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Biodiversity and conservation in the Tibetan Plateau

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The Tibetan Plateau (Qinghai-Xizang Plateau) is a unique biogeographic region in the world, where various landscapes, altitudinal belts, alpine ecosystems, and endangered and endemic species have been developed. A total of 26 altitudinal belts, 28 spectra of altitudinal belts, 12,000 species of vascular plant, 5,000 species of epiphytes, 210 species of mammals, and 532 species of birds have been recorded. The plateau is also one of the centers of species formation and differentiation in the world. To protect the biodiversity of the plateau, about 80 nature reserves have been designated, of which 45 are national or provincial, covering about 22% of the plateau area. Most of the nature reserves are distributed in the southeastern plateau. Recently, the Chinese government has initiated the ?Natural Forests Protection Project of China,? mainly in the upper reaches of the Yangtze and Yellow rivers. ?No logging? policies have been made and implemented for these areas.?

Biodiversity and conservation in the Tibetan Plateau ZHANG Bai-ping, CHEN Xiao-dong, LI Bao-lin, YAO Yong-hui (The State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing 100101, China) 1 Physical environment The Tibetan Plateau, 2.5 million km2 and averagely 4,500 m asl, is the loftiest, most immense and youthful massif of the earth. Well known as ?the roof of the world,? it towers up to the middle of the troposphere as a ?hot island? and gives rise to the so-called ?Tibetan atmospheric circulation? and ?Tibetan Monsoon System,? i.e., wind blows outward in winter and inward in summer (Ye and Gao, 1979). The most significant effect of the plateau as a ?hot island? is the inducement and reinforcement of the so-called ?Southwestern Monsoon? from the Bay of Bengal. Thanks to this effect, tropical monsoon climate extends northward to the southern piedmont plains of the Himalayas, and even along the Yarlungzangbu/Brahmaputra river valley into the interior of the plateau, to 29o30?N, that is nearly 6o north of the northern tropic of cancer. This forms climatically the so-called ?Wet tongue? in the southeastern plateau. Other parts of the plateau, especially the west and north, receive little moisture-laden air masses both from the Bay of Bengal and from the Arabian Sea. As a result, the annual mean precipitation decreases from 2,000-2,500 mm in the southeast to about 50-100 mm in the northwest (Figure 1), and the aridity increases from less than 1 to 25 (Liao, 1990). The region lying between 35o-36o30?N and 83o-86oE is a very dry place without flowering plants but only bare land or few dwarf cushion suffrutice. This is the ?High-cold arid core of the Tibetan Plateau? (Zheng, 2000). This pattern of regional climate, together with the striking vertical differentiation in its peripheral high and extremely high mountains, gives rise to varied climate types on the plateau, from humid tropical monsoon climate in the southeastern corner to extremely arid and frigid/cold climate in the northwest and in the extremely high, snow-covered mountains. The eastern and southernmost Tibetan Plateau have undergone active processes of species differentiation during the uplifting of the plateau, and become one of the main centers of species formation and differentiation in the world. All of these finally lead to a high variety of ecosystems and ecological processes on the plateau (Li, 1994), which makes the Tibetan Plateau one of the hotspot regions of global biodiversity. Figure 1 Relief and annual mean precipitation of the Tibetan Plateau 2 Biodiversity in the Tibetan Plateau 2.1 Diversity of ecosystems From southeast to northwest of four large ecosystems can be identified on the Tibetan Plateau, namely, montane forest, alpine shrub/meadow, alpine steppe, and alpine desert. This pattern of large-scale areal differentiation should have occurred on continental or even inter-continental scale. But it is concentrated on such a special land unit--the Tibetan Plateau. This pattern of areal differentiation can be called ?High plateau zonation? (Chang, 1981) or simply ?Tibetan zonation.? Every large ecosystem contains several medium ecosystems, some o

f which are endemic to the plateau. For example, the montane forest ecosystem in the southeast embraces low-mountain evergreen monsoon forest; low-mountain semi-evergreen monsoon forest; montane semi-evergreen broad-leaved forest; middle-mountain hard-leaf evergreen broad-leaved forest; middle-mountain evergreen coniferous forest; sub-alpine hard mulberry leaf evergreen broad-leaved forest; sub-alpine evergreen coniferous forest, etc. The alpine shrub/meadow ecosystem also has diversiform medium ecosystems: alpine evergreen leather-leaf shrub, alpine evergreen coniferous shrub, alpine deciduous broad-leaved shrub, and alpine cushion deciduous broad-leaved shrub. Moreover, dry-hot valley shrub ecosystems are special to the plateau. They are mainly distributed in the meridian valleys of the Hengduan Mountains in the southeastern Tibetan Plateau. They include sparse tree-thorn shrub-steppe (e.g., Phyllanthus emblica, Diospyros mollissima), succulent thorny shrub (e.g., Euphorbia royleana), leaflet deciduous broad-leaved shrub (e.g., Caryopteris monlolica, Ajania potaninii). Sub-alpine evergreen bamboo forest (e.g., Sinarundinaria nitida) is also very special to the plateau. The widespread alpine steppe (e.g., Stipa purpurea), alpine desert (e.g., Ceratoides campacta) and cushion-plants (e.g., Androsace tapete) ecosystems are peculiar to the plateau. A large variety of spectra of altitudinal belts have been identified in the peripheral and inner mountains of the plateau. A total of 26 altitudinal belts (medium ecosystems) and at least 28 spectra of altitudinal belts have been distinguished (Figure 2). This variety of ecosystems can hardly be found in any other region of the world. The most complex spectrum of altitudinal belts is found in the southern flank of Mt. Namjagbarwa (7,782 m asl) at the eastern end of the Himalayas. It contains 8-9 altitudinal belts, from monsoon forest to nival belt. The simplest spectrum, usually of only three altitudinal belts including sub-nival and nival belts, is found at the Keriya Pass of the Kunlun Mountains, and in Mt. Gelaindandong (6,621 m asl), the highest peak of the Tanggula Mountains in the middle of the plateau. Generally speaking, the spectrum shows simple in the inner and northern mountains and complex in the southeastern mountains of the plateau. This is due to relatively low elevation, deeply cut valleys and varied vertical climates in the southeastern plateau. Figure 2 Spectra of altitudinal belts in the Tibetan Plateau 2.2 Diversity of geographic elements The Tibetan Plateau is the mixing site of two biological territories, Holarctic and Paleotropic kingdoms botanically, Paleoacrtic and Oriental regions zoologically. Of the Paleotropic kingdom, the plateau contains 5 geographic elements: pantropic (e.g., Erythrina arborescena), tropic American & tropic Asia (e.g., Gibotium barometz), Paleotropic (e.g., Procris laevigata), tropic Asia to tropic Australia (Arenga pinnata), tropic Asia to tropic Africa (e.g., Arundo donax), and tropic Asia (or India-Malaysia). It also contains 8 Holarctic geographic elements (Table 1). The plateau acts as the center of species differentiation for many geographic elements. For example, of the North temperate, it is the differentiating center of such genera as Rhododendron, Primula, Saussurea and Pedicularis. Of the East Asia, Circaeaster, Hemiphragma and Chionocharis are native to the plateau. Other Holarctic elements include Old world temperate (e.g., Siberaea laevigata), Temperate Asia (Caragana jubata), Mediterranean, W. Asia to C. Asia (e.g., Cicer microphyllum), and C. Asia element (Ceratoides latens). The Tibetan Plateau is also characterized by various geographic elements of animals. This includes all four Oriental elements: the Hengduan-Himalayan element in the southeastern plateau (e.g., Ailuropoda melanoleuca, Bodorcus taxicolor, Presbytis entellus, Carduelis thibetana, etc.), Old world tropic/sub-tropic elements (e.g., Oanthera pardus, Bubulcus ibis, Egretta alba, Ceryle rudis, etc.), Southeast Asia tropic/sub-tropic elements (e.g., Macaca assamensis, Aonyx cinnerea, Muntiacu muntiak, Pericrocotus flammeus, Ophiophagus Hannah, etc.), and South China elements (e.g., Rhinopithecus gracilis, Ailurus fulgens, Babax lanceolatus, Rana pleuradeu, etc.). There are also many Paleoarctic elements, especially the Tibetan endemic elements (see below). Other paleoarctic elements contain the northern type of the Northeast China sub-region (e.g., Cervux elaphus, Lynx lynx, Remiz pendulinus, Phylloscopus trocuiloides, Rana temporaria, Agkistrodon halys, etc.), and the Central Asia type (e.g., Felis bieti, Felis manul, Dipus sagitta, Calandrella rufescens, Oenanthe isabellina, Oenanthe deserti, Eryx miliaris, etc.). Some northeastern types of the Northeast China sub-region are also found in the Tibetan Plateau, including Apodemus peninsulae, Mustela sibirica, Phylloscopus borealis, Luscinia cyane, Emberiza cia, etc. 2.3 Diversity of species The variety of ecosystems and the complicated interfaces between ecosystems provide favorable conditions for old species conservation, young species differentiation/specialization, and varied geographic elements mixing on the Tibetan Plateau. This accounts for the richness of species and endemic species on the Tibetan Plateau. More than 1,500 genera, covering 12,000 species of vascular plants have been recorded in the plateau; epiphytes 700 genera, more than 5,000 species; mammals 29 families, more than 210 species; birds 57 families, 532 species; and fish 115 species (Wu and Feng, 1992). However, species and communities are quite unevenly distributed on the plateau. The vast, environmentally harsh inland plateau has relatively few species. For instance, the extensive Qiangtang Plateau, one-fourth of the total plateau area, possesses only one-tenth of the species; while the Himalayan and the Hengduan mountain regions, only one-fifth of the total area, contain more than 80% of the species. The composition of the Tibetan biota features various endemic spe

cies. Most of them are old species remained in some local habitats of the plateau or species newly evolved, and usual ly confined to rather narrow habitats. In addition, the plateau acts as the modern harbor for many rare species due t o its relative primitivity. All this accounts for the variety of rare and endangered species in the plateau (Tables 2 and 3) and makes the plateau a key base for the protection of biodiversity in China and even in the world. Of the h igher plant, a most primitive species, Takakia lepidozioides, has been found in the plateau. It has the least chromos omes (n=4) in the terrigenous plants and could be called the ?living fossil? of the moss plant. Of the fern, many pro to-species such as Archangiopteris wallichiana, Alsophila spinulosa, Gymnosphaera andersonii, Sphaeropteris brunonian a, Dipteris conjugata, Lomariopsis spectabilis, and Sinopteris grerilleoides, have been recorded in the Tibetan Himal ayas and the Hengduan Mountains. Most of the gymnosperm of the plateau is rare, endangered and nearly extinct specie s, e.g., Cupressus gigantea growing only in the middle reaches of the Yarlungzangbu River valley, Cycas panzhihuaensi s in the Jinsha River valley, Cephalotaxus mannii, Cephalotaxus lanceolata, Larix mastersiana, Taxus wallichiana, et c. There is a large number of angiosperm in the plateau, and the mono-species or few species genera, often confined t o a narrow area and sparsely scattered, are particularly valuable and rare. The Tibetan Plateau is also well known fo r its variety of rare and endangered animals. Among them, the world-famous giant panda (Ailuropoda melanoleuca) is ju st distributed in the eastern high mountains and deep valleys of the plateau. Most of the wildlife is first-category protected animals of China. This includes Tibetan antelope (Pantholops hodgsoni), wild yak (Poephagus mutus), Tibeta n wild ass (Asinus kiang), etc. Other main animals involve Tibetan rabbit (Lepus oiotolus), Himalayan marmot (Marmot a himalayana), dark-lip pika (Ochotona curzoniae), pine field mouse (Pitymys leucurus), and such birds as Tibetan hai r-legged sand bird (Syrrhaptes tibetica), Tibetan snowbird (Tetraogallus tibetica), and Tibetan partridge (Perdix hod gsoniae). Table 2 Major endemic plants and their distribution in the Tibetan Plateau 3 Biodiversity conservation The importance of protecting biodiversity needs not to be emphasized. However, biodiversity protection is of special sign ificance in the Tibetan Plateau. Firstly, the plateau is one of the few hitherto not yet exploited treasuries of mont ane biological resources. There is a large amount of potential montane biological resources known but not yet well ut ilized or even not yet known to human. They are varied medical plants (Picrorhiza scrophulariiflora, Viburnum cylindr icum, Zanthoxylum tibetanum), amyloid plants (Quercus aquifolioides, Prunus mira), fibrous plants (Edgeworthia gardne ri), plants as raw material of chemical industry (Quercus semecarpifolia), ornamental plants (Magnolia rostrata), med ical animal (Moschus berezouskii), furry animal (Panthera uncia), meat animal (Cervus albirostris), and ornamental an imal (Tragopon satyra). Table 3 Endangered animal species in the Tibetan Plateau Secondly, there are plenty of germpl asm resources in domestic animals and cultivated plants of the plateau. Domestic yak (Bos grunniens) has its wild spe cies of wild yak (Pheophagus mutus) in the plateau. The latter is the ancestor of the former. The copulation of wild male yak and domestic female yak usually produce tall and vigorous offspring. It is significant that wild yak helps u pgrade the domestic yak (Feng et al., 1986). As for barley, its several wild species have been identified in the plat eau, e.g., Hordeum lagunculiforme, Hordeum spontaneum, Hordeum agriocrithon, Hordeum brevisubulatum, Hordeum bulbosu m, etc. They are all invaluable for barley improvement (Huang, 1992; Xu, 1992). A total of 5 cultivated subspecies an d 260 varieties of barley have been recorded in Tibet. Wild wheat (Triticum xizangense), including three sub-specie s, is also recorded in the plateau, together with close sibs such as Aegilops spuarrosa. They are useful in improvin g the quality of wheat. There are totally 83 varieties of wheat in Tibet. Several wild peas (Vicia sepium, Vicia bung ei, Vicia amoena), and wild species of Avena nuda and Polygonum fagopyrum have been also discovered. In addition, mos t of the Tibetan organisms have developed special genetic and/or ecological forms, and the plateau serves as the gen e pool of genetic diversity for domestic animals and cultivated plants. Figure 3 Distribution of national and provinc ial nature reserves in the Tibetan Plateau Thirdly, as is well known, the plateau is the headwater area of many larg e rivers in Asia. Soil erosion occurs when they flow through the steep peripheral areas of the plateau. If the forest s and other vegetation types of those areas were destroyed, much more intense soil erosion would be unavoidable; floo ding and silting up of reservoirs could easily occur downstream; water conservancy facilities could be seriously impa ired. In some extreme cases, the dams could break. Fourthly, most of the biological colonies and individuals are dist ributed in the transitional areas of Tibetan horizontal and altitudinal life belts, and they are very sensitive to en vironmental change. Therefore, monitoring the Tibetan biodiversity is simply monitoring global environmental change. Last but not the least, some of the Tibetan endemic animals and ecosystems are threatened by human activities. For in stance, Tibetan antelopes are still being poached and even slaughtered by law-breakers; the alpine steppe ecosystem i s degrading mainly due to overgrazing. In fact, the importance of the Tibetan Plateau in nature conservation has lon g been recognized with Chinese scholars and relevant officials. As early as 1956, Chinese scientists put forward a pr oposal for designating forest nature reserves at the third session of the First National People?s Congress. As a resu

lt, the first nature reserves (e.g., Wanglang, Labahe, etc.) were demarcated for the plateau in 1963. Since then, abo ut 80 nature reserves have been set up in the plateau. The most famous include the Wolong giant panda nature reserv e, the Qomolangma nature reserve, the Qinghai Lake Birds Island nature reserve, etc. The 45 national and provincial l evel nature reserves are listed in Table 4 and their spatial distribution shown in Figure 3. It can be seen that mos t of the nature reserves are located in the southeastern Tibetan Plateau and 10 of them are for giant pandas. The tot al area of nature reserves amounts to 544.5 thousand km2, about 22% of the plateau area. In addition, the three-rive r (Yangtze, Yellow and Lancang) headwater region nature reserve has been treated by Qinghai Province as a provincial nature reserve, and will very likely be upgraded to national nature reserve in the near future (the application is un derway). The most recent conservation activities are the initiation of the ?Natural Forests Protection Project of Chi na (NFPPC).? After the 1998 damaging flood along the lower reaches of the Yangtze River, the government of China reco gnized the strategic importance of natural forests in the upper reaches of the Yangtze River and in the upper and mid dle reaches of the Yellow River. As a result, a ban was strictly put on the logging in these areas in late 1998, and the NFPPC was put into play. Ecological and environmental construction is taken as the basic measures and breakthroug h for the implementation of ?Western China Development.? So, forest logging in the eastern Tibetan Plateau was force d to stop, and Table 4 National and provincial nature reserves in the Tibetan Plateau effective measures were taken t o strictly manage these forests. In the meantime, the government fully considered the problems resulting from ?no-log ging,? such as job relocation for the local forestry workers, their cost of living, the insolvent indebt of the loca l forestry enterprises, reduced local financial income, the social burden of the forest areas, etc. All of these are being compensated from the national budget, 80% from the central budget and the remaining 20% from the local budget. Thanks to this effective compensatory mechanism, most of the former tree-cutters have become tree planters. In additi on, administrative and legislative measures have been also taken to promote the protection of natural forests and to ensure the realization of no logging. Governments at all levels are required to issue ?no logging? orders, to cancel the annual production plan of the no-logging units, to cancel the logging team or give them other working opportuniti es, to seal up the logging machines, to fence mountains and road, to set up check stations, to cancel timber markets in and around the forest areas, to formulate relevant regulations and mechanisms, etc. Even in other forest areas, lo gging has enormously decreased. For example, the Tibetan government has reduced its annual timber yield from 220,000 m3 in 1998 to 140,000 m3 in 2001. 4 Problems and countermeasures Most of the nature reserves already established in t he Tibetan Plateau are usually not well managed. Quite often, little is invested in their facility construction and m anagement, and the workers are mostly poorly trained. Poaching is difficult to control, such as killing Tibetan antel opes in the Hoh Xil nature reserve. Therefore, the workers of the nature reserves should be well trained, and much mo re investment is needed. In this respect, international aid and cooperation is necessary and significant. After all, protecting the Tibetan biodiversity is the responsibility of our humankind. Considering the outstanding biodiversity and their importance of the plateau, the present nature reserves are still not enough and more are needed. What?s mor e, the biodiversity and biological resources of the plateau are far from clear. In-depth investigation and further re search should be organized. Only three eastern counties (Jomda, Gonjo, Markam) of the Tibet Autonomous Region are sit uated in the upper reaches of the Yangtze River, and thus included in the NFPPC. Other forest counties of Tibet are s till not. Considering their location and importance in biodiversity and ecology of the Tibetan Plateau, it is strongl y suggested that they should also be included in the NFPPC as soon as possible. References

关键词： Tibetan Plateau; biodiversity; nature reserve; endangered species

