sustainability

Article

GEF Innovative Forest Management Plan—Taking Grassland Forest Farm in Fengning County as an Example

Ziye Liu [1], Zhongke Feng [1,2,*] and Chen Chang [1]

[1] Beijing Key Laboratory of Precision Forestry, Beijing Forestry University, Beijing 100089, China; lzy0816@bjfu.edu.cn (Z.L.); changchen@bjfu.edu.cn (C.C.)
[2] Key Laboratory of Genetics and Germplasm Innovation of Tropical Special Forest Trees and Ornamental Plants, Ministry of Education, School of Forestry, Hainan University, Haikou 570228, China
* Correspondence: fengzhongke@126.com; Tel.: +86-138-1030-5579

Abstract: Currently, China's forest ecosystem focus is shifting from a single management objective to multiple management objectives, aiming to improve forest quality and maximize the benefits of ecosystem services. Many difficulties and problems are encountered in the long-term development of most northern state-owned forest farms—for example, the fragmentation and degradation of forest landscapes caused by poor forest management and extensive land use—resulting in an ecosystem that is unable to provide optimal services. This research was conducted on the Fengning Grassland Forest Farm, which is based on the GEF project of state-owned forest farms. We applied lessons from international advanced concepts, such as landscape restoration, and combinecombined all types of existing data and supplementary survey data on forest farms. In addition, we used multivariate statistical analysis and geostatistical analysis methods to optimize spatial layout and forest landscape structure. Strategies of landscape restoration and optimization, forest quality improvement, and grassland ecological restoration were proposed. A forest growth model was established to predict the annual growth of forests, calculate sustainable levels of annual cutting, calculate biomass and carbon sequestration in the management period, and evaluate the value of the ecological service functions of forest ecosystems in forest farms. Finally, a set of forest management methods was developed to effectively improve the sustainable management level of state-owned forest farms and enhance the service function of forest ecosystems.

Keywords: GEF; forest management; landscape restoration; forest quality improvement

Citation: Liu, Z.; Feng, Z.; Chang, C. GEF Innovative Forest Management Plan—Taking Grassland Forest Farm in Fengning County as an Example. *Sustainability* **2022**, *14*, 7795. https://doi.org/10.3390/su14137795

Academic Editor: Nancai Pei

Received: 4 May 2022
Accepted: 20 June 2022
Published: 27 June 2022

1. Introduction

China's forestry has entered the stage of joint development of quantity and quality, but the problems of insufficient total quantity, poor quality, and uneven distribution of forest resources are still very prominent. In addition, irrational forest management and extensive land-use patterns cause fragmentation and degradation of forest landscapes, rendering ecosystems unable to provide optimal ecosystem services. Therefore, there is an urgent need to explore ways to further improve forest quality and build healthy, stable, high-quality, and efficient forest ecosystems. Forest management is an important way to improve forest quality, and state-owned forest farms are an important part of China's forest resources. The total area of state-owned forest farms is 0.77 billion ha, accounting for 8% of China's land area [1]. The establishment and implementation of a forest management plan of state-owned forest farms is an important way to promote sustainable forest management and improve the quality and benefits of forest resources.

In December 2018, China officially launched the GEF project aimed at enhancing the ecosystem services of China's planted forests through forest landscape restoration and reform of state-owned forest farms. The project is funded by the Global Environment Facility (GEF) and is implemented by the International Union for Conservation of Nature and China's state forestry and grassland administration. The project will be implemented in Chengde, Ganzhou, and Bijie City in Hebei Province, and the implementation period will be 4 years. The Global Environment Facility (GEF) is a pilot project created by the World Bank in 1990 to support environmentally friendly engineering; the funded projects can be broadly divided into three categories: forest conservation, sustainable use of forests, and sustainable forest management. The GEF project for state-owned forest farms revolves around forest landscape restoration (FLR) and sustainable forest management (SFM) [2–4], to strengthen the sustainable management ability of state-owned forest farms in China, to clarify the ecological function of state-owned forest farms on the peripheral geographical landscape scale, and to evaluate the ecological, economic, and social benefits of state-owned forest farms for surrounding communities.

The main task of the GEF project for state-owned forest farms is to compile and implement the New Forest Management Program. The so-called New Forest Management Program is a forest management program based on the concept of forest landscape restoration, aimed at improving forest quality and ecosystem services. The innovation of the New Forest Management Scheme is unlike the traditional forest management scheme, which does not consider tree species and the forest composition, instead relying on experience and conventional forest management methods to nurture the trees. Most problems of forest management are related to spatial location, and the analysis of spatial structure is the basis of optimal management. Swanson et al. (1990) [5] studied forest management, land use, and riparian forest management at a landscape scale in the Pacific Northwest region of the United States. Jones et al., 1993, on the basis of a multiscale spatial analysis of forest stand, landscape, and region, using GIS as a tool, put forward the classification of forest landscape ecosystem as the first step of forest management according to the change in values and requirements of forest ecosystem management, replacing the traditional method of site classification and evaluation [6]. Heping (2002), on the basis of the heterogeneity of forest landscape in Li River, classified the Zhaoge watershed into landscape zones and forest landscape. Moreover, methods and measures for protecting, utilizing, and managing forest landscape resources in different landscape areas and landscape types were put forward [7]. The New Forest Management Scheme is based on the analysis of landscape patterns, using the dynamic method to adjust the degraded forest landscape to restore the landscape vitality and produce multiple benefits. Secondly, traditional forest management plans are based on experience, applying artificial interventions to the forest stand through planting, tending, conservation, thinning, etc., thus adjusting the forest stand structure. In contrast, the New Forest Management Plan is based on the forest DBH growth prediction model, which dynamically simulates the forest growth process and realizes forest growth prediction and scientific planning [8]. In order to determine the future forest resources and timber output, we should study the dynamic growth change of the forest [9]. Vanclay proposed that forest growth models, combined with other resources and environmental data, can be used for forecasting, programming, and guiding forest policy, providing an effective method for preparing resource projections [10]. Zhou used a TRIPLEX1.0 mixed model to simulate forest growth and yield in a forest ecosystem in Northeastern Ontario [11]. Forest management needs to not only obtain the current situation of forest resources, but also forecast the future information of forest resources in order to establish a reasonable forest management plan [12]. Lastly, the outcomes of traditional forest management plans are typically represented by the forest product, whereas the New Forest Management Plan will be evaluated in terms of the forest economy, society, ecology, and many other aspects. In the 1950s, the United States passed the Multipurpose Sustainable Production of State-Owned Forests Act [13,14], which states that the goal of forest management is to realize the multiple benefits of forests, while the policy of forest management is to produce wood resources, protect non-wood resources, and maintain biodiversity in state-owned forest farms. In 2004, Tongqian et al. objectively measured the service function of the forest ecosystem, combining the mechanism, utility, and type of service provided by the forest [15]. In 2005, Fang et al. conducted an in-depth study on the functions of forest ecological services, including the provision of forest products, the regulation of the environment, the enhancement of culture, and the maintenance of life, starting from direct and indirect economic benefits. They proposed functional indices for providing forest trees and byproducts, developing forest recreation, conserving water sources, fixing carbon dioxide and releasing oxygen, promoting the circulation of nutrients and their storage, purifying the air, maintaining the water and soil, maintaining biological diversity, preventing wind, and fixing sand to evaluate forest ecosystem service value in China [16,17]. The optimal allocation of forest resources based on the index of forest ecosystem service value is an important measure for sustainable forest management. In Table 1, we compare traditional and new forest management schemes.

Table 1. Comparison of the New Forest Management Scheme and traditional forest management programs.

Name	Business Philosophy	Means of Operation	Operating Gain
Traditional forest management programs	Experience-led and economic benefit-oriented	Routine management, experience-driven	Direct harvesting of wood products
New Forest Management Scheme	Using the concept of landscape restoration as reference to improve the spatial pattern of ecosystem	Scientific planning of forest management measures based on forest growth prediction technology	Comprehensive value of ecosystem service function

As part of the GEF project for the state-owned Fengning Manchu Autonomous County Grassland Forest Farm, a new forest management scheme was designed. The Grassland Forest Farm is one of the first pilot forest farms of the GEF project; for the first time, ground quadrilateral microplot surveys [18], aerial surveys by unmanned aerial vehicles (UAVs) [19,20], electrodynamic growth cones, and tree-ring analysis systems [21] were used to conduct supplementary surveys, addressing the shortcomings of the traditional forest management plan, such as incomplete data and untimely updates [22], thus improving the accuracy of the data. On the basis of all kinds of available data and supplementary survey data from the forest farm, the concept of landscape restoration was introduced into forest management planning for the first time. According to landscape type and characteristics, the present situation of forest resources and forest landscape in the Grassland Forest Farm was analyzed, and the land-use adjustment and ecological restoration measures were reasonably arranged, combining the relevant forestry policies and technical indicators of the state and Hebei Province. This study put forward multi-objective management and forestry measures, and an ideal forest management model was proposed on the basis of the forest growth prediction model and the rainfall density model, according to which the forest structure was evaluated, and a targeted management scheme was formulated to achieve the goal of forest farm forest quality improvement. In addition, according to GB/T38582-2020 ("Norms for the assessment of forest ecosystem services"), the ecological services provided by the vegetation of the Grassland Forest Farm were evaluated on the basis of the prediction model of forest DBH growth, and the ecological service function was predicted at the middle and end of the management period. This provided the basis for the quantitative evaluation of the ecological service function of the forest farm.

2. Materials and Methods

The Grassland Forest Farm is located on the southern edge of the Inner Mongolia Plateau, with a vast territory and complex terrain. The elevation is 1291–2039 m. The shady slope is long and gentle, while the sunny slope is short and steep. The Luanhe River system is under its jurisdiction, which is rich in water resources. The Grassland Forest Farm has a semiarid and continental monsoon plateau mountain climate in the temperate zone, with an annual average temperature of 6.7 °C, an extreme minimum temperature of −32.6 °C, and an extreme maximum temperature of 35.8 °C. The average temperature in the summer is 17.4 °C. The annual precipitation is about 400 mm. The location of the Grassland Forest Farm is shown in Figure 1.

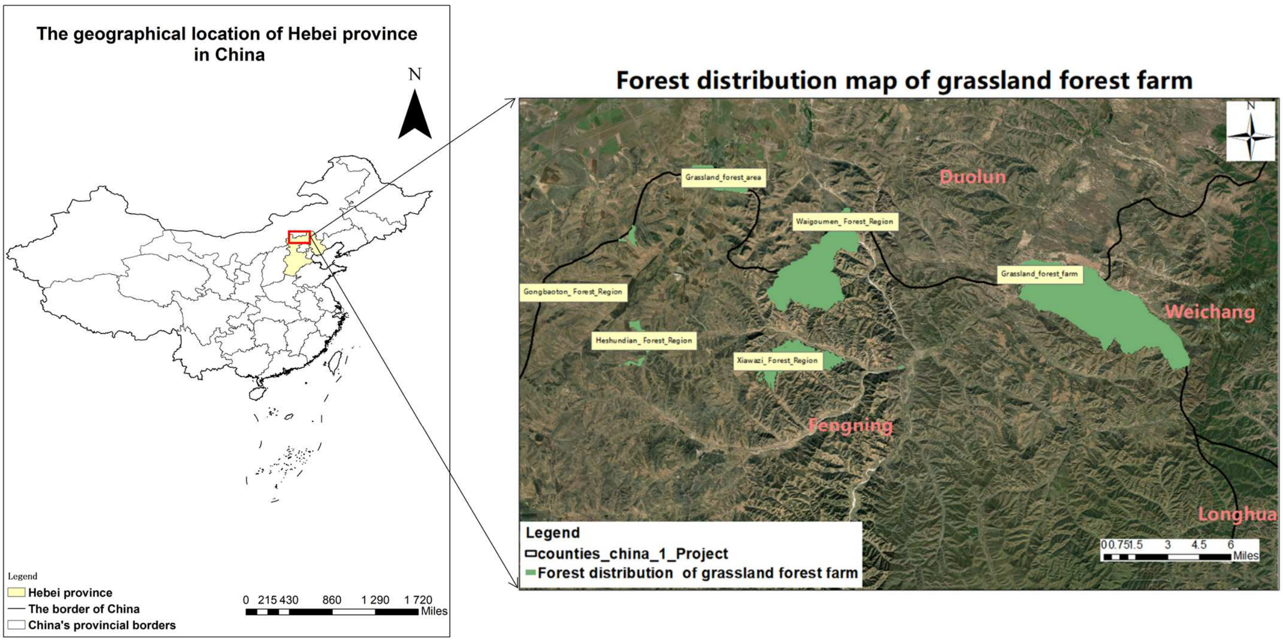

Figure 1. Geographical location of the Grassland Forest Farm.

The total area of the forest farm is 8685.81 ha, and the total area of forest land is 5447.67 ha, accounting for 62.72% of the total area. Trees, sparse forest, and special shrubs account for 34.35%, 7.32%, and 6.78% of the total area of forest land, respectively. In terms of non-forest land, grassland represents 2699.86 ha, accounting for 31.08% of the total forest area, cultivated land represents 279.2 ha, accounting for 3.21% of the total forest farm area, and water area represents 238.77 ha, accounting for 2.75% of the total forest area. Land-use types are shown in Figure 2.

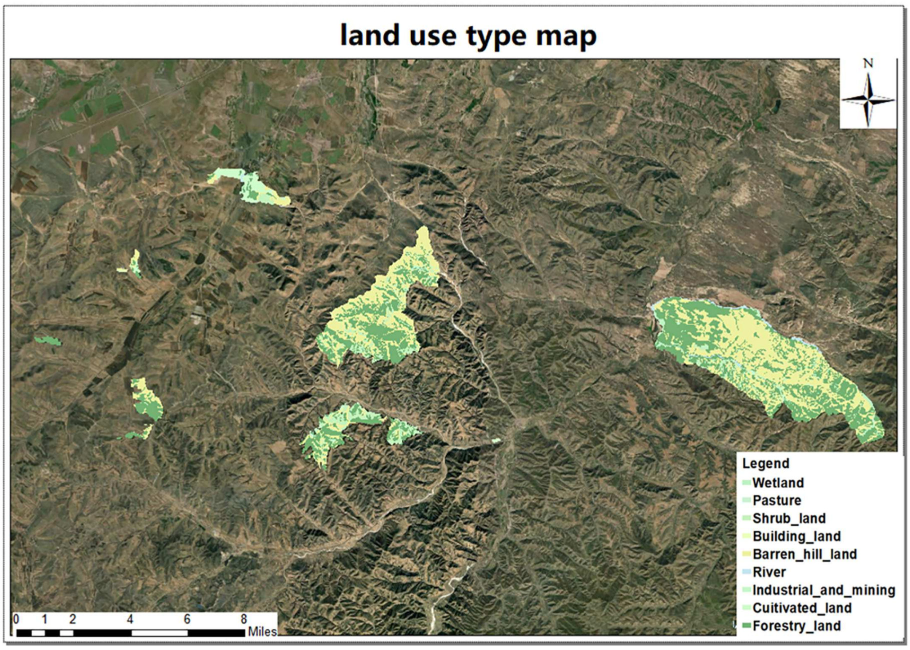

Figure 2. Map of land-use types.

2.1. Research Method

2.1.1. Supplementary Experiments

In order to accurately obtain the status quo of forest resources, supplementary investigations are needed. The main technical methods used are quadrilateral microplot surveys, UAV surveys, and electric growth cone sampling (Figure 3).

Quadrilateral microplot survey: The quadrilateral microplot observation method is a sample survey method with high efficiency, small error, and good standardization. During the survey, the observation sample is divided into sub-compartments near the forest center. The selection of trees in the sample plot should be representative, reflecting the whole forest situation. The stand factors and site factors related to the forest farm were obtained in small samples, including tree species, tree species composition, average DBH, average stand height, stand density, slope gradient, aspect, slope position, soil type, soil thickness, and humus thickness.

Unmanned aerial vehicle (UAV) survey: UAV images were used to mine the forest resource information; 4D products were formed to interpret tree species, crown diameter, forest quality, stand density, and other information. The natural dead wood in the UAV aerial images was analyzed using image recognition technology, while the crown area of single trees was automatically identified. The crown competitive growth state in small classes was obtained, and the stand survey factors were identified and measured from the images.

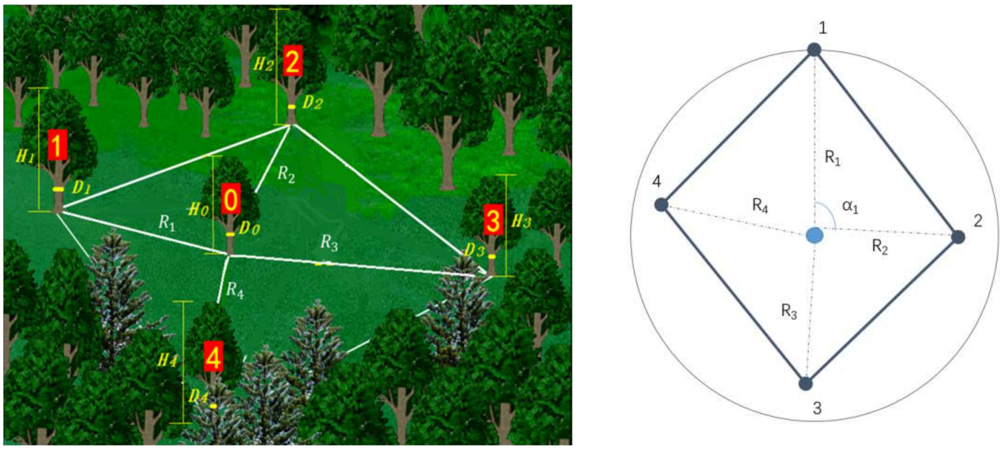

Figure 3. Diagram of quadrilateral microplot survey method.

Electric growth cone sampling: Tree ring information is an important characteristic of trees, playing a decisive role in determining tree age and growth [23,24]. Using electric growth cone sampling, the tree core can be automatically extracted, and the annual rings can be automatically identified. After obtaining the annual ring information, a growth model can be established combined with environmental factors, so as to reasonably predict the resources during a specific period.

2.1.2. Landscape Analysis

In the 1980s, Robert et al., 1989, on the basis of ecological processes, selected landscape indices according to the scale of study to describe the landscape pattern, contributing greatly to the innovation of landscape pattern research methods [25]. In the 1990s, Liding et al. 1996, proposed four new landscape pattern indices, including the landscape connectivity index, which greatly promoted the study of landscape patterns [26]. In this study, forest landscape analysis mainly involved the analysis of landscape types and landscape features, using the spatial analysis function of Arcgis software. The patches of landscape classification in this study were analyzed on the basis of the sub-compartment data from China's second forest resources survey. According to the site condition and vegetation type, the grassland forest farm was divided into the primary landscape and secondary landscape. The landscape diversity index and landscape evenness index were calculated for primary landscape [27]. The average area of each patch was 3.9 ha.

The landscape diversity index (fragmentation) reflects the number and proportion of landscape types:

$$H = -\sum_{i=1}^{m} P_i \log 2P_i, \tag{1}$$

where H is the diversity index, P_i is the area proportion of landscape type i, and m is the number of landscape types. A larger H value indicates a higher fragmentation degree between the embedded blocks in the landscape and greater landscape heterogeneity.

The landscape evenness index (evenness) characterizes the distribution uniformity of different landscape types:

$$F = (H/H_{\max}) \times 100\%, \tag{2}$$

where H is the Shannon diversity index, and $H_{\max}$ is the maximum Shannon diversity index.

For secondary landscape, the edge density of landscape types was calculated. The boundary density of landscape type refers to the ratio of the perimeter and area of a landscape type. When the perimeter per unit area is large, the landscape type is highly fragmented; conversely, when the perimeter per unit area is small, the landscape type is well preserved, with high connectivity.

2.1.3. Forest Ideal Density Calculation

The forest distribution is a result of the interaction between the environment and plants. Forest growth and distribution are impacted by climate, topography, soil, vegetation, water, and other factors (Wang et al., 2006) [28]. This study was based on the DBH growth model (Zhang, 2020; Qiu, 2020) [29,30]. According to the secondary survey and supplementary survey data of the Grassland Forest Farm in 2019, the tree characteristics (DBH and tree height), soil information (soil thickness), geographic information (longitude, latitude, elevation, slope, aspect, and slope position), climate and meteorological information (rainfall and temperature), and stand conditions (canopy density and stand density) under different site conditions were extracted, and the tree DBH growth prediction model was established to calculate the annual growth.

$$\Delta Y_{t+k}^{(j)} = e^{a_1^{(j)} \cdot d^{(j)} + a_2^{(j)} \cdot \ln d^{(j)}} \cdot e^{\sum b_j \cdot x_j}, \tag{3}$$

Here, j is the dominant tree species belonging to the tree group, d is the DBH information of tree j (cm), $\Delta Yt + k$ is the DBH increment predicted after 5 years (cm), a_1 and a_2 are the growth rate coefficients of tree species j, b_j is the growth comprehensive influence coefficient of tree species j, and x_j is the normalized processing coefficient of tree species j subject to changes in the stand, site, and competition factor.

There is an obvious difference in rainfall within the stand, as well as a difference in the rainfall intercepted by the canopy, which is mainly caused by the spacing between trees and rows. Rainfall within the forest is of great significance to the transformation of understory vegetation, soil moisture content, and low effective forest density (Lin, 2011) [31]. According to the environmental carrying capacity of a tree species, on the basis of the study of the ideal tree density by Jiaqi et al., a rainfall-density model was established to calculate the maximum density of trees at a certain age or diameter (mature stage) ${N^0}_{35}$, mainly determined by rainfall and growth.

$$\begin{gathered} 10R = a_1 V + a_2 \Delta V + \sum b_i x_i + c \\ N \le \frac{10R - \sum b_i x_i - c}{a_1 V + a_2 \Delta V}, \end{gathered} \tag{4}$$

Here, R is the rainfall (mm), N is the stand density, V is the volume, ΔV is the change in volume, and a, b, and c are parameters.

According to the predicted DBH growth trend, the growth times t_{i5} (i = 0, 1, 2, and 3) of each tree species in young, middle-aged, near-mature, mature, and over-mature forests were calculated, and the ideal density N_{i5} (i = 0, 1, 2, and 3) of each tree species in each diameter class was calculated on the basis of the tree loss rate (q = 1%) and growth time t_{i5}.

$$\begin{aligned} N_{35} &= K_i N_{35}^{o}\left(\frac{t_{40}-t_{30}}{t_{40}}\right) \\ N_{05} &= N_{35}/(1-q)^{(t_{35}-t_{05})} \\ N_{15} &= N_{35}/(1-q)^{(t_{35}-t_{15})} \\ N_{25} &= N_{35}/(1-q)^{(t_{35}-t_{25})}. \end{aligned} \tag{5}$$

To judge whether the forest has reached an ideal state, it is necessary to calculate the deviation of diameter density distribution of each tree species in the forest sub-compartment according to the ideal forest distribution theory. The relationship between the actual density and the ideal density for each diameter is expressed as follows:

$$\begin{aligned} \Delta_{i5} &= \left|N_{i5}^{*} - N_{i5}^{\#}\right|/N_{i5}^{*} \\ \Delta &= \left|N_{\text{Total}}^{*} - N_{i5}^{\#}\right|/N_{\text{Total}}^{*} \\ \Delta_{\text{Total}} &= \frac{\sum_{i=0}^{5} \Delta_{i5}+\Delta}{5}. \end{aligned} \tag{6}$$

On the basis of the DBH growth model and rainfall density model, an evaluation method for the ideal forest density is proposed in this paper. In the formula, N^* is the real density, and $N^\#$ is the ideal density; 0% ≤ Δtotal ≤ 10% is excellent, belonging to the ideal state, 0% ≤ Δtotal ≤ 20% is good, belonging to the ideal state, and 0% ≤ Δtotal ≤ 30% is satisfactory, according to the principle of maximum density. If Δtotal is negative or >30%, the real stand density is greater than the ideal stand density.

2.1.4. Ecological Benefit Evaluation

The ecological benefit evaluation included soil and water conservation, water conservation, windbreak and sand fixation, forest carbon sink, and other forest ecological service value analyses. According to GB/T38582-2020 ("Forest ecosystem service function evaluation specification"), the ecological service function of the Grassland Forest Farm vegetation was evaluated.

2.2. Technical Route

This study was carried out following the roadmap in Figure 4. Prior to the preparation of the forest management program, the basic data were first collected (forest resources survey report, forest land change report, historical management plan, local economic resources survey, government-related statistical data, local chronicles, and yearbook), analyzed, and summarized. Due to the lack of some basic data, additional investigations were needed (microplots, UAV images, and tree rings). Firstly, the status quo was analyzed and assessed according to the background data, including the basic situation, forest landscape analysis, ecosystem analysis, ecological service demand, and the main existing problems. The establishment of management objectives included primary objectives and secondary objectives, and the multi-objective management program was designed, including forest quality improvement, grassland ecological restoration, landscape restoration and optimization, and ecological service value enhancement.

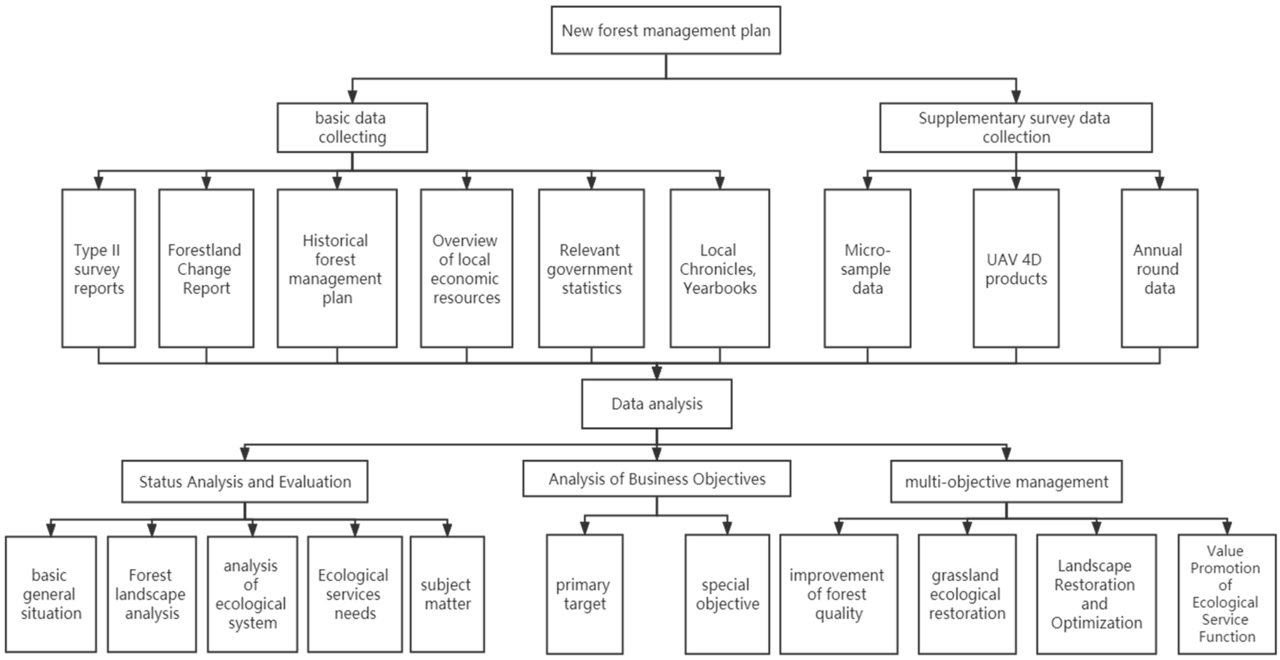

Figure 4. Technology roadmap.

3. Results

3.1. Forest Landscape Analysis

According to the site conditions, the primary landscape types of the Grassland Forest Farm were classified into remote mountain forest, hilly grassland, wetland forest, sandy meadow, and cultivated nursery stock (Table 2). According to the vegetation types, the secondary landscape types of the Grassland Forest Farm were classified into grassland, birch forest, larch forest, shrub forest, and oak hardwood forest. The forest landscape types of the Grassland Forest Farm were diverse, with high landscape heterogeneity and high fragmentation [32].

Table 2. Grassland Forest Farm landscape indices.

Landscape Richness	Landscape Diversity Index	Landscape Evenness Index
11	1.1527	0.7243

The landscape diversity index and evenness index were calculated for the five primary landscape types of the Grassland Forest Farm (Figure 5). The diversity index was 1.1527, indicating that the heterogeneity of each landscape type was high. The evenness index was 0.7243, indicating that the landscape diversity was large.

Remote mountain forest (steep terrain, open vision): Taking wind prevention as the main task, the cultivation of low shrubs should be strengthened around the ridge to reduce wind speed, while other regions should pay attention to soil and water conservation.

Hilly grassland (hilly slope, typical Yulin sparse tree grassland): Grassland degradation should be prevented, and soil desertification control should be strengthened.

Wetland forest (flat terrain, good biodiversity): The river wetland should be strengthened by filling the surrounding gully with vegetation.

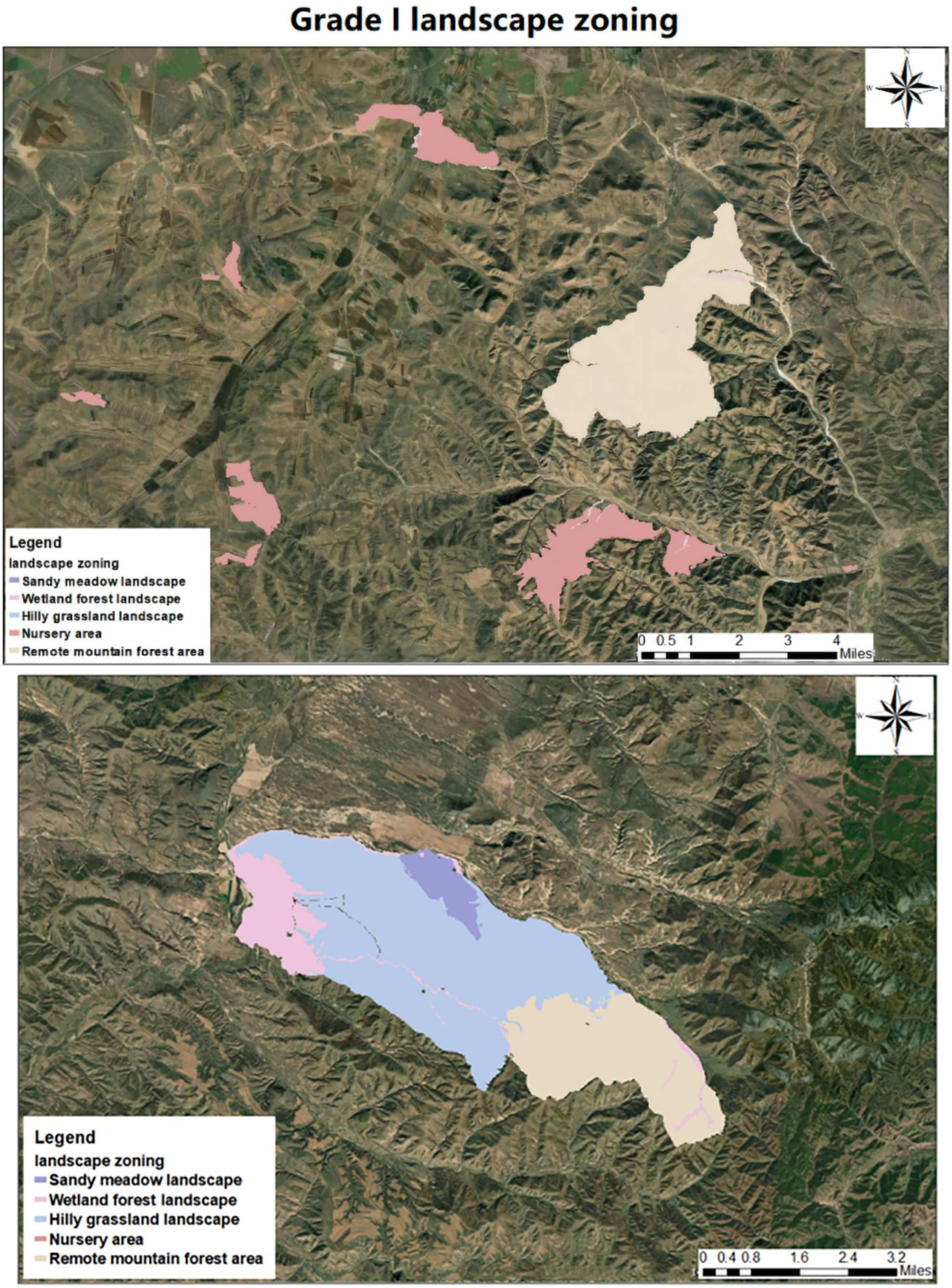

Figure 5. Grade I landscape zoning.

Sandy meadow (unique desert landscape): Vegetation cultivation should be strengthened in the desert edge zone, preventing further expansion of the desert area.

Cultivated nursery stock: Cultivated land should be reverted to forest and grassland in the nursery stock cultivation area by conducting high-quality seedling cultivation.

Among the secondary landscapes (Table 3 and Figure 6), grassland (120.56 km/km^2) had the longest patch edge, while *Pinus tabulaeformis* (0.98 km/km^2) had the shortest patch edge. By sorting the edge density of each landscape component, it was found that the order was roughly the same as the distribution order of the total perimeter of landscape component patches. Thus, landscapes with a large area and perimeter typically have a large boundary density and a high degree of landscape fragmentation, such as pastures. Conversely, landscapes with a small area and perimeter typically have a relatively low boundary, with low fragmentation despite the small distribution area, such as *Pinus tabulaeformis*.

Table 3. Analysis of landscape patch characteristics.

Landscape Type	Patch Size	Mean Value	Standard Deviation of Size	Fractal Dimension Index	Shape Index	Marginal Density	Total Edge
Pasture	5.32	3805.61	5.95	1.38	2.05	120.65	1,047,910.7
Poplar forest and birch mountains	2.97	1249.56	3.02	1.39	2	53.17	461,800.77
Larch forest	2.9	1229.02	4.02	1.36	1.7	41.95	364,380.19
Shrubbery	2.42	589.15	3.58	1.4	2.02	26.71	231,989.43
Mixed forest of tussah and other hardwoods	5.89	359.4	6.73	1.37	1.81	10.05	87,332.27
Wild apricot forest	4.1	82	4.29	1.33	1.4	1.98	17,189.31
Willow soft broad forest	4.16	41.6	6.46	1.38	1.98	1.28	11,096.3
Mixed forest of *Pinus tabulaeformis* and *Pinus sylvestris*	1.81	21.77	1.24	1.36	1.57	0.98	8469.58

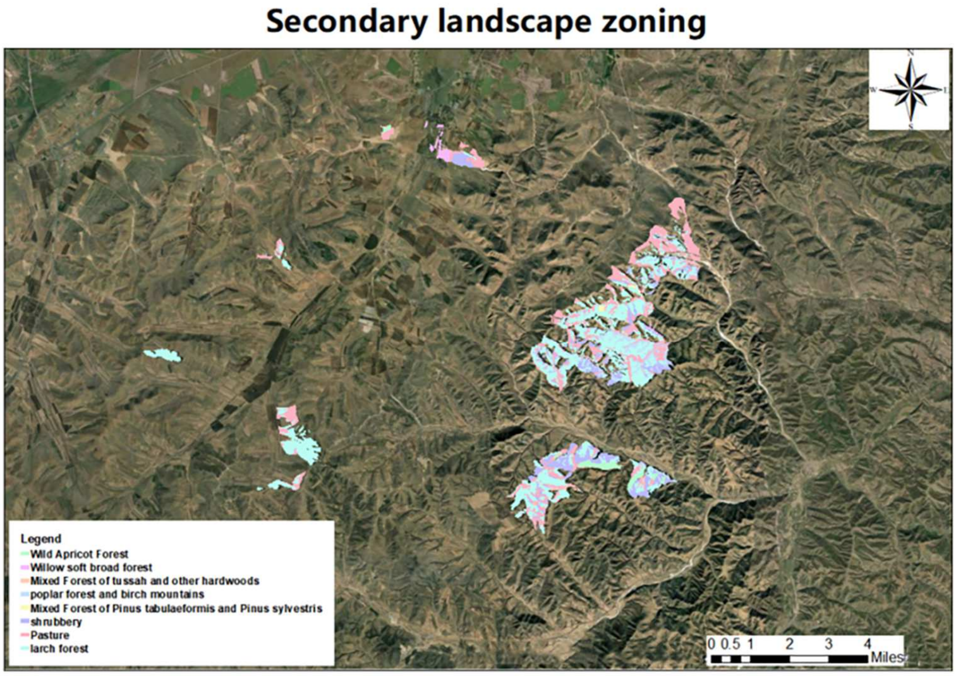

Figure 6. *Cont.*

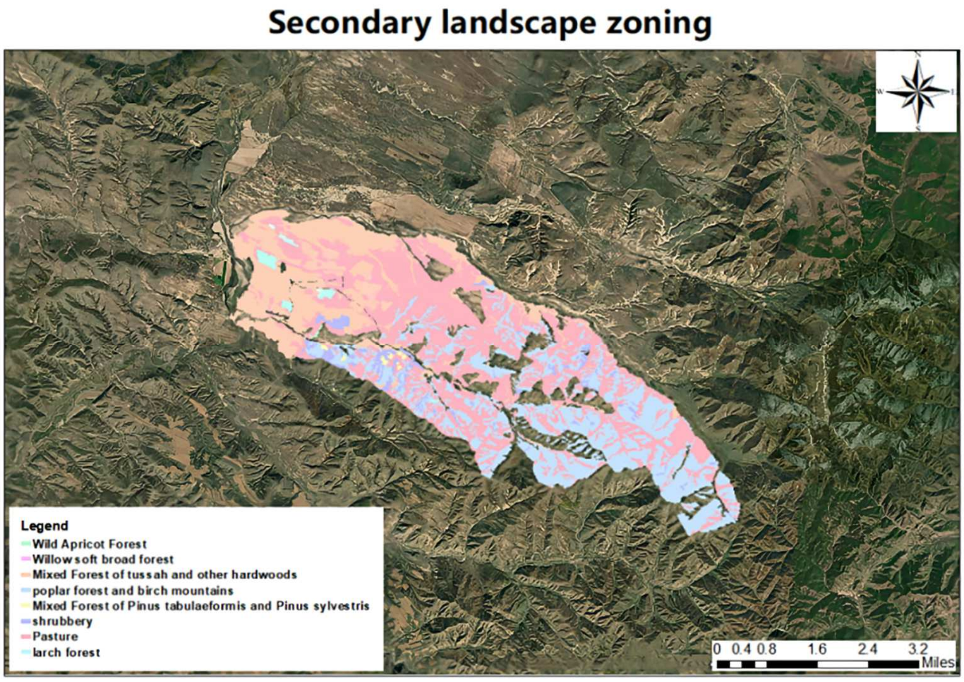

Figure 6. Secondary landscape zoning.

3.2. Analysis of Ecological System

3.2.1. Forest Resources

The dominant tree species in the Grassland Forest Farm are mainly *Betula platyphylla*, broadleaf mixed, larch, poplar, poplar, apricot, *Pinus tabulaeformis*, elm, and *Pinus sylvestris* (Figure 7), while the shrub species are mainly *Hippophae rhamnoides* and hazelnut. Among them, *Betula platyphylla*, *Larix gmelinii*, and *Ulmus pumila* are widely distributed, with a greater volume. *Larix gmelinii* has the largest area and is the most widely distributed, reaching 1359.24 ha. *Betula platyphylla* has the largest volume, reaching 44,783.43 m^3. Although the distribution of slow-growing poplar is lower, its average DBH and unit area volume are the largest at 16 cm and 78.83 m^3/ha, respectively. In addition, the stand density of *Hippophae rhamnoides* and hazelnut is more than 4000 plants/ha. Although the area of elm is relatively large, its stand density and canopy density are the smallest.

The Grassland Forest Farm mainly comprises windbreak forest, water conservation forest, water source forest, and timber forest. Among them, water conservation forests and water source forests are the most widely distributed, accounting for 2230.59 and 1593.18 ha, respectively, with the main functions of water and soil conservation [33]. In addition, although the stand density of water conservation forest is the largest (1064 plants/ha), the stand density of windbreak forest, water source forest, and timber forest is similar, with no significant difference. This shows that the functional ability of windbreak and sand fixation forest products in the Grassland Forest Farm cannot be ignored.

The status of forest resources in Grassland Forest Farm can be classified according to forest age, and their distribution in different age groups is shown in Tables 4–7. Young and middle-aged forests are the most widely distributed in Grassland Forest Farm, with an area of 2925 ha, accounting for 80.82% of the total. The density of overmature forests is the smallest, but the average DBH and unit area accumulation are much higher than those of other age groups at 83.18 m^3/ha, indicating that the forests in Grassland Forest Farm are mainly young and middle-aged forests, with strong growth and carbon sink potential.

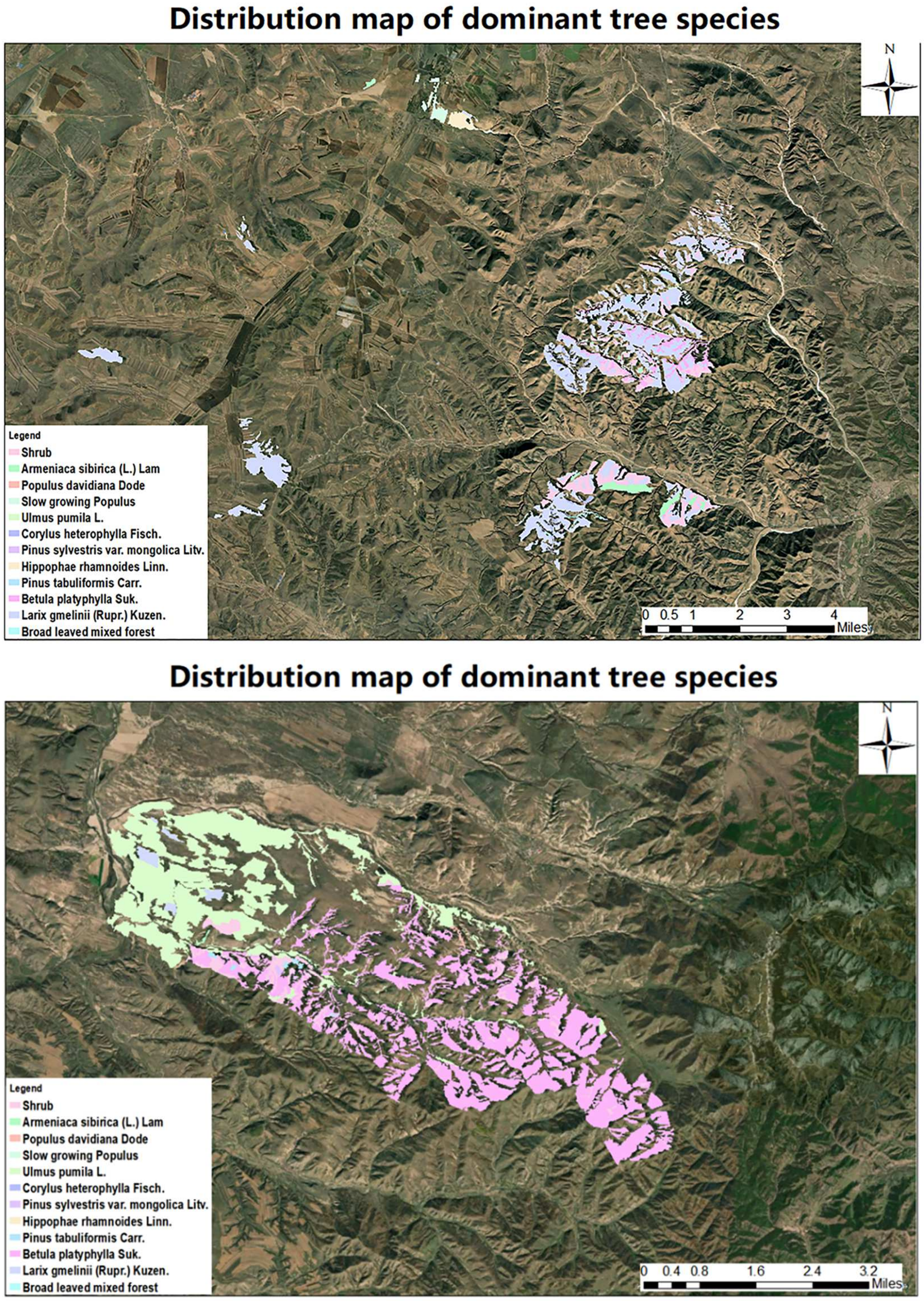

Figure 7. Distribution map of main tree species.

Table 4. Distribution of forest resources in the Grassland Forest Farm (by tree species).

Dominant Tree Species	Area (ha)	Total Savings (m^3)	Mean Diameter (cm)	Mean Canopy Height (m)	Crown Density	Per Unit Area of Stock (m^3/ha)	Stand Density (Plants/ha)
Betula platyphylla Suk.	1283.21	44,783.43	12.37	6.97	0.54	32.64	809
Broad-leaved mixed forest	10.87	117.39	8.00	7.33	0.30	10.80	625
Larix gmelinii (Rupr.) Kuzen.	1359.24	36,006.44	8.95	6.65	0.39	22.51	790
Slow-growing poplar	48.88	3703.34	16.00	8.43	0.47	78.83	541

Table 4. *Cont.*

Dominant Tree Species	Area (ha)	Total Savings (m^3)	Mean Diameter (cm)	Mean Canopy Height (m)	Crown Density	Per Unit Area of Stock (m^3/ha)	Stand Density (Plants/ha)
Shrub	498.4	-	-	0.41	-	-	-
Hippophae rhamnoides Linn.	37.86	-	-	1.00	-	-	4500
Armeniaca sibirica (L.) Lam	85.56	-	-	1.15	0.31	-	636
Populus davidiana Dode	4.01	113.68	11.50	9.10	0.30	28.35	600
Pinus tabuliformis Carr.	17.26	641.78	11.80	7.19	0.55	34.17	738
Ulmus pumila L.	899.48	13,598.45	12.32	6.47	0.20	15.92	353

Table 5. Distribution of forest resources in Grassland Forest Farm (by forest species).

Forest Category	Area (ha)	Total Savings (m^3)	Mean Breast-Height Diameter (cm)	Mean Canopy Height (m)	Crown Density	Per Unit Area of Stock (m^3/ha)	Stand Density (Plants/ha)
Windbreak	51.47	615.36	7.72	5.02	0.52	11.46	667
Water conservation	2230.59	61,243.71	8.53	5.60	0.46	22.12	1064
Shelter to protect river headwaters	1593.18	25,809.65	9.03	5.32	0.37	18.98	531
Timber	427.05	11,469.64	10.00	6.17	0.32	23.05	617

Table 6. Distribution of forest resources in Grassland Forest Farm (by forest age).

Forest Category	Area (ha)	Total Savings (m^3)	Mean Breast-Height Diameter (cm)	Mean Canopy Height (m)	Crown Density	Per Unit Area of Stock (m^3/ha)	Stand Density (Plants/ha)
Mature forest	46.59	1740.59	12.01	8.10	0.41	36.38	834
Overmature forest	2.51	223.50	23.00	9.55	0.15	83.18	398
Near-mature forest	644.72	25,142.64	11.35	8.12	0.43	36.53	858
Young forest	1268.92	15,746.62	8.91	5.42	0.25	10.73	515
Middle-aged forest	1656.08	56,285.01	11.62	6.94	0.52	29.99	787

Table 7. Area and volume of forest resources in Grassland Forest Farm (by origin).

Forest Category	Area (ha)	Total Savings (m^3)	Mean Breast-Height Diameter (cm)	Mean Canopy Height (m)	Crown Density	Per Unit Area of Stock (m^3/ha)	Stand Density (Plants/ha)
Natural initiation	2802.86	59,541.10	8.74	5.01	0.45	19.91	906
Seedling crop	62.72	-	-	1.10	0.30	-	506
Direct seeding	37.26	-	-	1.00	-	-	6000
Transplantation of saplings	1399.45	39,597.26	9.10	6.67	0.39	23.96	788

Grassland Forest Farm predominantly originates from natural germination and the planting of seedlings, with an area of 4202.31 ha, accounting for 97.67% of the total, and with a volume of 99,138.36 m^3. In addition, the average DBH of natural sprouts and seedlings is less than 10 cm, which is relatively small, indicating that the forest in this region is dominated by small-diameter trees, with great future growth and carbon sink potential.

3.2.2. Ecological Structure

Using the spatial analysis function of Arcgis, according to the types of soil degradation, slope, and aspect, the situation of soil desertification in Grassland Forest Farm was comprehensively analyzed. The potential area of soil and water loss was located on sunny slopes (with poor vegetation growth) greater than 15°. Soil erosion covered 473 sub-compartments with a total area of approximately 2267 ha. These sub-compartments included 286 small classes of difficult land, barren hills, and bare rocks, with an area of about 1596 ha, accounting for 70% of the total soil erosion land; future governance should focus on this region.

The ecological red-lined region is mainly distributed in Qingshila Village of Waigoumen Township and Waigoumen Village of Waigoumen Township, with a total area of 2405.55 ha. Detailed information is shown in Table 8. The present land types are tree forest, special irrigation, barren hills, difficult land, sparse forest, immature forest, wetland, bare rock, river, and pasture.

Table 8. Forest types and areas in ecological red-lined region.

Land Type	Forest Category	Degenerated Form	Area (ha)
High forest	Shelter to protect river headwaters	Serious desertification	1256.48
High forest	Water conservation	Serious desertification	
High forest	Shelter to protect river headwaters	Desertification	
High forest	Timber	Serious desertification	
High forest	Timber	Desertification	
High forest	Windbreak	Serious desertification	
High forest	Water conservation	Desertification	
Shrubbery	Shelter forest to protect river headwaters	Serious desertification	198
Shrubbery	Water conservation	Desertification	
Shrubbery	Water conservation	Serious desertification	
Shrubbery	Windbreak	Desertification	
Difficult afforestation land	/	Serious desertification	242.29
Difficult afforestation land	/	Desertification	
Sparse woodland	Shelter to protect river headwaters	Desertification	34.31
Sparse woodland	Timber	Serious desertification	
Afforestation land	Timber	Serious desertification	58.32
Wetland	/	Serious desertification	43.3
Bare rock	/	Serious desertification	5.45
Bare rock	/	Desertification	
River	/	/	16.4
Grassland	/	Serious desertification	2.22
Mountain waste	/	/	533.49

4. Discussion

According to the landscape analysis and ecosystem analysis, it can be seen that Grassland Forest Farm still faces problems such as soil erosion and land desertification. The gully area in the mountain valley is a sign of water and soil loss. Therefore, it is necessary to carry out engineering restoration in this area in order to achieve the main goal of landscape restoration and optimization.

In addition, the structure of tree species in Grassland Forest Farm is relatively single, mainly including larch, birch, elm, and other pine trees. In particular, the larch forest is purely artificial with a sparse density, uneven distribution, and poor ability to resist environmental changes. The birch forest is naturally sprouted and forms a mixed forest with poplar, which faces the problem of high density to a certain extent, contributing to the ecological vulnerability of Grassland Forest Farm. Therefore, one of the main objectives during the operation period is to optimize the stand structure and improve the forest quality.

In addition, the grassland area of the forest farm is deteriorating, and the desertification in some areas is serious, reaching the degree of partial or complete desertification. It is urgent to repair the grassland ecology. Therefore, landscape restoration and optimization and grassland quality improvement should be the main objectives.

Grassland Forest Farm is an important water conservation area in Beijing, Tianjin, and Hebei. It is also an important channel for the southern invasion of sandstorms from Inner Mongolia into Beijing, Tianjin, and Hebei. The ecological environment is fragile, and its location is very important. Therefore, wind prevention, sand fixation, and water conservation should represent the special objectives of the management period.

In general, the main factors restricting the forest management of Grassland Forest Farm include five aspects: low-quality and low-efficiency forests which need urgent afforestation and replanting, serious desertification in some areas, unreasonable forest structure, serious degradation of some grasslands, and lack of effective management and protection of some young and middle-aged forests (Figure 8).

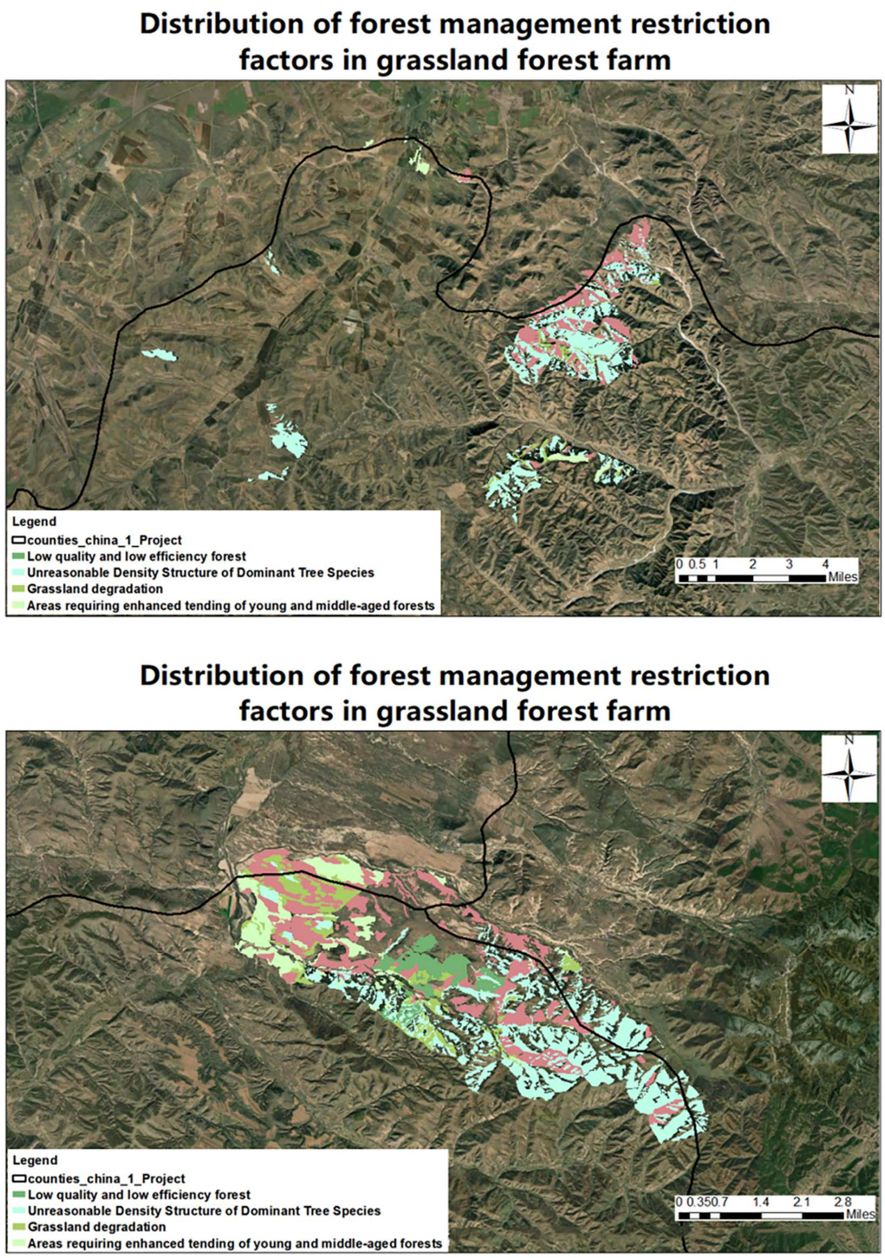

Figure 8. Distribution of forest management restriction factors in Grassland Forest Farm.

4.1. Landscape Restoration and Optimization

4.1.1. Functional Zoning

Starting from the development orientation of Grassland Forest Farm and forest management objectives, small classes with basically the same functions and connected regions can be classified as the same functional area or management area, and the management activities in these areas should match the management objectives. According to the main business objectives of Grassland Forest Farm (ecological recreation, wind prevention, and sand fixation), the landscape functions can be classified as ecological recreation areas (Yongtaixing area), water and soil conservation areas, and seedling cultivation areas. Considering the landscape characteristics of Grassland Forest Farm, the ecological recreation area can be divided into remote mountain forest areas, gentle hill grassland areas, wetland forest areas, and sandy landscape areas.

In the remote mountain forest area, located in the east of Yongtaixing with open vision and rich vegetation, ecotourism should be vigorously developed. Due to the high altitude and wind speed, more shrubs should be planted in order to reduce their effect.

In the gentle hill grassland area, located in the middle of Yongtaixing with a typical sparse forest grassland landscape, the landscape effect of Guishan is excellent. A viewing tower should be built to improve the viewing experience. Furthermore, attention should be paid to the governance of grassland degradation in the region.

In the wetland forest area, located in the west of Yongtaixing representing the water conservation area of Luan River Basin with great species diversity, we should strengthen the construction of wetland parks.

In the desertification landscape area, located in the north of Yongtaixing, the unique desertification landscape is a highlight for the development of ecotourism in Grassland Forest Farm. Scenic towers and post stations should be built to improve the viewing experience. Furthermore, water and soil conservation should be strengthened at the edge of sandy land to prevent further expansion of the desertification area.

In the soil and water conservation area, located in the western part of Waigoumen and the southern part of the grassland township, with a large slope, poor soil quality, and poor forest vegetation growth, hillsides should be closed for forest planning control to improve soil and water conservation.

4.1.2. Land-Use Adjustment

According to the current land use and the landscape analysis results, considering the basic farmland scope line, forest health infrastructure planning, and overall land-use planning, the topography, water, land, surrounding features, and other factors can be used to determine the area adjustment scheme. According to the range line of county-level basic farmland, topography, soil types, and other factors, the farmland can be adjusted beyond the scope of pasture or woodland, including the planting of larch in woodlands and the planting of alfalfa and rose in pastures. In the first phase, 41 sub-compartments with a total area of about 62.47 hectares will be adjusted.

4.1.3. Ecological Restoration

Engineering restoration should be increased in the gully region of the mountain valley, which is a sign of soil and water loss [34]. It is mostly distributed on the sunny slopes around the valley. The forest quality should be improved in the gully, the construction of mixed forest should be strengthened, and further collapse of the gully should be prevented. In this management period, the internal gully should be rectified into terraces, and more trees should be planted on the terraces and at the bottom of the gully. This will involve a total of 2218 small classes, with a filling area of 127.755 ha, as shown in Table 9. The location and effect diagrams are shown in Figure 9. The position and effect maps of gully engineering restoration are shown in Figure 10.

Table 9. Gully repair area.

Forest Compartment	Sublot	Proportion of Gully	Area of Gully
013H	813	2.31	21.2862
013I	621	6.11	66.827
013L	772	5.91	36.7281
013M	12	0.18	2.9142
Grand total	2218	14.51	127.7555

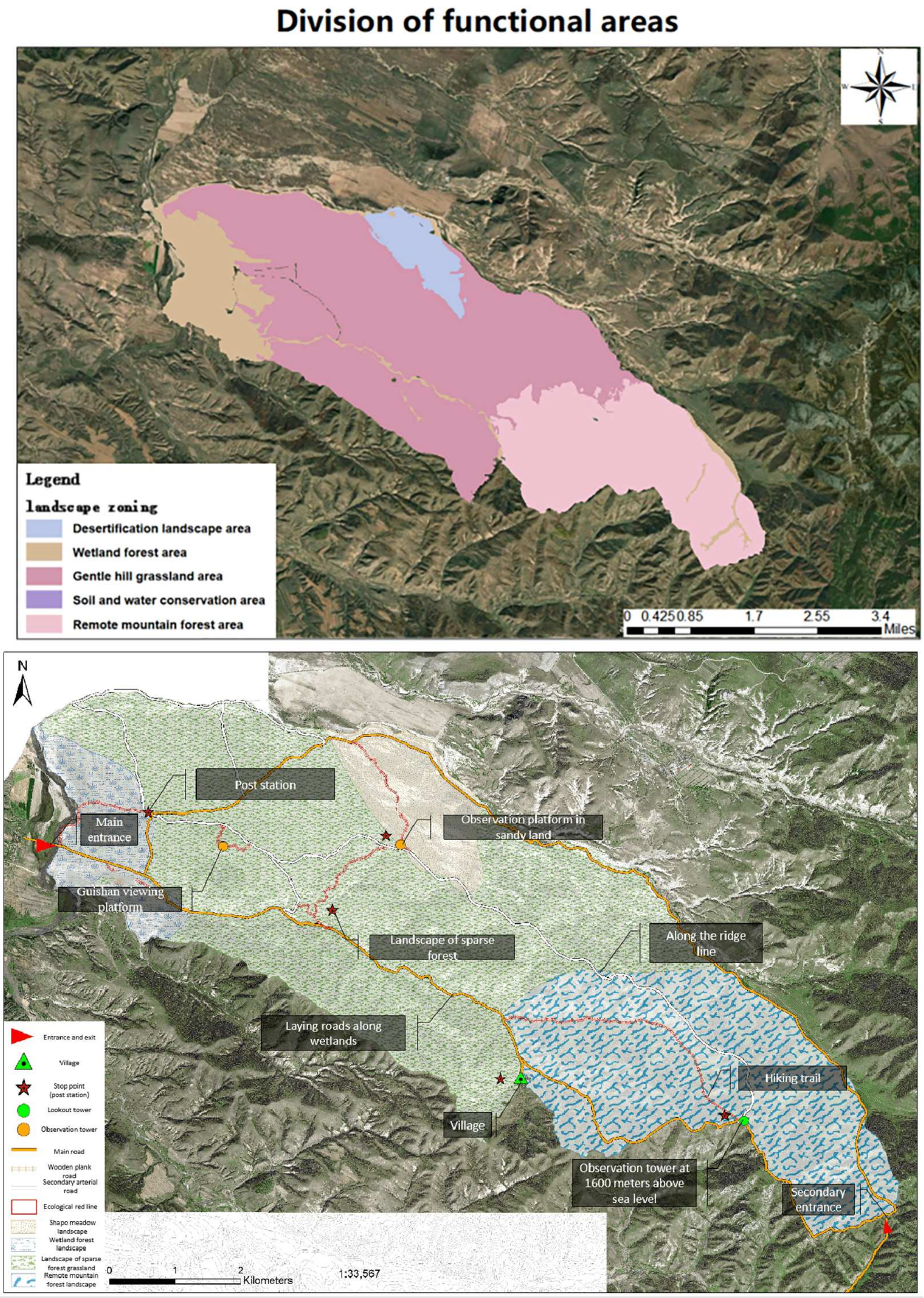

Figure 9. Functional zoning and planning.

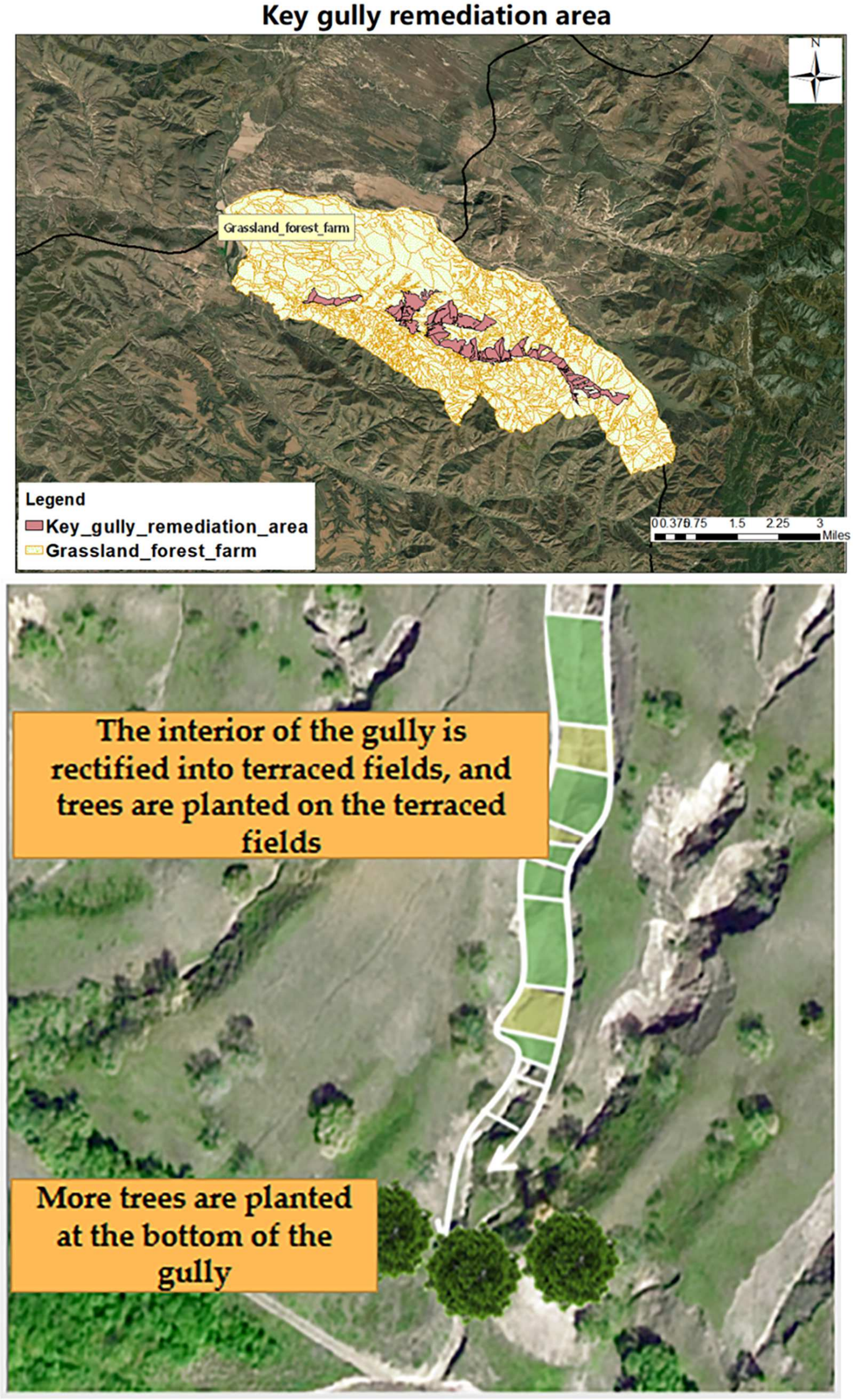

Figure 10. Position and effect maps of gully engineering restoration.

4.2. Forest Quality Improvement

4.2.1. Optimizing Stand Structure

According to the secondary survey and supplementary survey data of Grassland Forest Farm in 2019, the growth model of the main trees was established. The growth of tree species was calculated in combination with the volume model of Grassland Forest Farm within 10 years of the management period. At the same time, the stand structure was evaluated according to the ideal forest principle and the precision forestry measurement method. On the basis of the evaluation results, the forest quality improvement project was implemented. By optimizing the stand structure and strengthening the tending management, the forest quality and benefits of Grassland Forest Farm were improved, the windbreak and sand fixation ability was improved, and the multiple ecological functions of the forest were fully realized. Lastly, the annual tending plans of each forest type were determined.

According to the principle of ideal forest distribution, an evaluation of the dominant species *Betula platyphylla*, *Larix gmelinii*, *Pinus sylvestris* var. *mongolica*, *Ulmus pumila*, and others in Grassland Forest Farm was carried out, and the following corresponding measures for improving forest management were proposed: renovation, replanting, and tending. The ideal evaluation results and quality improvement measures are shown in Table 10.

Table 10. Ideal evaluation results and quality improvement measures.

Name	Evaluation Results of Rational Forest	Area	Number of Sublots	Measures for Forest Quality Improvement
Larch	High density	502.41	91	For middle-aged and young forest tending measures, reasonable thinning, timely pruning, and weeding to reduce density; for near-mature forest, mature forest management and protection measures, according to the situation of partial logging for sand barrier construction, after harvesting *Pinus sylvestris* seedlings to form mixed forest of different ages
	Density is too sparse	434.58	210	Introducing mixed tree species for supplementary planting, selecting mixed tree species such as *Pinus sylvestris* var. *mongolica*, and forming mixed forest of different ages
	Basically satisfying ideal distribution	371.33	132	Strengthening management and protection measures, appropriate amount of sanitary cutting can be carried out for larch on shady slope, and sand barriers can be laid in nearby sandy land according to the principle of proximity after cutting
Betula platyphylla	High density	1190.4	384	The young and middle-aged forests can be mainly managed and supplemented by young and middle-aged forest tending, and adopting low-intensity thinning, after which sand barriers can be laid in nearby sandy land according to the principle of proximity, and high-quality dry wood can be used for grassland fence construction to promote forest growth through tending
	Density is too sparse	83.81	55	Introducing mixed tree species and selecting mixed tree species such as *Pinus sylvestris* var. *mongolica* to form coniferous and broadleaved mixed forest

Table 10. *Cont.*

Name	Evaluation Results of Rational Forest	Area	Number of Sublots	Measures for Forest Quality Improvement
Ulmus pumila	Growth tends to be stable and basically meets the ideal distribution	899.48	163	The management and protection of young and middle-aged forests are given priority, supplemented by the tending of young and middle-aged forests; according to the actual growth status of trees and site conditions, irrigation time and methods can be reasonably arranged, the fertilization period, methods, and types can be selected, and appropriate cutting methods can be adopted for low-intensity tending thinning
Other tree species	Growth tends to be stable and basically meets the ideal distribution	171.09	50	Strengthening management and protection measures to prevent pests and diseases and improve forest land and forest quality

In addition, in order to ensure the uniqueness and scarcity of sparse forests, which have unique landscape characteristics, e.g., the 889.84 ha of sparse elm forests involving 161 sub-compartments, the tree species structure can be appropriately adjusted to ensure forest land hygiene and pest control. Furthermore, combined with grassland management measures, elm forests can be managed and protected to maintain their landscape and niche specificity.

4.2.2. Reasonable Annual Cutting and Forest Harvesting

Currently, the existing forest volume is 99,138.4 m^3; after management and protection, the forest volume can reach 126,770.7 m^3 in the next 5 years and 152,943.6 m^3 in the next 10 years, representing a growth accumulation of 53,805.2 m^3. The existing volume of larch forest is 36,006.44 m^3. After management and protection, the volume can reach 45,842.2 m^3 in the next five years and 52,837.6 m^3 in the next 10 years, representing a growth accumulation of 16,831.2 m^3. The current volume of birch–poplar mixed forest is 44,783.4 m^3. After management and protection, the volume can reach 58,839.0 m^3 in the next 5 years and 73,680.7 m^3 in the next 10 years, representing a growth accumulation of 28,897.3 m^3. The current volume of Yushu Forest is 13,598.45 m^3. After management and protection, the volume can reach 16,523.2 m^3 in the next 5 years and 19,681.8 m^3 in the next 10 years, representing a growth accumulation of 6083.3 m^3. Other tree species (poplar, *Pinus sylvestris*, *Pinus tabulaeformis*, and *Prunus armeniaca*) occupy a volume of 4750.0 m^3. After management and protection, the volume can reach 5566.4 m^3 in the next 5 years and 6743.5 m^3 in the next 10 years, representing a growth accumulation of 1993.4 m^3.Annual thinning target volume under different forest management types are shown in Table 11.

Table 11. Annual thinning target volume under different forest management types.

Forest Management Type	Amount of Tending Felling (m^3/Year)
Larch forest	1683.1
Betula platyphylla–poplar mixed forest	2889.7
Ulmus pumila forest	608.3
Other tree species (poplar, *Pinus sylvestris*, *Pinus tabulaeformis*, and *Prunus armeniaca*)	199.3
Footing	5380.4

4.3. Grassland Quality Improvement

4.3.1. Grassland Landscape Restoration

According to the supplementary investigation and analysis of the data of Grassland Forest Farm in 2019, there is 2667.36 ha of grassland, of which 481.69 ha of grassland and meadow have been seriously degraded, involving 107 small classes. Grassland desertification is serious in some areas, reaching the degree of partial or complete desertification. A total of 156 sub-compartments constitute a total of 1096.31 ha in Grassland Forest Farm, of which 151.72 ha is occupied by a total of 30 sub-compartments with serious desertification, in addition to 118 sub-compartments with 844.29 ha of different degrees of desertification.

On the basis of the above analysis, Grassland Forest Farm was divided into districts to establish a benign ecosystem, where the grasslands with extremely low productivity, serious degradation, and desertification were sealed for a long time. Comprehensive measures such as fencing and reseeding were adopted to improve the grassland production capacity, build sand barriers in the desertified land, and plant grasses in the grid to strengthen water and soil conservation and improve the survival rate of the grassland. The deserts existing in Grassland Forest Farm were gradually controlled, and the specific measures to reduce the surface air volume of sandy land and enhance the sand fixation capacity are shown in Table 12.

Table 12. Types and measures of grassland ecological restoration.

Types of Ecological Restoration	Degradation Degree	Area	Reclamation Activities
Management of severely degraded grassland	Severe desertification	166.57	1. Banning of grazing 2. Creation of a shrub belt perpendicular to the main wind direction on the edge of the sub-compartments, consisting of 6–9 rows of shrubs, with a sparse structure and multilevel sand control forest belt 3. Within the sub-compartments, local materials, wheat straw, shrub branches, etc. were buried perpendicular to the main wind direction, and a sheltered 1 × 1 m square sand barrier was constructed to improve sand fixation capacity 4. In the period of good hydrothermal climate, strip sowing, hole sowing, and spread sowing were used to rush planting and supplement forage to gradually improve the land desertification
	Partial desertification	315.12	1. Enclosure measures for small classes, establishment of web fences and barbed wire fences, and regular inspections by specialists 2. Layout of 1 × 1 m grid sand barrier to improve windbreak and sand fixation capacity 3. In the period of good hydrothermal climate, strip sowing, hole sowing, and spread sowing were used to rush planting and supplement forage to gradually improve the land desertification situation
Desert rehabilitation	Serious degradation	151.72	1. For semi-desertified or fully desertified plots, the measures of constructing a multilevel windbreak forest belt around the small class were first taken, and the tree species were a mixture of *Pinus sylvestris* var. *mongolica* and *Pinus tabulaeformis* 2. Wheat grass, shrub branches, etc., buried perpendicular to the direction of the main wind, were used to build a hidden 1 × 1 m grid sand barrier 3. Selective pasture cultivation after the rainy season based on actual conditions
	Desertification	844.29	Maintenance of desert landscape, while taking appropriate measures to combat further desertification

4.3.2. Enhancement of Additional Afforestation, Supplementary Irrigation, and Grass Planting

In order to increase the biodiversity construction on the edge of the sparse forest grassland landscape and control the internal damage of wind and sand, as shown in Figures 11 and 12, the windbreak vegetation was increased in the range of 15 m around the sparse forest grassland, with an area of 48.17 ha. The main vegetation types were *Vitex negundo*, *Prunus armeniaca*, hazelnut, clove, and oak. The sparse forest landscape was retained inside the existing landscape, while minimizing manual intervention.

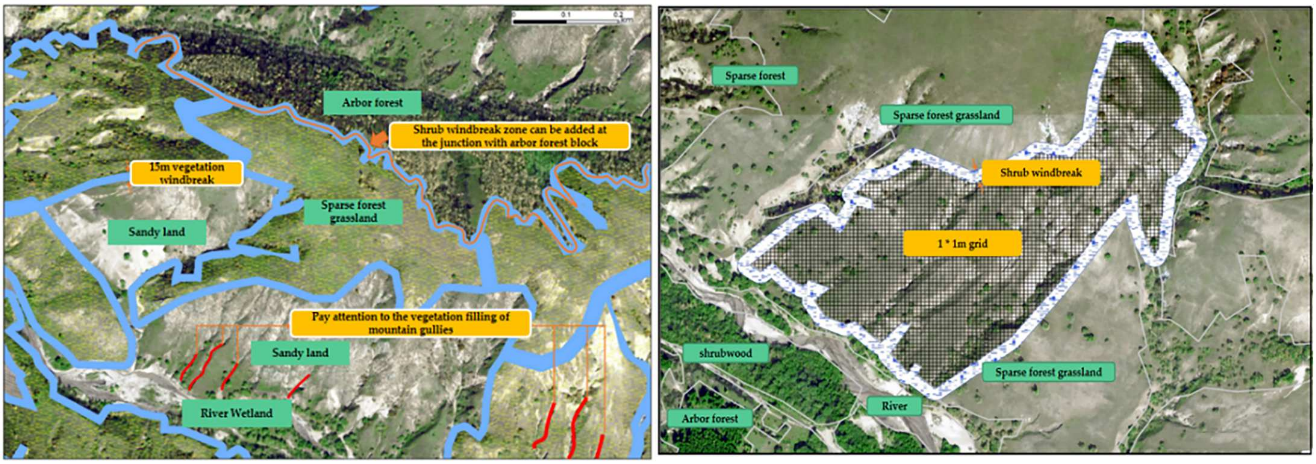

Figure 11. Construction of vegetation windbreak belt.

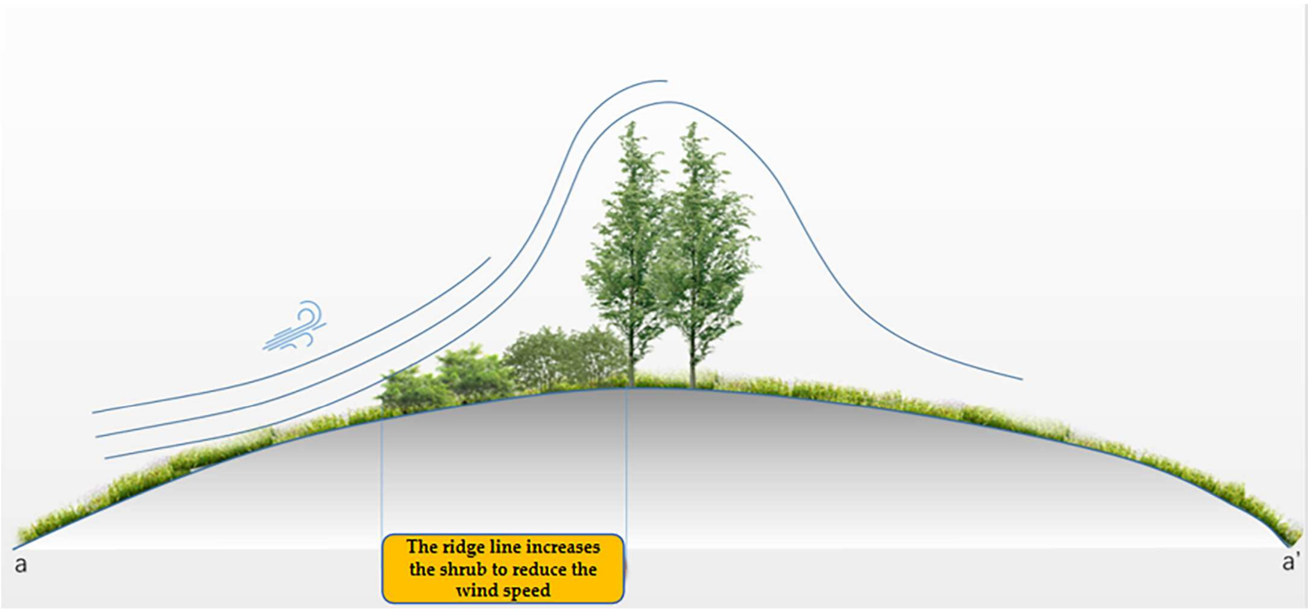

Figure 12. Chart of ridgeline shrub zone.

Shrub belts were added at the ridge line to reduce the impact of wind speed on the interior vegetation. Shrubs were dominated by *Vitex negundo*, *Salix psammophila*, *Hippophae rhamnoides*, hazelnut, almond, *Caragana korshinskii*, and *Ziziphus jujuba*. It is suggested that the ridge line of the remote mountain landscape area should be reconstructed first, with a length of ~23 km. To achieve the planting of a 5 m shrub belt, the area of shrubland needed to be planted is 11.5 ha.

Afforestation plans can be carried out in suitable barren hills and wastelands, and mixed forests of different ages can be created. Afforestation plans can be carried out according to the actual economic situation. The afforestation area is 346.7 ha, and the afforestation tree species can be *Pinus sylvestris* var. *mongolica*, *Litsea cubeba*, and *Prunus davidiana*.

4.4. Promotion of Ecological Service Function Value

In order to prevent wind, fix sand, conserve water, restore vegetation, and improve the ecological environment, Grassland Forest Farm should be divided into districts to establish a benign ecosystem, and grassland closure and fence construction should be carried out. The trend of grassland degradation, grassland quality decline, and ecological environment deterioration caused by human overload, overgrazing, and disorderly reclamation and excavation should be basically controlled, to prevent further expansion of the grassland degradation area. The rotational division of grassland for grazing livestock should be carried out, and corresponding rodent control measures should be taken. The desertification of grassland should be controlled to a certain extent, and the ability of wind and sand prevention and water conservation of grassland should be improved.

Long-term enclosure should be applied for extremely low-productivity, severely degraded, and sandy grassland, fencing and reseeding should be improved, grassland production capacity should be improved, a sand barrier should be constructed within the sandy land, and grass should be planted in the grid to strengthen soil and water conservation, thereby improving the survival rate of grassland. The grassland management and restoration of "black soil beach" and "loess beach" formed by extremely harmful rodents should be prioritized. Step-by-step control of deserts should be implemented in Grassland Forest Farm to reduce surface air volume and enhance sand fixation capacity. By improving forest quality and restoring and optimizing the forest landscape, the windbreak and sand fixation ability and the water conservation of the forest can be effectively improved. Moreover, the value of ecological services such as soil and fertilizer fixation, nutrient fixation, carbon fixation, and oxygen release, providing negative oxygen ions and purifying air in the forest ecosystem, can be improved. According to GB/T38582-2020 ("forest ecosystem service function evaluation standard"), the ecological service function [35,36] provided by vegetation in Grassland Forest Farm was evaluated to predict the ecological service function in the middle and late stages of operation (Table 13).

Table 13. Ecological service function value of Grassland Forest Farm in managerial period.

Item	Amount in 2020	Material Quality in 2025	Increment from 2020 to 2025	Material Quality in 2030	Increment from 2020 to 2025	Unit
Water conservation	12,279,280.3	13,360,151.8	1,080,871.4	14,632,547.2	2,353,266.8	Ton/ha·year
Windbreak and sand fixation	546,674.6	616,446.8	69,772.3	704,510.7	157,836.1	Ton/ha·year
Soil conservation/consolidation	176,442.1	187,273.3	10,831.2	206,000.7	29,558.6	Ton/ha·year
Soil/fertilizer conservation	13,423.0	14,175.2	752.2	15,592.7	2169.7	Ton/ha·year
Nutrient retention	10,656.3	11,337.7	681.4	12,471.4	1815.2	Ton/ha·year
Vegetation carbon sequestration	3640.4	4004.3	363.9	4270.1	629.7	Ton/ha·year
Oxygen release from vegetation	4986.5	5484.9	498.4	5848.9	862.5	Ton/ha·year
The number of negative oxygen ions produced	1.1×10^{22}	1.1×10^{22}	7.5×10^{20}	1.4×10^{22}	3.0×10^{21}	year
Air purification	628,945.9	712,579.2	83,633.3	855,095.0	226,149.2	Kg/ha year

5. Conclusions

Through an optimization of the spatial pattern, Grassland Forest Farm was divided into four functional areas: remote mountain forest, gentle hill grassland, wetland forest, and sandy landscape. During the management period, 125.76 ha of mountain valley and gully engineering restoration will be realized. A forest quality improvement project was implemented to improve the stand structure and increase the proportion of larch mixed forest by 30%. Furthermore, new afforestation, supplementary irrigation, and grass planting were increased by 438.94 ha, while 946.45 ha of desertified land was controlled, so as to improve the quality of the grassland and landscape. Through landscape restoration and optimization, as well as forest and grassland quality improvement projects, the area of windbreak and sand fixation vegetation was increased from 51.47 to 410.2 ha, and the sand fixation capacity was increased from 546,700 to 704,500 tons/ha·year. The water conservation capacity was increased from 12.2793 to 14.6325 million tons/ha·year.

Starting from the five development concepts of coordination, innovation, green, openness, and sharing, the New Forest Management Plan adheres to the theory of sustainable forest management, considering the rights and obligations of owners, operators, and managers when implementing policies in different areas. With the goal of cultivating a healthy, stable, and efficient forest ecosystem, through strict protection, active development, scientific management, and sustainable utilization of forest resources, the quality of forest resources and forest productivity can be improved to protect biodiversity and improve the living environment of wild animals and plants, enhance forest productivity and the overall function of the forest ecosystem, promote harmony between man and nature, and realize the sustainable development of forestry. Furthermore, the national and regional ecological needs can be met. Moreover, under the background of promoting the construction of a national ecological civilization, scientific ideas can be implemented to recognize forests and advanced technology can be applied to cultivate forests. With improving ecological functions and cultivating high-quality forests as the fundamental starting point, the sustainable management level in forest farms can be effectively improved, the service function of the forest ecosystem can be strengthened, and the construction of mountains, rivers, forests, lakes, and grasses as a community of life can be promoted, thus truly realizing the harmonious coexistence between humans and nature.

Author Contributions: Formal analysis, Z.L.; investigation, C.C.; methodology, Z.L. and Z.F.; project administration, Z.F.; resources, Z.F.; software, Z.L.; supervision, Z.F.; validation, Z.L. and C.C.; visualization, C.C.; writing—original draft, Z.L.; writing—review and editing, Z.F. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the key R & D projects in Hainan Province (zdyf2021shfz256) and Natural Science Foundation of Hainan University, grant numbers kyqd (Zr) 21115. Thanks to the "Green Wall of China Engineering" benefit evaluation system research for supporting this study.

Data Availability Statement: The steam and dispersion data of forest water consumption used to support the findings of this study were deposited in the PML_V2 global evapotranspiration and gross primary production repository (DOI:10.11888/Geogra.tpdc.270251). The average temperature data used to support the findings of this study were deposited in the combined Terra and Aqua MODIS land surface temperature and meteorological station data product for China (2003–2017) repository (DOI:10.5281/zenodo.3528024). The forest resource data in Grassland Forest Farm of Fengning County used to support the findings of this study were supplied by The National Forest Resource Smart Management Platform under license and cannot be made freely available.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Jing, L. Development and Implementation of Innovative Forest Management Plan. *For. Resour. Manag.* **2020**, 6–10. (In Chinese) [CrossRef]
2. Siry, J.P.; Cubbage, F.W.; Ahmed, M.R. Sustainable forest management: Global trends and opportunities. *For. Policy Econ.* **2005**, *7*, 551–561. [CrossRef]
3. Rametsteiner, E.; Simula, M. Forest certification—An instrument to promote sustainable forest management? *J. Environ. Manag.* **2003**, *67*, 87–98. [CrossRef]

4. Von Gadow, K.; Pukkala, T.; Tomé, M. (Eds.) *Sustainable Forest Management*; Springer Science & Business Media: Berlin/Heidelberg, Germany, 2001; Volume 1.
5. Swanson, F.J.; Franklin, J.F.; Sedell, J.R. Landscape patterns, disturbance, and management in the Pacific Northwest, USA. In *Changing Landscapes: An Ecological Perspective*; Springer: New York, NY, USA, 1990; pp. 191–213.
6. McNab, W.H.; Jensen, M.E. National hierarchical framework of ecological units. In *Ecosystem Management: Applications for Sustainable Forest and Wildlife Resources*; Yale University Press: New Haven, CT, USA, 1997; p. 181.
7. Heping, Z. Protection and sustainable utilization of forest landscape resources in the Li River River basin. *Guangxi For. Sci.* **2002**, 1–4. (In Chinese) [CrossRef]
8. Vanclay, J.K.; Skovsgaard, J.P. Evaluating forest growth models. *Ecol. Model.* **1997**, *98*, 1–12. [CrossRef]
9. Scolforo, H.F.; Scolforo, J.R.S.; Thiersch, C.R.; Thiersch, M.F.; McTague, J.P.; Burkhart, H.; Filho, A.C.F.; de Mello, J.M.; Roise, J. A new model of tropical tree diameter growth rate and its application to identify fast-growing native tree species. *For. Ecol. Manag.* **2017**, *400*, 578–586. [CrossRef]
10. Vanclay, J.K. *Modelling Forest Growth and Yield: Applications to Mixed Tropical Forests*; Cab International: Wallingford, UK, 1994.
11. Zhou, X.; Peng, C.; Dang, Q.L.; Chen, J.; Parton, S. Predicting forest growth and yield in northeastern Ontario using the process-based model of TRIPLEX1. 0. *Can. J. For. Res.* **2005**, *35*, 2268–2280. [CrossRef]
12. Qian, Y. Calculation and application of forest growth. *For. Investig. Des.* **2005**, 75–77. (In Chinese)
13. Dong, G. *Preparation of Forest Management Plan*; Anhui Agricultural University: Hefei, China, 2019. (In Chinese) [CrossRef]
14. Barnette, K. Multiple purpose forests and the national forest system. *New For.* **1999**, *17*, 119–127. [CrossRef]
15. Tongqian, Z.; Zhiyun, O.; Hua, Z.; Xiaoke, W.; Hong, M. Evaluation of forest ecosystem service function and its value in China. *J. Nat. Resour.* **2004**, 480–491. Available online: https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&dbname=CJFD2004&filename=ZRZX200404010&uniplatform=NZKPT&v=cjeADcH1fmF24I3lg571xJc_nYp1hJ4r28wtKpdig2ZLUtaYh2LeyTjq6DhniLiO (accessed on 3 May 2022). (In Chinese)
16. Fang, J.; Shaowei, L.; Xinxiao, Y.; Liangyi, R.; Jianzhi, N.; Yuanyuan, X.; Zhenming, Z. Evaluation of forest ecosystem service function and its value in China. *Chin. J. Appl. Ecol.* **2005**, 1531–1536. (In Chinese)
17. Miura, S.; Amacher, M.; Hofer, T.; San-Miguel-Ayanz, J.; Thackway, R. Protective functions and ecosystem services of global forests in the past quarter-century. *For. Ecol. Manag.* **2015**, *352*, 35–46. [CrossRef]
18. Zhao, X.; Feng, Z.; Zhou, Y.; Lin, Y. Key Technologies of Forest Resource Examination System Development in China. *Engineering* **2020**, *6*, 491–494. [CrossRef]
19. Yadong, L.; Minglan, C.; Changqing, L.; Zhongke, F.; Shuhua, J. Crown segmentation of UAV visible light DOM using level set method. *Trans. Chin. Soc. Agric. Eng.* **2021**, *37*, 60–65. (In Chinese)
20. Yanchao, Z.; Wu, H.; Yang, W. Forests growth monitoring based on tree canopy 3D reconstruction using UAV aerial photogrammetry. *Forests* **2019**, *10*, 1052.
21. Chen, C.; Xiulan, W.; Zhongke, F.; Sufen, S.; Lang, Z.; Wenyuan, M. Study on tree ring information extraction by electric growth cone combined with Python. *J. Agric. Sci. Technol.* **2020**, *22*, 97–105. (In Chinese) [CrossRef]
22. Chen, R.; Chen, W.; Hu, M.; Huang, W. Measuring improvement of economic condition in state-owned forest farms' in China. *Sustainability* **2020**, *12*, 1593. [CrossRef]
23. Schweingruber, F.H. *Tree Rings: Basics and Applications of Dendrochronology*; Springer Science & Business Media: Berlin/Heidelberg, Germany, 2012.
24. Evans, M.E.; Falk, D.A.; Arizpe, A.; Swetnam, T.L.; Babst, F.; Holsinger, K.E. Fusing tree-ring and forest inventory data to infer influences on tree growth. *Ecosphere* **2017**, *8*, e01889. [CrossRef]
25. Robert, M.G.; Robert, V.; Gardner, H.; Milne, B.T. Effects of changing spatial scale on the analysis of landscape pattern. *Landsc. Ecol.* **1989**, *3*, 153–162.
26. Liding, C.; Bojie, F. The ecological significance and application of landscape connectivity. *Chin. J. Ecol.* **1996**, *15*, 37–42.
27. Fan, C.; Myint, S. A comparison of spatial autocorrelation indices and landscape metrics in measuring urban landscape fragmentation. *Landsc. Urban Plan.* **2014**, *121*, 117–128. [CrossRef]
28. Wang, X.P.; Tang, Z.Y.; Fang, J.Y. Climatic control on forests and tree species distribution in the forest region of Northeast China. *J. Integr. Plant Biol.* **2006**, *48*, 778–789. [CrossRef]
29. Zhang, H.; Feng, Z.; Chen, P.; Chen, X. Development of a tree growth difference equation and its application in forecasting the biomass carbon stocks of Chinese forests in 2050. *Forests* **2019**, *10*, 582. [CrossRef]
30. Qiu, Z.; Feng, Z.; Song, Y.; Li, M.; Zhang, P. Carbon sequestration potential of forest vegetation in China from 2003 to 2050: Predicting forest vegetation growth based on climate and the environment. *J. Clean. Prod.* **2020**, *252*, 119715. [CrossRef]
31. Lin, C. *Hydrological Effect and Simulation of Forest Vegetation in Semi-Arid Loess Area of Western Shanxi Province*; Beijing Forestry University: Beijing, China, 2011.
32. Zou, L.; Wang, J.; Bai, M. Assessing spatial–temporal heterogeneity of China's landscape fragmentation in 1980–2020. *Ecol. Indic.* **2022**, *136*, 108654. [CrossRef]
33. Biao, Z.; Wenhua, L.; Gaodi, X.; Yu, X. Water conservation of forest ecosystem in Beijing and its value. *Ecol. Econ.* **2010**, *69*, 1416–1426. [CrossRef]
34. Jiao, J.; Zou, H.; Jia, Y.; Wang, N. Research progress on the effects of soil erosion on vegetation. *Acta Ecol. Sin.* **2009**, *29*, 85–91. [CrossRef]

35. State Forestry Administration of the People's Republic of China. *LY/T 1721-2008 Criteria for Assessment of Forest Ecosystem Services*; China Standard Press: Beijing, China, 2008; pp. 1–6.
36. State Forestry Administration of the People's Republic of China. *Code for Assessment of Forest Ecosystem Service Functions*; China Standard Press: Beijing, China, 2020; pp. 1–6.