Research on the Performance Evaluation Index System of Forest Management in Northeast China

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Abstract. Based on the two main lines of international forest sustainable management evaluation and the theory of process based performance evaluation, the article establishes a three-level forest management performance evaluation index system that is "oriented towards business effectiveness, based on business processes, and guided by business practices". By establishing causal relationships between hierarchical indicators, the combination of management process and effectiveness can be achieved, and forest management and management in Northeast China can be refined in the context of sustainable forest management.

Keywords: forest management; Performance evaluation; Indicator system; Construction principles

1 Introduction

In order to further grasp the current situation of forest management, relevant research on the construction of forest management performance evaluation index system will be carried out. Take forestry as a public organization, analyze its benefits in social construction, and overcome the phenomenon of industrial construction crisis to achieve the healthy development of ecological resources in China's economic market.

2 Business process level indicators

Combined with the existing international, national, regional and management unit level system, the relevant forest sustainable management standards and indicators are analyzed. Meanwhile, the forest management effect indicators suitable for northeast China should be selected (Table 1). These indicators mainly reflect the economic, social and ecological aspects related to forest.[1]

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Table 1. Management process layer indicators of forest management performance evaluation

Level 1 indicators	Secondary indicators	Index interpretation	Indicator source
Economic benefits	Growth rate of forestry output value	(Current forestry output value-forestry output value of previous period) / forestry output value of previous period * 100%	a b c d
	Operating investment-output ratio	Forest profit / investment expense * 100%, this index reflects the profitabil-ity of the forestry bureau to invest in afforestation	a b c d
Social effectresults benefit	The average wage level of the employees	Total payroll / number of employees	a b d
	Accession rate	(Number of people employed in current period-number of people employed in previous period) / number of people employed in previous year 100%	a b d
	The proportion of external (community) employment personnel	External (community) employed personnel / all employed personnel 100%	a b d
	Employee innovation	The number of patents applied for by the employees in each period and the number of non-patented technologies developed	b c d
Ecological benefit	Forest structure	Proportion of different types of forest area	a b c d
	Woodland utilization rate	Forest land area / forest land area is 100%	a b c d
	Forest consumption rate	The ratio of growth to cutting volume, forest growth stock / timber cutting stock is 100%	a b c d
	Forest tree stock volume per unit area	Current forest stock volume / forest land area is 100%	a b c d
	Growth capacity of forest trees per unit area	(Current forest stock-forest stock in the previous period) / woodland area 100%	a b c d
	Proportion of forestry pest disaster area	Forest pest disaster area / total forest area 100%	a b c d
	Proportion of forest fire area	Forest fire area / total woodland area: 100%	a b c d
	Proportion of artificial pure forest area of alien tree species	Artificial pure forest area of alien tree species / total forest land area is 100%	a b c d
	Proportion of woodland area with severely degraded soil	The woodland area / total woodland area is 100%	a b c d

The achievement of business performance goals requires a series of reasonable business processes, and business process evaluation is the key to forest management performance evaluation. Therefore, this article refers to the "Forest Management Technology Series Standards for State owned Forest Regions in Heilongjiang Province" and based on the business process research data of L Forestry Bureau and its affiliated forest farms in Northeast Forest Region, establishes forest management process layer indicators from four dimensions of quality, time, cost, and quantity, as well as process effectiveness and process management (Table 2).[2]

Table 2. Business Process Level Indicators for Forest Management Performance Evaluation

process name	quality	time	cost	number
Seedling raising process	Qualified rate of quarantine in the origin of seedlings	Seedling cultivation time consumption	Seed cost	Seedling yield
	Seedling utilization rate	Seedling raising process cycle	Employee Compensation	
	Damage rate of seedlings and trees		Other expenses	
Afforestation process	Acceptance rate of afforestation work	Afforestation consumption time	Seedling cost	Area of young forest tending
	survival rate	Afforestation process cycle	Employee Compensation	afforestation area
	Preservation rate		Other expenses	
	Plan completion rate			
Forest care process	Qualified rate of parenting homework	Childcare consumption time	Procurement and transportation costs	Forest tending area
	Plan completion rate	Forest tending operation process cycle	Employee Compensation	output
	sales growth	Forest tending (logging) work schedule cycle	Other expenses	sales volume
Forest management and protection process	Passing rate of fire handling acceptance	Fire handling time	Employee Compensation	Number of times for fire handling and rectification
	Error rate of forest pest and disease detection and reporting	Disease and pest control process cycle	Other expenses	Actual prevention and control work area
	Completion rate of prevention and control area plan			
	effect of prevention			

2.1 Quality oriented indicators

Anupindi et al. (2003) argue that process quality refers to the ability of business processes to produce and deliver high-quality products, including process accuracy, consistency in design specifications, and trustworthiness and maintainability of processes. The quality evaluation standards for business processes of forest management units vary depending on specific business characteristics. For example, the effectiveness of afforestation processes is comprehensively evaluated based on the "Technical Regulations for State owned Forest Region Reforestation", "Operating Rules for State owned

Forest Region Reforestation Operations", and the control characteristics of activity nodes in process management. [3]

2.2 Time oriented metrics

Time is an important evaluation indicator of process performance. Stalk and Hout (1990) proposed a concept based on time competition, emphasizing the importance of time indicators for performance evaluation. The mean and variance statistical values of process runtime reflect the stability of the process and are also a measurement dimension of process quality. For forest management business, time indicators include completion time of activities, interval time between activity nodes, and cycle of completing the entire process.[4]

2.3 Cost oriented indicators

Cooper and Kaplan (1995) proposed the Activity Based Costing (ABC) method, where activity is the most fundamental object of cost calculation. Process cost is the summary of the cost of all executed tasks in the process. The operational cost indicators of forest management mainly include employee salaries, depreciation expenses, application software expenses, seedling expenses, mechanical material consumption, transportation expenses, inspection expenses, sales expenses, etc.

2.4 Quantity oriented indicators

Peppard and Rowlan (1999) included quantity in the scope of process performance evaluation. Quantity can measure the overall process and the output of each activity, such as area and output, as well as indirectly measure the quality of the process, such as the number of errors and passes. Quantity is usually measured in units such as area, number, frequency, hours, number of people, and quota.

3 Management resource level indicators

This article establishes indicators for the management resource layer from two perspectives: resource capacity and resource allocation, to evaluate whether the resources invested in the process are sufficient to support the core execution ability of the process (Table 3).

Table 3. Forest Management Performance Evaluation Indicator System Management Resource Layer Indicators

Primary indicators	Secondary indicators	Explanation of indicators
resource capacity	Proportion of intermediate and senior technical titles among employees	Number of employees with intermediate and senior technical titles/total number of employees x 100%
	Completion rate of employee training	Number of employees trained/number of employees participating in training x 100%
	Equipment aging degree	Production equipment usage time/specified lifespan x100%
	Capital investment amount	Capital investment amount
Resource allocation	Number of participants	Number of employees allocated in the process
	Quantity of construction materials	Quantity of construction materials allocated in the process
	Investment proportion of funds	Amount of funds invested in the process/total amount of funds invested x 100%
	Information technology investment ratio	Amount spent on purchasing application software/total investment amount x 100%

4 Quantification of causal relationships in the indicator layer

4.1 Verification of indicator effectiveness

The correlation coefficient between two variables in a series of variables is calculated, which is the partial correlation coefficient. If the partial correlation coefficient of two indicator variables is high, there is a certain linear relationship between them. The partial correlation coefficient formula (Hu Jianying et al., 1996) is as follows:

$$\gamma_{12} = \frac{s_{x_1}, s_{x_2}}{\sqrt{s_{x_1}^2 \cdot s_{x_2}^2}} = \frac{\ell_{x_1,x_2}}{\sqrt{\ell_{x_1,x_1} \cdot \ell_{x_2,x_2}}} = \frac{\sum\left(x_1 - \overline{x_1}\right)\sum\left(x_2 - \overline{x_2}\right)}{\sqrt{\sum\left(x_1 - \overline{x_1}\right)^2 \sum\left(x_2 - \overline{x_2}\right)^2}} \quad (1)$$

$$\gamma_{12,3} = \frac{\gamma_{12} - \gamma_{12}\gamma_{23}}{\sqrt{1-\gamma_{13}^2}\sqrt{1-\gamma_{23}^2}} \left(i = 3\right) \quad (2)$$

$$\gamma_{12,34\ldots i} = \frac{\gamma_{12,34\ldots(i-1)} - \gamma_{1n,34\ldots(i-1)} - \gamma_{2n,34\ldots(i-1)}}{\sqrt{1-\gamma_{1n,34\ldots(i-1)}^2}\sqrt{1-\gamma_{2n,34\ldots(i-1)}^2}} \quad (3)$$

Simplified calculation:

$$\ell_{x_1,x_2} = \sum\left(x_1 - \overline{x_1}\right)^2 = \sum x_1^2 - \frac{\left(\sum x_1\right)^2}{n} \quad (4)$$

$$\ell_{x_2,x_2} = \sum\left(x_2 - \overline{x_2}\right)^2 = \sum x_2^2 \frac{\left(\sum x_1\right)^2}{n} \quad (5)$$

$$\ell_{x_1,x_2} = \sum\left(x_1 - \overline{x_1}\right)^2\left(x_2 - \overline{x_2}\right)^2 = \sum_{x_1,x_2} - \frac{\left(\sum x_1\right)\left(\sum x_2\right)}{n} \quad (6)$$

In equations (1) to (6), y_{12} For variables x_1, x_2 The correlation coefficient of, $s_{x_1}^2$ For variables x_1 The sample variance of, $s_{x_2}^2$ For variables x_2 The sample variance of, $s_{x_1x_2}$ Is a variable x_1, x_2 The sample covariance of, $\ell_{x_1x_1}$ do x_1 The sum of squared deviations from the mean square of, $\ell_{x_2x_2}$ do x_2 The sum of squared deviations from the mean square of, $\ell_{x_1x_2}$ do x_1, x_2 The sum of the products of mean deviations, $\bar{x}_1, \bar{x}_2$ Respectively as variables x_1, x_2 The mean of, n Is the number of observation data groups, $\gamma_{12,34...i}$ Represents a variable x_1, x_2 Remove variables $x_3, x_4, \ldots, x_i$ The correlation coefficient between the two after the influence of, i.e. the variable x_1, x_2 Partial correlation coefficient of.[5]

4.2 Quantification of causal relationships at the indicator level

Setting variables that affect high-level indicators y Lower level indicators for i Pieces, respectively $x_1, x_2, \ldots, x_i$, retrieve n Observation data. Due to the independent variable x_i And dependent variable y They all have units,The difference in the range of variable sample values can be significant, so the size of the partial regression coefficient cannot directly explain its impact on the dependent variable. It is necessary to standardize each variable and then calculate the partial regression coefficient of the equation. At this point, the standard deviation of each variable is the same, and the standardized partial regression coefficient obtained can reflect the magnitude of the influence of each variable on the dependent variable when other independent variables are fixed, and can also be compared with each other (Wang Binhui, 2014).

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_i X_i \quad (7)$$

$$y_1 = \beta_0 + \beta_1 X_{11} + \beta_2 X_{12} + \ldots + \beta_i X_{1i} \quad (8)$$

$$y_2 = \beta_0 + \beta_1 X_{21} + \beta_2 X_{22} + \ldots + \beta_i X_{2i} \quad (9)$$

$$y_n = \beta_0 + \beta_1 X_{n1} + \beta_2 X_{n2} + \ldots + \beta_i X_{ni} \quad (10)$$

In equations (7) to (10), $y_n, y_{n1}, x_{n2}, \ldots, x_{ni}$ Normalized values for the nth group of observed variables.

Solve to obtain respective variables x_i Standardized partial regression coefficient of β_i ,This standardized partial regression coefficient represents the degree to which low-level indicators support high-level indicators, which is the numerical value for quantifying causal relationships, as shown in Figure 1.

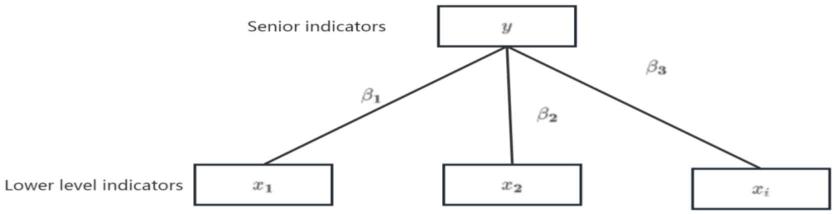

Fig. 1. Quantification of hierarchical causal relationship in forest management performance evaluation index system

Through qualitative analysis, this business performance indicator is decomposed into key processes, such as seedling cultivation, afforestation, and forest tending, to obtain a series of indicators for the forest resource cultivation process, such as afforestation survival rate, forest tending yield, process cycle, average pest control effect, employee compensation, etc. The causal relationship is quantified through mathematical statistical methods, Obtain the increment of afforestation preservation rate indicator variables at the business process level Δx Increment of forest volume index variable per unit area in the management effectiveness layer Δy The relationship between. Through the collection and analysis of causal data, further analyze the reasons for fluctuations in business performance, and conduct a scientific and comprehensive evaluation of the process and effectiveness of forest management.

5 Summary

This article conducts relevant research on the construction of a performance evaluation index system for forest management. On this basis, relevant analysis will be conducted on forest management to ensure that forest resources enter an orderly development track during construction. Provide correct guidance for the development of forestry and the regulations of relevant departments.

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