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Article

Analysis of the Network of Protected Areas in China Based on a Geographic Perspective: Current Status, Issues and Integration

Mengtian Cao [1,2], Li Peng [1,*] and Shaoquan Liu [1]

[1] Institute of Mountain Hazards and Environment, Chinese Academy of Sciences and Ministry of Water Conservancy, #9, Block 4, Renminnan Road, Chengdu 610041, China; E-Mails: Caomengtian@imde.ac.cn (M.C.); liushq@imde.ac.cn (S.L.)

[2] University of Chinese Academy of Sciences, No. 19A Yuquan Road, Beijing 100049, China

* Author to whom correspondence should be addressed; E-Mail: pengli@imde.ac.cn; Tel.: +86-28-8535-0278. Fax: +86-10-8523-7364.

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Abstract: With the continued growth of protected areas (PAs) in China in terms of the number, coverage and varieties of protected objects, how to efficiently manage the protected areas to ensure both resource protection and environmental protection has become a crucial research question. By applying a geographic perspective in an analysis of the development and evolution of protected areas in China, this paper presents the results of an analysis focused on the status and the types of current approaches to the management of natural protected areas to reveal the problems that exist in their management and to further explore an integration strategy for the protected area network. It proposes that the future management of protected areas should prioritize their legal status, the sustainable livelihood of individuals living in close proximity to them, and the establishment of a unified database to achieve grid and information management of the protected areas.

Keywords: protected area; geographic perspective; current status; issues; integration; biodiversity

1. Introduction

At present, the global biosphere is suffering from severe impacts imposed by the most extensive extinction of species since the Cenozoic era, making the loss of biodiversity one of the most important

environmental problems facing the world [1,2]. This problem is primarily attributable to environmental changes and the fragmentation of wildlife habitat resulting from human activities [3]. Over the past 50 years, natural resources on Earth have provided approximately 15 trillion pounds of natural products, such as fresh water, clean air and fish. However, human activities have destroyed approximately 2/3 of the environment that supports these resources, including rivers, forests and coastlines, resulting in, for example, regional climate change and natural disasters. In addition, approximately 60% of ecosystem services, such as drinking water and fishing, is unsustainable and is steadily deteriorating. Moreover, the pace at which wild species are becoming extinct has surpassed the background rate by 100–1000 times, presenting an extremely severe and serious situation for ecological protection [4].

In 1872, the U.S. established Yellowstone National Park, which was the world's first natural protected area, which marked the beginning of the construction of the modern PA. Since then, other countries in North America, Australia and Oceania Australia and Africa established their first PA [5]. The International Union for Conservation of Nature (IUCN) has defined PAs as a geographic space with a clear boundary that is acknowledged by the nation or related organizations (institutions or individuals), restrained by the law or other regulatory documents, and has natural, ecological or cultural value that can be preserved for a long time [6].

In accordance with the primary target and management method, the IUCN has classified PAs into six categories, including Strict Nature Reserve/Wilderness Areas, National Parks, Natural Monuments or Features, Habitat/Species Management Areas, Landscape/Seascape PAs and PAs with Sustainable Use of Natural Resources. This classification standard has been adopted by many countries and is also used as the standard classification for consolidating statistics on PAs by the UN National Park and Nature Reserves program [7].

Since the signing of the Convention on Biological Diversity (CBD) in 1992, multiple national governments around the world have agreed that the creation of natural PAs is a powerful method to cope with the destruction of biological diversity and ensure the restoration of the fragile ecological system and the sustainable utilization of natural resources [8,9]. At the end of 2007, the total number of PAs around the world exceeded 110,000, with the continental PAs surpassing 22 million km^2, which represents 14.72% of the total continental area [10]. The 2014 edition of the United Nations List of PAs reflects the significant progress made in the expansion of PA networks from only 9214 sites in 1962 to over 209,000 in 2014. The document also represents the considerable political commitment made by countries to this global conservation priority [11].

China's biological diversity is among the most abundant in the world. The country is home to 34,984 types of higher plants (ranking third in the world), 6445 types of vertebrates (the country ranks 13th in the world in this regard, with 7% of the world's total), and 10,000 identified species of fungus, (14% of the world's total) [12]. However, due to population expansion, development, an accelerated industrialization process, and climate change as well as the invasion of alien species and other factors, biological diversity in China has encountered severe threats [13–15]. To protect its ecology, China's government has created a number of PAs of various types in recent years, which has improved the environment to some extent. However, the effects of the PAs are not simply manifested in the increase in the number and coverage of protected species but also in the comprehensive evaluation of whether the particular distribution and types of PAs have formed an efficient network and whether they are

essentially protective when considering coverage ratios, protection efficiencies, management effects, detailed surveillance and other aspects [16,17].

To date, many countries and international organizations have already studied the improvements in PA networks and management methods. Based on the World Commission on Protected Areas (WCPA) in the IUCN framework for assessing the management effectiveness of PAs and PA systems, specific assessment methodologies have been developed and implemented in many countries according to their own situations. The assessment methodologies can generally be categorized into four types, including in-depth evidence-based assessments, comprehensive system-wide peer-based assessments, rapid expert-based scorecards, and categorical assumption-based assessments [18]. In terms of PAs' ecological compensation, countries such as the US and Sri Lanka have examined the willingness to pay for ecological restoration and environment protection through surveys to increase the use of related projects, make up for the inadequacy of government investment, and improve the level of public participation and governmental decision-making [19–21]. However, given the unsound network layout of PAs in China and the insufficient research to date on rational distribution, effective management, the representativeness of protection and other aspects [22,23], this paper reveals the major problems encountered by the current system of natural PAs in China from a geographic perspective by basing the analysis on the evolving pattern of PAs with the aim of developing a strategy for the integration of PAs into a network.

2. Development of Protected Areas in China

2.1. Types and Development of Protected Areas in China

At present, PAs in China include nature reserves, world natural and cultural heritage sites, scenic zones, wetland parks, forest parks, geological parks, and water conservancy scenic locations, of which nature reserves account for the largest area and have the greatest potential to influence environmental outcomes (Figure 1). In 1956, Dinghu Mountain in Zhaoqing, Guangdong province, was established as the first nature reserve; 19 additional reserves covering 694,000 hm^2, representing 0.07% of the national territory, were created between 1956 and 1966 [24]. Thereafter, the rate at which new nature reserves were created was moderate and included smaller areas that only protected forests or animals. During the period from 1966 to 1978, the construction of nature reserves nearly ceased, but since 1996, the number and coverage of nature reserves began to grow exponentially [25]. In 2007, the total coverage of nature reserves reached its peak at 151.88 million·hm^2 before beginning to decline at an increasing rate. At the end of 2012, 2669 nature reserves were established with a total coverage of 149.787 million·hm^2, occupying 14.94% of the national territory, among which national nature reserves totaled 363, with a coverage of 94.1456 million·hm^2. China has formed a large-scale network of nature reserves, applying effective protection for 90% of terrestrial ecosystem types, 85% of wildlife species and 65% of the habitats for higher plant communities [23,26].

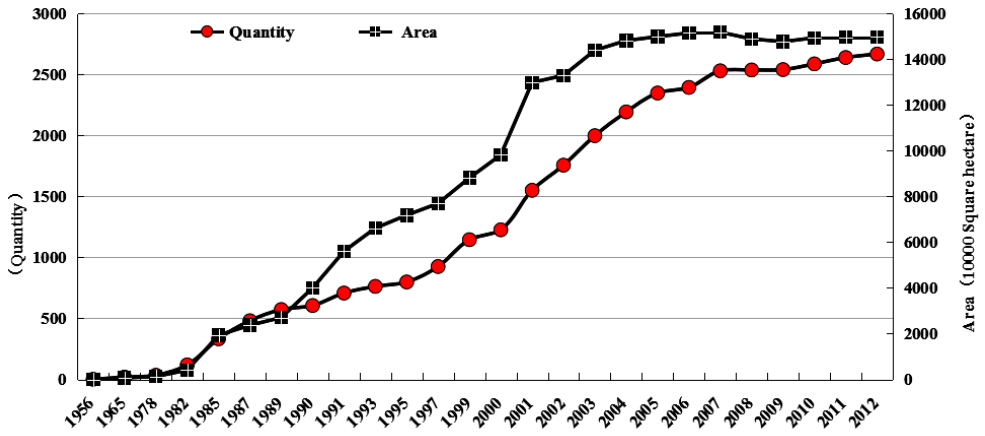

Figure 1. Historical annual development of nature reserves in China (by the end of 2012).

The distribution of nature reserves in China can be summarized as follows: in the west, the reserves are larger in area and smaller in number, with national PAs as the primary type; in the east, the reserves are smaller in area and larger in number with provincial and city-level PAs as the primary types (Figure 2). In addition, the coverage ratio of nature reserves is higher in regions with higher altitude, lower temperature, a dry environment and lower vegetation productivity, whereas the ratio tends in the opposite direction and the coverage is lower in regions with lower altitude, higher temperatures, a humid environment and higher vegetation productivity. Moreover, the ratio is higher in areas with considerable human activity and lower in areas with less human activity [27].

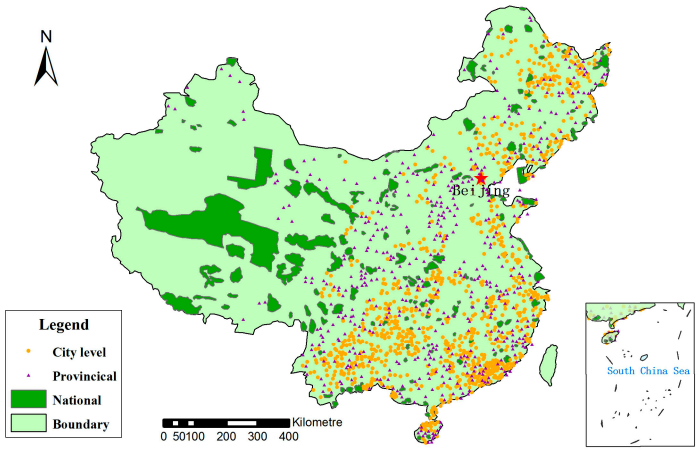

Figure 2. Distribution of national nature reserves in China.

2.2. Related Regulations on Protected Areas at the Governmental Level

The Chinese government is plays a dominant role in the creation of regulations and policies on PAs. Such regulations promote the political arrangements needed for ecological civilization, theoretical innovation and empirical exploration, thus facilitating harmony between humans and nature, individuals and society, and among individuals.

Important plans at the national level include the China National Major Function-Oriented Zoning Plan (MFOZ), the China National Biodiversity Conservation Strategy and Action Plan and a series of

ecological protection plans that are intended to promote the creation of various ecological protected areas and to optimize their spatial distribution (Table 1). From a local perspective, related industrial management departments have also implemented certain plans and regulations regarding nature reserves, wetlands, aquatic organisms, the protection of animal's genetic resources and other areas.

Table1. Important protected area plans at the national level in China.

Number	Year	Name	Content
1	1997	China National Nature Reserve Development Plan (1996–2010)	Creates a national nature reserve network with comprehensive types, a reasonable distribution, and suitable coverage that is effectively scientifically created and managed.
2	1999	China National Environmental Conservation System of the National Nature Reserve Development Plan (1999–2030)	Makes plans for of all national-level nature reserves throughout the nation.
3	2007	National Resource Conservation and Utilization Plan for Biological Species (2006–2020)	Proposes concrete requirements with respect to the protection and utilization of biological species and generic resources, stressing the benefits of fairly sharing biological resources and related traditional knowledge and promoting harmonious coexistence between man and nature.
4	2008	China National Ecological Function Regionalization (EFR)	Creates 216 ecological function zones in 50 significant regions to ensure national ecological security and to analyze ecological issues, ecological protections and restraint measures within each ecological function zone.
5	2008	China National Ecological Fragile Region Conservation Plan	Verifies the operationalization of ecologically frail regions, classifies the 8 most important ecologically frail regions and determines the core construction tasks in these regions.
6	2010	China National Biodiversity Conservation Strategy and Action Plan (2011–2030)	Verifies the prioritized biological diversity in protected areas, develops general targets strategic tasks and prioritized actions for biological diversity protection in China for the next 20 years.
7	2013	China National Ecological Conservation and Construction Plan (2013–2020)	Establishes an eco-restoration and disaster supervision warning system regarding human interventions in the environment. Confirms core project plans in three respects: the ecological and meteorological observation network, the business service platform and the development of an ecological service-oriented capability for human intervention in the climate.

3. Challenges Facing the Protected Area Network in China

3.1. Ineffective Management of Protected Areas

The Chinese government has resorted to a departmental management system based on the types of objects being protected in addition to a hierarchical management system that is aligned with administrative divisions. As indicated in Figure 3, the relevant management departments include the National Environmental Protection Department, the Agricultural Department, the Department of Housing Construction, the Forestry Department, and the Land and Resource Department. The management hierarchy comprises the global, country, provincial, city, and county levels. This management system has led to inconsistent regulatory standards across the various departments involved, which lack effective communication and information sharing, causing inefficient management. Because there might be multiple protected objects in a single PA that spans multiple administrative boundaries of different provinces and cities, difficulties in defining land ownership are inevitable results. This situation also leads to other important problems, such as intersecting boundaries, an imbalance between protection and development, and conflicts between PAs and communities [28]. Moreover, conflicts over management targets and benefits among different departments also lead to ambiguities in authority and duties, which can could result in inefficient management for a considerable proportion of the protected lands, and lead to a reduction in the value of protection or even the loss of an area entirely [29]. Therefore, the effective management of PAs has become an essential component for planning the pattern of PAs as well as a crucial link to connect project implementation, planning and funding [30].

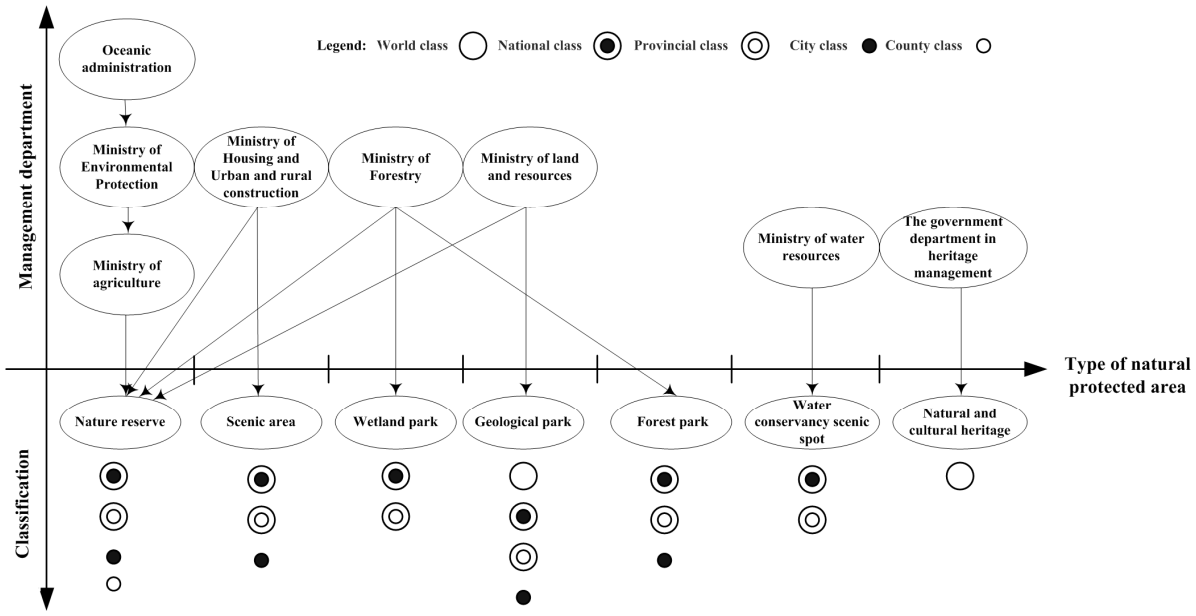

Figure 3. The types of Chinese protected areas and management systems.

Ecosystems integrate with several interconnected and interacting elements into a single functional entity. This concept stresses the inseparability, integrity, connection, coupling and fluidity between biological groups and the environment. The aim of the government is to complete a network structure through transmission and exchange to ensure the functional coordination of the units of the system

while increasing regulatory ability and stability. Thus, PAs should strive to be consistent with the boundaries of the ecosystem units and their respective sizes [31].

For example, multiple departments are responsible for managing a small watershed ecosystem, as depicted in Figure 4. Managing forest resources on the banks is the responsibility of the Ministry of Forestry, river channel management is the responsibility of the Water Department, fish resource management in the river is assigned to the Agricultural Department, land use management is the responsibility of the Department of Land, and resource and water quality management is overseen by the Department of Environmental Protection. Moreover, the administration of upstream and downstream areas is assigned to the jurisdiction of multiple departments, which therefore distributes the aforementioned resources among different administrative management departments. This approach to management has destroyed the integrity of the ecosystem and resulted in ambiguity with respect to rights and obligations. Therefore, there is a call for a comprehensive management department to implement unified regulation and management to avoid chaos and inefficiency.

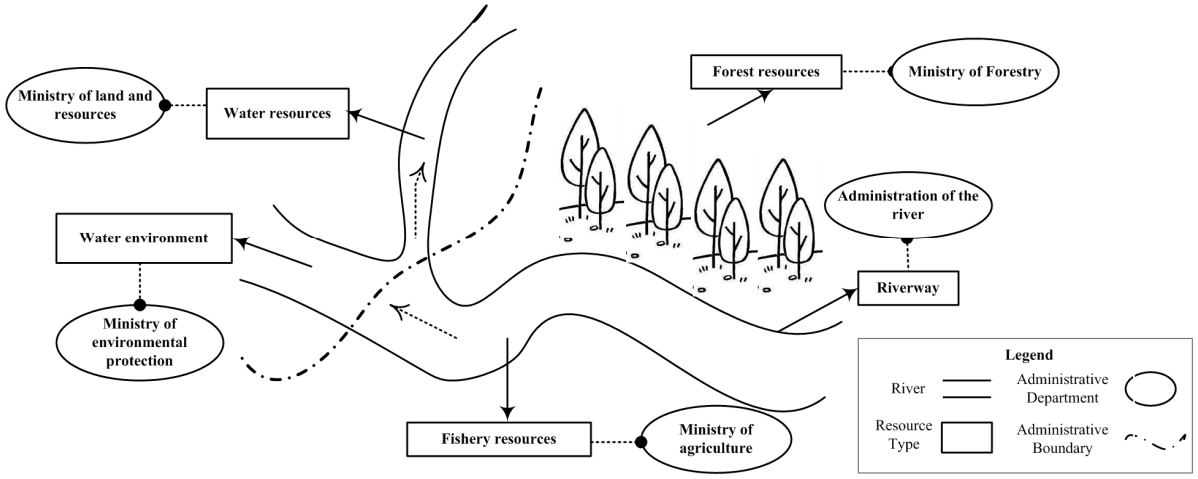

Figure 4. Example drawing the resource management of a small watershed ecosystem.

3.2. Unsound Legal Systems in Protected Areas

China has issued a series of environmental protection laws and associated regulatory rules, announced core animal and plant reserve lists, signed multiple international environmental treaties and formed a preliminary legal system for PAs, which provides legal guidance for their creation and management (Table 2). However, there is still no unified law on PAs, which hinders their overall protection. In addition, the current laws have failed to cover all types of PAs, with the result that certain types of areas lack laws that apply to them [32]. For example, no management law has been issued for the National Geological Park. Furthermore, conservation priority areas for biological diversity and core ecological functional zones and other places subject to macro regulation at the national level also lack specific laws and compelling assurances, meaning that large PAs are in reality "paper parks" [33,34]. Moreover, the definitions of PAs in laws and regulations are ambiguous and confusing and lack a clear, well-defined object. For instance, concepts such as a nature reserve in the nature reserve regulations, conservation areas for sources of drinking water in the water law, prime cropland preservation areas in the land administration law and enclosed and forbidden reserves for

land subject to desertification in the desertification prevention and control law all have intersecting and overlapping boundaries and definitions, which hinders the implementation of specific laws.

Table 2. Protected areas in the relevant laws and regulations of China.

Type	Name	Time	Organization
Laws	Water law	2002	National People's Congress Standing Committee
	Desertification Prevention and Control Law	2002	
	Law for the Protection of Wildlife	2004	
	Land Administration Law	2004	
	Forest Law	2009	
	Marine Environment Protection Law	2013	
	Environmental Protection Law	2014	
Regulations	Wild herb resource protection and management regulations	1987	State Council
	Wild plant protection regulations	1997	
	Nature reserve regulations	2011	
Protection Lists	The wildlife under special state protection list	2003	Ministry of Forestry Ministry of Agriculture
	National key protected wild plants list	2001	
	National protection of beneficial wild animals of important economic or scientific research value	2000	State Forestry Administration
	List of classified management of construction projects' environmental impact assessments	2008	Ministry of Environmental Protection
International Conventions	Convention on International Trade in Endangered Species of Wild Fauna and Flora	1981 *	Conference of Parties (COP)
	Convention Concerning the Protection of the World Cultural and Natural Heritage	1985 *	United Nations Educational, Scientific and Cultural Organization
	Ramsar Convention	1992 *	COP
	Convention on Biological Diversity	1992 *	UN Conference on Environment and Development

(Note: * The year when China joined the International Convention).

3.3. Redundancy in National Macro-Level Planning for Protected Areas

China has designed multiple national-level land protection plans to promote regional ecological and biological diversity conservation. However, because of the excessive coverage and ambiguous boundaries of PAs, local governments ignored them. As presented in Figures 5 and 6, there are 32 biological diversity priority areas that cover 2.32 million·km^2, and there are 25 core ecological functional areas that cover 2.32 million·km^2. Overlapping coverage exists for over one-half of the PAs, and the situation for areas designated to protect biological diversity is similar, which means that overlapping areas do not receive effective management. Ultimately, these areas, which are designated for protection under national plans simply languish at the conceptual level without actual implementation.

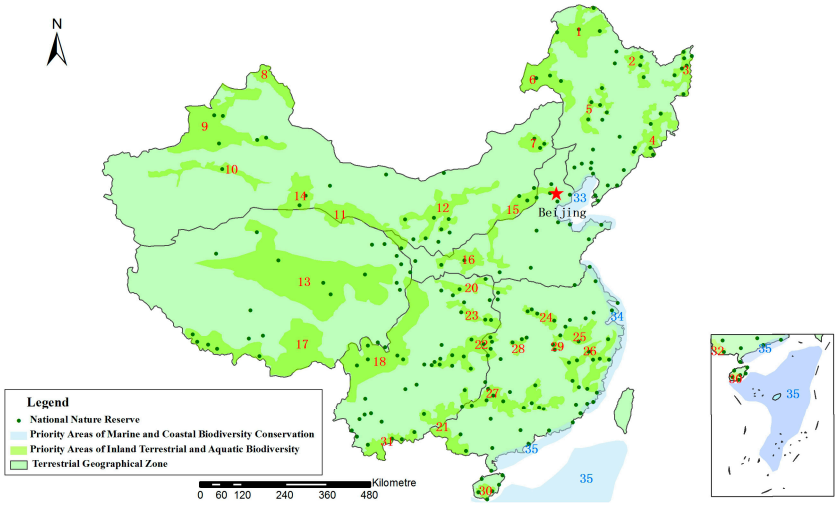

Figure 5. Distribution map of the priority areas for biodiversity conservation in China.

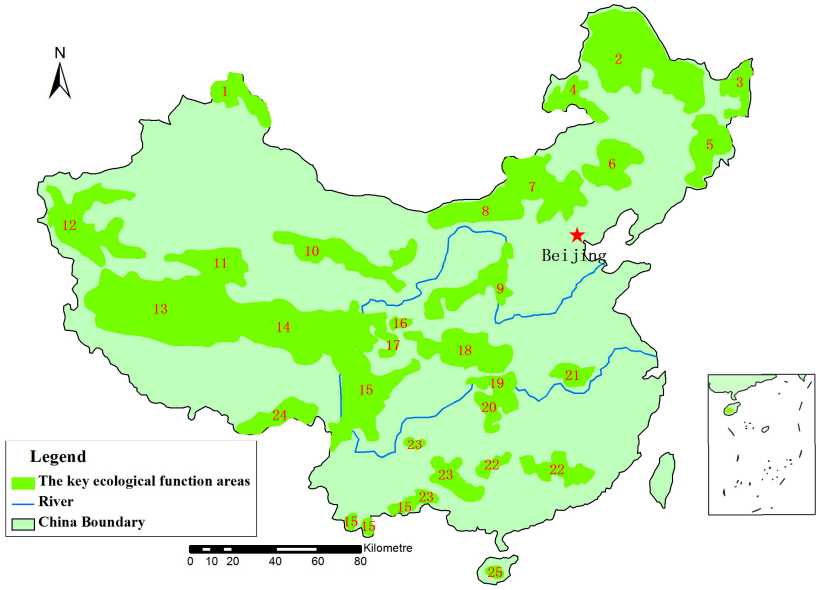

Figure 6. Distribution map of the key ecological function zones in China.

3.4. Unsound Ecological Compensation Mechanism

Under China's macro plan, core ecological functional areas play an essential role in biological diversity protection, water and soil conservation and national ecological security [35]. However, an effective mechanism for preventing threats to the ecological functions in these areas is still lacking. Moreover, due to their isolated locations and lagging social and economic development, the conflict between ecological protection and development is significant. Hence, it is a crucial policy goal to establish an ecological compensation mechanism to promote ecological protection and coordinate it with regional development [36].

Ecological compensation measures in China primarily include compensation for forest ecological benefits and ecological transfer payments. In 2001, compensation for forest ecological benefits was introduced with an investment of 20 billion Yuan and a scope of 70 million core ecological forests [37].

In 2009, the central government established the national core ecological transfer payment system under the general transfer payment system to encourage local governments to reinforce environmental protection efforts [38]. By 2012, national ecological transfer payments had amounted to 30 billion Yuan, covering more than 600 counties nationwide.

China has yet to establish a systematic ecological compensation mechanism or a definite compensation standard. Although the coverage of PAs is consistently increasing, considerable manufacturing and residential activities take place around PAs, and residents continue to engage in activities involving the use of natural resources, resulting in persistently escalating conflicts with local management institutions, which further increases the difficulty of managing PAs, especially in poor areas [39]. For instance, of the 592 poor counties in China, 183 contain PAs at the national, provincial, city and county levels, yielding a total of 228 PAs. Ecological transfer payments are primarily funded via appropriations based on administrative units and hierarchies; hence, it is difficult to connect them to the spatial units designated as confirmed functional areas, especially with regard to restricting improper construction in development zones [40].

4. Integration and Control of Protected areas in China

4.1. Definition and Practical Exploration of the Ecological Red Line Strategy

The Chinese government has issued a series of plans concerning PAs, but the management of PAs has been inefficient. Moreover, the laws and regulations were unsound, and the ecological compensation mechanism was imperfect. Therefore, the Chinese government advanced the strategy of ecological red lines, which refer to delineated in areas with key ecological functions and sensitive and vulnerable land/marine ecosystems. The system is designed to achieve the scientific integration of various types of PAs and to implement permanent protections.

The ecological red lines define strictly protected spatial boundaries and authorized limits for ecosystem services, thus ensuring environmental quality, the sustainable utilization of natural resources and other aspects, including that minimal standards are maintained regarding ecological functions and environmental quality and that an upper limit is placed on natural resource utilization [41]. To maintain national or regional ecological security and sustainable development, areas that require special protections have been delineated with protection requirements for the integrity and connectivity of ecosystems [42].

In 2014, the Ministry of Environmental Protection issued the National Ecological Red Line-Technical Guidelines for Delineating the Baseline of the Ecological Function (For Trial Implementation), which became China's first technical guidance document concerning the delineation of the ecological red lines. The National Water Conservancy Department, the Forestry Department and other departments have conducted several practical studies exploring concerning where to draw ecological red lines. However, each department has delineated its own ecological red line zones that inevitably lack coordination and cause inefficient management.

4.2. A Spatial Control Strategy for the Ecological Red Line

China should draft a "PAs law" that covers all types of PAs and formulate corresponding regulations for their management to ensure that PAs subject to the ecological red line can have a legal basis. A perfect punishment recovery mechanism should be established, and the responsibility for environmental protection of the Chinese government, related enterprises and individuals in ecological red line areas should be defined. In so doing, the ecological red line will become "the mandatory line" of the law. Based on the spatial integrity of the ecosystem, the importance of ecological corridors for maintaining ecosystem balance must be taken into consideration to prevent the fragmentation and isolation of ecological red line areas. Moreover, special management departments should be established to implement unified supervision to avoid unclear responsibilities resulting from management by multiple departments.

Establishing a perfect ecological compensation mechanism is an important aspect of strengthening the spatial control of the ecological red line. The externality of the geographic distribution of environmental assets results in an imbalance between the environment and economic development between developed areas and PAs [43]. To determine what resources are subject to compensation and who will receive compensation it, it is necessary to emphasize fairness in such questions and more generally, areas should be identified where the funds can be used more efficiently and their economic impact will be greater to prioritize the implementation of ecological compensation [44].

5. Discussions

In China, as a result of great efforts in ecological conservation, restoration, and sustainable development, the degraded environment have begun to recover. However, the management of PAs still faces many challenges that call for concrete actions. After years of development, the number, areas and types of objects under protection are increasing in China, and a network of PAs has been preliminarily established. However, the degree of coverage across different regions is unbalanced, and the management system in this field, which is based on different sectors and levels, has led to ineffective management. China has issued special environmental protection laws and regulations and a list of key animals and plants to be protected. Moreover, it has signed a number of international treaties on environmental protection, which has contributed to the development of a legal system for PAs. However, a unified basic law for PAs has not been developed, which has resulted in inconsistent legal concepts and unclear regulation. To improve the effectiveness of PAs, the Chinese government has followed a scientific approach to restructuring and integrating the various types of PAs, advanced a strategy for ecological red lines and crafted unified plans at the national level. However, this strategy remains in the conceptual stage, and progress has stalled. It is still possible to establish specialized management departments and a national unified spatial database on ecological protection to enable network and information management under unified state control in the future.

China has begun to attempt to compile comprehensive national balance sheets of environmental resources, and this effort may not only promote the efficiency of economic management but also serve as part of the criteria for evaluating government officials. Balance sheets of environmental resources can quantify the status of natural resource assets, environmental destruction levels, *etc.*, for economic

development purposes. They could also reflect the comprehensive development of politics, the economy and the society. The unanswered questions of how to measure natural resources in the balance sheets, how to audit leader's treatment of natural resources assets, and how to proceed with research and exploration show that there is still a long way to go, because no other country in the world has experience in these areas that China can draw upon. The process could be at least partially based on the experience of the green GDP experience, which has been explored in China recently. However, ensuring the sustainable livelihoods of individuals living near PAs must be considered. The establishment of PAs limits the exploitation and utilization of resources by the surrounding community, thereby restricting the development of the regional economy and limiting local livelihoods. Transfer payments and ecological compensation that rely solely on the government make the transformation of livelihoods challenging. Therefore, when establishing and managing PAs, the government must recognize the link between resource management and the demands of the local community. To improve the actual performance of regional ecological protection efforts, an adaptive management paradigm needs to be established to integrate the government, which is motivated by a "top-down" approach, and the local stakeholders, who are motivated by a "bottom-up" approach, to achieve balanced considerations of the dynamics and sustainability requirements of the targeted ecologically and economically coupled systems. The Chinese government could adopt a policy support strategy, a special industries and labor exporting strategy and a tailored industry and eco-tourism strategy to ensure that local residents have a diversity of livelihood choices.

Moreover, the effective management of PAs should be focused on both integrated measures and the management of single nature reserves. The main pillars of constructing an exterior support system include establishing scientific categorizing standards and a reasonable evaluation system and to improving the investment mechanism and the law system. Resources conservation and monitoring environmental impacts evaluation, scientific research, eco-tourism, and environmental education should all be enhanced to improve the effective management of PAs.

Currently, environmental non-government organizations (NGOs) play an important role in environmental protection around the world. In particular, NGOs have already been a positive participants in the environmental management of PAs for a long time in developed countries, and in China, there is still plenty of room for environmental NGOs to play a part in ecological conservation. Therefore, the study of how to encourage more participation from environmental NGOs and explorations of new methods of PAs management in China will represent crucial directions for research and choices in the future.

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Author Contributions

Mengtian Cao and Li Peng designed the research; Mengtian Cao and Shaoquan Liu performed research and analyzed the data; Mengtian Cao, Li Peng and Shaoquan Liu wrote the paper. All authors read and approved the final manuscript.

Conflicts of Interest

All authors declare no conflict of interest.

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