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Current Condition and Protection Strategies of Qinghai-Tibet Plateau Ecological Security Barrier

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Abstract

Qinghai-Tibet Plateau is important ecological security barrier of China and even Asia, and one of biodiversity conservation hotspots. Ensuring ecological security and protecting biodiversity are key tasks of ecological protection in Qinghai-Tibet Plateau. In Qinghai-Tibet Plateau, wildlife is very rich but there are many threatened species. During past 15 years, ecosystem pattern is stable, and ecosystem quality generally elevates in Qinghai-Tibet Plateau. Correspondingly, water retention, soil retention, and sandstorm prevention are improved and the trend of ecological degradation is suppressed. The construction of natural reserves and the implementation of ecological protection projects in Qinghai-Tibet Plateau contribute to the improvement of ecological security barrier function. However, due to the impacts of warm-wet tendency and human activities, Qinghai-Tibet Plateau is facing a series of ecological degradation risks, including frozen soil area withering, marsh reduction, wildlife habitat degradation, alien invasion, and ecosystem degradation. To further protect Qinghai-Tibet Plateau's ecological security barrier, the following measures could be taken, namely, optimizing spatial pattern of natural protected area, establishing natural protected area system mainly based on national park group, and implementing ecological protection and restoration projects.

Keywords

ecosystem pattern; ecosystem function; ecological issue; ecological security barrier; Qinghai-Tibet Plateau

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Current Condition and Protection Strategies of Qinghai-Tibet Plateau Ecological Security Barrier

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Abstract: The Qinghai-Tibet Plateau is an important ecological security barrier of China and even Asia, and one of the biodiversity conservation hotspots. Ensuring ecological security and protecting biodiversity are key tasks of ecological protection in Qinghai-Tibet Plateau. In the Qinghai-Tibet Plateau, wildlife is very rich but there are many threatened species. During the past 15 years, the ecosystem pattern is stable, and ecosystem quality generally elevates in Qinghai-Tibet Plateau. Correspondingly, water retention, soil retention, and sandstorm prevention are improved and the trend of ecological degradation is suppressed. The construction of natural reserves and the implementation of ecological protection projects in the Qinghai-Tibet Plateau contribute to the improvement of the ecological security barrier function. However, due to the impacts of warm-wet tendency and human activities, the Qinghai-Tibet Plateau is facing a series of ecological degradation risks, including frozen soil area withering, marsh reduction, wildlife habitat degradation, alien invasion, and ecosystem degradation. To further protect Qinghai-Tibet Plateau's ecological security barrier, the following measures could be taken, namely, optimizing spatial pattern of the natural protected area, establishing natural protected area system mainly based on national park group, and implementing ecological protection and restoration projects. **DOI:** 10.16418/j.issn.1000-3045.20210919001-en

Keywords: ecosystem pattern; ecosystem function; ecological issue; ecological security barrier; Qinghai-Tibet Plateau

The Qinghai-Tibet Plateau is located in Southwest China, covering the entire Tibet and Qinghai, and parts of Sichuan, Yunnan, Gansu, and Xinjiang, with a total area of about 2.6×10^6 km^2, and altitude in most regions of more than 4 000 m [1]. The Qinghai-Tibet Plateau, known as the "roof of the world", "the third pole of the Earth" and the "Asian water tower", has important functions such as water retention, soil retention, sandstorm prevention, carbon fixation and biodiversity conservation; the current conditions of its ecosystem quality and functions directly affect the ecological security of China, South Asia, and Southeast Asia. Therefore, it is an ecological security barrier of China and even Asia, and one of the global biodiversity conservation hotspots. Ensuring ecological security and protecting biodiversity are key tasks of ecological protection in the Qinghai-Tibet Plateau.

For ensuring the ecological security of the Qinghai-Tibet Plateau and continuously playing its role as an ecological security barrier, it is necessary to thoroughly grasp the current conditions and changes of the Qinghai-Tibet Plateau, thus understanding the ecosystem quality, functions and risk status. Based on the progress of Task Three "ecosystem and ecological security", Task Four "functions and optimizing system of ecological security barrier" and Task Five "biodiversity conservation and sustainable utilization" of China's Second Scientific Expedition and Research on the Qinghai-Tibet Plateau (hereinafter referred to as "the second scientific expedition"), and combined with the existing research results, this paper explained the conditions of the ecological security barrier and put forward ecological protection strategies for the ecological security barrier, so as to provide scientific basis and policy recommendations for protecting the functions of the ecological security barrier.

1 Current condition and changing characteristics of the ecological security barrier

1.1 Rich biodiversity

(1) The Qinghai-Tibet Plateau is rich in species. The statistics of the second scientific expedition indicated that there are 14 634 species of vascular plants in the Qinghai-Tibet

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Plateau, accounting for about 45.8% of the total vascular plants in China; therefore, it is an area with the most abundant and important vascular plants (Figure 1a). In Qinghai-Tibet Plateau, 1 763 species of vertebrates have been recorded (Figure 1b), accounting for about 40.5% of terrestrial vertebrates and freshwater fish in China [2].

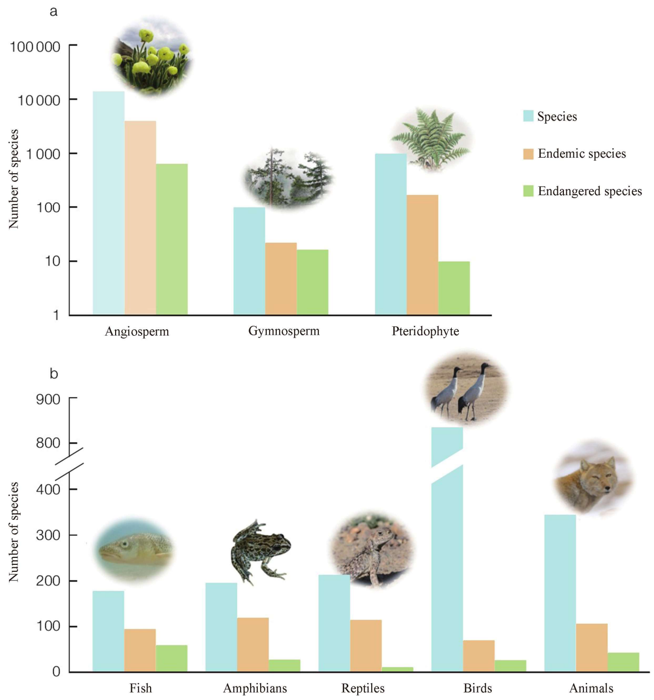

Figure 1 Number of species, endemic species, endangered species for vascular plants (a) and vertebrates (b) in the Qinghai-Tibet Plateau

(2) The Qinghai-Tibet Plateau has numerous endemic species. There are 3 764 endemic spermatophytes in the Qinghai-Tibet Plateau (excluding infraspecific taxa), accounting for 24.9% of endemic spermatophytes in China [3], among which, herbaceous plants, shrubs and arbor trees account for 76.3%, 20.4% and 3.3% of the endemic species (mainly the herbaceous plants) in the Qinghai-Tibet Plateau. As shown in the statistics of the second scientific expedition: The endemic vertebrates in the Qinghai-Tibet Plateau are high in proportion, accounting for 28.0% (494 species) (Figure 1b).

(3) The Qinghai-Tibet Plateau has numerous rare and endangered species. As shown in the statistics of the second scientific expedition, according to the standard of the Red List of the International Union for Conservation of Nature (IUCN), there are 662 threatened species and endangered species of vascular plants in the Qinghai-Tibet Plateau, accounting for about 1/5 of threatened and endangered vascular plants in China (Figure 1a); there are 169 threatened species among the vertebrates, accounting for 9.58% of all vertebrates in the Qinghai-Tibet Plateau (Figure 1b).

1.2 Stable ecosystem pattern and improved quality

(1) The Qinghai-Tibet Plateau has various fragile ecosystems, mainly including the grassland (60.73%), desert and bare land (18.63%), shrub (7.09%) and forest (5.37%), with small areas of farmland (0.74%) and towns (0.19%) (Figure 2). The Qinghai-Tibet Plateau is fragile in ecosystems, with 34.9% of alpine and arid deserts and sparse vegetation; it is severe in desertification, water and soil loss, and freeze-thaw erosion, with the extremely sensitive area of freeze-thaw erosion accounting for 84.9% of the total in China. The extremely sensitive areas of wind erosion, water erosion and rocky desertification account for 7.4%, 18.7% and 18.0% of the total in China, respectively.

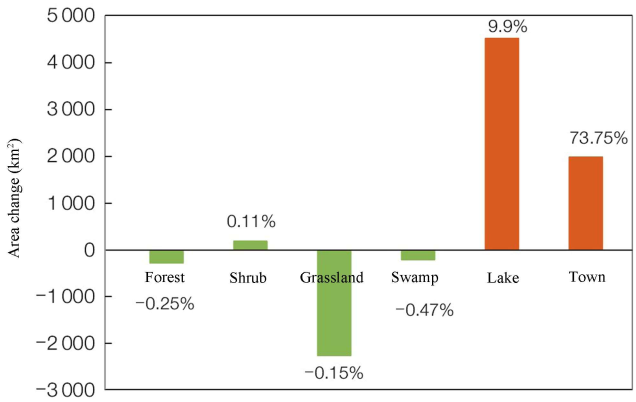

Figure 2 Area changes of ecosystems between 2000 and 2015 in the Qinghai-Tibet Plateau

(2) The ecosystem pattern is stable in the Qinghai-Tibet Plateau. From 2000 to 2015, the conversion area of ecosystem types in the Qinghai-Tibet Plateau was 1.76×10^4 km^2 (0.69%), far below the national average level (4.37%). The areas of forest (−0.25%), grassland (−0.15%), and swamp (−0.47%) decreased slightly, while the areas of urban and lake ecosystems increased by 73.75% and 9.99%, respectively (Figure 2). The inundated bare land and grassland due to lake expansion (33.2%), the conversion of other types to grassland (20.5%) and urban expansion (11.5%) accounted for 65.2% of the total variation area of ecosystems.

(3) The ecosystem quality has been generally improved. The proportion of high-quality grassland has been increased from 12.8% to 18.3%, and that of the high-quality forest has increased from 18.1% to 30.2%.

1.3 Gradual improvement of ecosystem functions

(1) Improvement of ecosystem functions. Since 2008, the surface vegetation coverage in 66.50% of the territorial area of Tibet has increased [4]. Since 2004, the surface vegetation coverage in 79.20% of the territorial area of the Three-River Source Region in Qinghai has increased. From 2000 to 2015, the water retention, soil retention and sandstorm prevention services in the Qinghai-Tibet Plateau increased by 0.70%, 1.45% and 69.65%, respectively.

(2) Reduction of area and degree of water and soil loss, desertification, and rocky desertification. From 2000 to 2015, the area of severe (intensive) water and soil loss in the Qinghai-Tibet Plateau decreased from 31.37 × 10^4 km^2 to 19.53 × 10^4 km^2; the area of severe desertification land decreased from 35.00 × 10^4 km^2 to 27.69 × 10^4 km^2; and the area of severe rocky desertification decreased from 2,400 km^2 to 2,300 km^2 (Figure 3).

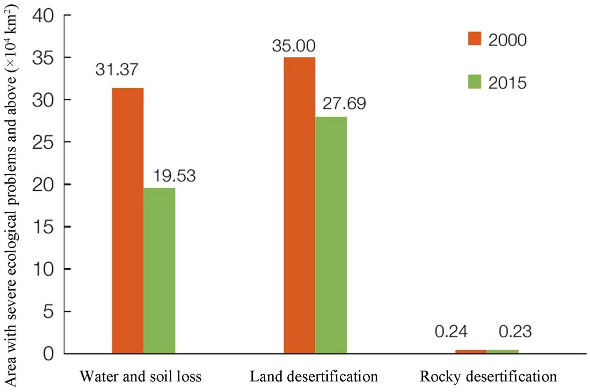

Figure 3 Area of degraded lands with severe level and above in 2000 and 2015 in Qinghai-Tibet Plateau

1.4 Large area of degradation ecosystem

(1) The area of degradation ecosystem is large. The Qinghai-Tibet Plateau still has a problem of ecosystem degradation. The proportion of forest and shrub degradation area reaches 59%, mainly distributed in the valley area of Hengduan Mountains; and that of grassland degradation reaches above 80%, mainly distributed in the northwestern Qinghai-Tibet Plateau.

(2) The area of water and soil loss is large, and desertification land is widely distributed, with rocky desertification in local areas. The area of moderate water and soil loss and above in the Qinghai-Tibet Plateau has reached 46.00 × 10^4 km^2, in which, the area of extremely severe water and soil loss and above accounts for 19.23%, mainly distributed in the alpine valleys at the southeast of the Qinghai-Tibet Plateau. The area of moderate desertification land and above has reached 46.90 × 10^4 km^2, mainly distributed in the arid areas at the northwest of the Qinghai-Tibet Plateau, especially the areas surrounding the Qiangtang Plateau and Qaidam Basin. The area of moderate rocky desertification has reached 4 267 km^2, mainly distributed in the karst area in the southeast of the Qinghai-Tibet Plateau.

1.5 Risks of ecological security

(1) Warm-wet tendency has been obvious and human activities have been intensified. In the past 50 years, the climate change in the Qinghai-Tibet Plateau has presented a warm-wet tendency [5]; the warming has been twice the global average temperature rise rate over the same period (with an increase of 0.3 ℃ to 0.4 ℃ every 10 years), marking the warmest period in the past 2000 years [6]; the precipitation has increased by 2.2% every 10 years [7]. The pressure of human activities such as population growth, overgrazing and road construction has been increasing. From 1980 to 2019, the population in the Qinghai-Tibet Plateau increased from 23.5 million to 34.255 million, with an annual growth rate of 0.97% (the annual growth rate of the national population: 0.90%). From 2000 to 2015, the actual livestock capacity of the Qinghai-Tibet Plateau increased from 145 million sheep units to 158 million sheep units①; the theoretical livestock capacity increased from 86 million sheep units to 94 million sheep units. The actual livestock capacity was more than 1.6 times the theoretical livestock capacity, and more than 80.93% of the counties were overgrazed. Although the theoretical livestock capacity in 2015 increased by 9.71% as compared with that in 2000, the actual livestock capacity increased by 9.36%, with similar growth rates.

(2) The continuing warm-wet tendency will exacerbate frozen soil area withering, a decrease of marsh wetland area and degradation of partial wildlife habitat. In the context of an average annual temperature increase of 0.052 ℃, the area of permafrost in the Qinghai-Tibet Plateau will shrink by 13.5% in 50 years, and 46% in 100 years; and the permafrost will only exist in the Qiangtang Plateau and extremely high mountains [8]. From 2000 to 2015, the areas of forest, shrub, and herbaceous swamp in the Qinghai-Tibet Plateau decreased by 2.48%, 1.03%, and 0.48%, respectively. As driven by climate change, some important natural habitats will be degraded and will increase the risk of the alien invasion.

(3) The intensified human activities will exacerbate the risks of fragmentation of wildlife habitats, alien invasion and local ecosystem degradation. On the one hand, as affected by cross-border port biological invasion, irrational release, species introduction, and logistics, the local biodiversity in the Qinghai-Tibet Plateau will be threatened [9]; major invasive species, such as *Spodoptera frugiperda*, *Ampullaria crossean* and *Solenopsis invicta*, have caused great harm in the Qinghai-Tibet Plateau; in addition, several other vicious alien species, such as *Trachemys scripta elegans* and *Rana catesbiana*, have been found in the Qinghai-Tibet Plateau [10,11]. On the other hand, wildlife habitats in the Qinghai-Tibet Plateau have been subject to severe fragmentation due to road construction. At the end of 2017, the total mileage of highways in Qinghai and Tibet was 30.6 times that of 1954, and the mileage of railways was 15.6 times that of 1965 [12]. In 2015, as affected by road cutting, the average patch area of forest shrubs, grasslands and swamps in the Qinghai-Tibet Plateau decreased by 36.6%, 40.1%, and 67.0%, respectively. In addition, grassland degenerated in local areas (such as low-altitude human activity-intensive areas in the Qiangtang Plateau Valley) as affected by human activities.

①Data source: *Qinghai Statistical Yearbook* (1981–2020) and *Tibet Autonomous Region Statistical Yearbook* (1981–2020).

2 Driving factors of changes in functions of the ecological security barrier

2.1 Natural protected areas (PAs) have played a key role in the preservation and protection of biodiversity resources

As of 2021, the Qinghai-Tibet Plateau has constructed 407 natural PAs and natural parks, with a total area of about 90.3×10^4 km^2, accounting for about 35.5% of the area of the Qinghai-Tibet Plateau. Among the PAs, there are 171 natural reserves at various levels (52 national and 61 provincial natural reserves), accounting for 91.8% of the total area of the PAs.

(1) PAs play an irreplaceable role in the preservation of biodiversity resources of the Qinghai-Tibet Plateau. The second scientific expedition found more than 30 new genera/species of animals and plants (Figure 4), including 2 new genera and 3 new species of animals, 10 new species of amphibians and reptiles, 1 new genera and 12 new species of insects, and 7 new genera/species of spermatophytes, pteridophytes, moss and lichen. Most of the new species (such as *Alpiscaptulus medogensis*, *Biswamoyopterus gaoligongensis*, *Odorrana dulongensis*, *Oligodon lipipengi*, *Cornus sunhangii*, and scarlet *Lysionotus pauciflorus*) were found in natural PAs. In addition to the new species, a number of wild fauna and flora thought to be extinct in the wild were found again in the natural PAs during the second scientific expedition. For example, the researchers took the first photo of a *Panthera tigristigris* in the Yarlung Zangbo Grand Canyon National Natural Reserve and found *Hemilophia serpens* which had disappeared for nearly a hundred years in the Haba Snow Mountain Natural Reserve.

(2) PAs play a vital role in the protection of endangered, flagship and key species in the Qinghai-Tibet Plateau. The second scientific expedition found that the establishment of Qiangtang and Hoh Xil national reserves and their conservation enabled the flagship species *Pantholops hodgsonii* to realize recovery growth in the past five years. The number of wild *P. hodgsonii* has increased from about 60 000 in 1995 to about 200,000 at present, making the degree of threat reduce to near threatened (NT) from endangered (EN). Since the establishment of the pilot Sanjiangyuan National Park, the quantity of ungulate species such as *Procapra picticaudata*, *Equus kiang*, *Cervus albirostris* and *Bos mutus* has restored significantly; the amount of predators such as snow leopards (*Panthera uncia*) and brown bears (*Ursus arctos*) has also increased; the degree of endangerment of wild animals such as flagship species snow leopard has also decreased. As for black-necked crane (*Grus nigricollis*), the only species living on a plateau among the 15 species of cranes around the world, the quantity has increased from over 2 000 to over 8 000, and the degree of endangerment has been adjusted from vulnerable (VU) to NT [13]. In Baima Snow Mountain National Nature Reserve, the number of Yunnan snub-nosed monkeys (*Rhinopithecus bieti*) was recovered from around 2 000 before the establishment of the reserve to around 2 500 in 2014.

2.2 Ecological protection construction projects have significantly promoted the improvement of functions of the ecological security barrier

(1) Major ecological projects have been smoothly implemented. The area protected by ecological projects in the Qinghai-Tibet Plateau has reached 80% of the total area, making Qinghai-Tibet Plateau one of the largest natural geographical units implementing ecological protection in China and even the world [14–17]. Major projects include ① Grassland ecological protection and construction projects. In 2018, the total area of the projects returning grazing land to grass land reached over 25.0×10^4 km^2, and that of rodent pest

Figure 4 Part of new animal species and plant species found in the second Qinghai-Tibet Plateau scientific expedition and research

(a) *Oligodon lipipengi*; (b) *Biswamoyopterus gaoligongensis*; (c) *Odorrana dulongensis*; (d) *Alpiscaptulus medogensis*; (e) *Cornus sunhangii*; (f) *Panthera tigris tigris* control projects reached 20.1 × 10^4 km^2. ② Forest ecological protection and construction projects. In 2018, the total area of artificial afforestation projects reached 1.85 × 10^4 km^2, and that of natural forest protection projects reached 1.13 × 10^4 km^2. ③ Water and soil loss comprehensive governance projects. In the past 30 years, the total area of comprehensive governance of small watershed water and soil loss reached 7 400 km^2. ④ Desertification land governance projects. In 2018, the total area of desertification land governance projects in the Qinghai-Tibet Plateau reached 6 400 km^2.

(2) The area of desertification has decreased, and wind-sand control in project areas has made remarkable achievements. After the implementation of the desertification prevention and control projects, the area of desertification in Tibet has decreased by 1 100 km^2, with an average annual decrease of 150 km^2. In the middle reaches of the Yarlung Zangbo River and its two tributaries, the shifting sandy land has decreased by 380 km^2, the semi-fixed sandy land by 160 km^2, the desertified cultivated land by 200 km^2, and extremely severe desertification land by 2 900 km^2 [4,18].

(3) Returning grazing to grassland has promoted grassland restoration. Since the implementation of the project of returning grazing to grassland and grassland ecological protection subsidy and reward policy, the vegetation coverage in the project area has been 16.9% higher than that outside the project area on average. The grass height in the project area has been increased by 2.04 cm (59.8%), and the above-ground biomass on grassland in the project area has been 24.25% higher than that on grazing grass outside the fence [4].

(4) Forest ecological projects have improved quality and efficiency, and significantly improved the carbon sequestration capacity. The second scientific expedition indicated that since the implementation of the natural forest protection projects, the total carbon storage in the natural forest protection project area in the Qinghai-Tibet Plateau has increased by 27.3 million tons per year. The forest coverage in Tibet has increased from 38.6% to 39.5%. Since the banning on deforestation, the total consumption of forest resources has decreased from 150.5 × 10^4 m^3 to 69.4 × 10^4 m^3, reducing consumption by 53.9%. From 2011 to 2016, the carbon sink of plantation forests in Tibet increased from 1.33 million tons per year to 2.03 million tons per year, with an increase of 52.25%.

3 Suggestions on improving the functions of the ecological security barrier

3.1 Optimizing and adjusting the spatial pattern of PAs

(1) Adjusting and optimizing the spatial distribution of PAs on the global spatial scale. The biodiversity-rich areas in the Qinghai-Tibet Plateau are mainly distributed in the southeast, but the PAs are mainly distributed in the central and western regions, resulting in a big gap in biodiversity conservation (Figure 5) [19]. In addition, 54% of the PAs have partial spatial overlap. Therefore, it is suggested to rationally adjust and optimize the spatial scope of PAs according to the results of the second scientific expedition, so as to achieve effective protection of biodiversity in the Qinghai-Tibet Plateau.

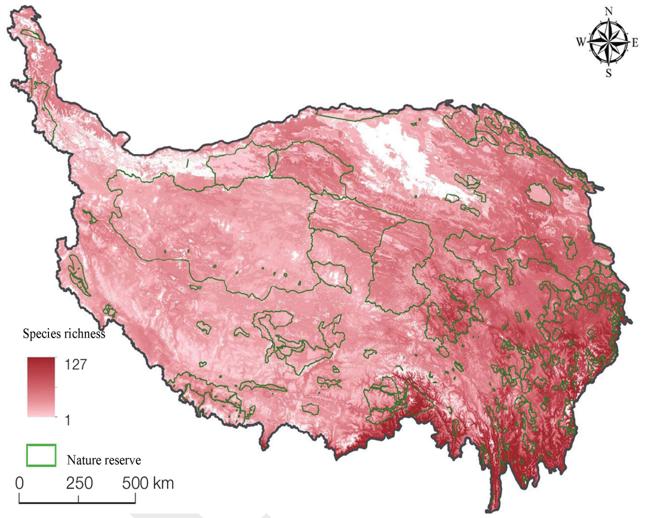

Figure 5 Spatial distribution of richness of wildlife under special protection and distribution of natural reserves in Qinghai-Tibet Plateau

(2) Optimizing the spatial scope of individual natural reserves on a typical regional scale. It is suggested to integrate the survey data of biodiversity systems collected during the second scientific expedition and the data of the distribution of protected areas, to optimize the scope of PAs and improve the protection efficiency. Taking Gaoligong Mountain located at the intersection of India-Myanmar and Eastern Himalayas global biodiversity hotspots as an example, after the northern section of Gaoligong Mountain in Yunnan Province was added to the Gaoligong Mountain National Nature Reserve (middle section of Gaoligong Mountain in Yunnan, 1 254 km^2) in 2000, the area was increased to 4 052 km^2, and 4 897 higher-level plants and 699 vertebrates ① were recorded. In 2021, the Gaoligong Mountain National Park was planned to be established, which will expand the scope of protection and connect the fragmented protected areas as a whole. The optimization of PAs has improved the biodiversity conservation capacity and the role of the first ecological security barrier in Southwest China.

① Data source: *Qinghai Statistical Yearbook* (1981–2020) and *Tibet Autonomous Region Statistical Yearbook* (1981–2020).

3.2 Establishing a natural PA system with national parks as its mainstay

(1) Establishing a national park group in the Qinghai-Tibet Plateau. It is suggested to establish a national park group led by 2 transnational national parks and 8 flagship national parks, and composed of 11 general national parks (Figure 6), including Qomolangma, Pamirs, Holy Mountains and Lakes, Yarlung Zangbo Grand Canyon, Siling Co-Pruo Gangri, Source of Yangtze River, Source of Yellow River, Source of Lancang River, Qilian Mountains, Giant Panda, Daocheng Yading, Dulong River-Gaoligong Mountain, Gongga Mountain, Qinghai Lake, Kunlun Mountain, Ruoergai, Water Yadan, West Tianshan, Shangri-La, Zhada Tulin and Zhari Shenshan national parks, so as to promote ecological protection and high-quality development of Qinghai-Tibet Plateau.

(2) Taking the lead in exploring the construction of transnational parks. The Qinghai-Tibet Plateau has a long border, along which, the neighboring countries have deployed PAs with national parks as the focus. The construction of national parks has a hidden supporting role for national border security, national ecological protection cooperation, and income generation and wealth of border residents. For example, Nepal has constructed Sagarmatha National Park on the southern slope of Qomolangma, and cultivated high-end eco-tourism products such as mountaineering and hiking, promoting the economic development of the community [20]. For another example, Pakistan has also established a national park in the Pamirs, as an important border education and tourism base [21]. In the reform of the national park system, China did not plan to construct transnational national parks; based on the demand for the construction of the "Belt and Road" and stabilizing the borders, it is suggested to plan ahead and explore the establishment of transnational parks in the Qinghai-Tibet Plateau.

3.3 Accelerating the implementation of the protection and restoration project of the Qinghai-Tibet Plateau ecological security barrier

(1) Systemically deploying ecological protection and restoration projects. As guided by the *Overall Planning of National Major Ecosystem Protection and Restoration Projects* (2021–2035), giving priority to the protection and focusing on natural restoration, we should integrate the key areas of ecological barrier functions, ecological problem areas, climate change impacts and future ecological risks. According to the conditions and main problems in each region, we can systemically deploy ecological protection and restoration projects and propose practicable measures conforming to the ecological principles.

(2) Promoting the construction of ecological civilization highlands in different regions. We should stick to the high-quality development path that gives priority to ecological protection and focuses on green development, taking full consideration of the ecological linkages among mountains, rivers, forests, fields, lakes, grasses, sand and ice and taking the protection and restoration of the ecological safety barrier as an important task for the construction of ecological civilization highlands. Ecological civilization pilot zones could be constructed in different regions; in addition, the ecological civilization construction should be unified with economic construction, political construction, cultural construction, and social construction in planning and operation. For example, the Tibet Autonomous Region implemented the Regulations on the Construction of National Ecological Civilization Highlands in the Tibet Autonomous Region in May 2021, and Qinghai Province implemented the Action Plan of Accelerating the Development of the Qinghai-Tibet Plateau into a National and Even International Ecological Civilization Highland in August 2021, to implement the systematic project of constructing Qinghai-Tibet Plateau ecological security barrier by levels.

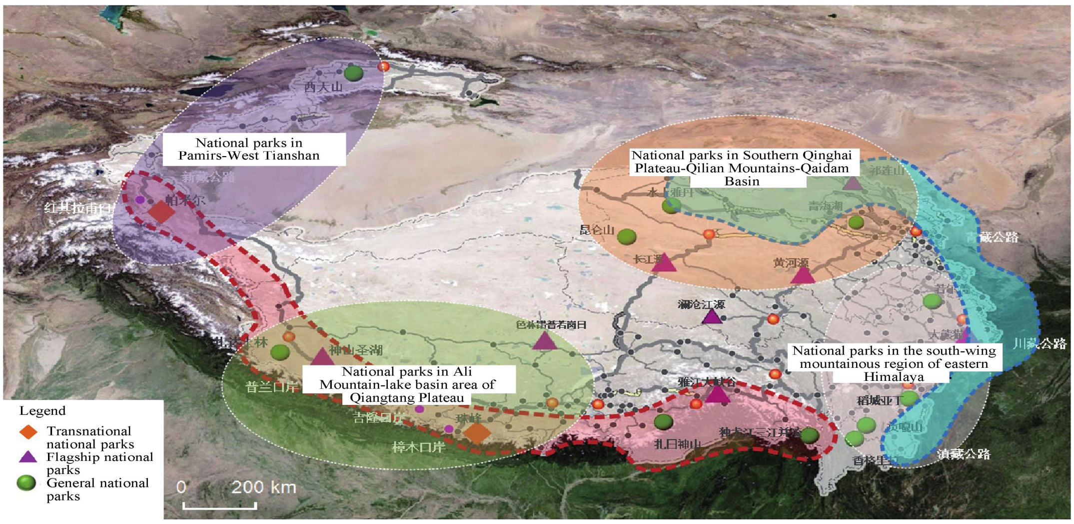

Figure 6 Spatial layout of national park group in Qinghai-Tibet Plateau

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