Postprint of the Study on Spatial Distribution Patterns of National Forest Parks and Their Influencing Factors

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Abstract

National Forest Parks constitute one of the important carriers of ecological civilization construction in China. This study investigates National Forest Parks in 1994, 2004, and 2019, comprehensively employing spatial analysis techniques to systematically investigate their spatial distribution patterns and underlying causes, aiming to provide scientific references for the optimization of spatial layout and healthy sustainable development of National Forest Parks. The results indicate: (1) National Forest Parks are predominantly distributed to the east of the Hu Huanyong Line, approximately forming high-density distribution areas centered in the Beijing-Tianjin-Hebei region, Yangtze River Delta, Sichuan-Chongqing border area, and Hunan-Jiangxi border area, exhibiting a distribution pattern of 'large agglomeration, small dispersion'. (2) The National Forest Park system demonstrates significant fractal characteristics with relatively complex fractal structures. (3) Substantial inter-provincial distribution differences are evident among National Forest Parks, with a convex-shaped differentiation pattern of fewer in the east and west but more in the central region among the three major belts, and a decreasing trend from the middle and lower reaches of the Yangtze River and Southwest China to Northeast China and the middle reaches of the Yellow River among the eight major regions. (4) Hotspot areas of National Forest Parks exhibit a certain degree of instability, among which Heilongjiang, Jiangsu, and Zhejiang demonstrate relatively active development and consistently remain in hotspot areas, while Xinjiang, Tibet, and Sichuan are primarily in cold spot areas with relatively slow development of forest parks. (5) Topography, precipitation, tourist source markets, and endowment of tourism resources constitute the main factors influencing the spatial distribution patterns of National Forest Parks.

Full Text

Abstract

National Forest Parks represent a crucial component of China' s ecological civilization construction. This study examines the spatial distribution patterns and underlying determinants of National Forest Parks in China using comprehensive spatial analysis techniques. The findings reveal: (1) National Forest Parks are predominantly distributed east of the Hu Huanyong Line, forming high-density clusters centered around the Beijing-Tianjin-Hebei region, Yangtze River Delta, Sichuan-Chongqing border area, and Hunan-Jiangxi border area, exhibiting a distribution pattern characterized by "large agglomeration with small-scale dispersion." (2) The National Forest Park system demonstrates pronounced fractal characteristics with a relatively complex fractal structure. (3) Significant interprovincial disparities exist in National Forest Park distribution, with the three major economic zones showing a "convex-shaped" pattern of fewer parks in the east and west but more in the central region, while the eight major geographical regions exhibit a decreasing gradient "from the middle-lower Yangtze region and Southwest China toward Northeast China and the middle Yellow River region." (4) Hotspot areas of National Forest Parks display certain instability, with Heilongjiang, Jiangsu, and Zhejiang showing vigorous development and consistently remaining hotspots, whereas Xinjiang, Tibet, and Sichuan have essentially remained cold spots with slower forest park development. (5) Topography, precipitation, tourist source markets, and tourism resource endowment constitute the primary factors influencing the spatial distribution pattern of National Forest Parks. These results provide scientific references for optimizing the spatial layout and promoting healthy, sustainable development of National Forest Parks in China.

Keywords: National Forest Park; spatial pattern; influencing factors; spatial analysis technology; China

Introduction

National Forest Parks constitute important tourist destinations in China and serve as primary venues for developing ecological, mountain, health, and leisure tourism. By the end of 2010, China' s forest parks had received over 400 million tourist visits annually, generating tourism revenue exceeding one trillion yuan, making forest tourism products among the most influential and attractive tourism offerings. Although terminology differs internationally—where they are generally called national parks—foreign scholars began researching forest parks in the 1960s, focusing on concepts and connotations, park pricing, tourist psychology, environmental protection, and management systems. Domestic scholars started later but have produced substantial research covering forest park concept definitions, tourism subjects and objects, tourism impacts, and interpretation systems.

With the advent of mass tourism, tourist demand has grown increasingly robust, leading to an abundance of tourism attractions, new products, and innovative formats. Spatial structure studies of tourism attractions have become a significant research domain, with scholars examining national parks, tourist attractions, wetland parks, heritage sites, traditional villages, and rural tourism destinations using GIS analysis techniques and mathematical statistical methods at national, provincial, and urban agglomeration scales. However, forest parks, as important tourism attractions and ecological tourism carriers, have received limited geographical research. Existing literature remains at the qualitative analysis stage using cross-sectional data, with no studies employing long-term panel data to quantitatively explore spatial structure evolution patterns and influence mechanisms. The systematic and in-depth nature of such research needs strengthening.

This study addresses this gap by using panel data of National Forest Parks from 1994, 2004, and 2019—three critical time nodes. The year 1994 marked the promulgation of the "Forest Park Management Measures" by the former Ministry of Forestry, which first classified China's forest parks into national, provincial, and municipal levels and established National Forest Parks' core position in forest tourism development. The year 2004 represented the inaugural year of the "Decision of the Central Committee of the Communist Party of China and the State Council on Accelerating Forestry Development" and the release of the "National Forestry Industry Development Outline," with provinces subsequently introducing supportive policies that created favorable conditions for forest park tourism development. The year 2019 represents the most recent year to ensure data timeliness and scientific validity.

Data Sources and Methods

Data Sources

Research data for National Forest Parks from 1994, 2004, and 2019 were collected primarily from the China Forestry Network (National Forestry and Grassland Administration Government Website, National Ecological Network). National precipitation data were obtained from the Chinese Academy of Sciences Resource and Environmental Science Data Center. National spatial administrative boundary vector data were sourced from the National Geomatics Center of China, while scenic area data came from the "China Tourist Attraction Development Report."

Research Methods

1.2.1 Nearest Neighbor Index The nearest neighbor index examines the spatial proximity among point elements to characterize their distribution patterns. The formula is:

$$R = \frac{\bar{r}_1}{\bar{r}_2} = \frac{\bar{r}_1}{\frac{1}{2\sqrt{D}}}$$

where R is the nearest neighbor index; $\bar{r}_1$ is the average actual nearest neighbor distance; $\bar{r}_2$ is the theoretical nearest neighbor distance; D is the density of National Forest Parks; n is the number of National Forest Parks; and A is the regional area. Generally, when $R < 1$, the distribution tends to be agglomerative; when $R = 1$, random; and when $R > 1$, uniform.

1.2.2 Geographic Concentration Index The geographic concentration index characterizes the spatial agglomeration degree of point elements, with values ranging between 0 and 100. Higher values indicate more concentrated distribution:

$$G = 100 \times \sqrt{\sum_{i=1}^{n} \left(\frac{X_i}{T}\right)^2}$$

where G is the geographic concentration index; n is the number of provinces; T is the total number of National Forest Parks; and X_i is the number of National Forest Parks in province i. The concentration degree is proportional to the G value.

1.2.3 Grid Dimension Measurement Grid dimension calculation is based on gridding the spatial distribution of National Forest Parks. By dividing the national map into different numbers of grids, the number of grids occupied by National Forest Parks, $N(r)$, varies with grid size r. Assuming National Forest Parks have scale-free spatial distribution characteristics:

$$N(r) \propto r^{-D_0}$$

where D_0 is the capacity dimension value. Assuming the probability of National Forest Parks in grid (i, j) is $P_{ij} = N_{ij}/N$, the information dimension value function is:

$$I(r) = -\sum_{i,j} P_{ij}(r) \log P_{ij}(r) \propto D_1 \log(1/r)$$

where D_1 is the information dimension value. The grid dimension value characterizes the equilibrium of National Forest Park distribution across China, generally ranging between 0 and 2. Higher values indicate stronger spatial distribution equilibrium, while lower values indicate greater concentration. When D_1 approaches 0, the system tends to concentrate along a geographic line; when D_1 approaches 2, distribution becomes uniform. When $D_0 = D_1$, the system exhibits simple fractal characteristics with equal probability distribution across grids.

1.2.4 ESDA Spatial Correlation Analysis Exploratory Spatial Data Analysis (ESDA) integrates spatial analysis methods to comprehensively examine geographic agglomeration states and reveal spatial interaction relationships. This study employs Moran' s I index and Getis-Ord G_i^* to explore spatial association patterns and cold/hot spot distributions.

The Moran' s I formula is:

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(X_i - \bar{X})(X_j - \bar{X})}{\sum_{i=1}^{n}(X_i - \bar{X})^2}$$

where X_i and X_j are observed values in regions i and j; n is the number of regions; $\bar{X}$ is the mean of all regional observations; S^2 is variance; and W_{ij} is the spatial weight matrix (1 for adjacent, 0 otherwise). Moran' s I ranges from -1 to 1, with values approaching 1 indicating clustering of similar attributes, -1 indicating clustering of dissimilar attributes, and 0 indicating no spatial autocorrelation.

To identify local cold/hot spots, Getis-Ord G_i^* is used:

$$G_i^*(d) = \frac{\sum_{j=1}^{n} W_{ij}(d) X_j}{\sum_{j=1}^{n} X_j}$$

Standardized as:

$$Z(G_i^*) = \frac{G_i^* - E(G_i^*)}{\sqrt{\mathrm{Var}(G_i^*)}}$$

When $Z(G_i^*) > 0$ and passes significance testing, the region is a hot spot with high-value clustering; when $Z(G_i^*) < 0$, it's a cold spot with low-value clustering.

Results

Spatial Distribution Characteristics

2.1.1 Density Distribution Features Using ArcGIS 10.0 kernel density analysis, National Forest Parks show an east-west disparity, predominantly distributed east of the Hu Huanyong Line, correlating with regional economic development. Eastern and central regions have more parks, while western regions have fewer. Across the three time periods, high-density clusters have formed around Beijing-Tianjin-Hebei, Yangtze River Delta, Sichuan-Chongqing border, and Hunan-Jiangxi border areas, with secondary clusters in the Changbai Mountains, Shandong Peninsula, and Guanzhong region. These areas are economically developed, densely populated, and have high forest coverage, providing material foundations for park distribution. Over time, high-density areas have gradually shifted southward, generally surrounding China' s three major forest regions (Northeast, Southwest, and Southern) in a "large agglomeration, small dispersion" pattern, with low-density areas in northwestern China.

2.1.2 Spatial Distribution Type Using ArcGIS 10.0 to calculate average actual and theoretical nearest neighbor distances (Table 1), the nearest neighbor indices for 1994, 2004, and 2019 are 0.62, 0.68, and 0.71, respectively, indicating agglomerative distribution across all periods with decreasing intensity over time. This suggests strong spatial correlation and synergistic effects in National Forest Park development, though the trend shows gradual movement toward equilibrium.

The geographic concentration indices for 1994, 2004, and 2019 are 27.64, 26.18, and 25.31, respectively, while uniform distribution indices would be 17.54, 17.54, and 17.54. The higher actual values indicate concentrated distribution, though the gap is narrowing.

Fractal analysis reveals capacity dimension values (D_0) of 1.21, 1.28, and 1.34 (with $R^2 > 0.99$), and information dimension values (D_1) of 1.12, 1.18, and 1.23, all showing significant fractal characteristics. Since $D_1 < D_0$, the system exhibits complex fractal structures with possible local clustering around mountainous areas or forests, reflecting unequal probability distribution due to varying forest resource endowments and socioeconomic development levels.

Regional Distribution Characteristics

Provincially, in 1994, National Forest Parks concentrated in Anhui, Shandong, Hunan, Yunnan, Shanxi, Heilongjiang, Liaoning, Henan, Guangdong, and Jiangxi, with these 10 provinces accounting for 63.36% of all parks while Tianjin, Tibet, and Ningxia had none. By 2019, all provinces had at least one park, with Zhejiang, Yunnan, Anhui, Jiangxi, Sichuan, and Shandong each having over 30 parks. Heilongjiang leads with 61 parks, while Tianjin and Shanghai have the fewest.

Across the three major economic zones, distribution consistently shows a "convex pattern" of fewer parks in eastern and western regions but more in the central region, though trends toward equilibrium are emerging. In 1994, the central zone had the most parks (45.69%), followed by the east (28.45%) and west (25.86%). By 2004, the west surpassed the east. By 2019, the gaps narrowed further, with the central zone at 38.45%, west at 32.62%, and east at 28.93%.

Among eight major geographical regions, distribution consistently shows a pattern decreasing "from the middle-lower Yangtze region and Southwest China toward Northeast China and the middle Yellow River region." In 1994, the middle Yangtze region had the most parks (20.85%), followed by Southwest China (17.15%) and Northeast China (14.91%), with Northwest China having the fewest (7.39%). This pattern persisted across all years.

Hotspot Distribution Characteristics

Global Moran' s I indices for the three periods are 0.18, 0.16, and 0.15 (all significant), indicating positive spatial autocorrelation that is weakening over time, suggesting a matthew effect in National Forest Park distribution with strong synergistic development potential.

Local Getis-Ord G_i^* analysis reveals a "southeast hot, northwest cold" pattern. Hotspots show instability: in 1994 they concentrated in southeastern and Bohai Rim regions, gradually migrating to southwestern and northeastern provinces by 2019. Cold spots remained relatively stable, primarily in northwestern China, though their number decreased. This indicates that as forest tourism develops and demand grows, the spatial distribution range of National Forest Parks is expanding and spatial disparities are narrowing.

Influencing Factors

2.4.1 Terrain Factors

National Forest Park distribution is significantly influenced by terrain, with a tendency to cluster around mountainous areas. Overlaying park distribution with national elevation data and extracting altitude values shows a Pearson correlation coefficient of -0.62 (significant), indicating strong negative correlation between elevation and park numbers. Classifying terrain into plains, hills, mountains, and plateaus reveals that over 50% of parks are located in plains and hills below 500m elevation, with plains below 200m having the most (over 30%). This characteristic—most parks having relatively low elevation—differs from common perception and should inform future tourism product development.

2.4.2 Precipitation Factors

Regional precipitation differences directly affect forest vegetation, which in turn influences local precipitation through evapotranspiration. Overlaying park distribution with precipitation data shows a Pearson correlation of 0.71 (significant). Classifying regions by precipitation into arid (<200mm), semi-arid (200-400mm), semi-humid (400-800mm), and humid (>800mm) zones reveals that humid zones have the most parks, with over 80% of parks in humid and semi-humid zones combined. This demonstrates that precipitation is a crucial factor, as forest parks depend on forest resources whose survival is directly affected by precipitation. Additionally, dense forest vegetation influences local climate and rainfall, a factor to consider in product development.

2.4.3 Tourist Source Market

As important tourism destinations, National Forest Parks are closely related to source markets. Urban residents constitute the primary market, attracted by good ecological environments, rich landscape resources, and high recreational value. Using buffer analysis with 50km and 100km radii around prefecture-level cities and provincial capitals, over 50% of parks fall within these buffers, though the proportion is decreasing. This indicates that while parks are significantly influenced by source markets, their tourism appeal is strengthening, attracting more non-urban residents. With the development of self-driving tours and improved transportation, the market radiation radius is expanding.

2.4.4 Tourism Resource Endowment

A-level scenic spots are important tourism carriers with good resource endowments, facilities, and accessibility. Buffer analysis with 50km intervals around A-level scenic spots shows that over 58% of National Forest Parks are within 50km of scenic spots, with Pearson correlation of 0.61 (significant). This strong symbiotic relationship is strengthening over time. Parks in resource-rich areas benefit from tourist flows, capital, and information from surrounding scenic spots, enabling differentiated development and mutual benefit.

Conclusions and Recommendations

3.1 Conclusions

This study analyzed the spatial distribution patterns and influencing factors of National Forest Parks using spatial analysis methods. Key findings include:

1. National Forest Parks are mainly distributed east of the Hu Huanyong Line, forming high-density clusters around Beijing-Tianjin-Hebei, Yangtze River Delta, Sichuan-Chongqing border, and Hunan-Jiangxi border areas, with secondary clusters in the Changbai Mountains, Shandong Peninsula, and Guanzhong region. The pattern shows "large agglomeration, small dispersion" around China's three major forest regions.

2. Parks exhibit agglomerative distribution with weakening intensity over time. Fractal characteristics are pronounced, with complex structures due to unequal probability distribution reflecting varying forest resource endowments and socioeconomic development.

3. Significant inter-provincial disparities exist, showing a "convex pattern" across three major zones (fewer in east and west, more in central) and a decreasing gradient across eight regions from the middle-lower Yangtze and Southwest toward Northeast and middle Yellow River regions.

4. The spatial pattern shows "southeast hot, northwest cold" with unstable hotspots. Heilongjiang, Jiangsu, and Zhejiang remain active hotspots, while Xinjiang, Tibet, and Sichuan are persistent cold spots.

5. Topography, precipitation, tourist source markets, and tourism resource endowment are the main influencing factors, manifesting as "preferring low elevation," "favoring humidity," "surrounding cities," and "proximity to scenic spots."

3.2 Recommendations

National Forest Parks are vital carriers of China' s forest tourism development. Research on their spatial differentiation provides scientific references for optimizing spatial layout and regional policy formulation.

1. **Increase eastern and western locations**: Although distribution is gradually equalizing, agglomeration persists. The state should increase parks in eastern and western regions, especially the east where demand is high but supply is insufficient. Priority should support provincial forest parks upgrading to national status.

2. **Strengthen cooperation**: The significant spatial correlation and Matthew effect suggest that regions, provinces, and individual parks should strengthen cooperation to form a community of shared destiny for forest park tourism development.

3. **Develop differentiated models**: Based on the four major influencing factors, parks should adopt three development models:

   - **Scenic-reliant model**: Parks near scenic spots should pursue cooperative development with complementary products and integrated tourism.
   - **Natural geographic element utilization model**: Parks should leverage their geographic advantages—high-altitude parks (>3500m) can develop extreme sports and special sightseeing; mid-altitude parks (1000-3500m) can create health and wellness products; low-altitude parks (<1000m) can offer cycling, camping, and hunting experiences.
   - **Market-driven model**: Parks near large source markets should develop forest vacation and health products for urban residents to enhance competitiveness.

China' s forest tourism development shows "four modernizations" : lifestyle-oriented tourism forms, ecological development approaches, comprehensive economic models, and refined management. However, product homogenization exists, requiring transformation and upgrading. Future development should adapt to local conditions, deepen resource characteristics, embed cultural connotations, and innovate products. Parks should leverage natural geographic conditions and location advantages for differentiated development. Due to data limitations, future research should employ longer time spans and classify parks by grade and type, while further investigating impacts of soil, temperature, and other natural geographic elements.

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Note: Figure translations are in progress. See original paper for figures.