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Discussion on the Stages, Thoughts and Driving Force of the Evolution of National Park Demarcation

Na Zhang*
Hefei University of Technology College of Architecture & Art, Hefei 230601, China

Abstract:

National park is a complex composite ecosystem with many uncertainties and faces the conflict of diversified management objectives. This paper traces the evolution of national park management objectives and delineation ideas in the context of different historical stages and reviews four stages of national park delineation ideas: purely natural landscape and natural assets conservation, species and population conservation, biodiversity conservation, and ecosystem integrity conservation. Then, this paper analyzes the island biogeography theory, metapopulation theory, landscape ecology theory, and social ecology theory of national park delineation and discusses the related population viability approach, landscape pattern approach, and ecosystem integrity approach while revealing how national park delineation evolves to achieve conservation goals under the combined effect of internal processes and external forces. Finally, it is pointed out that the boundary establishment of ecosystem management and ecosystem integrity conservation based on science and value has essential application value for the implementation of balancing human-land conflict in national parks, having significant implications for the current national park system pilot construction and boundary establishment in China.

Keywords*: National park, Delineation, Evolution, Biodiversity, Ecosystem integrity.*

I. INTRODUCTION

The loss of biodiversity and the severe degradation of the earth's ecosystem is one of the greatest crises faced by humanity today, and the establishment of national parks to shelter the growing biodiversity crisis is an effective measure taken by various countrie[1-3]. Since the establishment of Yellowstone National Park in the United States in 1872, especially in the second half of the 20th century, many protected areas, mainly national parks, have increased

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exponentially[4-5]. National parks began as a response to land encroachment and the protection of scenic resources, and academics and managers have been trying to resolve various conflicts within them through delineation and zoning, as the establishment of reasonable boundaries is an effective tool to achieve the multiple management goals of national parks[6-7]. However, the problems and dilemmas faced by national parks in different historical contexts are different, and the missions and management objectives they undertake are constantly reweighed, and the demarcation strategies needed to achieve their goals are also subject to change. From the birth of Yellowstone National Park to now, the idea of national park boundary delineation has changed fundamentally from the initial protection of purely natural landscapes and natural assets to the protection of species and populations, biodiversity, single-region ecosystem integrity, and ecosystem management across boundaries, gradually realizing a dynamic approach to boundary adjustment based on scientific assessment and monitoring[8-11]. Facing the difficulties of the scientific layout of national parks, this paper analyzes the background and process of the evolution of the idea of national boundary delineation, explaining systematically and completely how national parks have responded to the conflict management operation mechanism through boundary delineation in different development periods, as well as their achievements and problems, providing a scientific reference for the current national park pilot construction in China, and also promoting the construction of the theoretical system of national park planning and design further.

II. PROTECTION OF NATURAL SCENERY AND NATURAL ASSETS (1872-1933)

In the early 19th century, influenced by Romanticism, Transcendentalist ideas, and later nonutilitarian nature conservationism, there was a shift in American thinking from conquering wilderness to preserving it[12]. The artist George Catlin proposed establishing national parks to protect Indian culture, wildlife, and wilderness areas[13]. Through the efforts of Thomas Moran, Judge Cornelius Hedges, and Ulysses S. Grant et al., Yellowstone National Park was established in 1872 with the initial goal of "to preserve all its trees, ore deposits, natural wonders and scenery, and other features in their present state without destruction"[14-16]. Due to the remoteness and sparseness of Yellowstone National Park, the relative abundance of land resources at the time made their economic value not very important, so the scenic value of the area defined the park size and boundary location. Its core landscape resource, geysers, played a decisive role in the initial delineation, with the entire park defining an initial area of 8992 km2 to encompass the 200 active geysers and other geothermal features in the area[17].

After the establishment of Yellowstone National Park, the concept of national parks began to emerge and spread in some fast-developing European countries and colonies belonging to

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Western countries. A number of national parks were established, some of the more famous ones being the Royal National Park established in Australia in 1879[18], Banff National Park established in Canada in 1885, and Tongariro National Park established in New Zealand in 1887[19-20]. At this stage, there were two apparent commonalities in the goals of national park establishment: "to preserve natural scenery and cultural heritage" and "to provide recreational opportunities." For example, the U.S. National Park Service defines national parks as "the conservation of scenic beauty, natural and historic resources, wildlife, and their value within the national park system", while the Canada National Park Service calls them "as a first priority, the conservation of the natural and cultural heritage of national parks, ensuring that they remain healthy and intact to show the beauty and significance of the natural world"[21]. In each country, the national park managers focus on the natural attributes of the assets within the park, emphasizing the protection of scenic values, and use this to develop rules for protecting natural assets and delineating boundaries. The idea of delineating boundaries guided by the protection of scenic resources lacks a corresponding scientific basis. For example, the Mount Egmont National Park was established in New Zealand in 1900. In order to make the mountain scenery and asset resources no longer encroached by agricultural activities, the authority managers established a circular park boundary with its peak as the center of the circle of equal distance radius[22,23].Tracing the roots of this phase of the delineation idea requires a return to the background of creating the national park idea. There are two reasons for this: first, most of the people proposing the conservation idea were artists, especially painters, who were impressed by the natural landscapes or indigenous cultures of the sites and urgent to preserve them, such as George Catlin, Thomas Moran, William Jackson, who proved the inner wonders with paintings and photographs to promote the establishment of Yellowstone National Park. Secondly, tourism in national parks has not yet become a popular recreational activity due to the limitations of transportation (especially railroads); hence it did not have to face complex external pressures, and tourism was objectively neglected, so the various natural attributes got better protected[24-26].

III. CONSERVATION OF SINGLE SPECIES AND POPULATIONS (1933-1971)

Conservation goals of national parks changed around the 1930s, with the development of railroad transportation leading to a surge in national park visitation and the increasing threat of external forces making the parks ecological islands[27-28], resulting in severe destruction of species habitats within the parks, which became most evident in the endangerment and extinction of species at the top of the food chain. The boundaries of the initially established national parks were not established through scientifically planned pathways. Ecological constraints gradually emerged during development, such as the boundary of Banff National

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Park cannot accommodate the survival of wild wolves in the region and lacks corridors for their natural dispersal. The ecological science-oriented approach to national park management began to emerge at this time. The conservation goals of national parks changed from simply protecting natural landscapes and natural resources to protecting species and population habitats, with the core idea of avoiding national parks from becoming ecological islands driven by multiple external pressures. Under this influence, the idea of salvage conservation took the dominant position[29-30], and the conservation ecology theory began to become the mainstream idea of national park delineation and went through two stages: island biogeography balance theory and metapopulation theory.

Ecological delineation based on conservation biology became the norm in defining the boundaries of national parks during this period. In 1933, Wright proposed the design concepts that are still important for national park boundaries: minimum population and minimum area, and after that, the ratio of the protected area to perimeter[31-32]. In 1967, R. H. MacAr- thur and E. D. Wilson proposed the equilibrium theory of island biogeography, using a quantitative theoretical model to predict the equilibrium point of island biomes concerning the rate of topography and extinction under a given set of conditions, and for the first time elaborated the relationship between species richness and the degree of area and isolation[33]. This theory suggests that the species richness of islands depends on the rate of migration and extinction of species, i.e., there are two effects: the area effect and the distance effect - the extinction rate decreasing with increasing island size and the migration rate decreasing with increasing degree of isolation[34]. Conservation sites in island-like habitats of national parks operate as separate biomes or ecosystems, and the number of biological species in the park depends on the size of the island, age, diversity of habitats, accessibility and abundance of topiaries, and the balance between the rate of new species topography and the rate of extinction of existing species[35]. In the same period, the population viability analysis (PVA), with island biogeography as its theoretical origin, established the relationship between extinction probability and population size by analyzing and simulating population dynamic processes and used mathematical models to predict the future trend (growth/decline) of the population, reducing extinction to an acceptable level, which not only provided a vital research avenue for rare and endangered species conservation but also provided a scientific basis for the adjustment of the original national park boundaries and the demarcation of newly established national parks[36-37]. When Shaffer used a population stochastic model to study the population viability of brown bears in Yellowstone Park, he clearly proposed a minimum viable population to establish the relationship between extinction probability and population size by analyzing and simulating population dynamic processes[38], resulting in showing that the boundary line of Yellowstone National Park is in a strong limit to the sustainable survival of grizzly bears.

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In the 1980s, the accuracy and adaptive scope of island biogeography theory became controversial, and conservation biologists began to shift their research perspective to metapopulation theory[39]. Since species inhabit fragmented "island" habitat spaces and exist in metapopulation, species extinction often goes through the metapopulation stage, so the idea of national park delineation based on metapopulation theory has been applied. In 1969, Lavins proposed that a metapopulation is a collection of local populations within a relatively independent region, with each local population becoming whole through a certain degree of individual migration[40-41]. Spatially realistic metapopulation theory is a model of species dynamics in highly fragmented landscape environments. The movement and extinction of populations in landscape patch assemblages during the interaction of spatial patterns and population ecology is concerned with stochastic patch occupancy models and the presence and extinction status of focal species in habitat patches[42-43]. Therefore, the dynamics of extinction and recolonization among local populations in the habitat patch network, especially the extinction and recolonization of small populations within populations that result in altered migration, are crucial for establishing national park boundaries. Metapopulation theory has been extensively studied, and most research results indicate that the long-term persistence of endangered species requires at least multiple well-connected habitat patches, and the ideal spacing of habitat patches should meet the needs of migration[44-45]. In this process, many scholars have also analyzed the habitat suitability of species based on GIS technology and habitat distribution modeling method. National park boundaries were explored through the spatial distribution of habitat demand factors and key features (e.g., the spatial structure of vegetation, soils, and landscape elements), e.g., Sinha et al. used hierarchical analysis and GIS-based multi-criteria determination analysis to analyze the suitability of Sariska tiger habitat in India to establish the national park boundaries[46-47]. The metapopulation theory and the island biogeography theory have the same roots, as both theories explore the conservation of endangered species and biodiversity. Both adopt an area-segregation paradigm, but the island biogeography focuses on the effects of the scale of habitat fragmentation and structural segregation of species composition and the richness of species on islands. In contrast, the concept of metapopulation dynamics has focused on connectivity and changes within populations and regional persistence conditions for species with unstable local populations, avoiding local or even the eventual extinction of species[48-49]. Nonetheless, the variability of habitat ranges of conservation species in national parks and the complexity of species interactions make park demarcation difficult.

IV. CONSERVATION OF BIODIVERSITY (1972-1988)

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With the development of ecosystem ecology, restoration ecology, landscape ecology, and other theories, the management objectives of national parks began to emphasize the protection of ecosystems and ecological processes, and the objects of protection shifted from species, populations, and habitats to ecosystems at the biome level[50-51]. Ecosystem ecology was gradually becoming an essential basis for the decision of national park delineation ideas. In 1972, the "Convention Concerning the Protection of the World Cultural and Natural Heritage" initiated the conservation of ecosystem diversity, which proposed the protection of "threatened areas of animal and plant habitats" from "a scientific or conservation perspective." In 1992, the "Convention on Biological Diversity" defined biodiversity conservation as the main objective for the first time[52]. Since then, international conventions and conservation policies such as the "Strategic Plan for Biological Diversity 2011-2020", the "Nagoya Protocol", and the "Aichi Targets" have promoted the establishment of national parks and other protected areas to maximize the conservation of biological resources, and biodiversity conservation has been further promoted[53-55]. Currently, the global context is facing biodiversity loss and the sixth species mass extinction, and the international community generally recognizes the importance of biodiversity conservation, so biodiversity is gradually increasing in importance in the current park management objective system[56].

By nature, an ecosystem is a unitary collection of all organisms (e.g., communities) and their physical environment in a given area[57]. Biotic and abiotic components interact individually or with each other in a complex way most prominent feature is biodiversity. At all levels, human activities have caused huge impacts on biodiversity, landscape fragmentation and habitat destruction are the main reasons for the accelerated extinction rate of species worldwide, habitat loss and isolation are associated with land conversion caused by human activities[58], the migration of species, material cycling, and energy flow are dependent on various types of landscape spaces on the land, so the flourishing of landscape ecology in the 1980s Ecology has opened up new ideas for the study of biodiversity and has brought new ideas and methods to the delineation of national parks. Landscape ecology is mainly used to analyze the interrelationships of the natural-biological complexes that govern a regional unit and is derived from the close integration of two scientific perspectives of ecological landscape and biology, whose main study is landscape structure and spatial patterns[59]. The most suitable critical landscape elements for target species habitats and migration paths can be identified using the zoning and clustering methods of landscape maps. Then combining the graph-theoretical metrics with detailed geographic information and behavioral characteristics of organisms in the landscape, it is possible to construct corridors, patches, and background landscape components of ecosystem composition[60-62]. Based on this theory, common demarcation methods include the minimum cost distance model zoning method and the

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landscape resistance surface analysis method[63-65]. Many landscape indices describing landscape patterns and their changes have been developed in the process of spatial analysis of landscapes to establish the interconnection of patterns and processes, such as the number and size of patches, the number of patch subdimensions, the number and diversity of edges between landscape elements, and the dominance and spread. Species diversity in patches is related to the following patch characteristics in the following order: S = f [+ habitat diversity +/- disturbance + area + age + landscape heterogeneity - degree of isolation - boundary discontinuity](S is biodiversity), from the equation above, it can be seen that species diversity is significantly related to patch area. Thus, the conservation of rare and endangered species and the maintenance of a stable ecosystem area are major factors in delineating national park boundaries, while other factors such as the degree of isolation, age, and shape of the patches are secondary[66-67]. The landscape pattern index is the primary method to quantify the landscape pattern and ecological processes. However, many landscape pattern indices are in trouble because it is challenging to integrate the pattern and processes together; the concepts of "source" and "gather" are introduced into landscape ecology. The role of different landscape types concerning target species is analyzed through landscape evaluation models to evaluate the suitability of landscape spatial patterns and provide a way to design for biodiversity[68]. The graphical analysis of biodiversity conservation takes landscape elements as the core and research medium and constructs landscape patterns based on their spatial locations and relationships by taking landscape elements of various scales as conservation objects[69-70]. It proposes the rational use of landscape resources by studying the influence of landscape patterns on ecological processes, so landscape ecological construction and landscape structure design play an essential role in national park delineation for biodiversity conservation.

V. PROTECTING ECOSYSTEM INTEGRITY (1988-)

The national park is a social space with the background of humans, and its ecosystem structure and function are with social attributes. The increasing foreign invasion and threats make the ecosystem shift to a new balance, resulting in the unprecedented development of social ecology[71-72]. In 1988, Agree and Johnson formally proposed the concept of ecosystem management, and the coupling of humans and nature became the mainstream of national park management. Integrated ecosystem management treats people and nature as an organic whole, changing the goal of conservation from species, populations, and their habitats to complex ecosystems and emphasizing the management strategy of sustainable human-earth coexistence[73]. National park ecosystems are large, complex, and unstable Spatio-temporal structures with numerous uncertainties[74], and it is a management model based on multiple objectives for the whole system, which requires natural resource policies at appropriate spatial

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and temporal scales to meet human needs without compromising the integrity of ecosystems and processes while admitting the existence of multiple interests and stakeholders[75]. There is a lack of a holistic, organismic view of nature in the management and operation of national parks in the conservation and development process, resulting in severe conflicts in human-land relations, and external threats and internal conflicts have had a profound impact on the ecological integrity of national parks. At that stage, the conservation of ecosystem integrity became the primary basis for delineation. Conservation of ecosystem integrity is a derivation and expansion of biodiversity conservation, whose earliest and most influential concept can be found in Aldo Leopold's notion in an article on land ethics that "something is right when it tends to preserve the integrity, stability, and beauty of a biome; it is wrong when it tends to the opposite "[76]. Ecosystem integrity conservation emphasizes whether the main ecological features (composition, structure, function) and processes of an ecosystem occur within its natural range of variability, whether they are able to withstand and recover from disturbances caused by the natural environment or by human factors. In addition, whether the ecosystem can develop healthily while optimizing the geographical location in which it is located.

The ecosystem management is implemented based on specific temporal and spatial scales. At first, managers and related research scholars tried to solve ecosystem integrity within a large-scale national park boundary to ensure that the parking area could maintain the integrity of ecosystem structure, processes, and functions[77-78]. However, the scope of the interactions of ecological processes and the evolution of ecological patterns cannot be accomplished by a single boundary, especially the migration of organisms due to changes in climate, geological activity, and hydrology[79-80]. At the same time, the vast majority of threats to national parks come from outside the park boundaries, and conditions outside the boundaries are beyond the control of the National Park Service. In this scenario, ecosystem management has proposed large ecosystem security patterns, such as the informal Greater Yellowstone Ecosystem[81], which control adjacent land use patterns and intensities through cross-sectoral collaboration among federal government agencies, ensuring the availability of habitat corridors and avoiding their fragmentation[82-83]. Some scholars have also proposed using national parks as crucial nodes of ecogeographic zones in ecological security patterns, with their centers radiating to surrounding regions to achieve long-term protection of ecosystem integrity[84-85]. Ecosystem management needs to respond to human productive life activities beyond the boundaries and deal with the inevitable tensions between people and land while allowing for the right and necessity of biological movement within the national parks.

In fact, establishing the boundaries of international parks based on ecosystem integrity is a "passive" and "feedback" method of boundary delineation. It mainly assesses whether the

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ecosystem integrity of national parks within the established boundaries is effectively protected by monitoring the status of the ecosystem. If it is effective, the boundary is reasonable, and if not, the boundary needs to be further adjusted until it is effective, as shown in Figure 1 below. The key to ecosystem integrity assessment is to determine whether changes in the state of national park ecosystems under different use intensities are within the natural variability quotient. Therefore, the "driver-pressure-state changes-impact-response" process can be used as a system-based approach to capture the linkages between society and the environment. The feedback mechanism of zoning management provides a scientific basis for the dynamic adjustment of effective management strategies. When assessing the ecosystem integrity of protected areas, the first requirement is to develop conceptual models for the assessment and study their interactions by integrating and extending the conceptual models to different drivers and pressure conditions, providing an applicable framework for prioritizing and establishing boundaries in maintaining ecosystem integrity. In 1993, Woodley proposed a framework for monitoring the ecological integrity of national parks, which consists of three components: biodiversity, ecosystem processes, and stressors, and it judges management performance by assessing changes in ecosystem status through field monitoring, after which ecosystem integrity monitoring and assessment methods such as the Biological Integrity Index Evaluation System, the Three-Tiered Assessment Method, and the Measures of Success Framework Method were formed to assess the health of national park ecosystems within the boundaries and to judge the reasonableness of the boundaries.

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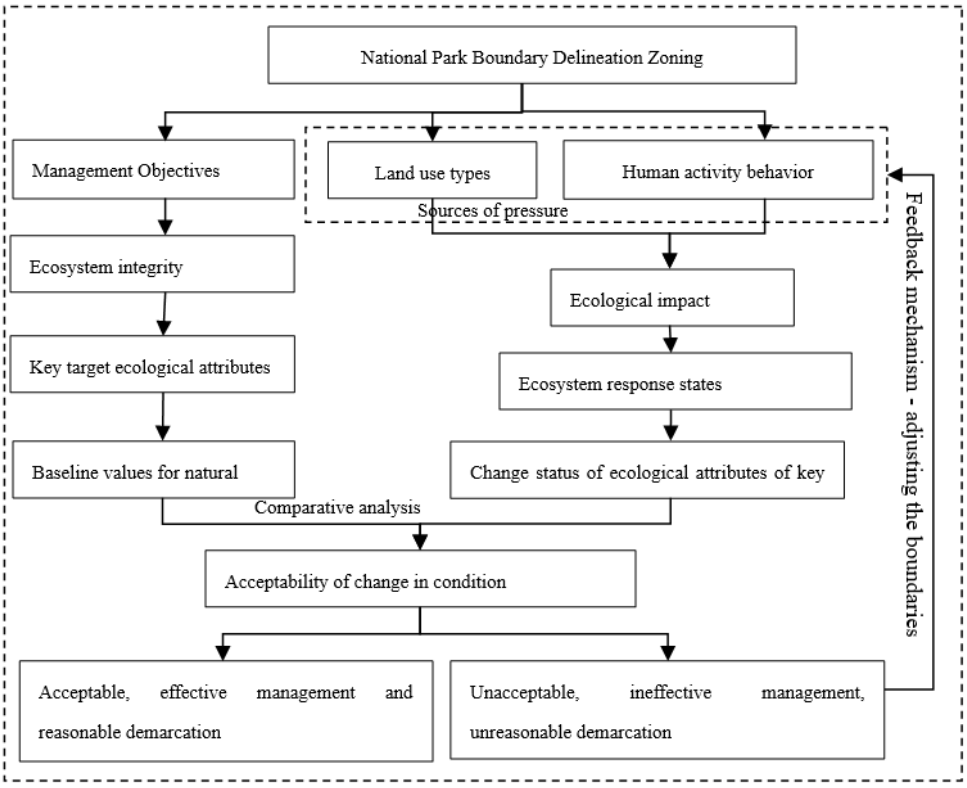

Figure 1. Ecosystem integrity of national park be applied in demarcation

VI. CONCLUSION

National park demarcation aims to achieve reasonable protection and utilization within the boundary and balance the contradiction between humans and nature. It can be seen from the evolution of national park demarcation ideas and methods that national park demarcation has moved from emotional to rational, free from the cognitive constraint of putting nature on top and putting a human on top, and gradually realizing science and value-oriented demarcation theories and methods (as Table 1). At the same time, there are some common understandings in the evolution of national park delineation ideas: One— the definition of boundary needs a scientific basis and operable transformation path, any delimitation ideas, theories, and methods need to be tested in practice, judging the rationality of the delimitation method and the effectiveness of the boundary through long-term monitoring and evaluation of the state of key indicators related to the ecosystem. Two—the establishment of national park boundaries is an essential means to achieve multiple objectives of management, which requires not only coordination of land use patterns, timing, scale, and intensity of stakeholders within the national park, but also attention to and control of adjacent spatial land-use patterns and human

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activities, as well as multi-sectoral cross-border cooperation; Three— the national park is a broad socio-ecological model in which humans play a dominant role, it can only be managed effectively based on the equity of stakeholder benefit sharing and the values we attach to nature.

TABLE 1. Evolution of ideas and methods of national park delineation

Stage	Conservation goals	Delineation idea	Delineation theory	Delineation method	Advantages
Stage one	Natural scenery and natural assets	Protection of core landscape resources		Equidistant radius method or boundary that encompasses core landscape resources	High scenic value areas are protected
Stage two	Species and populations	Conservation biology	Island biogeography theory	Population viability analysis	Analyze and simulate the process of population dynamics and establish the relationship between extinction probability and population size
			Metapopulation theory	Habitat Model Analysis Method	It is possible to explore the distribution space of suitable habitats based on the ecological habits of the target species
Stage three	Biodiversity	Ecosystem Ecology	Ecosystem Ecology Landscape Ecology	Minimum cost distance model zoning method	It is possible to visualize the dispersal of species in heterogeneous landscapes, and the development of computer technology

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					enables easy computation and moderate data requirements
				Landscape resistance surface analysis method	Recognize the relationship between potential trends in biospatial movement and changes in landscape patterns
Stage four	Ecosystem Integrity	Social ecology	Ecosystem management theory	Success framework, three-tier assessment method	Being suitable for ecosystem integrity in large scale areas, allowing for remote and rapid assessment

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