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Delineating an Integrated Ecological and Cultural Corridor Network: A Case Study in Beijing, China

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Abstract: This study shows that an integrated ecological and cultural corridor network can help guide city development strategies to better preserve ecological and cultural assets. Traditionally, protection zones and suitable development areas are often identified by separately considering natural elements of the ecosystem and elements of cultural significance. To achieve the purpose of cohesively protecting areas of ecological and/or cultural significance, we have developed a corridor-based spatial framework by integrating ecological and cultural assets. Ecological sources are identified by combining protection prioritization, nature reserves, and water bodies. Ecological corridors are delineated by using the minimum cumulative resistance (MCR) model on a resistance surface constructed from land-use data to connect ecological sources. Ecologically important areas are then delineated by creating a 5-km buffer zone from ecological sources and ecological corridors. Cultural corridors are historical routes and rivers surrounded by abundant cultural nodes. Like ecologically important areas, culturally important areas are delineated by creating a 5-km buffer zone from cultural corridors. Comprehensive regions are the overlap of ecologically and culturally important areas. Finally, the integrated network connects all comprehensive regions following ecological corridors and cultural corridors in such a way that the largest number of ecological sources and cultural nodes are reached. We applied this framework in Beijing, China, and the results show that there are 2011 km^2 of ecological sources, 30 ecological corridors, 423 cultural nodes, seven cultural corridors, and 10 comprehensive regions covering 2916 km^2 in the integrated network. The framework adds new insights to the methodology of considering ecological and cultural assets together in developing protection and development strategies.

Keywords: ecological corridors; cultural corridors; protection prioritization; MCR model; integrated network

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1. Introduction

Human settlements have evolved from a cluster of cities to metropolitan areas, metropolitan area belts, large metropolitan belts, and megalopolises [1]. The world population has increased exponentially under this massive urbanization. In 2019, the United Nations predicted that the world population will have increased to 9.7 billion by 2050 and 66% of the population will reside in urban areas [2]. The conflicts between economic development and ecological protection have been seriously exacerbated by the rapid and intense changes in the structure and function of the landscape [3,4]. The rapid influx of popular culture from developed countries into developing countries and the widespread homogeneity of cultural practices have marginalized or even led to the disappearance of many indigenous cultures. These factors are the cause of many serious problems in the world today, such as air and water pollution, cultural invasion, biodiversity loss, food insecurity, and rising crime rates. Some scholars have pointed out that the world and its constituent landscapes are on an unsustainable trajectory. The question of how to reduce the effects

of urbanization on the ecosystem in order to achieve urban sustainability has become an important focal point in the field of landscape ecology [5–8]. Sustainable development is a necessity, not a choice [9].

To achieve sustainable development, human beings must be in harmony with the environment in which they live. Ecosystem services are one of the important factors determining landscape sustainability. Among various definitions of ecosystem services [10–13], the most widely accepted is from the Millennium Ecosystem Assessment: ecosystem services are the benefits people obtain from ecosystems. Ecosystem services have been increasingly considered a crucial bridge between the environment and society, which also safeguard the natural capital for future generations and highlight the contributions of ecosystems to human wellbeing [14–16]. Although ecosystem service evaluation has received increasing attention over the years [17], most studies still use biodiversity conservation, ecological importance, ecological risk evaluation, and resilience assessment to recognize ecological sources when delineating ecological corridors [18,19].

Similar to how modern material civilization comes at the expense of biological diversity, modern spiritual civilization comes at the expense of cultural diversity. With industrialization and human expansion, the earth is losing its biological and cultural diversity. The influence of foreign cultures, the transformation of traditional lifestyles, the mobility of the population, and the over-exploitation of tourism have destroyed various intangible cultural heritage resources. Many cultural heritage resources are the products of the long-term interaction between human beings and the natural environment in indigenous societies, which can enable people to recover the memory of the past and to build new perspectives [20]. However, many ancient buildings, bridges, and other facilities are gradually being replaced by works of modern engineering, and numerous excellent cultural heritage sites are scattered and lack contact with each other, which causes them to disappear over time. It is extremely urgent to establish an integrated conservation strategy to breathe new life into these precious assets.

As for the protection of ecological and cultural resources, inclined research on ecological/cultural conservation strategies focused on the establishment and application of corridors system to solve the relationship between protection and development comprehensively and efficiently [20–25]. In fact, Lewis (1964) put forward the linear concept of "environmental corridor" earlier, which contains surfaces, slopes, rims, and adjacent lands paralleling the corridor. The author also pointed out that the protection of environmental corridor qualities needs the joint efforts of better guidelines, legislation, and volunteered participation, and these corridors can serve as a landscape foil to an ever-advancing urban landscape [26]. Nevertheless, ecological or cultural corridors were always concerned separately rather than simultaneously. The aim of most ecological corridors is to maximize the value of regulating ecosystem services and biodiversity conservation by enhancing the connectivity among landscape elements [27,28], while recreation and tourism, sense of place, and heritage protection are the main functions of cultural corridors [23,29]. The aims, problems addressed, managing approaches, and spatial scale of these two aspects all have significant differences, and the scientific research, management practice and political discourses of ecological conservation and cultural heritage protection have largely been isolated from each other [30]. The participation of local residents is far lower than that of government decision-makers in the planning and management of both ecological corridors and cultural corridors, but the stakeholders and participation manners involved are quite different [30,31]. The combination of ecological corridors and cultural corridors is quite necessary to enrich the study framework and improve spatial integrity.

In this study, we address a few important gaps in the knowledge: (1) in the context of rapid urbanization, which leads to the disappearance of indigenous cultures and ecologically sensitive areas, comprehensive research on the combination of the ecological corridor and cultural corridor is not enough, and (2) current protection studies and practices of ecologically sensitive sites and cultural sites are not linked. We have designed this study to: (1) construct an integrated ecological and cultural corridor-based framework,

(2) establish protection priorities by integrating protection values and protection costs, and (3) provide a scientific reference for optimizing the ecological spatial structure and promoting regional sustainable development. The rest of the paper is organized as follows. In Section 2, we describe the study area and our integrated framework. The application of the framework is presented in Section 3. In Section 4, we discuss our findings, and in Section 5, we summarize our conclusions.

2. Materials and Methods

2.1. Study Area

The study region, i.e., the city of Beijing (16,410 km^2), is located in Northern China and is characterized by a variety of landforms and a rich cultural history. The terrain of Beijing slopes downwards from the northwest to the southeast (Figure 1). The city's average population density was 1313 person/km^2, and the population density of the central urban area was 8929 person/km^2 in 2018. Along with rapid urbanization, the area of developed land dramatically increased from 485 km^2 in 1990 to 1525 km^2 in 2018. As a famous historical and cultural city, Beijing has hundreds of key cultural relic protection units, including 6 world heritage sites, such as the Great Wall and the Forbidden City.

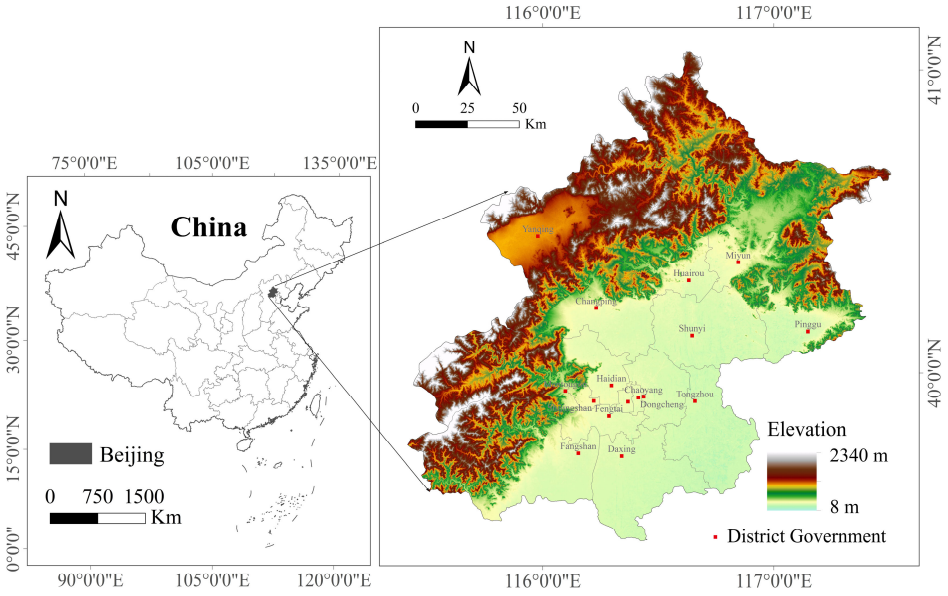

Figure 1. Location of Beijing and its Digital Elevation Model (DEM).

2.2. Data and Data Sources

The data used in this research include: (1) digital elevation model (DEM) data with a spatial resolution of 30 m, (2) land cover raster data with a spatial resolution of 30 m, which is reclassified into 6 types: developed land, forest land, farmland, grassland, water bodies, and unused land, (3) railroads, highways, and national roads in vector data format, (4) water bodies including rivers, lakes, and reservoirs in vector data format, (5) normalized difference vegetation index (NDVI) raster data with a spatial resolution of 1 km, which is resampled to 30 m, (6) the monthly and annual average precipitation of 18 weather stations from 1980 to 2012 in tabular data format, and among these weather stations, there are 6 in Beijing and 12 around Beijing, which can increase the accuracy of created raster in edge area, (7) soil composition and soil texture raster data with a spatial resolution of 1 km, which is resampled to 30 m, (8) nature reserves in vector data format, and (9) cultural heritage in vector data format. The spatial resolution of 30 m is used in all the raster calculations and outcomes. Appendix A Table A1 lists the data and data sources.

2.3. Methodological Framework

Figure 2 illustrates the conceptual framework of delineating the integrated network from ecological corridors and cultural corridors. Identifying ecological sources is the first step in delineating ecological corridors. Ecological sources consist of nature reserves, water bodies, and areas of high protection priority. Factors affecting the protection priority can be grouped into protection values and protection costs. Protection values reflect health and vulnerability, ecological importance, and the existing protection status of the targets [32,33]. Land use types, soil properties, and surface environment affect the ability to maintain biological resources and protection value. In this study, these factors were used in the process of deriving protection values from the amount of soil conservation. All protection interventions have associated costs, which include acquisition costs, management costs, transaction costs, damage costs, and opportunity costs, and protection costs are affected by many factors [34–37]. In this study, we included elevation (ELE), proximity to settlements (PSE), proximity to roads (PRO), and proximity to water bodies (PWA) in calculating the protection costs. Then, taking the protection costs as the resistance surface, paths connecting ecological sources were delineated as ecological corridors using the minimum cumulative resistance (MCR) model. When delineating cultural corridors, we considered designated cultural heritage sites to be cultural nodes. Since many cultural nodes are located along rivers and historical routes, we derived cultural corridors from the spatial distribution characteristics of cultural nodes and historical routes and rivers that have cultural and historical significance. Through a buffer analysis of the ecological sources and ecological corridors, ecologically important areas were obtained. Culturally important areas were acquired through a buffer analysis of cultural corridors. Then, ecologically important areas and culturally important areas were superimposed to obtain the comprehensive regions. Finally, the integrated network was delineated to connect the ecological sources, cultural nodes, ecological corridors, cultural corridors, and comprehensive regions.

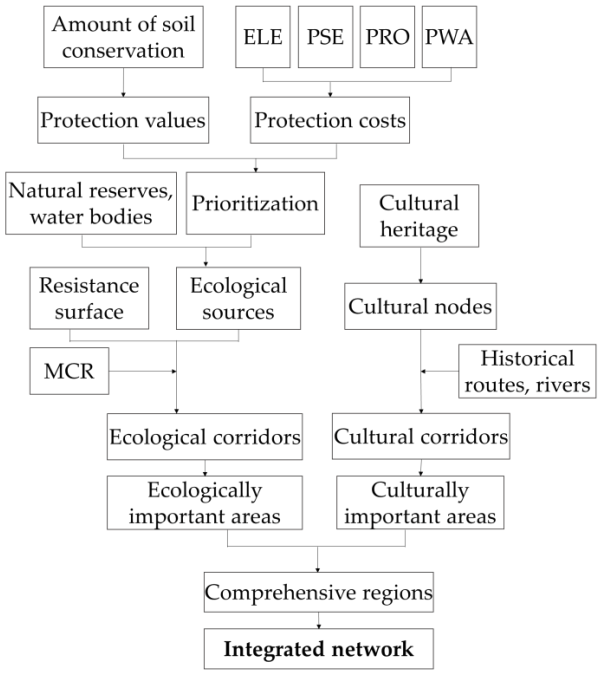

Figure 2. The framework for developing the integrated network.

2.4. Delineation of Ecological Corridors

2.4.1. Identification of Ecological Sources

We derived protection values from the amount of soil conservation. The function of soil conservation is mainly related to climate, soil characteristics, topography, and vegetation. We used the revised universal soil loss equation (RUSLE) to calculate the amount of soil

conservation in this study. RUSLE, proposed by Renard, is the most frequently used model [34,38]. It provides an ideal framework for assessing soil erosion and a clear perspective for understanding the interaction between erosion and its contributing factors. The model and its parameters are illustrated below.

$$A = A_0 - A_1, \tag{1}$$

$$A_0 = R{\cdot}K{\cdot}L{\cdot}S, \tag{2}$$

$$A_1 = R{\cdot}K{\cdot}L{\cdot}S{\cdot}C{\cdot}P, \tag{3}$$

where A is the amount of soil conservation ($t{\cdot}ha^{-1}{\cdot}year^{-1}$), A_0 is the amount of potential soil loss, and A_1 is the amount of actual soil erosion loss. Other factors are explained as below:

(1) R represents the erosivity factor ($MJ{\cdot}mm{\cdot}ha^{-1}{\cdot}h^{-1}{\cdot}year^{-1}$), which is calculated by monthly precipitation and annual precipitation.

$$R = \sum_{i=1}^{12}\left(1.735 \times 10^{(1.5\times lg\frac{P_i^2}{P} - 0.08188)}\right), \tag{4}$$

where P_i (mm) is the average precipitation of month i and P (mm) represents the multi-year average precipitation. We converted punctuated weather station data into raster data using the inverse distance weighted (IDW) tool in ArcGIS 10.5.

(2) K represents the soil erodibility factor calculated from the soil content ($t{\cdot}h{\cdot}MJ^{-1}{\cdot}mm^{-1}$).

$$\begin{aligned} K = \{0.2 + 0.3exp[-0.0256SAN(1 - SIL/100)]\} \times \left[\frac{SIL}{(CLA+SIL)}\right]^{0.3} \times \\ \left\{1.0 - \frac{0.25orgC}{[orgC+\exp(3.72-2.95orgC)]}\right\} \times \left[1.0 - \frac{0.7SN1}{SN1+\exp(-5.51+22.9SN1)}\right], \end{aligned} \tag{5}$$

where SAN, SIL, CLA, and $orgC$ represent the proportion of sand, silt, clay, and organic carbon in the soil respectively, $SN1 = 1 - SAN/100$.

(3) L represents the slope length factor.

$$L = (\lambda/22.13)^m, \tag{6}$$

$$m = \beta/(1+\beta), \tag{7}$$

$$\beta = (\sin\theta/0.0896)/[3.0(\sin\theta)^{0.8} + 0.56], \tag{8}$$

where λ is slope length, m is slope length index, and θ is slope measured in percentage.

(4) S represents the slope steepness factor.

$$S = \begin{cases} 10.8\sin\theta + 0.03 \ (\theta < 9\%) \\ 16.8\sin\theta - 0.50 \ (\theta \geq 9\%) \end{cases}, \tag{9}$$

(5) C is the vegetation cover management factor.

$$C = 0.6508 - 0.3436\log_{10} c, \tag{10}$$

$$c = \frac{NDVI - NDVI_{soil}}{NDVI_{veg} - NDVI_{soil}}, \tag{11}$$

where c is vegetation coverage, and $NDVI_{soil}$ and $NDVI_{veg}$ are the values of $NDVI$ when the confidence level is 5% and 95%, respectively.

(6) P is the support practices factor, which is a ratio of the soil loss with a conservation practice to soil loss from straight-row farming up and down the slope [39]. We used a P factor value of 1 in the study.

We normalized A into five classes using the Jenks Natural Breaks Classification method. The five class values represent the protection value (P_v). A P_v of "5" indicates the highest protection value and "1" the lowest. We derived the composite protection costs from elevation (ELE), proximity to settlements (PSE), proximity to roads (PRO), and proximity to water bodies (PWA). In China, land is state-owned or collective owned, and there are 2 types of costs due to conservation: the management cost of direct investment in the establishment and management of protection facilities, and the opportunity cost of abandoning the potential value of land economic use [40]. Management cost is mainly related to the type, area and local economic factors of the reserves [41]. Therefore, the 4 indicators related to elevation and distance in our study mainly affect the opportunity cost. Land in higher elevation areas is less desirable for development and less likely to be used for other economic purposes. Therefore, the opportunity cost is lower. The edge of settlements has a high probability of being used to build housing or other developments, so the opportunity cost lost due to conservation measures decreases as the distance to settlements increases. Roads can cause habitat fragmentation and ecosystem degradation, and land proximity to roads means it is potentially valuable for other economic use, so the opportunity cost is high near roads and decreases as the distance increases from roads. Considering the isolation effect of roads on ecological space, we selected the highways, national roads, and railroads in this study. Surface water bodies have a function of conserving water sources, but waterfronts are usually places of human activity. Therefore, the larger the distance from water bodies, the lower the opportunity cost. We used the "Euclidean Distance" tool in ArcGIS 10.5 to obtain the PSE, PRO, and PWR, then we reclassified these indicators to values from "1" to "5" and calculated the protection cost (P_c) as the weighted sum of them (the natural breakpoint method was used to perform the reclassification in this paper). The weights of ELE, PSE, PRO, and PWA are 0.3564, 0.3257, 0.1986, 0.1243 respectively, according to the research of Tao [42]. The protection cost, P_c, was reclassified to five discrete values, with "5" indicating the lowest protection cost and "1" the highest protection cost.

The protection priority was obtained by averaging the protection value and protection cost. In other words, high protection priority areas should have both high protection values and low protection costs. Protection priorities were calculated with the following formula:

$$P_r = \frac{P_v + P_c}{2} \tag{12}$$

where P_v is the protection value, P_c is the protection cost, and P_r is the protection priority, with a reclassified value from "1" to "5". Areas with a P_r value of "5" have the highest protection priority level and areas with "1" the lowest.

Finally, ecological sources were determined as areas with priority value of "5", and areas with the priority value of "4" that are located in nature reserves (see details of nature reserves from Appendix A Table A2) and water bodies. Nature reserves consist of wetlands and forests, which can reduce soil erosion, conserve water, adjust the local ecosystem, and provide habitats for rare animals, birds, plants, and aquatic wildlife. Water bodies (such as lakes and reservoirs) play an important role in flood prevention and the propagation of aquatic organisms.

2.4.2. Delineation of Ecological Corridors

The MCR model is excellent in terms of expressing the interaction between landscape patterns and ecological processes [43,44]. The first step in the MCR model is to create a resistance surface according to land-use type [45]. Different land-use types have diverse impacts on the ecological resistance coefficient. Distance from developed land partially reflects the impact of human activities on the ecosystem [18]. Opinion on the resistance coefficient is consistent among researchers: the highest resistance coefficient is associated with developed land and decreases as distance to developed land increases [46,47]. We compiled resistance coefficients from the literature, as shown in Tables 1 and 2.

Table 1. Resistance coefficients of different land-use types (R_l, a higher value means higher resistance).

Land-Use Type	Resistance Coefficient (R_l)
Forest land	1
Grassland	10
Rivers and wetland	20
Reservoir	30
Farmland	50
Other land types	80
Developed land	100

Table 2. Resistance coefficients of different distances from developed land (R_d, a higher value means higher resistance).

Distance From Developed Land (m)	Resistance Coefficient (R_d)
0~100	100
100~200	70
200~300	60
300~500	40
500~1000	30
1000~3000	10
3000~5000	5
>5000	1

We calculated the resistance surface using the following formula:

$$R_w = \frac{R_l + R_d}{2}, \quad (13)$$

where R_w is the weighted resistance, R_l is the resistance coefficient of different land-use types, and R_d is the resistance coefficient of different distances from developed land. For example, the weighted resistance value of a grassland grid (R_i = 10) that is 600 m from developed land (R_d = 30) is 20 (= (10 + 30)/2). To improve the accuracy of ecological corridor identification at the boundary, the scope of analysis of the resistance surface is larger than Beijing's administrative boundary.

The second step is to calculate the cost distance to ecological sources through the weighted resistance surface. This process was implemented with the "Cost Distance" tool in ArcGIS 10.5. The input source data raster layer is ecological sources and the input cost raster layer is the weighted resistance surface. The third step is to identify the least-cost paths from any ecological source to other ecological sources using the "Cost Path" tool in ArcGIS 10.5, and this step gives several different paths near ecological sources. Lastly, the paths with the fewest intersections with roads between two sources were selected as ecological corridors.

2.5. Delineation of Cultural Corridors

2.5.1. Identification of Cultural Nodes

People tend to choose cultural spots and scenic spots for social interaction, relaxation, education, and inspiration. There are often rich cultural heritage sites in urban and surrounding areas that have a long history, including material cultural heritage: that of historical, artistic, and scientific value, and intangible cultural heritage: traditional cultures that are related to life in an immaterial form. Material cultural heritage and intangible cultural heritage are always accompanied in space [48]. However, these cultural heritage sites are under pressure from urbanization and tourism development, which threaten their original authenticity and integrity. In this study, we selected the national and municipal cultural heritage sites designated by the State Council of China as cultural nodes. These

cultural heritage sites include ancient ruins, historic buildings, ancient tombs, lithoglyphs, historical and cultural towns/villages, etc., of significant historical and cultural value.

2.5.2. Delineation of Cultural Corridors

Cultural corridors are important bonds that link cultural nodes with human activities. They play an important role in tourism development, cultural heritage conservation, and the promotion of a sense of place [22,49,50]. The definition of a cultural corridor in this paper emphasizes its function of connectivity and inheritance. First of all, we identified the areas where cultural nodes are concentrated according to their distribution characteristics. Then, we delineated the routes and rivers that have important historical and cultural significance. We combined these two aspects to obtain the cultural corridors; in other words, the cultural corridors were determined according to whether a route or river has historical and cultural significance and whether there are a large number of cultural nodes around it. That is to say, cultural corridors are historical routes and rivers surrounded by abundant cultural nodes.

2.6. Delineation of the Integrated Network

The width of an ecological corridor has an important impact on the ecological function of the corridor. Some researchers believe that although different edge effects correspond to different corridor widths, generally speaking, the wider the ecological corridor, the better its ecological function [51,52]. On the basis of these research findings, we defined a 5 km buffer zone around ecological sources and ecological corridors as ecologically important areas. Herein, 5 km is a distance for future conservation planning and is not used as the actual corridor width. Similarly, we defined a buffer zone around cultural corridors as culturally important areas. Some researchers believe that the cultural corridor is an integrative concept with the purpose of integrating the conservation of cultural and natural resources [22,53]. Whether it is a corridor along a river valley, the Grand Canal corridor, or China's ancient Silk Road corridor, the conceptual scope is determined according to the objects to be protected [22,54]. Therefore, the buffer distance for cultural corridors in our study was determined by the distribution characteristics of cultural nodes. Comprehensive regions are the overlapping areas of ecologically and culturally important areas, which represent the areas with both ecological and cultural importance. The integrated network was then established by connecting ecological sources, cultural nodes, ecological corridors, cultural corridors, and comprehensive regions.

3. Results

3.1. Ecological Sources and Ecological Corridors

3.1.1. Ecological Sources

As illustrated in Figure 3, we drew out protection prioritization (Figure 3c) based on the protection value (Figure 3a) and protection cost (Figure 3b). The "priority 5" patches, which cover about 4.9% of the study area, are mainly located in the north and the southwest. There are 22 ecological sources after combining "priority 5" patches and "priority 4" patches in nature reserves and water bodies (Figure 3d). The total area of these ecological sources is 2011 km^2: about 12.3% of the study area. The vast majority of ecological sources are located in the northwest and the southwest. The largest ecological source (1150 km^2) is located in the northwest mountainous area and accounts for 57.2% of the ecological sources.

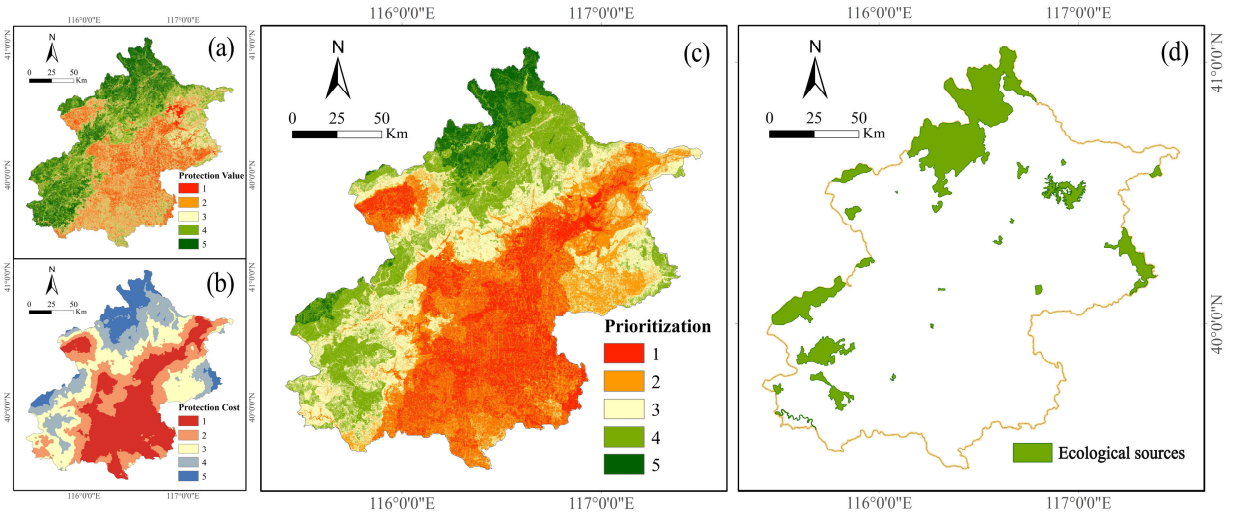

Figure 3. (**a**) Protection values, (**b**) protection costs, (**c**) protection prioritization, and (**d**) ecological sources.

3.1.2. Ecological Corridors

We can see from Figure 4 that ecological corridors connect all ecological sources together and interweave into an ecological network in space. There are 30 ecological corridors with a total length of 228 km, 6 of which extend to the central urban area, and another 7 to Hebei province. The connection to the central urban area encourages greenway construction in the central area of Beijing, and the ecological corridors extending to Hebei province can play an active role in regional collaboration. Hebei province may take these ecological corridors as a reference when they delineate their ecological corridors.

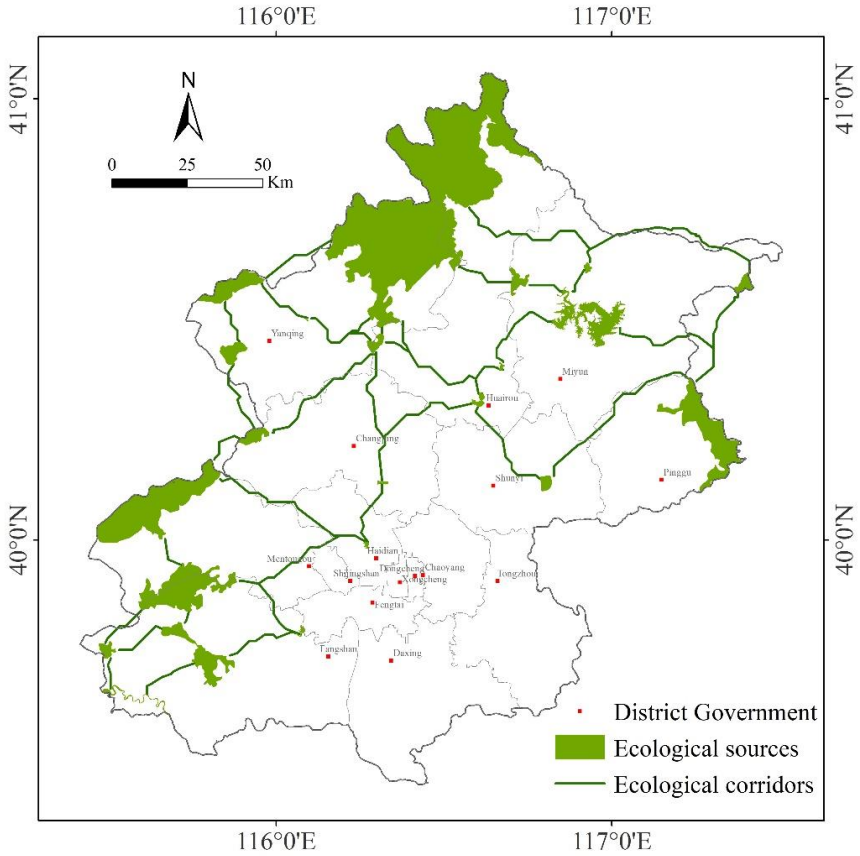

Figure 4. Ecological corridors.

3.2. Cultural Nodes and Cultural Corridors

3.2.1. Cultural Nodes

Figure 5 illustrates the 423 cultural nodes. More than half are in the central urban area and the rest are scattered in the peripheral area (see Appendix A Table A3 for details). More cultural nodes are in the southwest and fewer in the northeast. Six historical and cultural towns/villages are all in peripheral areas with lower levels of urbanization, where many high-value historical buildings and ancient features are completely preserved. For example, Lingshui village has extremely rich cultural deposits that originated from the Ming Dynasty. In the north of Beijing, the Great Wall extends from the west to the northeast, along which there are many famous historical relics, such as Badaling, which is famous for its magnificent scenery, facilities, and profound history.

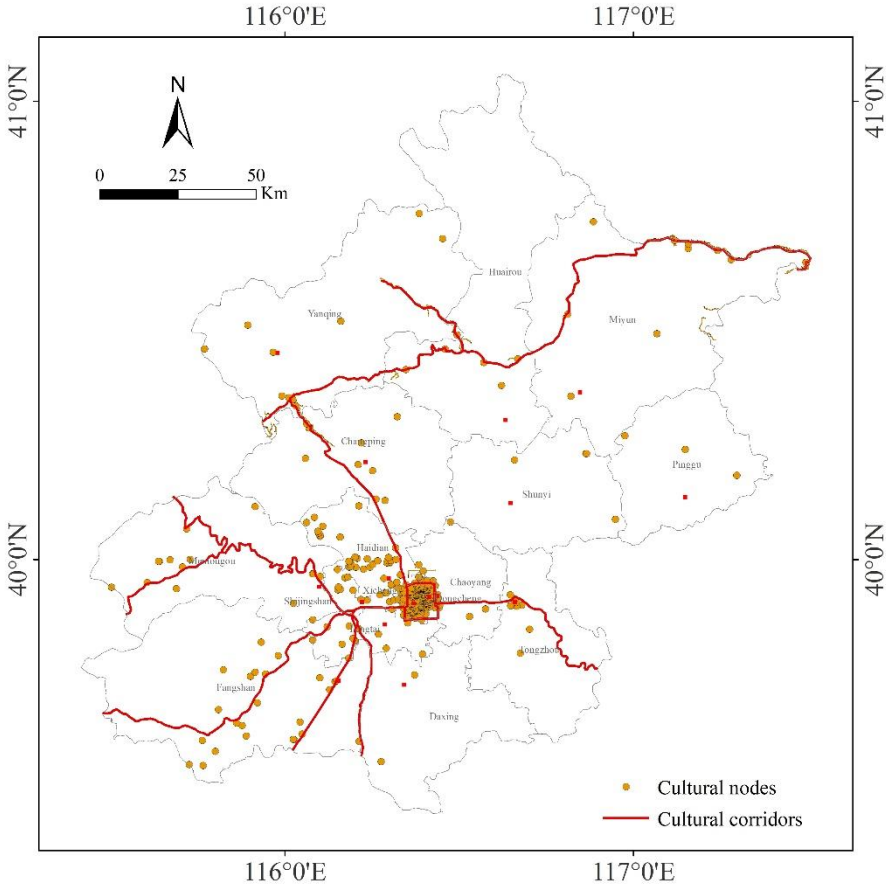

Figure 5. Cultural nodes and cultural corridors.

After observations and trials, we found that a total of 83% of the cultural nodes are within 5 km of the cultural corridors, and these cultural nodes show significant spatial agglomeration characteristics. Therefore, 5 km is an appropriate width to conduct a buffer analysis of cultural nodes in order to delineate the culturally important areas.

3.2.2. Cultural Corridors

Figure 5 presents the cultural corridors in Beijing. The total length of these cultural corridors is 851 km. They are listed below:

(1) The central district cultural corridor is bounded by the second ring road, which encloses 32.93% of Beijing's cultural heritage. There are many cultural nodes in the area along the corridor, which has a large population. Visits to the heritage sites are more frequent than in other cultural corridor areas. At the same time, the impact from outside is greater and protection is more difficult.

(2) The Great Wall cultural corridor extends along the ridgeline of the northern exurbs from west to northeast and covers famous heritage sites such as Badaling, Juyong Pass, Mutianyu, and Simatai. The development of the related cultural industry has promoted economic development and environmental protection in the area.
(3) The Yongding-Qingshui River cultural corridor is mainly in the Mentougou District, extending from the south to the source of the Yongding River and its tributary, Qingshui River. The rich history in this corridor has led to numerous ancient villages and buildings being located there. The cultural corridor plays an important role in promoting the ancient capital, improving the ecological environment, and providing recreational space.
(4) The Grand Canal cultural corridor extends from the city center to Hebei province, along which there are Huitong River, Tonghui River, Wanning bridge, and Dongbuya bridge. As the longest canal in the world, the Grand Canal has played an important role in the cultural and economic development and exchange between the north and the south of China. It was granted World Heritage site status in 2014.
(5) The Beijing–Guangzhou line cultural corridor along the Beijing–Guangzhou railroad to Hebei province begins in the city center. It is an ancient recreational route. There are numerous cultural nodes in the vicinity of the corridor, such as Lugou bridge, Liangxiang tower, and Liuli River bridge.
(6) The Beijing–Taiyuan line cultural corridor along the Beijing–Taiyuan railroad to Hebei province also originates in the city center. It is an ancient recreational route. Famous heritage sites along the cultural corridor include the Peking Man Site at Zhoukoudian, Tantuo temple, and Yao Guangxiao grave.
(7) The Beijing–Baotou line cultural corridor is one of the imperial roads from the Ming Dynasty and Qing Dynasty. It starts from the city center and extends along the Beijing–Baotou railroad to the Badaling Great Wall and Ming Tombs. Famous heritage sites along the cultural corridor include the Beijing–Zhangjiakou Railway and Juyong Pass.

3.3. The Integrated Network

As illustrated in Figure 6, the integrated network visually reveals the relationships between ecological sources, cultural nodes, ecological corridors, and cultural corridors. Ecological sources are mainly distributed in exurbs, while cultural nodes are mainly located in central urban areas. However, the suburbs where ecological sources and cultural nodes coexist, such as Badaling Great Wall, Lingshui village, and Gubei town, are often the most popular tourist destinations, because they have multiple functions including leisure, experiencing traditional culture, and acquiring knowledge. Ecological corridors connecting all ecological sources interweave into a network in the exurbs, while cultural corridors radiate outward from the central urban area. At the same time, ecological corridors and cultural corridors share some intersection areas in the suburbs, which provide convenient positions for us to identify comprehensive regions.

The comprehensive regions that have both ecological and cultural importance cover an area of 2916 km^2, and are mainly distributed in forestland. We numbered these regions from 1 to 10, as illustrated in Figure 6. The Great Wall landscape and the Great Wall culture are the outstanding features of Numbers 1–4. Number 5, a famous tourist destination, is a region with a concentrated distribution of historical and cultural heritage, characterized by royal gardens from the Qing Dynasty. There is a tremendous legacy and beautiful scenery along the Yongding river in Numbers 6–7. Historical and cultural villages and ancient buildings are concentrated in Number 8. There are a lot of celebrated cultural heritage sites in Number 9, such as the Zhoukoudian Peking Man Site, the Jin mausoleum site, etc. Number 10 is located in the famous Juma River scenic spot. In these regions, rich ecological assets and cultural nodes blend well in space, and ecological corridors coexist with cultural corridors. The integration of mountains and cultural heritage is the prominent feature of Chinese mountain culture.

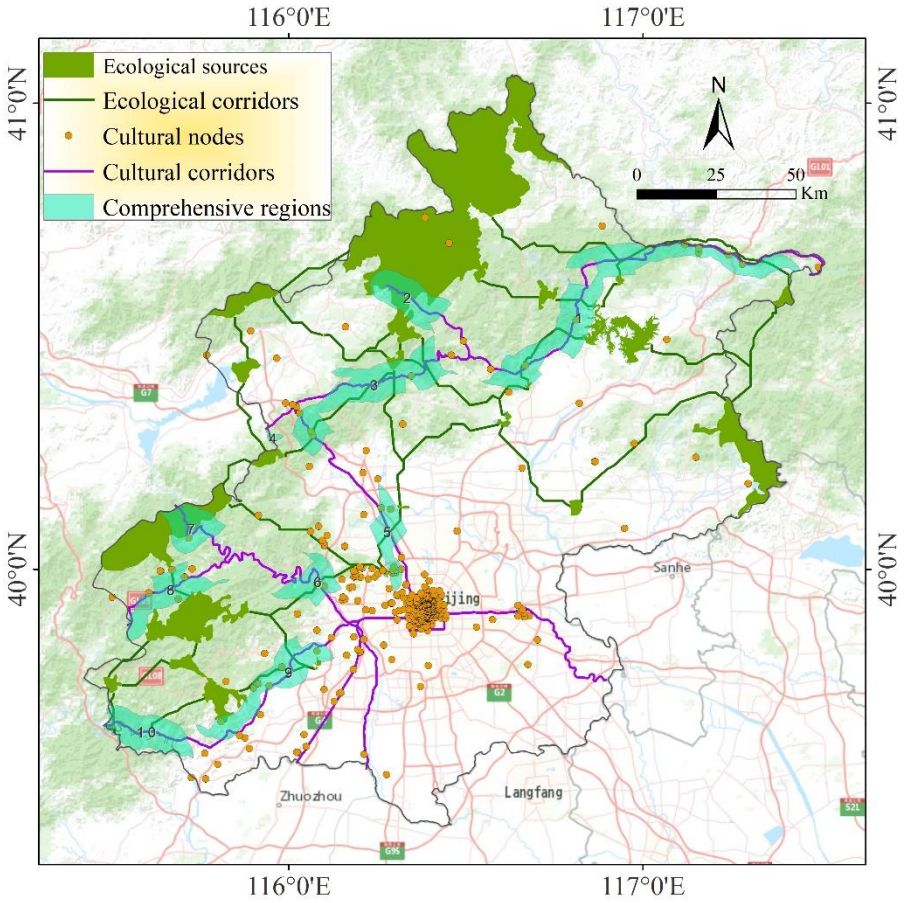

Figure 6. Integrated network.

4. Discussion

The coordination between protection and development is a vital basis for regional planning. Extreme protection or development can lead to unsustainable regional development [3]. Identifying ecological sources based on their protection priority is an effective way to build a smart protection plan. Special guidelines for protection and development can be formulated according to the different characteristics of priority levels, which is also beneficial in terms of the efficient use of funds. Areas in the most urgent state should receive the earliest attention, and urban construction and other development activities should be strictly restricted in these areas. In the case study of Beijing, ecological sources and cultural nodes have shown distinct spatial distribution characteristics. Ecological sources are mainly located in a mountainous region with a large area of forestland and grassland. Cultural nodes are concentrated in the built-up areas, and they are greatly and easily affected by human development activities. However, human beings have been seeking ways to organically integrate with the natural environment. For example, many temples, relics, and traditional villages are integrated into the natural environment, which attracts a large number of tourists every year and provides people with places for leisure activities.

The protection and construction of ecological corridors is still problematic because both ecological benefits and economic development are important for urbanized areas [55]. In the ecosystem, the barrier effect of road networks on biological pathways cannot be ignored. Unlike ecological corridors, cultural corridors in this paper are delineated according to the distribution features of cultural heritage, rivers, and historical routes, which is a subjective process. Although the size and influence radius of cultural heritage have not been taken into account, cultural corridor buffers reveal priority protection areas and systematize the protection of cultural heritage. These culturally important areas deserve priority heritage

protection and strict construction control in order for them to retain their local cultural atmosphere.

In the comprehensive regions, in which ecological assets and cultural nodes coexist harmoniously in space, heritage protection, ecological protection, and landscape renovation are the main tasks. These comprehensive regions hold great importance in landscape planning and cultural heritage protection for decision-makers and planners. It is extremely necessary to apply strict and effective measures to reduce the destruction of natural ecology and cultural heritage as a result of human development activities. Some regions have done better in this regard, such as comprehensive region Number 8, and the ecological environment and historical and cultural villages all have been well protected. However, in some other regions, like Number 10, ecological problems such as habitat degradation and water quality deterioration have emerged due to the over-exploitation of tourism activities. In a nutshell, what these regions need is more systematic policies and management strategies. Some engineering and cultural heritage protection measures should be taken into consideration, such as building underground passages, overpasses, cultural squares, relic parks, and cultural attractions. Construction activities should be strictly controlled, and landscape renovation should be carried out in existing construction areas.

The heritage datasets used in our study are the list from official heritage discourse, which is reliant on the knowledge claims of technical and aesthetic experts, and institutionalized in state cultural agencies and amenity societies [56]. Previous studies have shown that public participation can be an effective tool in landscape planning and management [31], but the expression of subaltern discourses of community participation in heritage management and conservation processes in our study is insufficient. In order to reveal the potential elements, participatory strategies and field investigation should be included in future research, and experts involved in research, management, and marketing of cultural heritage as well as local residents should be involved in this process.

Although there are distinctive differences between ecological corridors and cultural ecological corridors, some potential similarities remain. For example, some researchers focused on the topics of cultural heritage, tourism, ecosystem services in landscape corridor study at the same time [57–59]. However, so far, the study of cultural corridors remains relatively weak compared to that of ecological corridors [18,30], and there has not been a systematic methodology framework to combine ecological corridors and cultural corridors in the same context. Therefore, it is quite necessary to enrich the research of corridor framework by combining ecological corridor with cultural corridor. Ecological protection is not a local or personal matter, but one that needs the collaboration of experts from different disciplines and policymakers from different regions. The protection of cultural relics is not only a matter for cultural relic workers but also planners and decision-makers. The integrated analysis of ecological corridors and cultural corridors is significant for the implementation of an integrated protection strategy.

5. Conclusions

In this paper, we presented a method to delineate an integrated network that combines ecological corridors and cultural corridors. Along the integrated framework, we located many cultural heritage sites in areas that would be considered suitable for development using the traditional method, which only considers ecological elements when defining protection zones. We identified these areas as not being suitable for large-scale development, as it will lead to the destruction or even disappearance of local traditional features. Ecological and cultural corridors perform different functions, but they serve the same purpose of improving the quality of life. By considering them together, we can demonstrate the integral connection between them and cohesively protect areas of ecological and/or cultural significance. The integrated network can provide more reasonable suggestions for the optimization of the urban spatial structure. Different well-directed protection strategies can be adopted for three types of regions: ecologically important areas, culturally important areas, and ecologically and culturally important areas (comprehensive regions),

which were obtained by buffer analysis and superposition analysis of ecological sources, ecological corridors, and cultural corridors.

This research method has no strict limit in terms of study scale, so it can be applied on larger (urban agglomeration) and smaller (county) scales as long as the data accuracy is acceptable, making it easy for decision-makers to implement at different levels. Our framework on the integrated network combines ecological corridors and cultural corridors in the same context, which makes the research on the two no longer isolated. Based on the result, we promote coordination of diversified aims, such as ecosystem services evaluation, biodiversity conservation, recreation and ecotourism, and heritage protection.

There is still room for improvement in our integrated network. Because the ecological corridors identified in our study are lines, we plan to explore practical quantitative methods to determine the width of corridors to guide the construction of an ecological network in the future. We also plan to include more views of local communities in the next phase of the study. The current setting of cultural corridor buffer distance is uniformly applied to all corridors. We realize that the influence radii of different cultural heritage sites can be quite different and plan to further explore more suitable methods for delineating variable cultural corridor buffer distances, which could be a combination of quantitative methods and qualitative methods to incorporate site specific information. In addition, we plan to collect local input of cultural sites to complement the heritage datasets. Finally, comprehensive regions are currently delineated from overlay analysis. We plan to enhance the method with stakeholder input and field investigation. We anticipate that accurate and practical delineation of the integrated network will support sustainable development goals.

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Appendix A

Table A1. Data sources in this study.

Data Name	Data Source
Digital Elevation Model (DEM)	Geospatial Data Cloud site, Computer Network Information Center, Chinese Academy of Sciences. (http://www.gscloud.cn)
Land cover data (2018) Roads (2018) Water bodies (2018) NDVI (2018)	International Scientific & Technical Data Mirror Site, Computer Network Information Center, Chinese Academy of Sciences. (http://www.resdc.cn)
Monthly average meteorological data (1980–2017)	China Meteorological Administration (http://cdc.nmic.cn/home.do)
Soil data	Cold and Arid Regions Sciences Data Center at Lanzhou (http://westdc.westgis.ac.cn)
Nature reserves (to 2017)	Beijing Municipal Environmental Protection Bureau (http://www.bjepb.gov.cn/bjhrb/index/index.html)
Cultural heritages (to 2019)	State Administration of Cultural Heritage (http://www.sach.gov.cn/)

Table A2. Nature reserves in Beijing (to 2017).

Name	Main Protection Objects	Type
Song mountain	Wild animals, such as golden eagle, natural oil pine forest	Forest ecosystem
Baihua Mountain	Temperate secondary forest, such as brown eared pheasant, arethusa and Dahurian larch	Forest ecosystem
Labagoumen	Natural secondary forest	Forest ecosystem
Wild duck lake	Wetland and migratory bird	Wetland
Yunmeng Mountain	Secondary forest	Forest ecosystem
Yunfeng Mountain	Secondary Pinus Tabulaeformis	Forest ecosystem
Wuling mountain	Valuable and rare animals and plants, natural secondary forests and typical forest ecosystems.	Forest ecosystem
Sizuolou	Natural secondary forest and national protected plants (wild soybean, Amur corktree, tilia amurensis and Acanthopanax)	Forest ecosystem
Yudu mountain	Forest and wild animals and plants	Forest ecosystem
Lianhua mountain	Wild animals and plants	Forest ecosystem
Datan	Natural secondary forest and wild animals and plants	Forest ecosystem
Jinniu lake	Wetland	Wetland
Baihebao	Water conservation forest	Forest ecosystem
Taian mountain	Forest and wild animals and plants	Forest ecosystem
Shuitou	Forest and wild animals and plants	Forest ecosystem
Puwa	Forest ecosystem	Forest ecosystem
Hanshiqiao	Wetland and migratory bird	Wetland
Juma river	Aquatic wildlife, such as Giant salamander	Wetland
Huaisha and Huaijiu river	Aquatic wildlife, such as Giant salamander, needle-mackerel and mandarin duck	Wetland
Shihuadong	Karst caverns	Geological heritage
Chaoyang temple	Fossil wood	Geological heritage

Table A3. List of Cultural Heritage Sites in Beijing.

Number	Name	Level
1	Ancient Cliff Dwelling Site	Beijing Municipal
2	Anti-Japanese War Sites of Yuzi Mountain	Beijing Municipal
3	Architectural Heritage of Beijing Normal University	Beijing Municipal
4	Architectural Heritage of Leshan Park	Beijing Municipal
5	Architecture Remains of Daci Yanfu Palace	Beijing Municipal
6	Architecture Remains of Nations' Affairs Office	Beijing Municipal
7	Back Hall of Capital City Temple	Beijing Municipal
8	Bai Yihua Martyr Cemetery	Beijing Municipal
9	Baipu Temple	Beijing Municipal
10	Baoguo Temple and Gu Tinglin Temple	Beijing Municipal
11	Beiguan Dragon Temple	Beijing Municipal
12	Beihai, Tuancheng	Beijing Municipal
13	Beijia Park	Beijing Municipal
14	Beijing Babaoshan Revolutionary Cemetery	Beijing Municipal
15	Beijng Newspaper Museum	Beijing Municipal
16	Bi Xia Yuanjun Temple Site of Yahuan Mountain	Beijing Municipal
17	Cai Yuanpei's Former Residence	Beijing Municipal
18	Changxindian "Twenty-seven" Revolutionary Sites	Beijing Municipal
19	Chaozhong Bridge	Beijing Municipal
20	Charity Temple	Beijing Municipal
21	Chen Duxiu's Former Residence	Beijing Municipal
22	Cheng Yanqiu's Former Residence	Beijing Municipal
23	Chengze Park	Beijing Municipal
24	Chinese Episcopal Church	Beijing Municipal
25	Church of St. Michael	Beijing Municipal
26	Clay City Site at Caizhuang	Beijing Municipal

Table A3. *Cont.*

Number	Name	Level
27	Coloured Glaze Factory of the Ministry of Works of Qing Dynasty	Beijing Municipal
28	Confucius Temple	Beijing Municipal
29	Congress of the Republic of China	Beijing Municipal
30	Cross-Street Building of Sanguan Pavilion	Beijing Municipal
31	Cuandixia Ancient Residential village	Beijing Municipal
32	Da Park	Beijing Municipal
33	De Shoutang Pharmacy	Beijing Municipal
34	Diaoyutai and Yangyuan Temple	Beijing Municipal
35	Dinghui Temple	Beijing Municipal
36	Dongsi Mosque	Beijing Municipal
37	DongYue Temple	Beijing Municipal
38	Dongyue Temple, Shangzhuang	Beijing Municipal
39	Doudian Clay City	Beijing Municipal
40	Drama Stage of Anhui Guide Hall	Beijing Municipal
41	Drama Stage of Yangping Guide Hall	Beijing Municipal
42	Early Buildings of Beijing Hotel	Beijing Municipal
43	Eight Sites of Xishan Mountain	Beijing Municipal
44	Fanzi Stone Inscription	Beijing Municipal
45	Female Normal College of Former National Beiping University	Beijing Municipal
46	Fire God Temple of Huashi	Beijing Municipal
47	Fomer Site of Continential Bank (Beijing)	Beijing Municipal
48	Forked Road City	Beijing Municipal
49	Former Furen Univeisity	Beijing Municipal
50	Former Peking Union Medical College	Beijing Municipal
51	Former Sino-France University	Beijing Municipal
52	Former Site of American Embassy	Beijing Municipal
53	Former Site of Austrian Embassy	Beijing Municipal
54	Former Site of Bank of Communications	Beijing Municipal
55	Former Site of Bank of Gold	Beijing Municipal
56	Former Site of Banque Indosuez (Beijing)	Beijing Municipal
57	Former Site of Baoshang Bank	Beijing Municipal
58	Former Site of Bazaar	Beijing Municipal
59	Former Site of Beijing Origin	Beijing Municipal
60	Former Site of Belgian Embassy	Beijing Municipal
61	Former Site of Branch College of Beijing Normal University	Beijing Municipal
62	Former Site of British Embassy	Beijing Municipal
63	Former Site of Central Bank	Beijing Municipal
64	Former site of China Geology Investigation Institute	Beijing Municipal
65	Former Site of Chinese Bible Society	Beijing Municipal
66	Former Site of Citibank	Beijing Municipal
67	Former Site of Duan Qirui Government	Beijing Municipal
68	Former Site of Dutch Embassy	Beijing Municipal
69	Former Site of Exhibition Hall of Geology, Beijing University	Beijing Municipal
70	Former Site of French Embassy	Beijing Municipal
71	Former Site of French Post Office	Beijing Municipal
72	Former Site of General Post Office of the Qing Dynasty	Beijing Municipal
73	Former Site of Japanese Embassy	Beijing Municipal
74	Former Site of Jiaoshi Building and Baiyou Building of Fuyu Female School	Beijing Municipal
75	Former Site of Nanyuan Army Headquarters	Beijing Municipal
76	Former Site of North Telephone Subexchang of Beiping	Beijing Municipal
77	Former Site of Notre Dame French School	Beijing Municipal
78	Former Site of Salt Industry Bank	Beijing Municipal
79	Former Site of Tongzhou Army	Beijing Municipal
80	Former site of work study program in France in Chang Xindian	Beijing Municipal
81	Former Site of Zhengyangmen East Station of Beijing Fengtian Railway	Beijing Municipal
82	Former Teaching Building of Luhe Middle School	Beijing Municipal
83	Fuguo Street Quadrangle, Xicheng District	Beijing Municipal

Table A3. *Cont.*

Number	Name	Level
84	Fusheng Temple	Beijing Municipal
85	Fuyou Temple	Beijing Municipal
86	Girderless Pavilion	Beijing Municipal
87	Glacial Striae	Beijing Municipal
88	Gold Hall of Huguo Temple	Beijing Municipal
89	Gonghua City	Beijing Municipal
90	Gonghua Palace	Beijing Municipal
91	Gongjian Ice Cellar	Beijing Municipal
92	Great Hall of Lingyan Temple	Beijing Municipal
93	Guangfu Temple	Beijing Municipal
94	Guanghua Temple	Beijing Municipal
95	Guangji Bridge	Beijing Municipal
96	Heilong Pool and Longwang Temple	Beijing Municipal
97	Heping Temple	Beijing Municipal
98	Hongluo Temple	Beijing Municipal
99	House at East Imperial Root South Street, Dongcheng District	Beijing Municipal
100	House at North Buzong Hutong, Dongcheng District	Beijing Municipal
101	House at Weijia Hutong, Dongcheng District	Beijing Municipal
102	Huguang Guide Hall	Beijing Municipal
103	Huixian Hall	Beijing Municipal
104	Hunan Guide Hall	Beijing Municipal
105	Huoshen Temple	Beijing Municipal
106	Imperial Ancestral Temple	Beijing Municipal
107	Imperial City Wall Site	Beijing Municipal
108	Imperial College Street	Beijing Municipal
109	Jade Emperor Tower	Beijing Municipal
110	Ji Xiaolan's Former Residence	Beijing Municipal
111	Jiaolao Tai	Beijing Municipal
112	Jiemin Hall	Beijing Municipal
113	Jinghua Publishing House	Beijing Municipal
114	Jingming Park	Beijing Municipal
115	Jingyi Park (Xiangshan Moutain)	Beijing Municipal
116	Jintai Academy	Beijing Municipal
117	Jiufeng Seismic Station	Beijing Municipal
118	Juesheng Temple	Beijing Municipal
119	Kang Youwei's Former Residence	Beijing Municipal
120	Lao She's Former Residence	Beijing Municipal
121	Lejia Garden	Beijing Municipal
122	Li Dazhao's Former Residence	Beijing Municipal
123	Liangxiang Tower	Beijing Municipal
124	Lingzhao Temple	Beijing Municipal
125	Liuyang Guide Hall	Beijing Municipal
126	Long'an Temple	Beijing Municipal
127	Longquan Temple of Bailong Pool	Beijing Municipal
128	Lotus Pool	Beijing Municipal
129	Lu Xun's Former Residence	Beijing Municipal
130	Lumi Warehouse	Beijing Municipal
131	Lvzu Pavilion	Beijing Municipal
132	Main Building of Beijng Library	Beijing Municipal
133	Main Building of Italian Embassy Site	Beijing Municipal
134	Mansion of Beile Tao	Beijing Municipal
135	Mansion of Crown Prince of Ning County	Beijing Municipal
136	Mansion of Crown Prince of Shuncheng County	Beijing Municipal
137	Mansion of King Chun	Beijing Municipal
138	Mansion of King Fu	Beijing Municipal
139	Mansion of King Heng	Beijing Municipal
140	Mansion of King Li	Beijing Municipal

Table A3. *Cont.*

Number	Name	Level
141	Mansion of King Qing	Beijing Municipal
142	Mansion of King Seng	Beijing Municipal
143	Mansion of King Zheng	Beijing Municipal
144	Mansion of Princess Hejing	Beijing Municipal
145	Mao Dun's Former Residence	Beijing Municipal
146	Martyr Li Dazhao cemetery	Beijing Municipal
147	Mei Lanfang's Former Residence	Beijing Municipal
148	Memorial of Sun Yat Sen's Death	Beijing Municipal
149	Monument to the Luanzhou Uprising	Beijing Municipal
150	Monument to the Martyrs who Died in the Anti-Japanese War in Wanping County	Beijing Municipal
151	Nangangwa Bridge	Beijing Municipal
152	Niangniang Temple of North Peak	Beijing Municipal
153	Nianhua Temple	Beijing Municipal
154	Ninghe Temple	Beijing Municipal
155	Niujie Street Mosque	Beijing Municipal
156	No.36 Fuxue Hutong, Dongcheng District	Beijing Municipal
157	No.63–65 Quadrangle, Dongsiliutiao, Dongcheng District	Beijing Municipal
158	North Guide Hall of Tingzhou, Fujian	Beijing Municipal
159	North New Warehouse	Beijing Municipal
160	Old Messuage	Beijing Municipal
161	Old Style Shops	Beijing Municipal
162	Public Elder Longevity Tower	Beijing Municipal
163	Publishing Factory Site of Ministry of Finance of the Republic of China	Beijing Municipal
164	Puzhao Temple	Beijing Municipal
165	Qi Baishi's Former Residence	Beijing Municipal
166	Qinghe Hancheng Site	Beijing Municipal
167	Qingyin Pavilion of Yunhui Building	Beijing Municipal
168	Randeng Tower	Beijing Municipal
169	Remains of Mansion of Zhaohui	Beijing Municipal
170	Remains of the School Department in Qing Dynasty	Beijing Municipal
171	Residence Group of Union Hospital	Beijing Municipal
172	Riverside City and Enemy Platform	Beijing Municipal
173	Rong Tomb Site at Yuhuangmiao Mountain	Beijing Municipal
174	Ruins of Shang, Zhou Dynasty at Liu Lihe	Beijing Municipal
175	Sansheng Temple	Beijing Municipal
176	Shangzhai Cultural Site	Beijing Municipal
177	Shaoxing Guide Hall	Beijing Municipal
178	Sheng Pingshu Drama Stage	Beijing Municipal
179	Shifang Buddists Tower	Beijing Municipal
180	Shijia Hutong, Dongcheng District	Beijing Municipal
181	Shuanglin Temple	Beijing Municipal
182	Shuiguan Great Wall	Beijing Municipal
183	Shuntian State-run School	Beijing Municipal
184	Shuqu Square Stele of Zhengyang Bridge	Beijing Municipal
185	Sibei Temple, Tao ranting	Beijing Municipal
186	No.11 Quadrangle, Neiwubu Street, Dongcheng District	Beijing Municipal
187	No.11 Quadrangle, Xisibei 3, Xicheng District	Beijing Municipal
188	No.129 Quadrangle, Lishi Hutong, Dongcheng District	Beijing Municipal
189	No.13,15 Quadrangle, Fangjia Hutong, Dongcheng District	Beijing Municipal
190	No.15 Quadrangle, Qian Gongyong Hutong, Xicheng District	Beijing Municipal
191	No.19 Quadrangle, Xisibei 3, Xicheng District	Beijing Municipal
192	No.2 Quadrangle, Guoxiang Hutong, Dongcheng District	Beijing Municipal
193	No.20 Quadrangle, Xinkai Road, Chongwen District	Beijing Municipal
194	No.23 Quadrangle, Xisibei Avenue 6, Xicheng District	Beijing Municipal
195	No.7,9 Quadrangle, Back Yuan'en Temple Street, Dongcheng District	Beijing Municipal
196	No.15 Quadrangle and its Tile Carving, Dongmianhua Hutong, Dongcheng District	Beijing Municipal
197	No.25 Quadrangle, Art Museum East Street, Dongcheng District	Beijing Municipal

Table A3. *Cont.*

Number	Name	Level
198	No.153 Quadrangle, Di'anmenxi Avenue, Xicheng District	Beijing Municipal
199	No.93 Quadrangle, Fuchengmennei Street, Xicheng District	Beijing Municipal
200	No.255 Quadrangle, Gulou East Avenue, Dongcheng District	Beijing Municipal
201	No.13 Quadrangle, Heizhima Hutong, Dongcheng District	Beijing Municipal
202	No.5 Quadrangle, Maoer Hutong, Dongcheng District	Beijing Municipal
203	No.7,9 Quadrangle, Qiangulouyuan Hutong, Dongcheng District	Beijing Municipal
204	No.7,9 Quadrangle, Qianyongkang Hutong, Dongcheng District	Beijing Municipal
205	No.15 Quadrangle, Shajing Hutong, Dongcheng District	Beijing Municipal
206	Quadrangle, Xijiaominxiang Street 87, Beixinhua Street 112, Xicheng District	Beijing Municipal
207	No.25–37 Quadrangle, Xitangzi Hutong, Dongcheng District	Beijing Municipal
208	Site of Chinese Communist Delegation of the Ministry of Military Transfer in 1946	Beijing Municipal
209	Site of European and American students' Association	Beijing Municipal
210	Site of Hebei-Rehe-Chahaer Advance Army Commander's Headquarter of Eight Route Army	Beijing Municipal
211	Site of Taiye Pool at the Mid-capital of the Kin Dynasty	Beijing Municipal
212	Site of the Farmer and Worker Bank of China	Beijing Municipal
213	Site of Tuanhe Palace	Beijing Municipal
214	Site of Xizhi Men Station of Pingsui	Beijing Municipal
215	Sites of Bai Fuquan	Beijing Municipal
216	Sites of Da Baotai Tombs of Western Han Dynasty	Beijing Municipal
217	Songzhu Temple and Zhizhu Temple	Beijing Municipal
218	South Mansion of King Chun	Beijing Municipal
219	South New Warehouse	Beijing Municipal
220	Southeastern Corner Tower of the City	Beijing Municipal
221	Stage and Guandi Temple at Huapen Village	Beijing Municipal
222	Stone Buddha in Baishui Temple	Beijing Municipal
223	Stone Sculptures of Yi Sanga	Beijing Municipal
224	Temple of Empress of Fengtai	Beijing Municipal
225	Temples and Yunshui Cave at Shangfang Moutain	Beijing Municipal
226	The Bell Tower	Beijing Municipal
227	The Chairman Mao Memorial Hall	Beijing Municipal
228	The Drum Tower	Beijing Municipal
229	The Former Chartered Bank	Beijing Municipal
230	The Front of Former Site of Qian Xiangyi	Beijing Municipal
231	The Front of Former Site of Rui Fuxiang	Beijing Municipal
232	The Front of Quanjude Roast Duck	Beijing Municipal
233	The Great Hall of Pudu Temple	Beijing Municipal
234	The Great Hall of Shuntian Mansion	Beijing Municipal
235	The Interior Office of Inspecting the Imperial Government in Qing Dynasty	Beijing Municipal
236	The Land Altar (Zhongshan Park)	Beijing Municipal
237	The Remains of Beijing City Wall in Ming Dynasty	Beijing Municipal
238	The statue of Wei Taihe	Beijing Municipal
239	The Tenth Hotel at Grain Shop Street	Beijing Municipal
240	Three Eighteen Martyr Monument	Beijing Municipal
241	Tianli Coal Factory Site	Beijing Municipal
242	Tiewa Temple	Beijing Municipal
243	Tomb of Crown Prince of Fu County	Beijing Municipal
244	Tomb of Laoshan of Han Dynasty	Beijing Municipal
245	Tomb of Li Zhuowu	Beijing Municipal
246	Tomb of Liang Qichao	Beijing Municipal
247	Tomb of Sunyue	Beijing Municipal
248	Tomb of Tianyi	Beijing Municipal
249	Tomb, Stele and Status of Zhan Tianyou	Beijing Municipal
250	Tombs of Lu Huixiang's Family	Beijing Municipal
251	Tombs of Soldiers and Men Killed in the Battle of Gubeikou	Beijing Municipal
252	Tongyun Bridge and Remains of Zhang Jiawan City Wall	Beijing Municipal
253	Tongzhou Mosque	Beijing Municipal
254	Tower of Zen Master Wuai	Beijing Municipal
255	Tuancheng Fortress	Beijing Municipal
256	Tucheng	Beijing Municipal

Table A3. *Cont.*

Number	Name	Level
257	Wanning Bridge	Beijing Municipal
258	Waterworks of Qing Dynasty	Beijing Municipal
259	Weiming Lake District, Former Yanjing University	Beijing Municipal
260	Wofo Temple	Beijing Municipal
261	Wuta Tower	Beijing Municipal
262	Xianliang Temple	Beijing Municipal
263	Xianying Temple	Beijing Municipal
264	Xihuang Temple	Beijing Municipal
265	Xishiku Church	Beijing Municipal
266	Xiuyun Temple	Beijing Municipal
267	Xuanren Temple	Beijing Municipal
268	Xuechi Ice Cellar	Beijing Municipal
269	Xuhua Pavilion and Song Hall	Beijing Municipal
270	Yandun	Beijing Municipal
271	Yang Jiaoshan Temple	Beijing Municipal
272	Yaowang Temple of Fengtai	Beijing Municipal
273	Yinshan Tower	Beijing Municipal
274	Yiyuan Park	Beijing Municipal
275	Yongning Catholic Church	Beijing Municipal
276	Yuansheng Palace	Beijing Municipal
277	Yun Tai	Beijing Municipal
278	Yuqian Temple	Beijing Municipal
279	Zhao Tower	Beijing Municipal
280	Zhaoxian Temple	Beijing Municipal
281	Zhengyang Gate and Arrow tower	Beijing Municipal
282	Zhengyi Temple	Beijing Municipal
283	Zhongshan Guide Hall	Beijing Municipal
284	Zhou Jixiang Tower	Beijing Municipal
285	Zhu Yizhun's Former Residence	Beijing Municipal
286	Cuandixia Village, Zhaitang Town	National
287	Gubeikou Town	National
288	Jiaozhuanghu Village, Longwantun Town	National
289	Lingshui Village, Zhaitang Town	National
290	Liuliqu Village, Longquan Town	National
291	Shuiyu Village, Nanjiao Town	National
292	Ancient Building Group in Cuandixia Village	National
293	Ancient Cliff Dwelling in Yanqing	National
294	Ancient Weather Station	National
295	Anhui Guide Hall	National
296	Badaling Great Wall	National
297	Baiyun Temple	National
298	Baoguo Temple	National
299	Beihai and Tuancheng	National
300	Beijing Bell Tower, Drum Tower	National
301	Beijing City Walls of the Ming Dynasty	National
302	Beijing Huguang Guide Hall	National
303	Biyun Temple	National
304	Bolin Temple	National
305	Bridge of Liuli River	National
306	Buddists Hall, Stone Inscription and Tower of Kongshui Cave	National
307	Changchun Temple	National
308	Cheng'en Temple	National
309	Chinese Episcopal Church	National
310	Chongli Residence	National
311	Church of Xi Shiku	National
312	Cishou Temple Tower	National
313	Commerce Building in Dashila Area	National
314	Confucius Temple	National

Table A3. *Cont.*

Number	Name	Level
315	Da Gaoxuan Hall	National
316	Dahui Temple	National
317	Dajue Temple	National
318	Desheng Gate Archery Tower	National
319	Dongyue Temple, Beijing	National
320	Duobao Buddist Tower of Liangxiang	National
321	Early Architectures inTshinghua Univeisity	National
322	East Hall	National
323	Embassy Architecture Group of Dongjiaominxiang	National
324	Fahai Temple	National
325	Fayuan Temple	National
326	Former Site of Agricultural Experimental Farm of Qing Dynasty	National
327	Former Site of Beijing Branch of China Bible Church	National
328	Former Site of Beijing Female Normal College	National
329	Former Site of Beijing Parliament	National
330	Former Site of Beiping Library	National
331	Former Site of Branch College of Beijing Normal University	National
332	Former Site of Exhibition Hall of Geology, Beijing University	National
333	Former Site of Main Campus of Furen University	National
334	Former Site of National Mongolian Tibetan School	National
335	Former Site of Peking Union Medical College	National
336	Former Site of Radio 491	National
337	Former Sites of Shengxin Middle School and Youzhen Female Middle School	National
338	Former Sites of the Army and Navy Departments of the Qing Dynasty	National
339	Gate of Heavenly Peace	National
340	Guangji Temple	National
341	Guanyue Temple	National
342	Guide Hall of Sun Yat-sen	National
343	Guo Moruo's Former Residence	National
344	Imperial Ancestral Temple	National
345	Imperial Archives	National
346	Imperial College	National
347	Jianruiying Martial Arts Hall	National
348	Jiaozhuanghu Tunnel Battle Site	National
349	Jietai Temple	National
350	Jingming Park	National
351	Juesheng Temple	National
352	Ke Park	National
353	Li Dazhao's Former Residence	National
354	Lingyue Temple	National
355	Lu Xun's Former Residence in Beijing	National
356	Lugou Bridge	National
357	Mansion of Crown Prince of Keqin County	National
358	Mansion of King Chun	National
359	Mansion of King Fu	National
360	Mei Lanfang's Former Residence	National
361	Memorial Park of Luanzhou Uprising of Xinhai Year	National
362	Modern Bank Building Group in Xijiaominxiang	National
363	Modern School Buildings Group in Tongzhou	National
364	Moke Temple	National
365	Mout Jing	National
366	Nankou-Badaling Section of Jing-Zhang Raiway	National
367	Niujie Street Mosque	National
368	Peking Man Site at Zhoukoudian	National
369	Prince Gong's Mansion and Park	National
370	Publishing House Site of Ministry of Finance of the Republic of China	National
371	Pudu Temple	National
372	Qingjinghuacheng Tower	National
373	Red Building in Peking University	National

Table A3. *Cont.*

Number	Name	Level
374	Remains of Great-Capital City Wall of Yuan Dynasty	National
375	Shangzhai Site	National
376	Shifang Pujue Temple	National
377	Shuangqing Villa	National
378	Shuiguan Site of the Mid-Capital of the Kin Dynasty	National
379	Simatai Section of Great Wall	National
380	Site of Jinling	National
381	Site of Liuli River	National
382	Site of Old Summer Palace	National
383	Site of Shizi Temple	National
384	Song Qingling Children's Science and Technology Museum	National
385	Song Qingling's Former Residence in Beijing	National
386	South Hall	National
387	Southeastern Corner Tower of the Beijing City	National
388	Staiton Building of Beijng Railway Station	National
389	Summer Palace	National
390	Tantuo Temple	National
391	Temple of Heaven	National
392	Temple of the Moon	National
393	Temple of the Past-Ages Emperors	National
394	Temple of Wen Tianxiang	National
395	The Altar to the Sun	National
396	The Forbidden City	National
397	The Lama Temple	National
398	The Land Altar	National
399	The Ming Tombs	National
400	The Site of Atomic Energy	National
401	The Site of the Two-Seven Strike in Changxindian	National
402	The Monument to the People's Heroes	National
403	Tianning Temple Tower	National
404	Tomb and Temple of Yuan Chonghuan	National
405	Tomb of Jingtai	National
406	Tomb of King Chun	National
407	Tombs of Matteo Ricci and Foreign Missionaries of Ming, Qing Dynasties	National
408	Wanshou Temple	National
409	Wansong Elder Tower	National
410	White Tower of Miaoying Temple	National
411	Wuta Temple Tower	National
412	Xiannong Altar	National
413	Yanyuan Buildings of Weiming Lake	National
414	Yao Guangxiao Tomb Tower	National
415	Yasili Hall	National
416	Yinshan Forest of Pagodas	National
417	Yun Terrace in Juyong Pass	National
418	Yunju Temple Tower and Stone Scripture of Fangshan	National
419	Zhengang Tower	National
420	Zhengyang Gate	National
421	Zhihua Temple	National
422	Zhizhu Temple	National
423	Zhong Nan Hai	National

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