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Evaluation of Prioritized Natural Landscape Conservation Areas for National Park Planning in China

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Abstract: Protecting representative natural ecosystems, rich biodiversity, and unique natural landscapes are the main considerations in China's national park planning. Here, we mapped the distribution of China's natural landscapes and evaluated their protection values for national park planning and construction. Grading evaluation methods combining standard comparison, inventory method, and expert consultation were used, and four levels of natural landscapes were identified. Furthermore, priority areas for national parks establishment were also proposed. Of all the landscapes evaluated, 76 were extremely important, 481 were important, 2070 were moderately important, and 1213 were slightly important. A total number of 67 priority areas for natural landscapes were identified with a total area of 1,218,000 km². They comprised land and sea areas of 1,148,000 and 69,000 km², respectively. We suggest strengthening natural landscape protection by establishing natural parks in priority areas. Our study will contribute to the effective protection of natural landscapes in China.

Keywords: natural landscape; national park; evaluation; prioritized protected area

1. Introduction

“Establishment of protected area system with national parks as an essential part” is currently an important concept in the nature protection declaration in China [1]. National parks constitute the most important element in nature protection as they represent high-priority natural ecosystems, natural landscapes, natural heritage sites, and biodiversity [1,2]. The uniqueness and protection priority of natural landscapes are consequently important criteria for establishing national parks in China.

The International Union for Conservation of Nature (IUCN) defines national parks as “large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities” [3]. Consequently, according to the conditions of China's natural resources and the requirements for declaring national parks, China's national parks include strictly protected and managed areas designated to conserve the authenticity and integrity of natural ecosystems, landscapes, and habitats of rare and endangered animals and plants that are representative of the

country [4]. They constitute the most important aspects of China's natural ecosystems, the most unique natural landscapes, and its natural heritage and rich biodiversity. National parks have global value and are recognizable national symbols [2].

Generally, countries should consider the characteristics of natural landscapes and formulate corresponding evaluation criteria to select locations where national parks can be established. In the United States, national parks must be of national significance and constitute regions of rare yet typical natural landscapes or biological relics. They must also be places with outstanding natural sceneries, such as peculiar geomorphic features or sharp contrasts between these features and vegetation, magnificent views, or other special landscape features [5,6]. Japan's national parks contain beautiful landscapes that are representative of the country, comprising at least two different landscape elements representing diverse sceneries [7]. National parks in South Africa encompass an important variety of national and global biodiversity. They are examples of (or contain representatives of) South African natural systems, scenic areas, or cultural heritage sites [8]. Australian national parks protect scenic areas of national and global significance for the purposes of spirituality, science, education, recreation, and tourism [9], and British national parks advocate the integration of natural and rural landscapes [10]. Although China has not defined criteria for the establishment of national parks, the assessment criteria for existing protected areas mostly involve natural landscapes, including nature reserves, scenic areas, and forest, wetland, geological, and desert parks.

Natural landscape assessment is mainly approached from natural landscape aesthetic value, which is evaluated by perception methods, and the major impetus for systematic analyses and studies of landscape beauty occurred during the decade of the 1960s and the early 1970s [11]. Assessing landscape value levels from a visual perspective [12,13] and visual landscape assessment and management are used to classify and evaluate landscape visual resources through intuitive structures and easy-to-observe natural landscape conditions [14,15]; an expert approach and a perception-based approach that contains various survey-research and psychological scaling methods are applied to obtain quantitative measures of perceived landscape aesthetic quality [16]. The scenic beauty estimation (SBE) method is a psychophysical method developed by the US Forestry Department [17]. The SBE method estimates scenic beauty judgements for various natural scenes, taking photographs or slides as the evaluation medium to develop a beauty scale that reflects the beauty of each landscape by scoring [18,19]. Currently and more generally, landscape and aesthetics show a scientific perspective [20]. Technical methods, such as remote sensing and geographic information system (GIS) are used to analyze natural landscape quality and aesthetic value from a land-use perspective [21,22]. However, these methods mainly focus on small-scale, specific natural landscapes, and there is a lack of a system for assessing national natural landscapes.

There are huge numbers of precious natural landscapes in China. Many of them are important parts of heritages and protected areas in the world, including 55 world heritages, 34 world biosphere reserves, and 39 world geoparks. However, many of them have been threatened or even destroyed by human activities such as urban and rural construction, tourism, mining, and logging. Under this background, we aimed to determine the spatial distribution of natural landscapes, their protected values, and propose suggestions for their protection by establishing national parks. Specific objectives included understanding the general status of natural landscapes in China, establishing criteria to evaluate the classes of natural landscape areas, identifying priority areas for natural landscape conservation areas, and finally proposing suggestions for the establishment of national parks and other types of protected areas. Our study will contribute to the reasonable and effective protection of natural landscapes in China, maintaining natural heritage for humans and the whole world. Our study also provides a valuable example for the identification of areas for natural landscape protection in other places around the world.

2. Materials and Methods

2.1. Natural Landscape Data Sources

Based on the requirements for declaring national parks in China, we proposed that natural landscapes designated for the establishment of national parks should contain one or more natural feature. They included geological landforms, rivers, lakes, wetlands, wildlife, and other elements of scenic beauty with high aesthetic and scientific values. Under the premise of strict protection, such areas can be used for scientific research, education, tourism, and other activities. These landscapes have features of both authenticity and protected value. Considering that the majority of the natural landscapes were included in existing protected areas, the existing protected areas collected from different government departments were the major sources for landscape evaluation. They included world heritage areas, world geoparks, Ramsar wetlands of international importance, nature reserves, scenic areas, geoparks, forest parks, desert parks, wetland parks, and ocean parks. In addition, supplemental data outside the protected areas were obtained from *China National Geography*, *China Heritage Sites*, *China Domestic Travel*, *China View* and other books, magazines, and websites related to geography, tourism, and sceneries. These areas met two criteria: a large-scale natural area with aesthetic or scientific value, and unique landscape characteristics. A total of 3840 natural landscapes were selected, including 3758 from protected areas, and 82 from the literature. The data basically covered the major natural landscapes across the entire mainland of China, which was the scope of this research. For each item of landscape data, we collected basic attributes including names, protected targets, area, landscape features, locations, scopes, or boundaries to be used in further analysis.

Based on the collected information and related criteria we divided the natural landscapes into four types (i.e., terrestrial, hydrological, biological, and meteorological landscapes) and 17 contents (Table 1). These criteria are “Scenic Spot Planning Rules” [23], “Touristic Resources Classification, Investigation and Evaluation” [24], and “China Forest Park landscape resources grade evaluation” [25].

Table 1. Natural landscape classification for China.

Landscape type	Content (Examples)
Terrestrial	Mountains (Tai Mountain), deserts (Alashan Desert), canyons (Yarlung Zangbo River Grand Canyon), Danxia landform (Danxia Mountain), Karst (Lijiang River landscape), geological relics (Jixian geological relics), coasts and islands (Weizhou Island), volcanoes (Wudalianchi volcanic group)
Hydrological	River wetlands (Yunnan Three Parallel Rivers), lake wetlands (Qinghai Lake), waterfalls (Huangguosuo Waterfall), marsh wetlands (Ruoergai Wetlands)
Biological	Forests (<i>Larix gmelinii</i> , Greater Khingan Mountains), grassland meadows (Hulun Buir Grassland), rare animal and plant habitats (Wolong giant panda habitat)
Meteorological	Sun, moon, and stars (Mount Emei Buddha Light), clouds and snow (Huangshan Sea of Clouds)

2.2. Natural Landscape Evaluation Criteria

We developed assessment criteria for natural landscapes with reference to guidelines and assessment criteria of different protected areas in China and other countries, such as “Guide to World Heritage Sites” [26], “World Geopark Network Guidelines and Standards” [27], and “China Recommended Appraisal Procedures and Standards of World Geoparks” [28]. More detailed guidelines can be found in the references [29–34]. Five indicators included typicality, aesthetics, authenticity, integrity, and historical and cultural values were considered in these criteria, and each

indicator was divided into four classes (i.e., extremely important, important, moderately important, and slightly important) (Table 2).

Table 2. Natural landscape evaluation criteria for China.

Typicality	<ul style="list-style-type: none"> • Extremely important: Outstanding in the same type of natural landscape, rare in the world, with global significance. • Important: Representative within the same type of natural landscape, unique to China, with national significance. • Moderately important: Representative within the same type of domestic natural landscapes, with provincial significance. • Slightly important: Representative within low-level natural landscapes, with no outstanding characteristics, with regional significance.
Aesthetics	<ul style="list-style-type: none"> • Extremely important: Extremely unique and outstanding natural scenery, very high aesthetic value, and global tourism attraction. • Important: Unique and outstanding natural scenery, high aesthetic value, and national tourism attraction. • Moderately important: Unique natural scenery, high aesthetic value, and provincial tourism attraction. • Slightly important: Natural scenery with some aesthetic value and tourist attraction.
Authenticity	<ul style="list-style-type: none"> • Extremely important: Ecosystem is in its original state, with a high proportion of natural habitats and little disturbance from human activities. • Important: Ecosystem is in its primary or quasi-primary state, with a high proportion of natural habitats, virtually in its natural state, with little disturbance from human activities. • Moderately important: High proportion of natural habitats and little disturbance from human activities. • Slightly important: Relatively low proportion of natural habitats, with some disturbance from human activity.
Integrity	<ul style="list-style-type: none"> • Extremely important: Compared with similar natural landscapes, completely well-preserved, and the area is large enough to fully protect the natural landscapes. • Important: Compared with similar natural landscapes, well-preserved, and the area is large enough to fully protect the natural landscapes. • Moderately important: Compared with similar natural landscapes, well-preserved for the most part, and the area is relatively large and can basically protect the natural landscapes. • Slightly important: Compared with similar natural landscapes, preserved for part of the landscapes, and the area is relatively small but can hardly protect the natural landscapes.
Historical and cultural values	<ul style="list-style-type: none"> • Extremely important: with extremely rich historical and cultural resources that reflect religious culture, important historical events, national identity, and traditional national culture. • Important: with rich historical and cultural resources that reflect the development of human society at a specific historical stage or the characteristics of national folk customs. • Moderately important: with general historical and cultural resources that reflect certain characteristics of the history development or national traditional culture. • Slightly important: with few historical or cultural resources.

2.3. Grading of Natural Landscapes

Considering the large number of natural landscapes and the lack of detailed information for many non-famous natural landscapes, we adopted a grading evaluation method. Simple and objective methods were used in the evaluation of low-level landscapes, and complex and subjective expert consultation was used for high-level landscapes. The grading evaluation had three phases as shown in Figure 1.

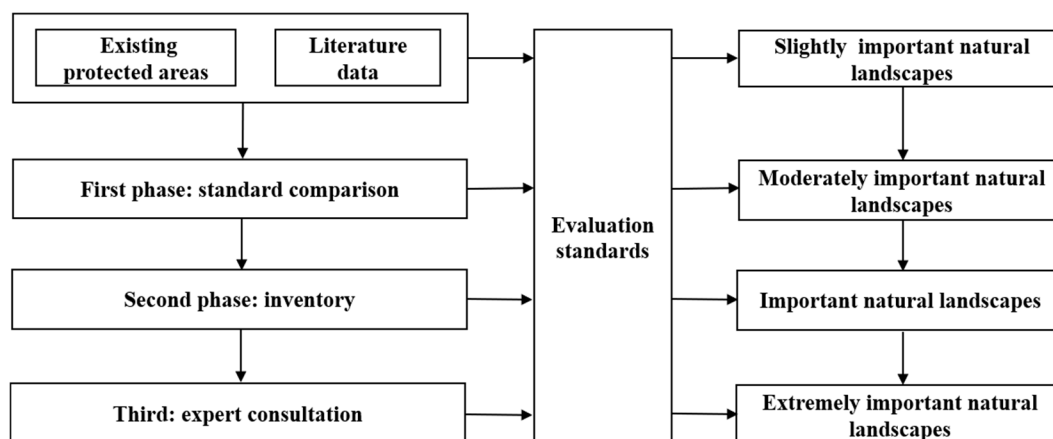


Figure 1. Grading evaluation process for natural landscapes in China. According to the evaluation criteria, natural landscapes were evaluated and selected from a low to a high level, using existing protected areas and literature data as the main landscape sources. We separated moderately important natural landscapes and level above from slightly important natural landscapes according to the standard comparison method, separated important natural landscapes and level above from moderately important natural landscapes according to the inventory method, and separated extremely important natural landscapes from important natural landscapes according to the expert consultation method.

In the first phase, we used the standard comparison method to select landscapes of a moderately important level or above. If natural landscapes were in an existing protected area, we compared its related protected area standard [23–34] with the requirements of the natural landscape standard (Table 2). If the natural landscape area was not a protected area, we compared information from the literature with the natural landscape standards. In this phase, slightly important landscapes were eliminated and the others remained for the second phase.

In the second phase, we used the inventory method to select landscapes of an important level or above. All attributes including names, protection targets, protection levels, locations, types, and landscape characteristics were used. Moderately important landscapes were eliminated and the others remained for the third phase in accordance with the natural landscape evaluation criteria.

In the third phase, we utilized the expert consultation method to select extremely important landscapes. An expert evaluation indexes system was established (Table 3), which contained national representativeness, authenticity, integrity, historical and cultural value, and other necessary conditions for national park constructions, the importance of ecological location, urgency, feasibility, and noninterference [4]. In this phase, important landscapes were eliminated and extremely important landscapes were selected.

Table 3. Expert evaluation indexing system for extremely important natural landscapes in China.

Index	Element
National representativeness	Uniqueness of natural landscape, national and international importance or special significance
	Representativeness of ecosystems in ecological regions, richness in flora and fauna
Authenticity	Proportion of natural habitats and conservation of natural status
Integrity	Size of area, full protection of key ecological processes or natural landscapes, and long-term survival of representative species
Ecological location importance	Important ecological shelters in national or regional level
Historical and cultural values	Ethnic representativeness and influence
Urgency	Protection urgency
Feasibility	Clear ownership and management rights of natural resource and assets, traffic accessibility
Non-interference	Sensitivity towards exploitation and utilization of natural resources and other human activities

2.4. Boundary Determination of Priority Areas for Natural Landscape Protection

Three principles were considered in the determination of the boundaries of priority areas for natural landscape protection. First, priority areas should contain the extremely important natural landscapes, integrated with adjacent areas with the same type of natural landscape. This ensured the integrity of the natural landscapes. Second, the boundaries of protected areas containing natural landscapes can be used, especially those of nature reserves. Third, the boundaries were demarcated according to natural geographical boundaries, such as ecosystems, vegetation, landforms, and rivers.

3. Results

3.1. Grading of Natural Landscapes

A total of 3840 natural landscapes were comprehensively evaluated. Of them, 76 were extremely important landscapes, 481 were important landscapes, 2070 were moderately important landscapes, and 1213 were slightly important landscapes (Figure 2, Table 4). The extremely important natural landscapes were located in the great mountains, rivers, and lakes with high levels of representative, authenticity, and integrity. The slightly important natural landscapes were places for public leisure and recreation with aesthetics and tourist attraction, and strong accessibility with a relatively small area and moderate authenticity.

There were more natural landscapes in eastern and central China, and the majority were at moderately and slightly important levels with relatively low value, small area, and good accessibility. On the contrary, there were fewer natural landscapes in western China (including northwestern and southwestern regions) with high proportions of extremely important and important natural landscapes. Many landscape areas were large wilderness areas with high authenticity and integrity.

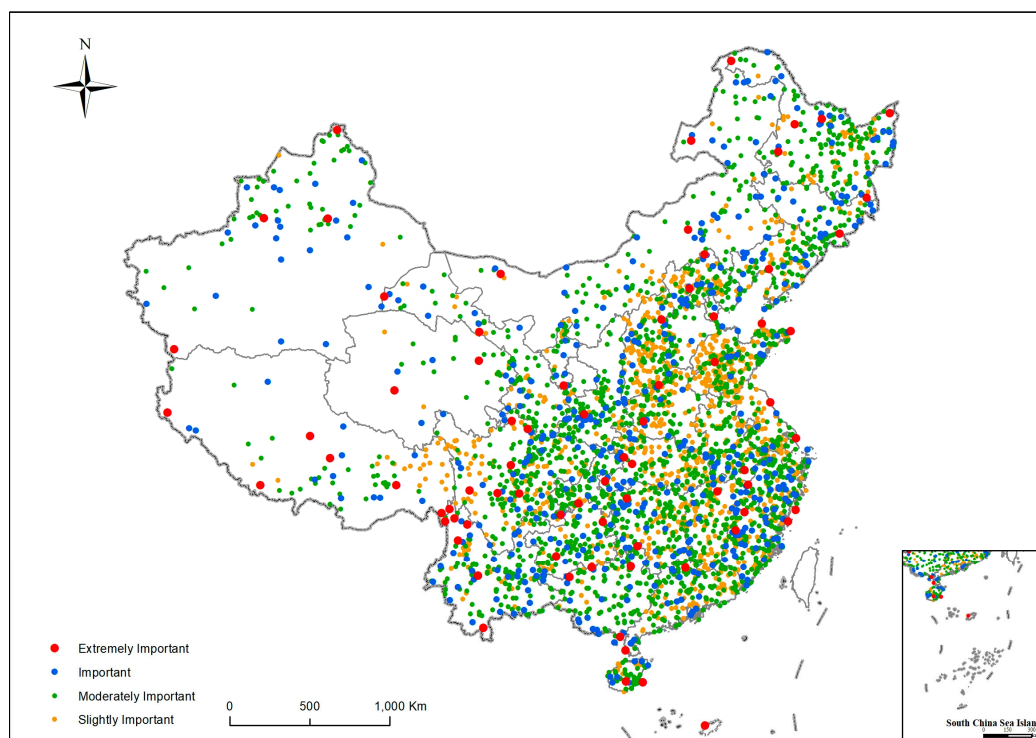


Figure 2. Natural landscape grading distribution across China.

Table 4. Natural landscape grading distribution by region in China.

	Extremely Important	Important	Moderately Important	Slightly Important
Northeastern	10	78	281	102
Eastern coast	15	94	507	450
Central	16	130	590	422
Southwestern	24	97	418	175
Northwestern	11	82	274	64

3.2. Natural Landscape Types and Distribution

Due to the relatively low representation of moderately and slightly natural landscape, extremely important and important natural landscapes were selected for classification. Of 254 terrestrial landscapes, 92 were hydrological landscapes, 211 were biological landscapes, and 66 were meteorological landscapes (note that meteorological and the other landscape types overlapped) (Figure 3).

Terrestrial landscapes mainly included mountains, deserts, canyons, Danxia landforms, karsts, volcanoes, natural relics, coasts, and islands. Of them, mountain landscapes were mainly distributed along China's main mountain ranges, desert landscapes were mainly in arid and semi-arid areas in northwestern China, and canyon landscapes were mainly along large mountains and rivers. Danxia landscapes were mainly distributed along the southeastern coast, central-southern China, parts of northwestern China, karst landscapes in Guangxi, Guizhou, Yunnan, and Chongqing in southwestern China, and volcanic landscapes mainly in Heilongjiang, Jilin, Yunnan, and Hainan. Besides, two types of natural relic landscapes (i.e., geological and paleontological relics) were relatively scattered, and coasts and islands were distributed along China's southeastern coastal areas.

Hydrological landscapes mainly included river, lake, and marsh wetlands, and waterfalls. Of them, river and lake wetland landscapes were distributed along China's main water systems, coastal shoal landscapes along the eastern coast, and forest swamp wetland landscapes were mainly within the Greater and Lesser Khingan areas in northeastern China. In addition, volcanic lake landscapes were mainly distributed in Heilongjiang and Jilin in northeastern China, wetland desert oasis

landscapes in northwestern China, alpine meadow wetland landscapes in southwestern China, salt lake landscapes mainly in the Qinghai–Tibet Plateau, and waterfall landscapes were distributed in the karst area in southwestern China.

Biological landscapes mainly included forests, grasslands, meadows, and rare animal and plant habitats. Among them, forest landscapes were mainly representative forest ecosystems in northeastern and southern China, and grassland and meadow landscapes were mainly distributed in Inner Mongolia, the Qinghai–Tibet Plateau, and the Tianshan hinterland, among other areas. In addition, rare animal and plant habitats were mainly distributed in the central Qinling Mountains, Qinghai–Tibet Plateau, plains along the central and lower reaches of the Yangtze River, and northeastern China.

Meteorological landscapes mainly included the sun, moon, stars, clouds, mist, ice, and snow. Of them, sun, moon, and star landscapes mainly included sunrise and sunset (in Tai Mountain), Buddha light (in Mount Emei), aurora (in Greater Khingan Mountains), and starlight (in Bosten Lake) landscapes. Besides, cloud, mist, ice, and snow landscapes mainly included cloud–mist and snow–ice landscapes, such as the Huangshan Sea of Clouds, Lushan Waterfall, and Great Khingan Mountains Arctic Village snow and ice landscape.

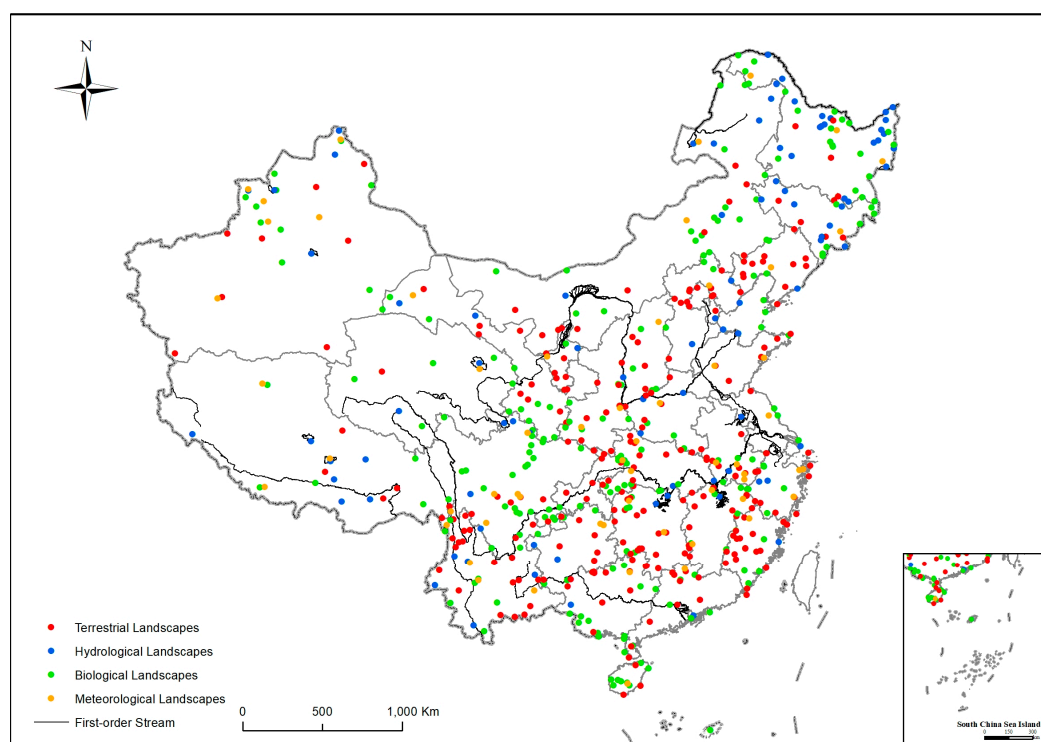


Figure 3. Distribution of important natural landscapes and levels above in China..

3.3. Priority Areas for Natural Landscape Conservation

A total of 67 prioritized areas for natural landscape conservation were identified. Prioritized areas covered a relatively large area in western China, and small areas in eastern and central China (Figure 4). The southwestern region was dominated by mountains, animal and plant habitats, plateau lakes, marsh wetlands, and canyons, including the Qomolangma, giant panda habitats, Qinghai Lake, Zoige Wetland, and Three Parallel Rivers Area. Northwestern China was dominated by mountains and deserts, including the Tianshan Mountain, Qilian Mountain, Kumutag Desert, and Alashan Desert. Northeastern China was mainly comprised of mountain, forest, grassland, and wetland landscapes, including the Changbai Mountain, Greater Khingan Mountain virgin forest, Hulun Buir Grassland, and Lesser Khingan Mountain swamp wetland. Central and eastern China were dominated by mountains, wetlands, karst, Danxia landform, and other unique landforms, including

Shennongjia, Poyang Lake, northern Jiangsu coastal wetland, Lijiang River landscape in Guilin, and Wuyi Mountain.

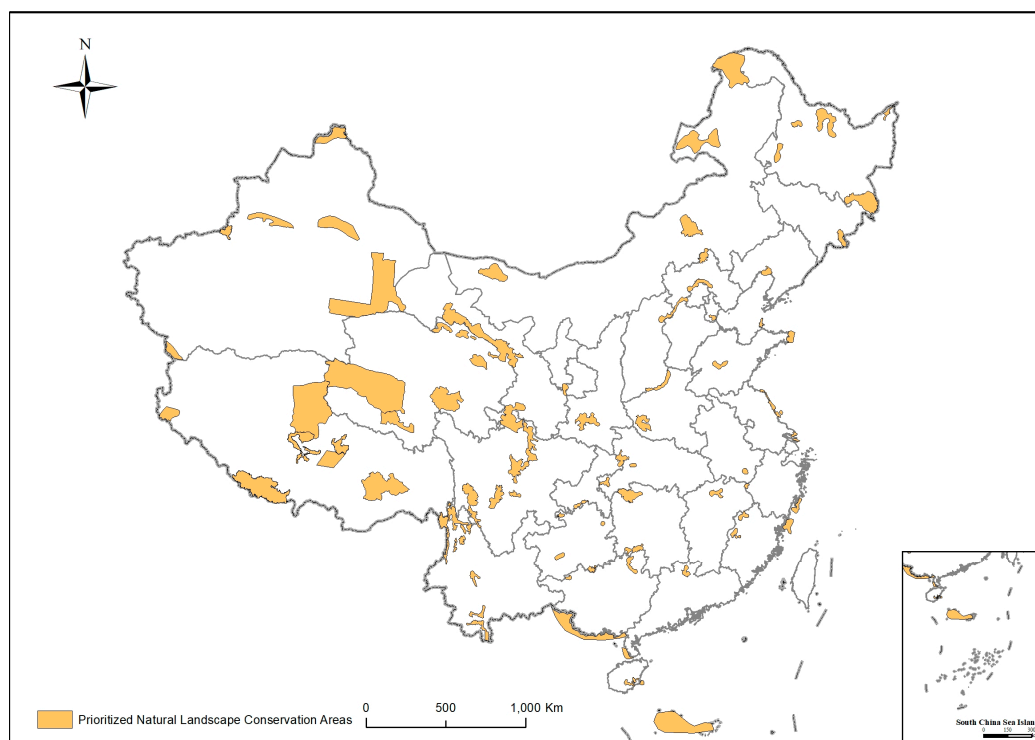


Figure 4. Prioritized natural landscape conservation areas in China. With extremely important natural landscapes as the basis, surrounding natural landscapes of the same type were integrated and boundaries of natural landscape protection prioritized area were delimited.

3.4. Conservation Efficiency of Priority Areas for Natural Landscape Conservation

Priority areas for natural landscape conservation covered an area of 1,233,000 km², with a land area of 1,162,000 km², accounting for 12.1% of the total national land surface. The priority areas covered a sea area of 71,000 km², accounting for 1.5% of the nation's territorial waters. These areas contained all of the extremely important landscapes and 94 (i.e., 20%) of the important natural landscapes. They also covered 178 moderately important and 48 slightly important natural landscapes. Generally, the priority areas achieved a high degree of protection of nationally representative natural landscapes in China.

4. Discussion

For the first time, we evaluated the status of natural landscapes in China and identified priority areas for conservation. We found that natural landscapes in western China had a lower density, covered a larger area, and had a higher proportion of extremely important landscapes compared to those in central and eastern China (Table 5). Similarly, priority areas in western China were also larger (on average 851,000 km²) than in central China (on average 112,000 km²) or eastern China (on average 270,000 km²). These might be an intergraded reason of natural condition and human disturbance. Western China is an ecologically fragile area, with very high elevation and arid areas. The region has large areas of wilderness and very low human population density. Natural landscapes in this region are large mountains, deserts, grassland or habitats for large mammals, with a very high level of integrity. Priority areas such as Hoh Xil and Qiangtang Plateau have large areas. On the contrary, the natural environments in central and eastern China were more suitable for human habitation, with higher population density and larger scales of urbanization and transportation construction. After a long period of development, the remaining natural landscapes had a low level of integrity and a small area. Therefore, for the large surface area and fragile ecological environment

in western China, large-scale human activities including illegal entering, tourism development, grazing, hunting, fishing, and logging should be restricted in the priority areas. Within the priority areas in central and eastern China, measures should be taken to protect the authenticity and integrity of natural landscapes, and strengthen regional comprehensive conservation and management.

Table 5. Proportions of natural landscape grading distribution by region.

	Extremely Important (%)	Important (%)	Moderately Important (%)	Slightly Important (%)
Western China	3.06	15.63	60.44	20.87
Central China	1.38	11.23	50.95	36.44
Eastern China	1.63	11.19	51.27	35.91

We used diversified methods to evaluate natural landscapes in China. Most existing evaluations of natural landscapes were for small-scale areas, and were used in urban or rural planning, landscape planning, and ecological planning [13–15,21,22]. Both perception and technical approaches have been used frequently. Perception approaches, like visual landscape assessment and the scenic beauty estimation method, were from a subjective perception to evaluate the aesthetic value and uniqueness of natural landscapes and scenery. Technical approaches such as remote sensing and GIS were from an objective perception to evaluate landscape integrity, authenticity, and quality. However, the aims of this study focused on natural landscape conservation by evaluating the aesthetics, integrity, uniqueness, and authenticity of natural landscapes on a national scale. It was difficult to meet these needs using these two methods. Therefore, based on previous standards and evaluations of protected natural landscapes, grading evaluation methods combining standards comparison, inventory, and expert consultation were adopted. This allowed for the final identification of priority areas for natural landscape conservation. The research methods improved on traditional evaluation methods and explored the values of natural landscapes based on existing research resources.

Our study will contribute to achieving effective protection of natural landscapes in the face of the new protected areas system [35]. In terms of the landscape construction requirements of the new protected area system, national parks mainly protect nationally representative natural landscapes, nature reserves mainly protect natural landscape areas of special significance, and nature parks mainly protect important natural landscapes with aesthetic value [1]. Based on the level classification of natural landscapes, we suggest that extremely important natural landscapes should be candidate areas for national parks. Important and some moderately important natural landscapes with high comprehensive values should be candidate areas for nature reserves. The remaining moderately important and slightly important landscapes should be candidate areas for natural parks.

5. Conclusions

From a macro perspective, natural landscapes on a national scale were evaluated for the first time in this study, by obtaining priority natural landscape characteristics, determining the spatial distribution of valuable natural landscapes, and proposing priority areas for national parks. Three main conclusions were reached. First, we graded natural landscapes into four levels depending on their typicality, aesthetics, authenticity, integrity, and historical and cultural values. Of the four levels of landscapes, 76 were extremely important, 481 were important, 2070 were moderately important, and 1213 were slightly important. Second, the numbers of natural landscapes in eastern and central China were higher than in western China, however, the average area was much lower in western China. Third, a total of 67 priority conservation areas were identified, which were mainly distributed in western China. They covered a total area of 1,233,000 km² which comprised land and sea areas of 1,162,000 km² and 71,000 km², protecting a high degree of representative national natural landscapes.

The purpose of this research was to recognize the value and distribution of natural landscapes by evaluation, and propose candidate areas for national parks. However, several limitations might exist. Firstly, natural landscape data was incomplete, and some precious natural landscapes might not be covered in the existing protected areas and literature in this study. Secondly, the methods require improved accuracy and objectivity. Thirdly, the boundaries of priority areas should be adjusted for the establishment of natural parks or other types of protected areas. In the future, solutions to these problems need to be identified, and more efficient and reasonable protection measures of natural landscapes is required by the establishment of national parks, nature reserves, and nature parks.

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