Evaluation Model of the Ecology Benefit Value of Woodland in China

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Abstract Main influencing factors affecting the ecology benefit value of woodland are analyzed, mainly including the water conservation value, environment cleaning value, water and soil conservation value, and climate regulation value. Evaluation model of the ecology benefit value of woodland is put forward which can deal with the uncertain information. Method for determining index weights is discussed, as well as the processing method for uncertain information during the evaluation of ecology benefit value of woodland. Finally, the feasibility and convenience of the evaluation model of the woodland ecology benefit value are illustrated with examples.

Key words Ecology benefit of woodland, Evaluation, Uncertain information, Weight, China

As the international community is paying attention to the ecological environment, countries all over the world are actively solving the problems of ecological pollution. During the process of ecological improvement, returning farmland into woodland becomes the most important measure to increase the woodland coverage rate. Woodland resources provide not only the society with wood and other material products, but also the good environment and other nonmaterial products. Therefore, it is necessary to formulate relevant evaluation system of woodland ecological benefits, so as to provide a scientific basis for government departments[1-2]. Researchers all over the world have mainly three kinds of views on the evaluation of woodland ecological benefits. First, woodland ecological benefits should be evaluated based on the Marxist labor theory of value, differential land rent theory, and economical theory. Second, woodland ecological benefits should be established based on the optimum efficiency theory in socialist economy. Third, other researches argue that woodland ecological benefits should be established on the basis of marginal utility theory[2]. At present, China is at the initial stage of market economy, and market mechanism is not mature enough. Thus, it is difficult to accurately evaluate the ecological benefits of the intangible goods without market exchange, such as ecological economy. In this paper, uncertainty evaluation method is used to analyze the factors affecting the ecological benefits of woodland land. Evaluation model for the ecological benefit value of woodland land is established and the weights of influencing factors in this evaluation model are obtained. Finally, the uncertain information is processed in the evaluation of woodland ecological benefits.

1 The main influencing factors for the evaluation of woodland ecological benefits

Evaluation system of woodland ecological benefits mainly includes the evaluation method and the main influencing factors of woodland ecological benefits. In order to better evaluate the value of woodland ecological benefits, the main influencing factors of woodland ecological benefits are put forward[1-2].

1.1 Water conservation value The primary function of woodland is to store a large amount of water, which is mainly determined by the features of woodland soil, the soil thickness and the litter thickness in woodland.

1.2 Environment cleaning value It mainly refers to the value of air filtrated by woodland, the value of water purification, and the value of absorbing carbon dioxide and releasing oxygen.

1.3 Water and soil conservation value Woodland can effectively reduce the water and soil loss. Its roots can fix the soil and prevent soil erosion; its dead leaves can maintain the soil nutrient and reduce the sediment.

1.4 Climate regulation value Luxuriant branches can effectively withstand exposure to the sun, postpone the changes of air temperature and soil temperature, increase the humidity of woodland air, and reduce the woodland temperature.

2 Design of the evaluation model of woodland ecological benefit value

2.1 Evaluation model of woodland ecological benefit value Evaluation process of woodland ecological benefit usually firstly finds out a factor set affecting the woodland ecological benefit value, and selects the corresponding evaluation standards of woodland ecological benefit as the comment set. After determining the weights of factors in factor sets, single factor evaluation is carried out. Finally, comprehensive evaluation on a certain model is conducted. Thus, we have the integrated assessment model of woodland ecological benefit value[3]:

$$Benefit = C_1 \times W_1 + \cdots + C_4 \times W_4 \quad (1)$$

where *Benefit* is the total value of woodland ecological benefits, variable C_i ($i = 1, \cdots, 4$) represent the water conservation value, the environment cleaning value, the water and soil conservation value, and the climate regulation value, respectively.

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Variable $W_i(i=1,\cdots,4)$ is the weight of $C_i(i=1,\cdots,4)$.

2.2 Determination method of index weights based on ordered weighted operator During the evaluation on woodland ecological benefit value, weight of influencing factors is determined. And index weight directly affects the final evaluation results. In order to summarize the advantages and to compensate the disadvantages in the determination methods of index weight, a series of index weights are obtained by different determination methods during the evaluation of woodland ecological benefit value. Ordered weighted operator (*OWA*) is used to obtain the final index weight[3-4].

The four factor weights determined by m methods are $\eta_j = (w_{1j},\cdots,w_{4j})^T \quad j=1,2,\cdots,m$.

Weight of the ith influencing factor by *OWA* is

$$W_i = OWA_\omega(w_{i1},\cdots,w_{im}) = \sum_{j=1}^{m}\omega_j b_j \qquad (2)$$

where $\omega=(\omega_1,\cdots,\omega_m)^T$ is the index weighted vector associated with *OWA*[3]; $\omega_j\in[0,1]$, $\sum_{j=1}^{m}\omega_j=1$, and b_j is the jth maximum element of $w_{ij}(j=1,2,\cdots,m)$.

2.3 Uncertain information processing method in woodland ecological benefit value During the evaluation on the woodland ecological benefit value, evaluation information is difficult to be quantified due to the factor uncertainty and randomness. At the same time, due to the fuzziness and uncertainty of human thought and the complexity of evaluation problems, it is more reasonable to use the interval number to evaluate the woodland ecological benefits. In other words, interval number is adopted as the comment set when determining the evaluation index set: evaluation set = {very good, good, fair, poor, very poor} and its corresponding interval is (0.9,1], (0.7,0.9], (0.5,0.7], (0.3,0.5], and (0,0.3][3].

When using interval number to evaluate the woodland ecological benefits, interval number can effectively deal with the uncertainty and randomness of evaluation, but there are also operational difficulties. Therefore, before aggregation, interval number is converted into real number by continuous ordered weighted operator:

Assuming that $[a^-,a^+]$ is the interval number, $f([a^-,a^+]) = \int_0^1 \frac{dp(x)}{dx}(a^+ - x(a^+ - a^-))\,dx$ is the *OWA* operator of continuous interval number, which is short for $C-OWA$ operator. Let $p(y)=y^r(r\geqslant 0)$, we have $f([a^-,a^+]) = \frac{a^+ + ra^-}{r+1}$[4].

3 Calculation example analysis

Ecological benefits value of a certain woodland is evaluated so as to offer references for its development and exploitation. Experts are invited to evaluate the four factors affecting the woodland ecological benefits. Based on the statistical analysis of the evaluation information, the minimum and maximum evaluation values put forward by the expert group are selected after eliminating the significant unreasonable evaluation information. Hence, we have the following evaluation information:

$B=[0.52,0.73],[0.61,0.82],[0.80,0.93],$
$[0.71,0.92]$

At the same time, experts calculate the weights of four evaluation indices from both subjective and objective aspects, which are water conservation value, environment cleaning value, water and soil conservation value, and climate regulation value. Table 1 reports the results of index weights by using five methods of Delphi method, analytic hierarchy process, maximizing deviation method, multi-object planning method, and chain scoring method.

Table 1 Index weights obtained by different methods

Method	Water conservation value	Environment cleaning value	Water and soil conservation value	Climate regulation value
Analytic hierarchy process	0.210 0	0.260 0	0.190 0	0.160 0
Delphi method	0.428 6	0.560 0	0.480 0	0.390 0
Maximizing deviation method	0.259 5	0.320 0	0.190 8	0.206 1
Multi-object planning method	0.233 9	0.310 0	0.153 2	0.420 0
Chain scoring method	0.266 1	0.183 5	0.174 3	0.229 4
Comprehensive weighted value	0.241 6	0.308 9	0.225 3	0.224 1

Ordered weighted operator is used to aggregate the index weights obtained by five different weight determination methods. Among them, position weight is calculated according to the equation mentioned in references [3], which is $\omega = (0, 0.400\,0, 0.500\,00, 0.100\,0, 0)^T$. The comprehensive weight of the four evaluation indices is obtained, the result of which is listed in the last line in Table 1. Hence, the index weight is

$W=(0.241\,6, 0.308\,9, 0.225\,3, 0.224\,1)$

According to the continuous ordered weighted operator $C-OWA$, the interval evaluation information of expert is converted into the real-type evaluation value[5]. If $p(y)=y^3$, the following evaluation information is obtained:

$\tilde{B}=0.572\,5, 0.662\,5, 0.832\,5, 0.762\,5$

Evaluation result of woodland ecological Benefit according to comprehensive evaluation model (1) is obtained:

$Benefit = \tilde{B}\times W' = 0.701\,4$

Therefore, the comprehensive evaluation value of the woodland is $0.701\,4\in(0.7,0.9]$, indicating that the comprehensive evaluation result of woodland ecological benefit is "very good". However, according to the data analysis, the ecological benefit of this woodland is only at the edge of "very good" and close to "fair". Therefore, it is necessary to strengthen the management of the woodland. And it is best to wait a while if there is a better exploitation land.

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able development is a dynamic and multidimensional process, involving the sustainability of economy, society and environment. Therefore, analysis of the economic costs should be strengthened during the urban sustainable development.

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4 Conclusion

Woodland ecological benefit value is a new research direction and a new field for getting rich. Local governments should make a comprehensive plan for woodland deepening reform from the aspects of woodland land, woodland transfer, dewoodlandation, ecological compensation and so on, so as to gradually form a sound development mechanism for collective woodlandry, and to realize the objectives of resource growth, harmonious woodland, farmers' income increase, and sound ecological environment. At the same time local governments should clarify the property rights of woodland, establish woodlandry ecological efficiency compensation fund at provincial level, adhere to the principle of "he who is benefited shall give compensation; and he who develop the woodland shall protect it", raise the woodlandry ecological efficiency compensation fund mainly by financial investment and through all kinds of channels, reasonably determine the compensation standards, and improve the standards according to the economic and social development and the financial strength.

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