Evaluation of Service Function Value of Forest Ecosystem for Natural Forest Protection Project in Xiuwen County

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Abstract. According to LY/T 1721-2008 Forest Ecosystem Service Function Evaluation Specification, this paper constructs a forest ecosystem service function evaluation index system for the natural forest protection project based on the characteristics in the process of implementation of the natural forest protection project in Xiuwen County, and assesses the value of forest ecosystem service function of the natural forest protection project in Xiuwen County from 1998 to 2015 by using materials of Xiuwen County natural forest protection project, forest resource inventory data, and ecological monitoring materials. The results show that the total value of the forest ecosystem service function value of the Xiuwen County Natural Forest Protection Project in Guizhou Province reached 29.281 billion by 2015, the annual average is 1.62712 billion yuan, and the total value is increasing year by year. Among the different forest ecosystem service functions, two functions carbon sequestration and oxygen production and water conservation a have the largest value that shows that the Xiuwen County Natural Forest Protection Project plays an important role in carbon sequestration and oxygen production and water conservation. In response to the existing problems, suggestions for improving the service functions of forest ecosystems are put forward.

1. Introduction

The report of the 19th National Congress of the Communist Party of China proposed to implement major ecological system protection and restoration projects, improve the natural forest protection system, and increase ecological system protection. Therefore, carrying out the evaluation of the service function value of the forest ecosystem of the natural forest protection project is an inevitable requirement for testing the degree of achievement of the natural forest protection project policy objectives, perfecting the second phase project policy, and strengthening the construction of forestry ecological civilization.

China started to protect natural forests through the implementation of the Natural Forest Protection Project. With the completion of the first phase of the Natural Forest Protection Project and the implementation of the second phase in 2011, its benefit or impacting evaluation has been brought into the research vision of more scholars. The contents include: analysis of factors affecting the efficiency of forestry production technology of farmers in the natural forest protection project area [¹], research on the evaluation index system of the implementation effect of natural forest protection projects [²], comprehensive benefit evaluation of natural forest protection projects [³], ecological benefit evaluation of natural forest protection projects [⁴,⁵,⁶], evaluation of the
implementation efficiency of natural forest protection projects \cite{7}, analysis of the impact of the natural forest protection project on the service functions of forest ecosystems in forest areas \cite{8}, evaluation of the livelihood impact of the second phase of the natural forest protection project in the western collective forest area \cite{9}, Natural Forest Protection Project Forest Ecosystem Service Function Value Evaluation \cite{10,11}, Western Natural Forest Protection Project Area Ecological Service Value Evaluation \cite{12}.

Through the dynamic evaluation of the service function value of the forest ecosystem of the Natural Forest Protection Project from 1998 to 2015 in Xiuwen County, Guizhou Province, this paper tries to discover the objective reality of project implementation, enriches the content of regional forest ecological benefit evaluation, and provides management and ecological management of forest ecosystems. Compensation provides some basis, which is of great significance for improving the follow-up policy of the Natural Forest Protection Project.

2. Overview of the Natural Forest Protection Project in Xiuwen County

Xiuwen County is part of Guiyang City in Guizhou Province, located in the hilly plains of central Guizhou on the Yunnan-Guizhou Plateau. In 1998, Xiuwen County began to implement the natural forest protection project pilot project. In 2000, the first phase of the natural forest protection project was officially launched. The first phase of the Natural Forest Protection Project was completed in 2010 and the second phase of the Natural Forest Protection Project (2011-2020) is currently being implemented.

3. Research Methods and Index System Construction

3.1. Evaluation Method

This paper uses market value method, shadow project method and cost expenditure method to evaluate the value of forest ecosystem service functions of the natural forest protection project in Xiuwen County from 1998 to 2015 \cite{13}.

3.2. Data Sources

(1) Field research. In order to grasp the basic information, the research team went to the natural forest protection project area in Xiuwen County in January 2014 to conduct on-site investigations, using seminars, questionnaire surveys and other methods to discover the impact of the natural forest protection project implementation on the case county, laying a foundation for understanding the characteristics of the evaluation objects basis.

(2) Collect basic data. Collected the report on the results of the second-class forest resource survey in Xiuwen County in 2009, the implementation plans of the first and second phases of the natural forest protection project, the summary materials of the natural forest protection project, the summary materials of the forestry bureau, the work design and effectiveness inspection materials of the natural forest protection project from 1998 to 2015, etc. Based on the above data, it can be concluded that the implementation area of the natural protection project in Xiuwen County, the completion of the task and the capital investment and other aspects of information.

(3) Collect relevant parameters. Collect the relevant literature results obtained by scholars in the research of Guiyang City, Guizhou Province and the Southwest Karst Region to obtain the
calculation parameters of the relevant indicators in the same ecological location or the same ecological location as Xiuwen County; Collect Xiuwen County Water Resources and Hydrological Bureau, Meteorological Bureau, Related monitoring data of soil and fertilizer stations and other departments.

(4) Collect public data. When calculating the value of forest ecosystem services, refer to the social public data released by the national authority.

3.3. Construction of Indicator System

This paper refers to the evaluation index system established by LY/T 1721-2008 Forest Ecosystem Service Function Evaluation Specification [14] and "China Forest Resource Accounting Research in the Construction of Ecological Civilization System" [13], combined with the characteristics of the implementation of the Xiuwen County Natural Forest Protection Project, A total of 7 functions (conservation of water source, conserve soil, accumulation of nutrients, carbon fixation and oxygen release, purification of atmospheric environment, protection of biodiversity, Forest recreation) and 13 indicators were selected to evaluate the service function value of the forest ecosystem of the natural forest protection project in Xiuwen County, Guizhou Province.

3.4. Index Calculation Formula and Parameters

3.4.1. Water Conservation

This paper selects two indicators, water regulation and purified water quality, to evaluate the water conservation function of the natural protection project in Xiuwen County.

(1) Adjust water volume.

\[ U_{\text{regulating pondage}} = R \cdot \theta \cdot A \cdot C \text{price} \]  \hspace{1cm} (1)

\( U_{\text{regulating pondage}} \): the value of forest stand regulation water volume (yuan·a\(^{-1}\)); \( C \text{price} \): the market transaction price of water resources (yuan·m\(^{-3}\)), taking 4.48 yuan·m\(^{-3}\)[13]; \( R \): average annual precipitation (mm); \( \theta \): runoff coefficient; according to the "Comprehensive Water Resources Planning of Xiuwen County, Guizhou Province (Part 1)" [15], the annual average rainfall in Xiuwen County is 1050 mm, and the runoff coefficient is 0.29. \( A \): Forest area (hm\(^2\)), including the forest management and protection area of the Natural Forest Protection Project and the newly planted forest area.

(2) Purified water quality.

\[ U_{\text{purify water}} = R \cdot \theta \cdot A \cdot C \text{水} \]  \hspace{1cm} (2)

\( U_{\text{purify water}} \): the value of forest stand purification water quality (yuan·a\(^{-1}\)); \( C \text{水} \): sewage treatment cost (yuan·t\(^{-1}\)), taking 1 yuan·t\(^{-1}\)[13].

3.4.2. Conserve the Soil

(1) Soil consolidation.

\[ U_{\text{soil reinforcement}} = A \cdot (X_2 - X_1) \cdot C / \rho \]  \hspace{1cm} (3)

\( U_{\text{soil reinforcement}} \): value of forest stand soil fixation (yuan·a\(^{-1}\)); \( A \): natural forest protection project forest management and protection area and newly planted forest area (hm\(^2\)); \( X_2 \): soil erosion
modulus without forest land (t·hm\(^{-2}\)·a\(^{-1}\)); \(X_1\): Soil erosion modulus of forest land (t·hm\(^{-2}\)·a\(^{-1}\)); calculated according to the relevant data and calculation results in "The Value Evaluation of Forest Ecosystem Service Function in Guizhou Province" [16]. The average erosion reduction modulus of the forests in Guizhou Province is 21.42 t·hm\(^{-2}\)·a\(^{-1}\), that is (\(X_2-X_1\))=21.42 t·hm\(^{-2}\)·a\(^{-1}\); \(C_\pm\): excavation and transportation of a unit volume of soil Cost (yuan·m\(^{-3}\)), take 63 yuan·m\(^{-3}\)[13]; \(\rho\): soil capacity (t·m\(^{-3}\)), take 1.32t·m\(^{-3}\)[17].

(2) Maintaining fertilizer.

\[ U_{\text{fertilizer}} = A \left( X_2 - X_1 \right) \left( \frac{NC_1}{R_1} + \frac{PC_1}{R_2} + \frac{KC_2}{R_3} + C_3 \cdot M \right) \]  

\(U_{\text{fertilizer}}\): forest stand fertilizer value (yuan·a\(^{-1}\)); \(N, P, K\) are the forest stand soil nitrogen, phosphorus, potassium and organic matter content (%); \(M\) is the forest stand soil organic matter content (%), according to "Xiuwen County Land and Soil Resources Survey and Zoning Report" [18], it can be concluded that the soil N content is 0.28%, the P content is 0.01%, the K content is 0.28%, and the soil organic matter content is 2.05%; \(R_1, R_2\) And \(R_3\) are the nitrogen content of phosphate diamine fertilizer, the phosphorus content of phosphate diamine fertilizer, and the potassium content of potassium chloride fertilizer (%), the values are 14%, 15.01%, 50%, respectively [13]; \(C_1, C_2\) And \(C_3\) are the price of phosphoric acid diamine fertilizer, the price of potassium chloride fertilizer and the price of organic matter (yuan·t\(^{-1}\)), the values are 3300 yuan·t\(^{-1}\), 2800 yuan·t\(^{-1}\), 800 yuan·t\(^{-1}\)[13].

### 3.4.3. Accumulation of Nutrients

\[ U_{\text{nurtrion}} = AB_{\text{year}} \left( N_{\text{nurtrion}} \frac{C_r_1}{R_1} + P_{\text{nurtrion}} \frac{C_r_2}{R_2} + K_{\text{nurtrion}} \frac{C_r_3}{R_3} \right) \]  

\(U_{\text{nurtrion}}\): the accumulated nutrient value of the forest stand (yuan·a\(^{-1}\)); \(A\): the total forest area (hm\(^2\)), including the forest management and protection area of the natural protection project and the newly planted forest area; \(B_{\text{year}}\): forest stand net productivity (t · Hm\(^{-2}\)·a\(^{-1}\)), according to the formula of Fang Jingyun et al. [19] in the document "Biomass and Net Production of Forest Vegetation in my country", net productivity of main forest types, which are Lamb, Pinus, armandii Franch, Cunninghamia, lanceolata (Lamb.), Hook., Populus L., Cryptomeria, Hooibrenk ex Otto et, Dietr, Cupressus funebris, Endl., Cinnamomum, camphora (L.) presl, Quercus acutissima, Betula L., Soft broads and Shrub, can be obtained. \(N_{\text{nurtrion}}, P_{\text{nurtrion}}\) and \(K_{\text{nurtrion}}\) are the forest tree nitrogen, phosphorus, and potassium content (%). According to the measurement results of nutrients accumulated by different dominant tree species in Guizhou Province [20-23], each dominant tree species has the nitrogen, phosphorus and potassium content such as Lamb, Pinus, armandii Franch, Cunninghamia, lanceolata (Lamb.), Hook., Populus L., Cryptomeria, Hooibrenk ex Otto et, Dietr, Cupressus funebris, Endl., Cinnamomum, camphora (L.) presl, Quercus acutissima, Betula L., Soft broads and Shrub can be deduced.

### 3.4.4. Carbon Fixation and Oxygen Release

(1) Carbon fixation.

\[ U_{\text{Carbon sequestration}} = 1.63R_\text{Carbon}C_\text{Carbon}A \cdot B_{\text{year}} C_\text{Carbon} \]  

\(U_{\text{Carbon sequestration}}\): carbon sequestration value of vegetation (yuan·a\(^{-1}\)); \(A\): see the explanation in formula (5); \(C_\text{Carbon}\): carbon sequestration price (yuan·t\(^{-1}\)), taking 48.18 yuan·t\(^{-1}\)[13]; \(R_\text{Carbon}\): the content of carbon in CO\(_2\) (%), the value is 27.27% [13].
(2) Oxygen release.

\[ U_{\text{oxygen release}} = 1.63C_{\text{oxygen}}A \cdot B_{\text{year}} \quad (7) \]

\[ U_{\text{oxygen release}} \] the value of forest stand oxygen release (yuan·a\(^{-1}\)); \( A \): see the explanation in formula (5); \( C_{\text{oxygen}} \): oxygen price (yuan·t\(^{-1}\)), take 1108 yuan·t\(^{-1}\). 

### 3.4.5. Purify the Atmosphere

Different forests have different functions for absorbing sulfur dioxide, fluoride and nitrogen oxides. Refer to the relevant data in the "Evaluation of Forest Ecosystem Service Function of Guizhou Province" \[16\] to calculate the indicators of different forests in Guizhou Province for air purification per unit area, such as Lamb, Pinus, armandii Franch, Cunninghamia, lanceolata (Lamb.), Hook., Populus L., Cryptomeria, Hooibrenk ex Otto et, Dietr, Cupressus funebris, Endl., Cinnamomum, camphora (L.) presl, Quercus acutissima, Betula L., Soft broads and Shrub.

1. Absorb sulfur dioxide.

\[ U_{\text{SO2}} = K_{\text{SO2}}A \cdot Q_{\text{SO2}} \quad (8) \]

\[ U_{\text{SO2}} \] the value of forest stand's absorption of sulfur dioxide (yuan·a\(^{-1}\)); \( K_{\text{SO2}} \): Sulfur dioxide treatment cost (yuan·t\(^{-1}\)), which is 1550 yuan·t\(^{-1}\); \( Q_{\text{SO2}} \): The forest stand's unit area absorbs sulfur dioxide Amount (t·hm\(^{-2}\)·a\(^{-1}\)); \( A \): Natural Forest Protection Project forest management and protection area and newly planted forest area (hm\(^2\)).

2. Absorb fluoride.

\[ U_{\text{fluoride}} = K_{\text{fluoride}}A \cdot Q_{\text{fluoride}} \quad (9) \]

\[ U_{\text{fluoride}} \] the value of fluoride absorbed by forest stands (yuan·a\(^{-1}\)); \( K_{\text{fluoride}} \): fluoride treatment cost (yuan·t\(^{-1}\)), take 890 yuan·t\(^{-1}\); \( Q_{\text{fluoride}} \): forest The amount of fluoride absorbed per unit area (t·hm\(^{-2}\)·a\(^{-1}\)).

3. Absorb nitrogen oxides.

\[ U_{\text{nitrogen oxides}} = K_{\text{nitrogen oxides}}A \cdot Q_{\text{nitrogen oxides}} \quad (10) \]

\[ U_{\text{nitrogen oxides}} \] the value of nitrogen oxide absorbed by forest stands (yuan·a\(^{-1}\)); \( K_{\text{nitrogen oxides}} \): nitrogen oxide treatment cost (yuan·t\(^{-1}\)), take 810 yuan·t\(^{-1}\); \( Q_{\text{nitrogen oxides}} \): the amount of nitrogen oxide absorbed per unit area of the forest stand (t·hm\(^{-2}\)·a\(^{-1}\)).

4. Dust retention.

\[ U_{\text{dust}} = K_{\text{dust}}A \cdot Q_{\text{dust}} \quad (11) \]

\[ U_{\text{dust}} \] annual dust retention value of the forest stand (yuan·a\(^{-1}\)); \( K_{\text{dust}} \): dust retention management cost (yuan·t\(^{-1}\)), taking 190 yuan·t\(^{-1}\); \( Q_{\text{dust}} \): the amount of dust retention per unit area of the forest stand t·hm\(^{-2}\)·a\(^{-1}\).

### 3.4.6. Protection of Biodiversity

\[ U_{\text{Organism}} = A \cdot S_{\text{Organism}} \quad (12) \]

\[ U_{\text{Organism}} \] is the annual biodiversity conservation value of the forest stand (yuan·a\(^{-1}\)); \( A \): see the explanation of formula (8); \( S_{\text{Organism}} \) is the biodiversity conservation value per unit area (yuan·hm\(^{-2}\)·a\(^{-1}\)) Using the research results of Liu Xiao \[16\] and others, we can get the value per unit area of the biodiversity of the main tree species in the forest ecosystem of Xiuwen County, such as
Lamb, Pinus, armandii Franch, Cunninghamia, lanceolata (Lamb.), Hook., Populus L., Cryptomeria, Hooibrink ex Otto et, Dietr, Cupressus funebris, Endl., Cinnamomum, camphora (L.) presl, Quercus acutissima, Betula L., Soft broads and Shrub.

3.4.7. Forest Recreation
Calculated based on the forest tourism income of Xiuwen County in each year. Based on the value of forest tourism income provided by the statistics of Xiuwen County in recent years, the annual growth rate of forest tourism income in Xiuwen County is calculated, and finally the forest tourism income of each year is calculated.

4. Results and Analysis
4.1. Forest Resources Status of the Natural Forest Protection Project in Xiuwen County
According to the "Supplementary Investigation Report of the Third Forest Resources Planning and Design Survey Results of Xiuwen County" [24], the county's forest land is 45537.33 hm² (excluding the part of the Zhazuo Forest Farm directly under the province), of which 24183.24 hm² is forest land, accounting for 53.11% of the forest land; shrubs The forest land is 15180.6 hm², accounting for 33.34% of the forest land. Among the forested land area, the arbor forest is 24175.63 hm², accounting for 99.96% of the forest land. In the area of arbor forests, the main tree species: Masson pine, Huashan pine, fir, poplar (group), cedar, cypress, camphor, oak, birch, soft broad, etc., account for 46.51% and 4.40% respectively, 3.25%, 1.98%, 2.36%, 2.34%, 1.98%, 8.32%, 13.98%, 9.60%, and calculate the proportion of tree species in the forest management and protection area based on this proportion, and determine the proportion of tree species in the new afforestation according to the operation design.

The forest area of the Natural Forest Protection Project in Xiuwen County is composed of forest management area (national investment management area) and newly planted forest area (artificial forestation, fly-seeded forestation and closed mountain forestation). The forest area of the Natural Forest Protection Project in Xiuwen County was 2041hm² and 2098hm² in 1998 and 2000 respectively, and the lowest forest area was 29273hm² and the highest was 36516hm² in each year from 2001 to 2015, among which, the annual forest management area since 2001 was between 29273-36200hm².

4.2. Physical Quantity of Forest Ecosystem Service Functions of the Natural Forest Protection Project in Xiuwen County
According to the above indicator calculation formula and parameters, the results of the physical quantity of forest ecosystem service functions of the natural forest protection project in Xiuwen County of Guizhou Province from 1998 to 2015 are obtained: the total physical quantity of water conserving is 16,165,354 thousand tons, and the average annual physical quantity is 89,875,000 tons; the mass of solid soil is 11.5421 million tons, and the average annual physical volume is 641,200 tons; the mass of fertilizer-maintaining material is 65,100 tons, and the average annual physical volume is 3,600 tons; the total physical volume of accumulated nutrients is 242,600 tons, the annual average physical volume is 13,500 tons; the total physical volume of carbon sequestration is 1,872,600 tons, and the average annual physical volume is 104,000 tons; the total physical volume of oxygen released is 5.0622 million tons, and the average annual physical volume is 281,200 tons; the total physical volume of sulfur dioxide is 47,100 tons, and the average annual physical volume is 2600 tons; the total physical volume of fluoride absorption is 15,200 tons, and the average annual physical volume is 0.08 million tons; the total physical volume of nitrogen oxides is 0.20 10,000 tons, the average annual physical volume is 0.01 million tons; the total physical volume of dust retention is 7,336,200 tons, and the average annual physical volume is 407,600 tons.
4.3. The Value of the Forest Ecosystem Service Function of the Natural Forest Protection Project in Xiuwen County

According to the above indicator calculation formulas and parameters, the total value of forest ecosystem service functions of the Natural Forest Protection Project in Xiuwen County of Guizhou Province from 1998 to 2015 was 29.288.1 billion yuan, with an average annual value of 1.62712 billion yuan.

5. Conclusions and Recommendations

5.1. Conclusion

The evaluation results of the forest ecosystem service function of the natural forest protection project in Xiuwen County show that the total value of the forest ecosystem service function value of the natural forest protection project in Xiuwen County by 2015 totaled 29.281 billion yuan, an annual average of 1.62712 billion yuan. From the point of view of value composition: the total value of water conservation is 8.85861 billion yuan, accounting for 30.25% of the total value; the total value of conserving soil is 1.70436 billion yuan, accounting for 5.82% of the total value; the total value of carbon sequestration and oxygen production is 9.33892 billion yuan The total value of accumulated nutrients was 4.45649 billion yuan, accounting for 15.22% of the total value; the total value of purifying the atmosphere was 1.4677 billion yuan, accounting for 5.00% of the total value; the total value of protecting biodiversity The value is 3.28237 billion yuan, accounting for 11.21% of the total value; the total value of forest recreation is 1815.9 million yuan, accounting for 0.62% of the total value.

From 1998 to 2015, after the implementation of the natural protection project in Xiuwen County, the order of contributing rate of the total value of the various functions of the forest ecosystem service function was: carbon sequestration and oxygen production> water conservation> nutrient accumulation> biodiversity protection> conservation Soil>Clean the atmosphere>Forest recreation.

Based on the area determined by the implementation plan of the first and second phases of the natural forest protection project (the area of investment appropriation construction and management and protection of the national natural forest protection project), this paper evaluates the forest ecological service value of the natural forest protection project in Xiuwen County, reflecting the ecological benefits brought by national investment. However, in the first and second phases of the natural forest protection project, the actual management and protection area in Xiuwen County is larger than the national investment management and protection area, therefore there is still a part of the natural protection project investment that overflows the ecological benefits.

5.2. Suggestions

(1) Increase investment in unit area of forest management and protection, and increase the enthusiasm of forest management and protection personnel.

(2) Adjust the forest stand structure and improve forest quality.

(3) Develop local characteristic tourism industries in accordance with local conditions.

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