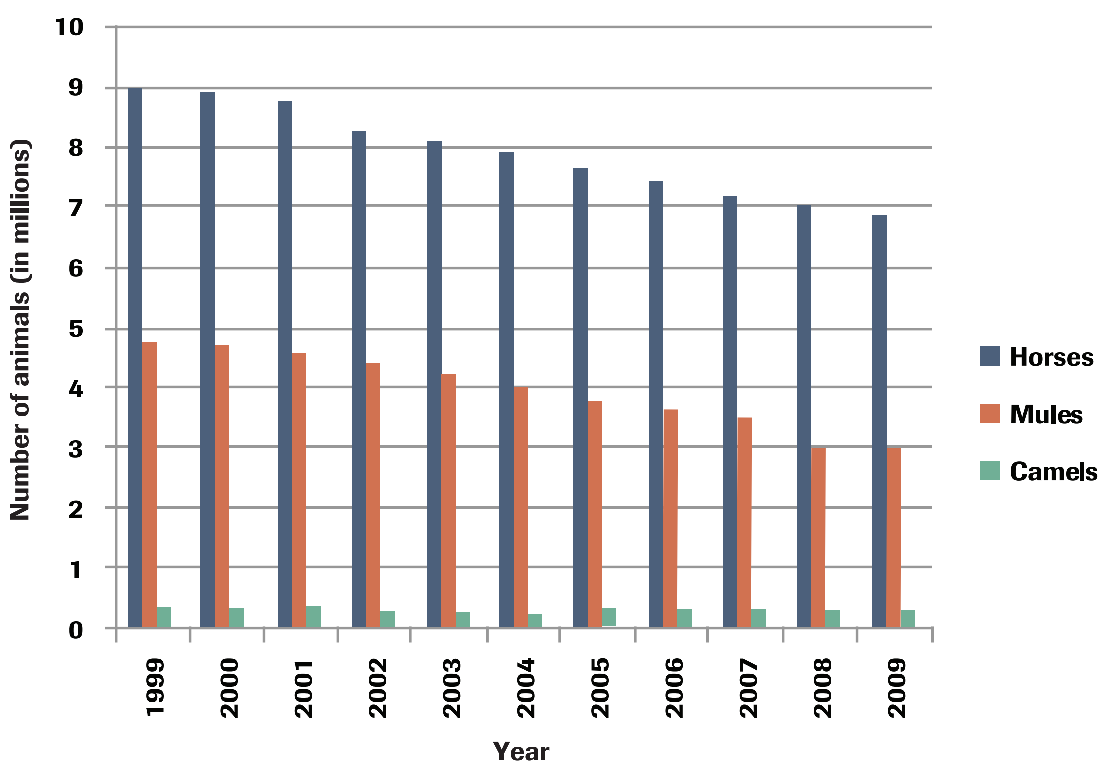


Figure 1–24. Number of horses, mules, and camels in China, 1999-2009 (Food & Agriculture Organization, 2011)



Together, these efforts have helped to slow degradation, but have not halted or reversed it. There has been considerable debate as to the effectiveness of these programs in different regions of China. Nevertheless, in 2006, the State Forestry Administration claimed that the rate of desertification had slowed to 3,000 km^2 per year from the annual rate of 10,400 km^2 at the end of the last century (Reuters.com, 2006).

E. Forest Uses

To guide forest use, the Central Government passed a Forestry Law in 1984, which was subsequently updated in 1998. The Forestry Law (1998) identifies five forest types: protection, special purpose, timber, economic, and fuel. These types can be categorized as either public benefit or commercial (Figure 1–25). *Public benefit forests* are generally intended to remain in a natural state in order to provide ecological and human health benefits, though some economic development may be possible. By contrast, *commercial forests* are intended for activities which can provide revenue. According to the State Forestry Administration (SFA) (2010), commercial forests comprise 57% of forests and public benefit forests comprise 43% (Figure 1–26). Together, timber forests and protection forests comprise nearly all of the forest cover in China (94%), while special purpose forests, economic forests, and fuel forests are much rarer.

As the Biodiversity Chapter describes, China's forests have experienced several periods of significant and widespread deforestation since the late 1950s. In response, the Central Government has attempted to restore forest cover by investing upwards of 1 trillion RMB into six forest conservation programs (Tables 1–6 and 1–7). These programs utilize a combination of afforestation and timber harvesting bans or limits.

Figure 1–25. Types of forest in China[8]

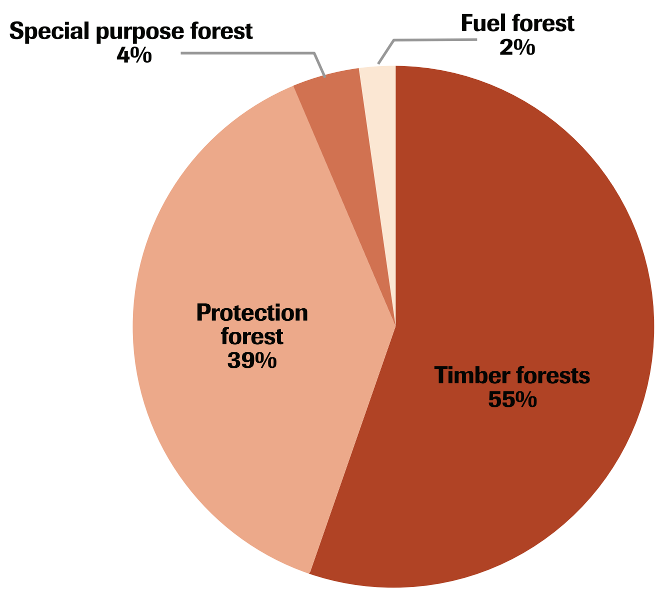
Public benefit forests

- **Protection forests**—Also called shelter forests, the goal is to protect key ecological and economic values such as water source conservation, water and soil conservation, wind and sand breaks, embankments, farmland, and cattle grazing.
- **Special-purpose forests**—Goals include national defense, environmental protection, and scientific research.

Commercial forests

- **Timber forests**—Goal is timber production including, but not limited to, bamboo.
- **Economic forests**—Goal is the production of "fruits, edible oils, drinks, flavorings, industrial raw materials, and medicinal materials."
- **Fuel forests**—Goal is the production of fuelwood.

Figure 1–26. Types of forests in China, 2010 (State Forestry Administration, 2010)



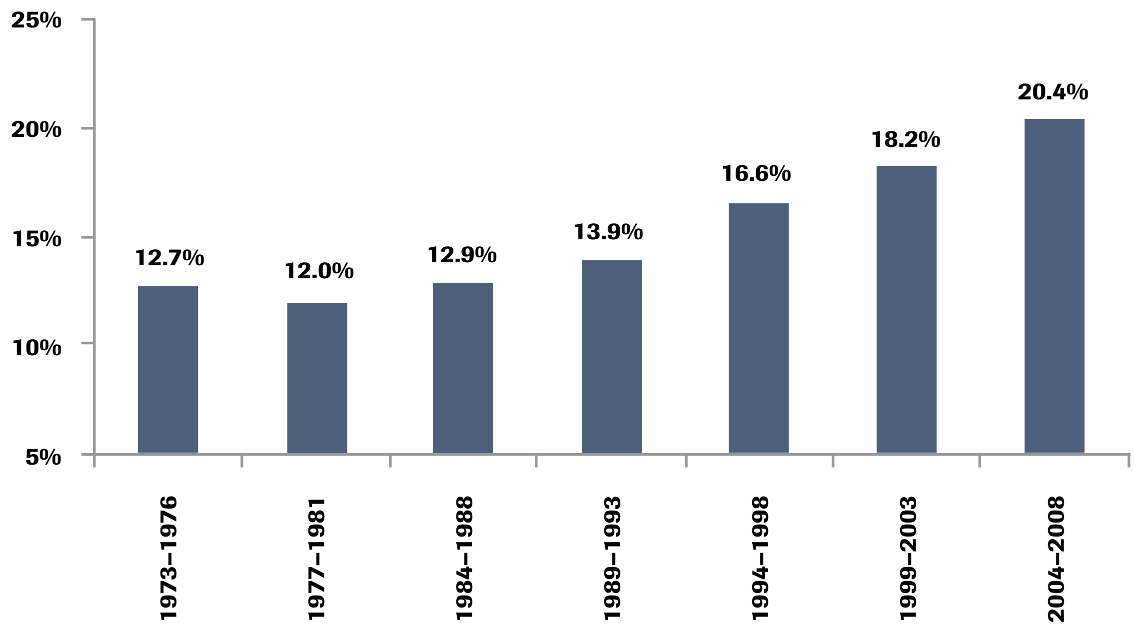
[8] Forestry Law Article 4, as modified

1. Afforestation

As of 2007, China had planted more than 49 billion trees and shrubs through government-sponsored efforts (State Forestry Administration, 2007) (Yang & Ci, 2008). In 2008 alone, 540 million people planted 4.7 million hectares of forest across the country, which is an area larger than Switzerland (Xinhua News Agency, 2009). As a result of these efforts, from 1981-2008, State Forestry Administration calculations of forest cover increased from 12% to 20% of total land cover (Figure 1–27). Forest cover has increased by approximately 12.6 million hectares since the 1980s, with the largest increases occurring in the southeast (5.3 million hectares), southwest (3.2 million hectares), and north (2.2 million hectares) (Liu & Tian, 2010).

The Central Government aims to achieve 23% forest cover by 2020, and 26% by 2050 (State Forestry Administration, 2007). Much of the reforestation and afforestation is planned for northern China, with 30% in Inner Mongolia alone to combat desertification, reduce dust storms, and maintain or restore ecosystem services such as carbon sequestration.

Figure 1–27. Forest cover in China from 1973-2008, according to seven national forest inventories conducted by the State Forest Administration (State Forestry Administration, 2009) (State Forestry Administration, 2006) (People's Daily, 2005) (State Forestry Administration, 2005)[9]



[9] According to an expert from the State Forestry Administration (SFA), specific percentages of forest cover may not be entirely comparable pre- and post-1998 due to different methodologies applied (Liu, 2011)

Figure 1–28. Tree planting in Tengchong County, Yunnan. Photo by The Nature Conservancy

China's afforestation efforts can be divided into two phases distinguished by their emphasis on forest type. Prior to 1997, afforestation focused largely on commercial (i.e., timber) forests. In 1980, for example, China planted 4.1 million hectares, 61% of which occurred in timber forests and 15.4% of which occurred in protection forest. After 1997, afforestation declined in timber forests and increased in protection forests through the implementation of China's six forest conservation programs such as the Natural Forest Protection Program and Grain to Green. In 2007, for example, 16% of all afforestation occurred in timber forests, while 71% of afforestation occurred in protection forests. This change reflected a shift in China's forest development strategy from economic functions to ecological functions.

Afforestation efforts generally have been improving in China since 1978, due to better methodologies and planning. Nonetheless, the forest restoration programs are not without their critics; there has been much debate around their appropriateness and ability to meet goals related to desertification, biodiversity, ecosystem services, and socioeconomic values (Liu et al., 2008) (Cao et al., 2009) (Wilske, et al., 2009) (Yin et al., 2010). Afforestation efforts have been generally successful at increasing vegetative cover. However survival rates and benefits to biodiversity have been variable largely due to the planting of monocultures or limited numbers of species, as well as limited attention to topography, climate, and hydrology. This has been particularly true on commercial plantations (The World Bank Group, 2000), where afforestation efforts have focused more on increasing available timber volume than on diversifying species mix. While there is some variation in species mix, the species of choice in the north include poplars, aspens, Chinese pine, and Mongolian pine (*Pinus sylvestris* var. *mongolica Litv.*); and in the south include eucalyptus, Chinese fir and Chinese red pine, (Chen., 2010). China has started to expand the species mix it uses, recognizing that limited species diversity can leave trees susceptible to disease and insect infestations. As one expert described, "Some of the forest planted in the past has had suboptimal results caused by using unsuitable tree species and initial densities, as well as by some of the afforestation methods" (Yang & Ci, 2008).

Based on China's aforementioned goals for future forest cover, it is expected that afforestation efforts will continue for the foreseeable future. The locations and processes for future efforts are yet to be determined, however. Several of the main afforestation programs were slated to end by 2010 including the Beijing-Tianjin Desertification Control Program and five of six projects of the Key Shelterbelt Construction Program. Two other programs could end in the near future – the Fast-Growing High-Yielding Timber Plantation Program in 2015 and Grain to Green in 2016. Whether the government will let these programs expire, renew these programs, or institute different programs remains to be seen. It should be noted that NFPP was slated to expire in 2010, but the government renewed it until 2020 and increased funding (State Forestry Administration, 2011). Furthermore, the government may encourage greater involvement of the private sector and other stakeholders. Regardless of where and how afforestation occurs, forest conservation will remain an important issue in China due to climate change, land conversion, and demand for timber.

2. Timber Harvest and the Timber Ban

The State Council sets the allowable timber harvest through the five-year provincial quotas (Figure 1–29). China's reported harvest climbed from 6 million m^3 in 1949 to 68 million m^3 in 1995. It is important to note that there is almost certainly a discrepancy between reported and actual logging in China. Illegal logging is an ongoing problem in the country; producers do not necessarily adhere to quotas and undeclared production is common (Sun et al., 2005). In any case, after 1995, the timber harvest reportedly declined due to the general degradation of mature timber forest resources and the logging ban issued through the Natural Forest Protection Program (NFPP) (Zhu et al.). Through the NFPP, commercial logging of natural forests (as opposed to plantations) has ceased in 13 provinces in the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River. Commercial logging of natural forest has also been reduced in northeastern China and Inner Mongolia. (Zhang S., 2010).

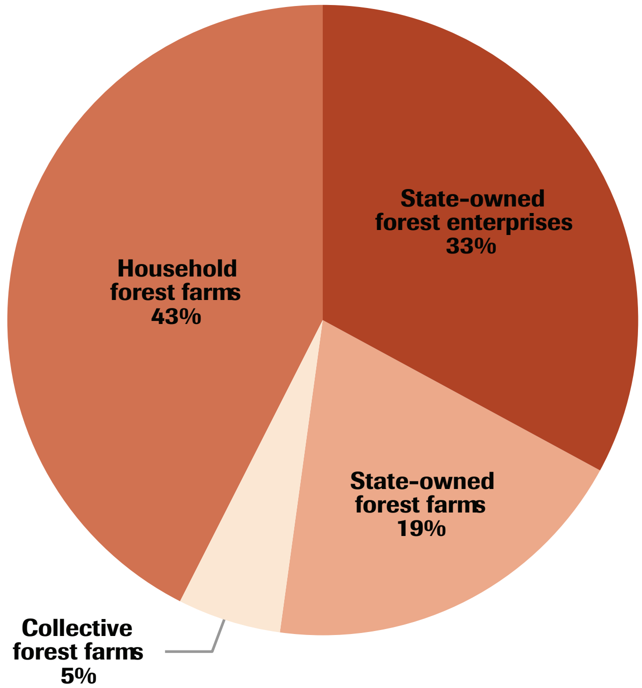
The NFPP is aiding the recovery of China's forests, but is also causing a gap between domestic demand and supply. Timber consumption is on the rise; from 1989-2006, timber consumption climbed from 107 million m^3 to 250 million m3, and in 2009 reached 457 million m^3 (Lu) (Fordaq, 2010). If timber consumption continues to increase into the future, the gap between supply and demand will widen unless China increases domestic harvests or imports.

There are four sources of domestic timber supply: state-owned forest enterprises, state-owned forest farms, collective forest farms, and household forest farms (Figure 1–30). As of 2005, state-owned forest enterprises (135) were mostly located in northeast and southwest China, state owned forest farms (4,000) in northwest China, and collective and household farms in southern provinces such as Fujian and Guangdong. State-owned and collective/household-owned forests each contribute approximately 50% of China's domestic timber supply (Sun et al., 2005).

Government policy has been to shift timber production from state-owned natural forests to collectively-owned plantation forests. As a result, timber harvest from state-owned forests has decreased greatly while timber production from collective forests has increased (Sun et al., 2005). Collective harvests have been unexpectedly reduced in some areas, however, as the logging ban was arbitrarily extended in many areas of the country to select collective forests (China.org.cn, 2002). In any case, domestic timber harvests are likely to increase in the years to come. With the government's mass tree planting efforts, the country will certainly have timber resources to harvest, if it chooses to do so. At a minimum, harvests would occur on the 13 million hectares covered by the Fast-Growing and High-Yielding Timber Plantation Program (Table 1–6).

Figure 1–29. The government allows timber harvest in specified parts of the country, such as in parts of Yunnan (below). Photo by Zhang Weiwei

Figure 1–30. Timber production in China by different producers, 2002 (Sun, Wang, & Gu, 2005)



3. Harvest of fuelwood and non-timber forest products

"Where there are forests and communities, there will be fuelwood gathering" (Yu, 2010). The demand for fuelwood in China far exceeds available resources. Annual fuelwood harvesting accounts for 33% of total forest resource consumption, while fuelwood forest accounts for only 2-3% of China's total forest area (Zhang, 2006). As a result, peasants expand their fuelwood harvests into timber forests and protection forests. To address these pressures, the State Forestry Administration aims to "actively establish" more fuelwood forests (State Forestry Administration, 2007). In addition, the government is encouraging the use of alternative energy sources such as solar cookers.

Harvest of non-timber forest products (NFTP) is also common throughout China. NFTPs include "products used as food and food additives (edible nuts, mushrooms, fruits, herbs, spices, and condiments, aromatic plants, game), fibers (used in construction, furniture, clothing or utensils), resins, gums, and plant and animal products used for medicinal, cosmetic, or other purposes" (Kleinn et al., 2006). In China, more than 6,000 plant species are used for medicinal purposes, 80% of which grow in forests. Other common NFTPs in places such as Yunnan Province include mushrooms, walnuts, pine nuts, eucalyptus oil, and honey (Kleinn et al, 2006). Because many NFTPs are spontaneously collected by local communities, estimates of total yield are difficult to obtain. However, the logging ban may be prompting local communities to more sustainably harvest non-timber forest resources (Yu, 2010).

Table 1–6. Summary of China's six key forest conservation programs, listed in descending order of actual or needed investment

Program and Duration	Grain to Green (a.k.a. Sloping Land Conversion Program) (1999-2008, renewed until 2016)	Natural Forest Protection Program (1998-2010; renewed until 2020)	Wildlife Conservation and Nature Reserve Development Program
Investment	430 billion RMB.	340.2 billion RMB (96.2 billion RMB in Phase I, from 1998-2010; plus 244 billion RMB in Phase 2, from 2010-2020).	135.7 billion RMB are needed from 2001-2030.
Goal	By 2010, reforest 15 million ha of cultivated land and 17 million ha of land in the "waste mount ains" and other areas suitable for afforestation.	Phase I: Protect and restore natural forests primarily through implementing logging bans, protecting natural forest, and reforesting 8.7 million ha. Phase II: By 2020, increase the area of afforestation by 5.2 million hectares, forest reserves by 1.1 billion m^3, and carbon sinks by 416 million tons.	Strengthen the conservation of wild flora and fauna by increasing nature reserve numbers. By 2010, nature reserves should total 1,800 (including 220 national-level) and cover 16.1% of total land area. By 2030, they should total 2000 (including 280 national-level) and cover 16.8% of total land area. By 2050, they should total 2,500 (including 350 national-level, and 2000 managed by SFA) and cover 18% of total land area.
Geographic Scope	25 provinces.	17 provinces (logging ban in 13), with emphasis on the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River.	All of mainland China.
Achievements	As of 2009, 9.2 million ha of cultivated land were converted, and trees and shrubs had also been planted on 18.4 million ha of waste mountains and other areas suitable for afforestation, thereby exceeding goal.	Stopped commercial logging of natural forest in the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River. Reduced commercial logging of natural forest in northeast-ern China and Inner Mongolia. Protected 98 million ha of natural forest as of 2007. As of 2009, reforested 5.9 million ha.	As of 2009, the total number of nature reserves totaled 2,541 and covered approximately 15.4% of the country.
Sources	(State Forestry Administration, 2007) (State Forestry Administration et al.) (Wang X., 2006) (people.com.cn, 2010)	(State Forestry Administration, 2007) (Wang X., 2006) (Liu et al., 2008) (Department of Afforestation and Greening, 2010) (State Forestry Administration, 2011)	(State Forestry Administration, 2007) (State Department of Wildlife and Forest Plants Conservation, State Forestry Administration, 2010) (State Department of Wildlife and Forest Plants Conservation, State Forestry Administration) (State Forestry Administration, 2006). (Ministry of Environmental Protection, 2009)

Table 1–6 continued from page 77. Summary of China's six key forest conservation programs, listed in descending order of actual or needed investment

Program and Duration	Fast-growing and High-yielding Timber Plantation Program (2001-2015)	Beijing-Tianjin Desertification (Sandstorm) Control Program (2000-2010)	Key Shelterbelt Construction Program (duration varies by project; see Table 1–7)
Investment	71.8 billion RMB.	41.2 billion RMB as of 2010.	From 2003-2007, 6.3 billion RMB was invested in 5 of the 6 programs.
Goal	Increase domestic timber supply and sustainable rural economic development by establishing 13 million ha of timber production base. Eventually meet domestic demand for timber with the production base.	By 2010, return 1.3 million ha of farmland and 1.3 million ha of waste land/ mountain to forest; plant new forest on 4.9 million ha; and "treat" 10.6 million ha of grassland. Immigrate 180,000 farmers based on ecological considerations.	Across 6 large landscapes, plant trees 49.3+ million ha and "improve" 5.9+ million ha of inefficient shelter forest. See Table 1–7.[10]
Geographic Scope	18 provinces.	5 provinces (Inner Mongolia, Hebei, Shanxi, Beijing, Tianjin).	28 provinces across 6 project sites.
Achievements	As of 2009, 7.3 million ha of timber production base had been established.	As of 2010, forest cover reached 15%; afforestation totaled 6.0 million ha, and 8.7 million ha of grasslands were treated.	From 2001-2008, at least 43 million ha had been planted.
Sources	(State Forestry Administration, 2007) (State Forestry Administration, 2010) (Department of Afforestation and Greening, 2010)	(State Forestry Administration, 2007) (Ministry of Agriculture, 2010) (Chinamining.org, 2011) (National Development and Reform Commission, 2008)	(State Forestry Administration) (State Forestry Administration, 2005) (State Forestry Administration, 2010)

[10] "Improving" forest in this context involves a variety of activities to enhance a forest's structure, function, and productivity, such as planting trees which are suitable to the site.

Table 1–7. Projects of the Key Shelterbelt Construction Program (State Forestry Administration) (State Forestry Administration, 2005)

China invested 6.3 billion RMB in five of the six programs from 2003-2007, not including the Upper and Middle Reaches of Yangtze River shelter program. Investment for the Three Norths Shelterbelt program totaled 57.9 billion RMB. The authors did not find investment information for the other programs.

Project	Goal	Geographic Scope	Duration	Achievements
Coastal Shelter Program	Plant 1.4 million ha of forest and improve 1.0 million ha of "inefficient shelter forest."	11 provinces	Phase I: 1990-2000 Phase II: 2001-2010	In Phase I, 3.2 million ha were planted.
Plains Greening Project	During Phase II, increase vegetative cover by 5.5 million ha.	26 provinces	Phase I: 1987-2000 Phase II: 2001-2010	In Phase I, 7.0 million ha were planted.
Pearl River Shelter Program	During Phase II, plant 2.3 million ha of forest and improve 1 million ha of "inefficient shelter forest."	6 provinces (Jiangxi, Hunan, Yunnan, Guizhou, Guangxi, Guang-dong)	Phase I: 1996-2000 Phase II: 2001-2010	In Phase I, 0.7 million ha were planted.
Taihang Mountains Afforestation Project	Plant 3.6 million ha of forest over the life of the project.	4 provinces (Beijing, Hebei, Henan, and Shanxi)	Phase I: 1994-2000. Phase II: 2001-2010	As of 2005, 2.6 million ha had been planted.
Three Norths Shelterbelt Program	Plant 35.1 million ha of forest over the life of the project.	13 provinces	Total project: 1978-2050. Phase IV: 2001-2010	As of 1998, 20 million ha had been planted. 9.5 million ha were planted from 2001-2010.
Upper and Middle Reaches of Yangtze River Shelter Program	Plant 6.9 million ha of forest and improve 3.9 million ha of "inefficient shelter forest."	17 provinces	2001-2010	At least 6.9 million ha have been planted.

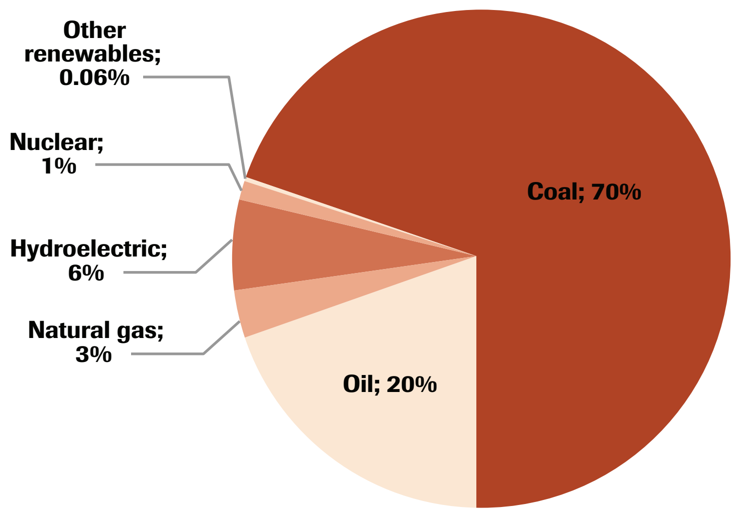
F. Mining & Energy Development

China has one of the largest mining sectors in the world, is the world's largest energy-producer, and is the first or second largest energy consumer (World Bank and International Finance Corporation, 2002) (U.S. Energy Information Administration, 2008).[11] Both production and consumption of energy are on the rise, which will impact biodiversity as China constructs more coal mines, oil and gas wells, commercial wind farms, and other infrastructure to fuel its energy needs (Figure 1–31).

[11] The International Energy Agency (IEA) claims that China has become the world's largest energy consumer (International Energy Agency, 2010) but the Central Government refutes this claim (Hook, 2010).

China's mining activities, consumption, and production of all energy types are growing, and will have an increasingly large footprint on the landscape. Western and central China in particular will experience increasing pressure for energy development because many of the untapped and lesser-tapped oil and gas fields are located there, as are the coal reserves and the areas with highest potential for wind and solar energy development. Specifically, 58% of coal reserves are located in central China, while 36% of coal reserves, 12% of oil and 53% of known natural gas reserves lie in western China. The abundance of available mineral and energy resources poses threats to fragile the ecosystems in the mountainous and desert regions of central and western China, and has called for rising attention on post-mining reclamation, particularly since China has made a late start in reclamation relative to other countries (China Academy of Land & Resource Economics) (Cao, 2007).

Figure 1–31. Total energy consumption in China by type (2008), recreated from (Energy Information Administration, 2011)

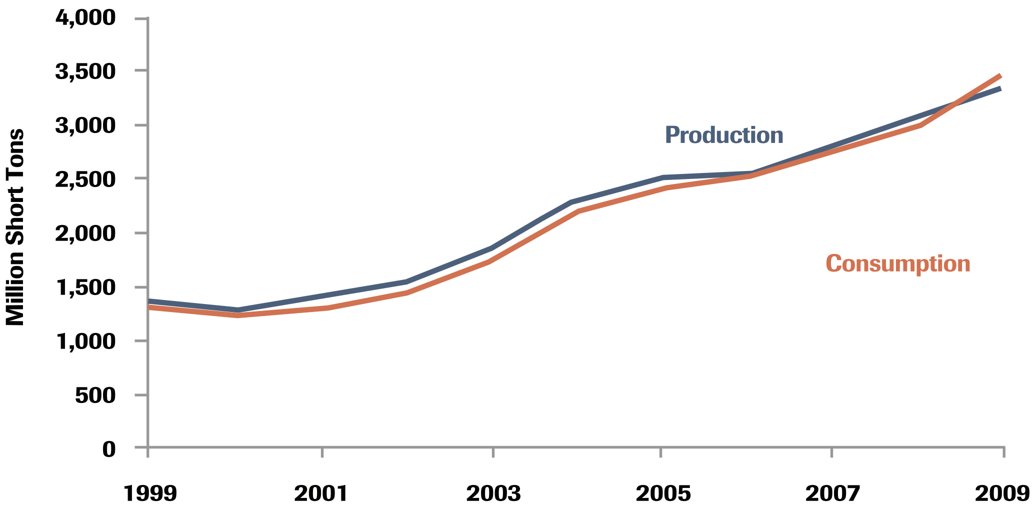


1. Coal and Other Mining

China is the world's largest producer of coal (44% of the world total in 2009) and a number of other minerals, such as rare earth elements which are used in electronic devices for defense, alternative energy, and communications industries (98% of the world total in 2009). It also provides gold (13% of the world total in 2009), and in 2009, produced upwards of 25% of the world production of other minerals such as aluminum (primary), antimony, iron ore, lead, manganese ore, mercury, molybdenum, tin, tungsten, vanadium, and zinc (Table 1–8). From 2005-2009, production of all of these minerals increased by an average of 48%. Of the various forms of mining, coal mining arguably has the greatest impact on China's landscape based on the sheer volume of minerals extracted if nothing else—more than 3 billion metric tonnes according to a 2009 estimate (Brown, et al., 2011).

With 14% of the planet's known minable coal reserves, China boasts the third largest coal reserves in the world behind the U.S. and Russia (Energy Information Administration, 2011). The production and consumption of coal more than doubled between 1999 and 2009 (Figure 1–32).

Figure 1–32. China's coal production and consumption, 1999-2009, reprinted from (Energy Information Administration, 2011)



Although the vast majority of China's provinces produce coal, it is distributed unevenly across the country. China has approximately 30,000 coal mines, 24,000 of which are small mines that produce one-third of the country's total coal production (Yang, 2007). Most of its reserves (81%) lie in the provinces of Xinjiang, Inner Mongolia, Shanxi, and Shaanxi. The government has identified 14 large coal bases, each of which consist of a series of individual mines (Figure 1–33) (Chinamining.org, 2011):

Coal and other mining activities are impacting China's landscape through land conversion, erosion, subsidence, and other means. The area directly impacted by any given mine) (coal or otherwise) is relatively limited (i.e., 18-20 hectares on average for a large-scale mine) (He, 2008), but the associated infrastructure can be significant and add to the impact. For example, more than 300 cities and towns had been established around mining projects in China as of 2006 (He, 2008). During the early 1990s, domestic mining activities resulted in the loss of approximately 1 million hectares of cultivated land (approximately 1% of total domestic cultivated land at that time), 1 million hectares of forest land, and 260,000 hectares of grassland (Liu). According to another source, by 2004, mining had destroyed or degraded 2 million hectares and by 2008, the number had increased to 3 million hectares (Wang, 2004) (Li, 2009). Subsidence and erosion also impact the landscape—he mining area. In the Huabei and Huadong coal mining regions[12], coal mining causes the subsidence of approximately 7,000 hectares annually (He, 2008). In Yunnan Province, 2,000 hectares of land were destroyed in geological disasters caused by mining from 1989-2000, and 22 million tons of soil was eroded. The government invested 200 million RMB in post-disaster treatment (Zou & Mao, 2004).

[12] The Huabei region includes Beijing, Tianjin, Hebei, Shanxi and Inner Mongolia provinces; the Huadong region includes Shanghai, Shandong, Jiangsu, Anhui, Zhejiang and Fujian provinces.

Figure 1–33. Distribution of coal resources in China

1. Shendong—Southwestern Inner Mongolia
2. Shaanbei—Northern Shaanxi
3. Huanglong—Central Shaanxi
4. Jinbei—Northern Shanxi
5. Jinzhong—Southern Shanxi
6. Jindong—Southeastern Shanxi
7. Mengdong (Dongbei)—Southeastern Heilongjiang, Liaoning
8. Lianghuai—Northern Anhui
9. Luxi—Southwestern Shandong, Central Shandong
10. Henan—Central Henan
11. Jizhong—Southern and Northwestern Hebei
12. Yungui—Western Guizhou, Southeastern Yunnan
13. Ningdong—Northern Ningxia
14. Zhundong—Central and Eastern Xinjiang

Table 1–8. Production of select minerals for which China produced at least 25% of the world's total in 2009 (Brown, et al., 2011)

Mineral	2005	2006	2007	2008	2009	% change '05 – '09	World total in 2009	% of World total in 2009
Aluminum (primary)	7,806,000 Metric tonnes	9,358,400 Metric tonnes	12,558,600 Metric tonnes	13,178,200 Metric tonnes	12,846,000 Metric tonnes	65%	36,900,000 Metric tonnes	35%
Antimony	151,457 Tonnes (metal content)	156,200 Tonnes (metal content)	163,000 Tonnes (metal content)	183,000 Tonnes (metal content)	166,200 Tonnes (metal content)	10%	179,000 Tonnes (metal content)	93%
Coal	2,205,000 Millions of metric tonnes	2,373,000 Millions of metric tonnes	2,536,000 Millions of metric tonnes	2,682,000 Millions of metric tonnes	3,050,000 Millions of metric tonnes	38%	6,938,000 Millions of metric tonnes	44%
Iron ore	420,493 Millions of metric tonnes	588,171 Millions of metric tonnes	707,073 Millions of metric tonnes	824,011 Millions of metric tonnes	880,171 Millions of metric tonnes	109%	2,248,000 Millions of metric tonnes	39%
Lead	1,142,000 Tonnes (metal content)	1,331,000 Tonnes (metal content)	1,402,000 Tonnes (metal content)	1,402,700 Tonnes (metal content))	1,610,000 Tonnes (metal content)	41%	3,900,000 Tonnes (metal content)	41%
Manganese ore	7,500,000 Metric tonnes	8,000,000 Metric tonnes	10,000,000 Metric tonnes	11,000,000 Metric tonnes	12,000,000 Metric tonnes	60%	33,400,000 Metric tonnes	36%
Mercury	1,094,000 Kilograms	760,000 Kilograms	798,000 Kilograms	1,333,000 Kilograms	1,300,000 Kilograms	19%	1,700,000 Kilograms	76%
Molybdenum	30,000 Tonnes (metal content)	43,900 Tonnes (metal content)	67,700 Tonnes (metal content)	81,000 Tonnes (metal content)	93,500 Tonnes (metal content)	212%	231,000 Tonnes (metal content)	40%
Rare earth elements	119,000 Metric tonnes	133,000 Metric tonnes	120,000 Metric tonnes	125,000 Metric tonnes	120,000 Metric tonnes	1%	123,000 Metric tonnes	98%
Tin	121,600 Tonnes (metal content)	126,300 Tonnes (metal content)	145,900 Tonnes (metal content)	121,500 Tonnes (metal content)	128,000 Tonnes (metal content)	5%	279,000 Tonnes (metal content)	46%
Tungsten	51,200 Tonnes (metal content)	45,000 Tonnes (metal content)	41,000 Tonnes (metal content)	43,500 Tonnes (metal content))	50,000 Tonnes (metal content)	-2%	62,300 Tonnes (metal content)	80%
Vanadium	17,000 Tonnes (metal content)	17,000 Tonnes (metal content)	18,000 Tonnes (metal content)	18,500 Tonnes (metal content))	20,800 Tonnes (metal content)	22%	58,000 Tonnes (metal content)	36%
Zinc	2,547,800 Tonnes (metal content)	2,844,200 Tonnes (metal content)	3,047,700 Tonnes (metal content)	3,186,000 Tonnes (metal content))	3,091,600 Tonnes (metal content)	21%	11,400,000 Tonnes (metal content)	27%

2. Oil

China is the fourth largest producer of oil behind Saudi Arabia, Russia, and the U.S, and is the second largest consumer of oil behind the U.S. (Central Intelligence Agency, 2011). Since the early 1990s, its oil consumption has grown at a far faster rate than its oil production (Figure 1–34). In fact, oil production has remained relatively flat for the last two decades. Companies have already tapped the largest and most easily accessed oil fields and have increased production in harder-to-access reserves to offset slowdowns in older fields.

Approximately 85% of China's oil capacity is located onshore and 15% is located offshore. The onshore resources are distributed widely throughout the country and their productivity varies greatly. The largest and oldest oil fields such as Daqing and Shengli are located in the northeastern part of the country (Energy Information Administration, 2011).

On-shore production growth is expected to remain stable. Newer exploration and production has been focused in western China including, but not limited to, Xinjiang, Sichuan, Gansu, and Inner Mongolia. The Energy Information Administration (2011) reports exploration and production activities within the Inner Mongolia Autonomous Region (Ordos Basin) and the Xinjiang Uygur Autonomous Region (Junggar, Turpan-Hami, and Tarim Basins) (Figure 1–35).

Production from China's offshore resources is expected to increase. For example, the China National Offshore Oil Corporation (CNOOC) plans to double its production in Bohai Bay. Offshore areas of focus include the Bohai Bay region in northeastern China (the oldest oil-producing offshore zone and the second-largest producing oil field in China in 2010), the Pearl River Delta, and the South China Sea. The East China Sea has received lesser attention.

Figure 1–34. China's oil production and consumption, 1990-2012, reprinted from (Energy Information Administration, 2011)

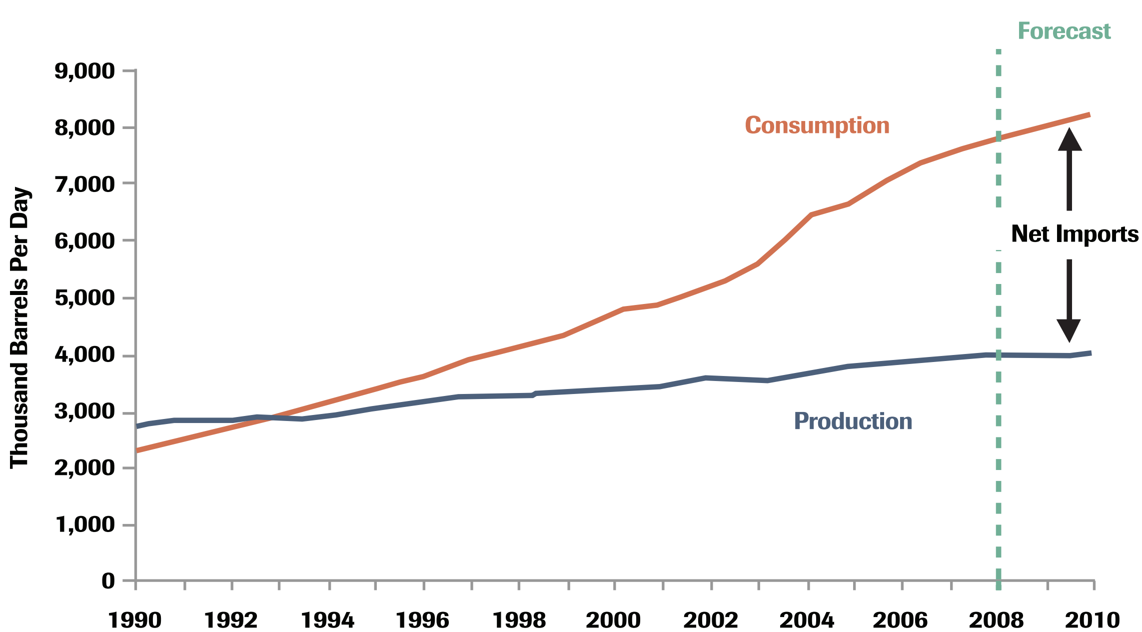


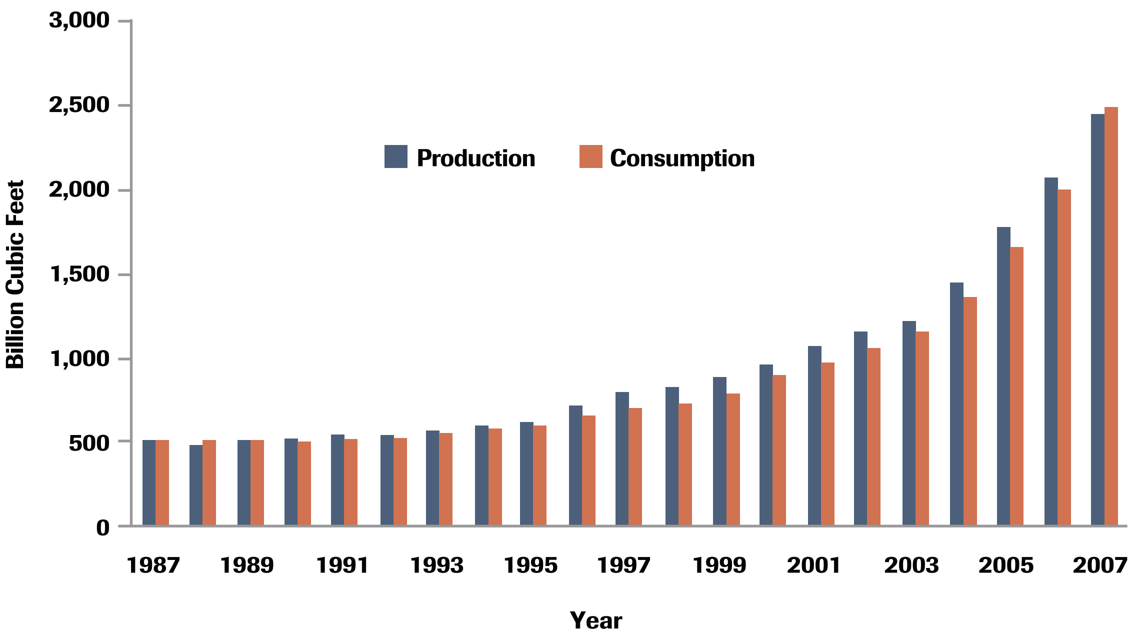
Figure 1–35. Oil and gas basins (Wang, 2008)

3. Natural Gas

China has moderate domestic natural gas reserves; its production and consumption more than doubled between 2001 and 2007 (Figure 1–36). According to one estimate, the country is ranked thirteenth in the world in terms of proven natural gas reserves, with 3 trillion cubic meters. By comparison, Russia—the top-ranked country—has 16 times the reserves of China, while the U.S—the fifth-ranked country—has more than double the reserves (Central Intelligence Agency, 2011). China's production of natural gas is on par with that of the Netherlands and Norway and is ranked eighth in the world. The U.S. and Russia are currently the top producers in the world, each with an annual output that is more than 6 times that of China's (Central Intelligence Agency, 2011).

Onshore, China's known natural gas deposits are located primarily in Shaanxi in the north (Ordos Basin), Xinjiang and Qinghai in the northwest (Tarim, Junggar, and Qaidam Basins), and Sichuan in the southwest (Sichuan Basin), (Figure 1–35). Xinjiang produces the most gas of any province. The Tarim Basin is likely to be the focus of significant additional development, given that it holds half of China's proven reserves, but only 12% of the basin had been explored as of 2009. Offshore, the South China Sea and Bohai Bay in the Yellow Sea are the focus of most natural gas development (Energy Information Administration, 2011).

Figure 1–36. China's natural gas production and consumption, 1987-2007 (2006 and 2007 are estimates), reprinted from (Energy Information Administration, 2011)



4. Hydropower

According to at least one expert, China is experiencing an "absolute, incredible proliferation of hydropower construction" (Harrison, 2011). This construction will continue: In January 2011, the Central Government released the "No.1 Document" and *The Decisions on Speeding-up Reform of Water and Resources*, which established water conservation as a primary goal of the country over the next 5-10 years. China plans to complete the "harnessing" of major medium- and small-sized rivers during the *12th Five-Year Guideline (2011-2015)*, and will invest 4 trillion RMB into the construction of water facilities over the next decade (Zhu, 2011) (chinanews.com, 2011) (Yao & Lin, 2011).

China boasts the greatest hydropower potential and number of hydropower stations of any country in the world, and less than half of its 542 million kw of technically feasible capacity has been developed to date (Zhao, 2009). China doubled its total installed capacity between 2004 and 2010, from 100 million kw to 200 million kw. The Three Gorges Dam in Hubei Province, operational in 2008, has the largest hydropower capacity of any dam on the planet (18,200

MW), as well as the notoriety for displacing the most people (1.2 million), flooding the largest number of cities and towns (13 cities, 140 towns, 1,350 villages), and creating the longest reservoir on Earth (more than 600 kilometers) (International Rivers) (Figure 1–37).

Figure 1–37. The Three Gorges Dam has the largest hydropower capacity in the world, and has created the longest reservoir on Earth. Photo by Brian Richter

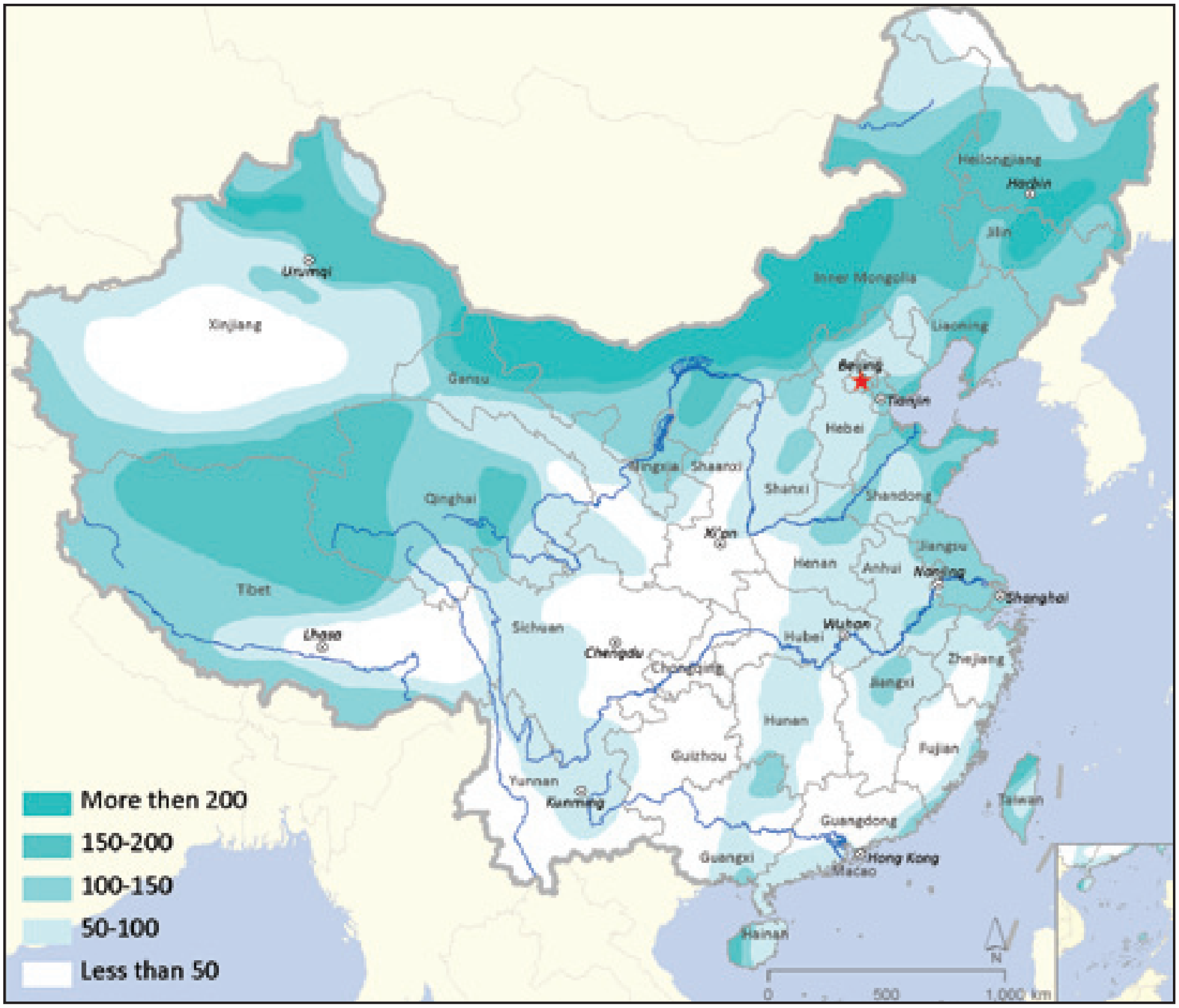
China tallied 45,000 hydropower stations as of 2010 and more than 85,000 dams as of 2007 (Wang & Zhao, 2010) (Guo et al., 2010). As of 2007, 5,200 of those dams (either built or under construction) were higher than 30m, and more than 140 dams were slated to be over 100m high (Wang & Zhao, 2010). The country is in the process of constructing the world's tallest dam, Shuangjiangkou Dam in Sichuan Province, which will be 312m high—nearly the height of the China World Trade Center in Beijing. Small dams are also very common throughout China, generally built by private companies and local governments for hydropower.

Mass construction of additional hydropower stations and dams will continue, fueled by the country's desires for electricity, flood control, water supply, and irrigation. In 2009, the National Development and Reform Commission (NDRC) announced a goal to increase non-fossil fuel energy consumption to 15% of the primary energy mix by 2020, and to reduce carbon dioxide emissions by 40-45% from 2005 levels (www.yunnan.cn, 2010); to meet this goal, at least 330 million kw of hydropower is required. Most of this development will be concentrated in Yunnan, Sichuan, Qinghai, and Tibet, where vast hydropower still remains untapped. Hydropower development is complete in Guangxi, Chongqing, and Guizhou provinces (www.yunnan.cn, 2010). For water supply, which is more of an issue in the dry north than in the wetter south, several major dams and diversions will eventually transport water from south to north as part of the South-to-North Water Diversion Project. Water will travel from the old Grand Canal to Tianjin (East Route), from the Han River at the Danjiangkou Reservoir to Beijing (Middle Route), and from the Upper Yangtze tributaries to the Yellow River (West Route).

5. Wind

The World Wind Energy Association describes China as "the locomotive of the international wind industry" (World Wind Energy Association, 2010). China more than doubled its wind capacity every year from 2006-2009, and is the largest market for new turbines. As of 2010, it boasted the largest wind capacity in the world, with nearly 45,000 MW of installed capacity. By comparison, the U.S. has the second largest installed capacity with 40,000 MW and Germany has the third largest, with 27,000 MW (World Wind Energy Association, 2011). China has already far exceeded its goal of 30,000 MW of installed capacity by 2020 (National Development and Reform Commission, 2007). It should be noted that despite the growth in its wind industry, China's wind production still represents just 1.2% of its total electricity supply according to a 2010 estimate (World Wind Energy Association, 2011). Nonetheless, wind development is having a significant footprint on China's landscape. Wind development is primarily ecologically impacting the grasslands and Gobi desert of the northwest, the "Sanbei Region" spanning the northern part of the country, and the eastern coastal dry lands, islands, and shores (Figure 1–38). Liaoning, Xinjiang, Inner Mongolia, and Guangdong are developing most quickly.

Figure 1-38. Wind potential in w/m² (Lin, 2010)



6. Other

Of the array of energy resources in China, the development of coal, oil, natural gas, wind, and hydropower may have the greatest impact on China's landscape. However, the government also aims to increase production of other renewable energy resources such biomass and solar. The government has identified these resources as development priorities (National Development and Reform Commission, 2007). Furthermore, additional oil and gas pipeline construction is anticipated. Individually developing these resources may not have a particularly large effect on terrestrial biodiversity values, but it will certainly add to cumulative impacts.

Biomass—The sources of China's biomass energy include straw from biomass energy plantations, agricultural crops, livestock waste, industrial organic water waste, municipal sewage, and garbage. The biomass energy plantations may involve some conversion of native ecosystems.

As the NDRC (2007) explains in its "Medium and Long-Term Development Plan for Renewable Energy," "Energy plantations will be grown in marginal areas (including barren mountains, barren land, and sandy areas suitable to afforestation) to supply feedstock for agriculture and forestry based biomass power generation." As of 2007, China had planned to create more than 13 million ha of "high-yield and good quality" biomass energy plantation bases within 15 years (State Forestry Administration, 2007).

Solar energy—China's best solar resources lie in far western China in the Qinghai-Tibetan Plateau, far from population centers in the east. China aims to provide small scale solar power stations in regions where villages and households do not have electricity, particularly Tibet, Qinghai, Inner Mongolia, Xinjiang, Ningxia, Gansu, and Yunnan. The government is also constructing solar energy demonstration projects in open and deserted areas in Inner Mongolia, Gansu, and Xinjiang (National Development and Reform Commission, 2007). In terms of commercial operations, the government aims to connect to the grid 400 MW of solar photovoltaic and solar thermal by 2020 (National Development and Reform Commission, 2007). The footprint of these operations on the landscape may be relatively limited; for example, if one estimates approximately seven acres of disturbance for every one MW of solar energy, a total of only 2,800 acres may be impacted based on the 2020 goal.

Pipelines—China's uneven geographic distribution of oil and natural gas, as well as increasing demand for these fuels, has prompted the country's construction of a pipeline system to transport the resources to consumers. The construction of pipelines and associated roads often leads to a host of other impacts to ecosystems as formerly inaccessible areas become accessible for a range of activities such as hunting, logging, and mining. China has undergone a period of "expedited development" of pipelines since 1996 (Qi, 2009), and an average of 5,000 km was constructed annually from 2003-2008 (Shen & Li, 2010). Estimates of the extent of current pipelines vary widely. According to one source, approximately 78,000 km of oil and gas pipelines had been established across China as of 2011, of which 40,000 km were for natural gas, 20,000 km were for crude oil, and 18,000 km were for refined oil (Qian & Yu, 2011). According to another source, China's largest oil and gas producer (China National Petroleum Corporation; CNPC) constructed 270,000 km of pipeline from 2006-2010, exceeding the total laid in the previous 42 years (China Daily, 2011).

More pipeline construction is expected as China increases its imports, increases natural gas production, and increasingly shifts oil production from the older fields in the northeast to newer fields in more remote parts of the country. For example, as of 2009, plans were in place for China to construct import lines from Russia and Myanmar, most notably through the ecologically sensitive Altai region of northern Xinjiang. Part of the Russia-China line is completed and runs from Siberia to Daqing; a second stage of construction is slated to be complete by 2014, after which the pipeline will run for 4,700 km (BBC News, 2011). CNPC aims to construct 270 km of pipeline, to total 540 km, by 2015 (China Daily, 2011).

G. Transportation

To support its economic growth, China is investing major resources in expanding road and rail networks. The vast majority of existing transit is located in eastern China, where the majority of the population resides. New highway and high-speed railway development will occur there also, though secondary road construction is also an emphasis in western China. Further fragmentation of biodiversity habitat is a major concern, although China does make concessions for wildlife in its road construction. For example, there was significant effort to conserve wildlife passage routes during the construction of the Lhasa railroad.

1. Road Construction

As with population, road density is greatest in eastern China. In 2004, the State Council issued the "National Expressway Network Plan," aiming to expand roads from all major cities over a 30-year period. The plan envisions a "7-9-18 Network" consisting of 7 expressways from Beijing, 9 expressways running north-south ("verticals"), and 18 expressways running east-west ("horizontals"). Together, these roads would total 85,000 km—68,000 km for highways, regional ring roads, and connecting roads, and 17,000 km for other smaller roads.

As of 2007, the Central Government had constructed 42,000 km of major roads to complete five verticals and seven horizontals, thereby forming the backbone of the national expressway system. By 2009, China had already exceeded its goal by constructing 75,000 km of roads (The Transport Politic, 2009). For comparison, China and the U.S. now have roughly equivalent highways systems in terms of length (U.S. Department of Transportation).

The government has also dedicated attention to rural transit. From 2004-2005, China completed a major rural road-building effort and nearly doubled the length of rural roadways from 1.9 million km to 3.5 million km (Figure 1–39). In just over a year, China constructed more paved rural roads than were built during the previous 50 years combined (Hessler, 2010).

2. Railway Construction

China is also dedicating significant resources to railway construction and has developed a "Mid-term and Long-term Railway Network Scheme" (2008). Currently, there are approximately 78,000 km of railroads in China, which like roads, are concentrated in eastern China. The Central Government will invest 5 trillion RMB to newly construct 40,000 km of railroads by 2020 (china.com.cn, 2008) (Ministry of Railways, 2008). Once completed, the rail network will connect most cities with populations of at least 200,000 (China Railway Construction Corporation Limited, 2008). Two types of railways are being constructed: very high speed lines for passenger use between major cities, and typical high-speed lines for regional, commuter, and freight trains (The Transport Politic, 2009). According to the plan, eight very high-speed passenger-dedicated railways (Beijing-Shenzhen, Beijing-Shanghai, Beijing-

Ha'erbin, Shanghai-Shenzhen, Xuzhou-Lanzhou, Hangzhou-Kunming, Qingdao-Taiyuan, and Nanjing-Chengdu) totaling 13,368 km in length and intercity passenger transport systems in densely populated areas will be constructed. The Shanghai-Kunming line will be the longest at 2,264 km long—roughly the distance between Boston and Miami.

Figure 1–39. Length of roadways in China from 2001-2009, including but not limited to major highways (china.com.cn, 2008) (Ministry of Transport, 2009) (Xu, 2010)