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Study on forest ecosystem damage assessment system and management system

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ABSTRACT

Ecological environment damage events will destroy or damage the balance between animal and plant habitats and ecosystems, and even pose a threat to China's ecological security. However, at present, there are some problems in the identification and evaluation of forest ecosystem damage, such as imperfect evaluation system, insufficient quantitative evaluation methods, imperfect damage compensation management system, and lack of analysis of the overall damage of the interaction between human activities and forest ecosystem. Based on the damaged object, the system involves a total of four first-class indicators, including physical damage, mental damage, economic forest fruit loss, forest by-products loss, processing and manufacturing loss, forest tourism loss, scientific research literature and history loss, soil conservation loss, water conservation loss, wind prevention and sand fixation loss, carbon fixation and oxygen release loss, atmospheric purification loss. There are 14 secondary indicators of emergency treatment fee and investigation and evaluation fee, as well as 22 tertiary indicators, and the value quantification method of each indicator is clarified by using market value method, alternative cost method, shadow engineering method, recovery cost method and other methods. The article also discusses the management system of forest ecosystem damage from the two aspects of forestry technology department and judicial administration department. The purpose is to provide reference for the quantification and standardization of forest ecosystem damage assessment technology and the improvement of management system.

Keywords: Forest Ecosystem; Index System; Value Quantification; Damages; Management System

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1. Introduction

Ecosystem damage is an important part of ecological environment damage. Eco environmental damage refers to the adverse changes of environmental elements such as atmosphere, surface water, groundwater and soil, and biological elements such as plants, animals and microorganisms caused by environmental pollution and ecological destruction, as well as the degradation of ecosystem functions composed of the above elements^[1]. As the contradiction between the rapid growth of social economy and human demand and the ecological carrying capacity intensifies, the structure and function of typical ecosystems degrade, and eco-environmental damage events occur frequently. According to statistics, China's eco-environmental damage compensation events have increased by 25% per year^[2], making the industry's demand for identification and assessment of eco-environmental damage very urgent^[3-7]. In September and December 2015, the *Overall Plan for the Reform of the Ecological Civilization System* and *The Pilot Plan for the Reform of*

the Compensation System for Ecological and Environmental Damage were issued successively, putting forward the overall requirements and objectives of the reform of the ecological environment damage compensation system; in January and June 2016, *The Notice on Regulating the Management of Environmental Damage Judicial Appraisal* and *The General Outline of Technical Guidelines for Ecological Environmental Damage Appraisal and Assessment* included the identification of seven items, including air pollution environmental damage, soil and groundwater environmental damage, and forest ecosystem environmental damage, into the important content of ecological environment damage judicial identification, and discussed the general principles, procedures contents and methods are specified.

The quantitative assessment of eco-environmental damage and the improvement of the identification and assessment technology system are the basis of a scientific and reasonable eco-environmental damage compensation system^[8]. At present, some achievements have been made in the research on ecological environment damage assessment and management at home and abroad^[9-13], Attiwill *et al.*^[14] suggested that forest resources should be managed on the basis of understanding the ecological process of forest natural disturbance; Barnhouse *et al.*^[15] discussed three parts of natural resource damage assessment: quantification of natural resource damage and reduction of ecological services, causality assessment and baseline establishment; Neshat *et al.*^[16] combined Dempster-Shafer theory with GIS as a new method for groundwater pollution risk assessment; Hossain *et al.*^[17] used LCA technology to analyze the impact of ecological concrete on the ecological environment and its sustainability. However, due to the late start of environmental damage assessment research in China, the research on the scope definition, threshold judgment, quantitative compensation and other technical methods of damage assessment of ecosystems such as forests, grasslands, fresh water, oceans, farmland, cities and so on is still relatively lacking^[18-20], which needs continuous refinement and in-depth research.

Forest is the main body of terrestrial ecosystem, a huge “green wealth” owned by human beings, and plays an important role in supporting the earth’s life system. However, industrial pollution, indiscriminate cultivation and occupation of forest land, indiscriminate mining of wild plants and other phenomena have become increasingly fierce with the process of human industrial civilization^[21,22], causing great damage to forest habitats, and related issues have therefore received a lot of attention. However, the research related to forest ecosystem damage mostly focuses on the damage to forest natural resources and ecosystem services^[23-25], which fails to fully realize the complex relationship between human activities and forest ecosystem interaction, and the cognition of forest ecosystem damage is lack of integrity; at the same time, there are problems in the identification and assessment of forest ecosystem damage, such as decentralized responsibilities and imperfect management systems^[26], so it is imperative to formulate a scientific and effective forest ecosystem damage assessment system and management system. On the basis of combing the connotation, object and category of forest ecosystem damage, this paper takes the whole of human and forest ecosystem as the research object, constructs the evaluation index system of forest ecosystem damage, and analyzes the management system of forest ecosystem damage from the management system of forestry technology department and judicial administration department. It is expected to provide reference for further improving the quantification and scientization of forest ecosystem damage assessment technology in China.

2. Concept and object of forest ecosystem damage

2.1 Concept and definition of forest ecosystem damage

Based on the concept of ecological environment damage, forest ecosystem damage is the damage or damage of forest and its ecosystem service function caused by the adverse changes of environmental factors such as atmosphere, soil and water caused by ecosystem damage behavior, with

forest ecosystem as the research subject. The causes of forest ecosystem damage include forest vegetation degradation^[27], forest vegetation destruction^[28-30] and wound damage of construction projects^[31,32]. Among them, the changes in soil physical and chemical properties, the reduction of water resources, the increase of soil erosion and habitat destruction caused by human production and living emissions and the predatory use of natural resources

have a particularly obvious adverse impact on forest productivity, forest biodiversity and forest ecosystem functions; when the ecological environment damage of forest ecosystem exceeds its environmental carrying capacity, its self-healing and purification ability will be weakened, which will lead to a series of ecological environment problems. The damage process of forest ecosystem is shown in **Figure 1**.

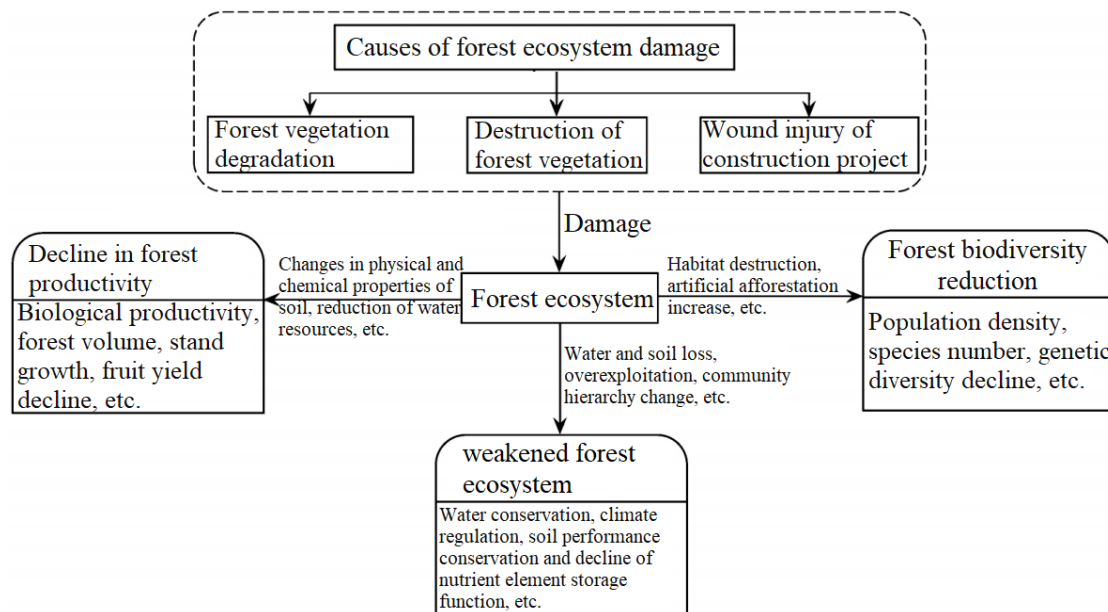


Figure 1. Process definition of forest ecosystem damage.

2.2 Damage objects of forest ecosystem

Forest ecosystem has multiple functional benefits of economy, ecology and society, and has many complex links with human production and life, which also leads to the inevitable impact of forest ecosystem damage on human production and life. As shown in **Table 1**, the value of product services (food, raw material production) and cultural services (aesthetic landscape, cultural education) of forest ecosystem mainly depends on relevant human activities, and the victims are mainly individuals or enterprises and institutions engaged in relevant industries; the value of forest ecosystem ecological regulation services does not depend on human activities, and its victims are mainly the public. Different victims have different claim subjects in the damage compensation system. Therefore, in order to make the forest ecosystem damage assessment and compensation work have continuity, and the

assessment object is more consistent with the claim subject, this study divides the damaged object of forest ecosystem damage into three aspects: personal safety, human activities and ecosystem function. Among them, there is no overlap between the damage category of personal safety and the other two categories; however, due to the complex relationship between human activities and forest ecosystem functions, the damage boundary between them in the process of forest ecosystem damage determination is not clear, and there is overlap.

2.2.1 Personal safety damage

The damage of forest ecosystem to human safety is mainly caused by the pollution of forest air, water and soil or the consumption of contaminated forest fruit products, which has adverse effects on human health, such as disease, disability, death or mental state damage.

Table 1. The relationship between human activities and the damage of forest ecosystem functions

Service function type	Damage of forest ecosystem functions	Whether attached to human activities or not	Human activities
Provisioning service	Food production	Yes	Production of economic forest fruit products/forest by-products
	Raw material production	Yes	Processing and manufacturing industry
Ecological regulating service	Soil conservation	No	—
	Water conservation	No	—
	Windbreak and sand fixation	No	—
	Carbon fixation and oxygen release	No	—
	Atmospheric purification	No	—
Cultural service	Aesthetic landscape	Yes	Forest tourism
	Cultural education	Yes	Scientific research literature and history
Support service	Maintain nutrient circulation	No	—
	Bio-diversity	No	—

“—” means no corresponding function.

2.2.2 Human activity damage

(1) Economic forest fruit production: the quantity or quality of economic forest fruits, nuts and other products is reduced due to forest ecological environment pollution or water resources reduction, including the loss of afforestation and forest management costs that have been paid in the early stage.

(2) Production of forest by-products: the damage of forest ecosystem leads to the reduction of edible fungi, bamboo shoots, wild vegetables and other forest by-products, and even the loss caused by extinction.

(3) Processing and manufacturing industry: the loss caused by the reduction of forest area and environmental pollution caused by the production reduction or even shutdown of wood and bamboo processing and manufacturing industry, spice production, biochemical processing and manufacturing industry and other enterprises using wood and bamboo as raw materials.

(4) Forest tourism: forest resources attract a large number of tourists to visit and explore with their unique landscape and diversified development. However, due to the reduction of forest area and the change of landscape structure caused by fire, pollution, forest land occupation and other behaviors, forest scenic spots or places that can provide leisure and entertainment for people are closed and the number of tourists is reduced.

(5) Scientific research, literature and History: the damage of forest ecosystem leads to the loss caused by the reduction of Forest Science, education, history, culture and other values.

2.2.3 Function damage of forest ecosystem

(1) Supply services

Food production: due to environmental pollution or forest ecosystem damage such as land requisition and occupation, the dry and fresh fruits and forest by-products provided by the forest for human beings are reduced, the quality is reduced, and even extinct. It is the same as the damage content of economic forest fruit production and forest by-products production in human activities.

Production of raw materials: the damage behavior of forest ecosystem leads to the reduction in the quantity or increase in the cost of various raw materials such as standing trees, standing bamboos, oil plants and traditional Chinese medicine provided by the forest to human beings by changing the forest area, forest biological productivity, forest canopy density and forest succession. It is the same as the damage of processing and manufacturing industry in human activities.

(2) Ecological regulation services

Soil conservation: the damage of forest ecosystem causes the decline of forest canopy density and the change of community hierarchy, which

leads to the decline of canopy interception, tree trunk flow, litter layer's ability to intercept rainfall, and increases the loss of soil loss.

Water conservation: compared with no forest land, the plants and soil in the forest ecosystem have higher water content, which plays an important role in water storage and water purification. The damage of forest ecosystem leads to the loss of surface and underground water storage capacity and effective runoff by affecting the forest area, plant community structure and soil physical and chemical properties.

Wind prevention and sand fixation: the damage behavior of forest ecosystem reduces its ability to weaken the wind intensity and reduce the sand carrying capacity by changing the structure and process of vegetation, resulting in the loss of soil loss and increased wind sand damage.

Carbon fixation and oxygen release: forest ecosystem can absorb carbon dioxide and release oxygen through photosynthesis of plants; at the same time, forest vegetation and soil also have strong carbon sequestration capacity, which plays a role in weakening the urban heat island effect and regulating urban and rural climate. When the forest ecosystem is affected by environmental pollution, fire and human disturbance, the reduction of forest area and the decline of vegetation biomass will lead to the loss of forest carbon sequestration and oxygen release capacity.

Air purification: the damage behavior of forest ecosystem leads to the loss of sulfur dioxide, fluoride, nitrogen oxide and heavy metals absorbed by the forest, the amount of negative ions provided and the quality of dust fall retardation.

The realization of ecological regulation services of forest ecosystem does not depend on human activities, and there is no intersection and overlap between its damaged category and the damaged category of human activities.

(3) Cultural services

Aesthetic landscape: the damage of forest ecosystem destroys human aesthetic experience of forest landscape and leads to the damage of forest aesthetic value by changing the growth law of trees and the selection, collocation, color and other

structures of tree species. It is the same as the damaged content of forest tourism in human activities.

Culture and education: the damage of forest ecosystem will not only destroy the unique ecological charm of the forest, hinder people's longing for and knowledge of the forest, but also increase the difficulty of forestry science research and cause losses to the cultural and educational function of the forest ecosystem. It is the same as the damaged content of scientific research literature and history in human activities.

(4) Support services

Support services of forest ecosystem include maintaining nutrient cycle and biodiversity, and its value has been directly or indirectly reflected in the value of product services, ecological regulation services and cultural services of forest ecosystem. Therefore, in order to avoid double counting of forest ecosystem damage process, this paper will not consider the loss of forest ecosystem support services alone.

3. Construction of forest ecosystem damage assessment index system

3.1 Establishment of forest ecosystem damage assessment index system

In addition to the losses borne by individuals, enterprises, institutions and public health in **Table 1**, there are also some expenses paid by the state and the government for emergency treatment and damage investigation in order to protect the public and speed up the restoration of forest ecosystem. In the process of forest ecosystem damage assessment, if the damage value of each function is taken into account, it will inevitably lead to repeated calculation and inaccurate assessment results. Therefore, this study follows the four principles of scientificity, systematization, comparability and operability, and constructs the forest ecosystem damage assessment index system (**Table 2**) after eliminating the indicators of human activities and forest ecosystem function damage.

3.2 Valuation method of forest ecosystem damage assessment indicators

This study clarifies the value calculation

method of relevant indicators from four aspects: personal safety damage, human activity damage, forest ecosystem function damage and other related damage (Table 2).

Table 2. Assessment index system of forest ecosystem damage

Target layer	Indicators		
	First-level indicator	Second-level indicator	Third-level indicator
Forest ecosystem damage	Personal safety damage	Physical damage	Physical damage
		Mental damage	Mental damage
	Human activity damage	Economic forest fruit loss	Loss of economic forest products Loss of afforestation cost
		Loss of forest by-products Processing and manufacturing losses	Loss of forest by-products Loss of commodity timber Downtime losses Shutdown loss Loss from suspension of business
		Forest tourism loss Loss of scientific research, literature and history	Loss of tourism income Loss of scientific research, literature and history
Functional damage of forest ecosystem	Loss of soil conservation	Reduce sediment deposition loss Reduce non-point source pollution losses	
	Loss of water conservation	Water storage loss	
	Loss of windbreak and sand fixation	Reduce land desertification loss	
	Loss of carbon fixation and oxygen release	Carbon sequestration loss Oxygen release loss	
	Atmospheric purification loss	Absorption loss of sulfur dioxide Loss of absorbed nox Dust retention loss	
Other	Emergency treatment fee	Emergency treatment fee	
	Investigation and evaluation fee	Investigation and evaluation fee	

3.2.1 Personal safety damage

On the premise of confirming that personal safety is infringed, such as adverse changes such as disease, disability, death or mental state, which constitute a causal relationship with forest ecosystem damage, The amount of the victim's loss shall be calculated according to the relevant treatment methods in "the Interpretation of the Supreme People's Court of Some Issues concerning the Application of Law for the Trial of Cases on Compensation for Personal Injury"^[33] and the Interpretation of the Supreme People's Court of Some Issues concerning the Application of Law for the Trial of Cases on Compensation for Personal Injury^[34].

3.2.2 Human activity damage

(1) The loss of economic forest fruit

For the loss measurement of the fruit value of economic forests, the market value method is used for calculation, which is divided into three categories: fruit yield loss, quality loss and afforestation

loss. Among them, afforestation loss refers to the invalid cost that can no longer obtain economic benefits after the damage of the costs invested in the initial stage of forest fruit afforestation and over the years^[26]. The formula is as follows:

$$L_{\text{fruityield}} = A \times (Y_N - Y_D) \times P_N \quad (1)$$

Where, $L_{\text{fruityield}}$ is the loss of fruit output (yuan); A is the damaged area of economic forest (km^2); Y_N is the fruit yield in the baseline state (kg/km^2); Y_D is the annual yield of fruits after damage (kg/km^2); P_N is the average unit price of fruit (yuan/kg).

$$L_{\text{fruitquality}} = A \times (P_N - P_D) \times Y_D \quad (2)$$

Where, $L_{\text{fruitquality}}$ is the fruit quality loss (yuan); A is the damaged area of economic forest (km^2); P_N is the average unit price of fruit in the baseline state (yuan/kg); P_D is the average unit price of fruit after damage (yuan/kg); Y_D is the annual yield of fruit per unit area (kg/km^2).

$$L_{FM} = L_F + L_M \quad (3)$$

$$L_F = AC_F \times (1 + r)^n \quad (4)$$

$$L_M = \sum_{i=1}^n AC_{Mi} \times (1 + r)^i \quad (5)$$

Where, L_{FM} is the loss of afforestation cost (yuan); L_F is the loss of afforestation cost (yuan); L_M is the loss of forestry expenses (yuan); A is the forest damage area (km²); C_F is the afforestation cost per unit area (yuan/km²); n is the afforestation time (a); r is the interest rate (%); C_{Mi} refers to the forestry cost per unit area over the years (yuan/km²); i is the afforestation time (a).

(2) Loss of forest by-products

The calculation of the loss of forest by-products is complex, and it is simplified according to the operability principle of the index system^[35]:

$$L_{\text{forestby-products}} = \sum_{i=1}^n f_i \times (A_{iN} - A_{iD}) \times A \quad (6)$$

Where, $L_{\text{forestby-products}}$ is the loss of forest by-products (yuan); f_i is the unit price of the i -th forest by-product (yuan /kg); A_{iN} is the yield per unit area of the i th forest by-product in the baseline state (kg/km²); A_{iD} is the yield per unit area of the i -th forest by-product after damage (kg/km²); A is the forest damage area (km²).

(3) Processing and manufacturing losses

The losses of processing and manufacturing industry include direct economic losses and indirect economic losses. The former is mainly the loss of commodity timber; the latter is the cumulative cost-effectiveness of relevant personnel shutdown losses, factory shutdown losses and store shutdown losses directly caused by forest land encroachment and forest ecosystem damage^[23]. The calculation formula is as follows:

$$D_{\text{commocalwood}} = (WA_N - WA_D) \times A \times P - RV_w \quad (7)$$

Where $D_{\text{commercialwood}}$ is the loss of commercial wood (yuan); WA_N refers to the wood volume per unit area in the baseline state (m³/km²); WA_D refers to the timber volume per unit area after damage

(m³/km²); A is the forest damage area (km²); P is the price of wood production cost (yuan/m³); RV_w is the residual value (yuan).

$$L_{SD} = N_{SD} \times T_{SD} \times P_w \quad (8)$$

$$L_{\text{Discontinued}} = N_c \times T_{\text{Discontinued}} \times P_c \quad (9)$$

$$L_{\text{outofbusiness}} = T_{\text{outofbusiness}} \times P_D \quad (10)$$

Where, L_{SD} is shutdown loss (yuan); N_{SD} refers to the number of shutdown (person); T_{SD} is downtime days (d); P_w is the average daily wage (yuan person⁻¹ d⁻¹); $L_{\text{Discontinued}}$ is the shutdown loss (yuan); N_c is the product output (piece /d); $T_{\text{Discontinued}}$ is the shutdown time (d); P_c is the ex-factory price of the product (yuan/piece); $L_{\text{outofbusiness}}$ refers to the loss of suspension of business (yuan); P_D is daily turnover (yuan/d); $T_{\text{outofbusiness}}$ is the number of days of closure (d).

(4) Forest tourism loss

In the process of forest ecosystem damage, the forest tourism loss is evaluated according to the actual difference between the post damage tourism income and the baseline tourism income.

(5) Loss of scientific research, literature and history

The cultural and historical value of forest scientific research is greatly affected by human subjective feelings and needs, and the quantitative methods are difficult to unify. According to the actual situation of damage, experts' evaluation method^[26,36], willingness to pay method^[37,38] and fuzzy comprehensive evaluation method^[39] can be selected for calculation.

3.2.3 Forest ecosystem functions

Referring to the calculation method of gross ecosystem product (GEP) in relevant literature^[40], this study adopts alternative cost method, shadow engineering method, restoration cost method and other methods to calculate the value of nine tertiary indicators of forest ecosystem soil conservation, water conservation, wind and sand prevention, carbon fixation and oxygen release, and atmospheric purification after baseline and damage, and the difference is the loss of corresponding indicators. The calculation formula is as follows:

$$L_{\text{function}} = \sum_{i=1}^9 (V_{iN} - V_{iD}) \times A \quad (11)$$

Where, L_{function} is the loss of forest ecosystem (yuan); V_{iN} is the unit area value of the i -th index under the baseline state (yuan/km²); V_{iD} is the unit area value of the i -th index after damage (yuan/km²); A is the forest damage area (km²).

3.2.4 Others

Other losses are mainly the emergency treatment fees and investigation and evaluation fees borne by the government and relevant units, which are calculated according to the actual expenditure.

4. Forest ecosystem damage management system

The construction of the evaluation index sys-

tem has laid the foundation for the scientific evaluation of forest ecosystem damage^[2], but whether the whole system and subsequent compensation, restoration, compensation and other work can be effectively implemented largely depends on whether there is a relatively complete management system, mechanism and legal system as a support. Improving the forest ecosystem damage management system can not only optimize the identification and evaluation process and methods, reasonably solve relevant disputes and compensation, but also effectively prevent the recurrence of similar forest ecosystem damage events. Therefore, this paper establishes the management system of forest ecosystem damage, and studies it from two aspects: the forestry technology department and the judicial administration department (Figure 2).

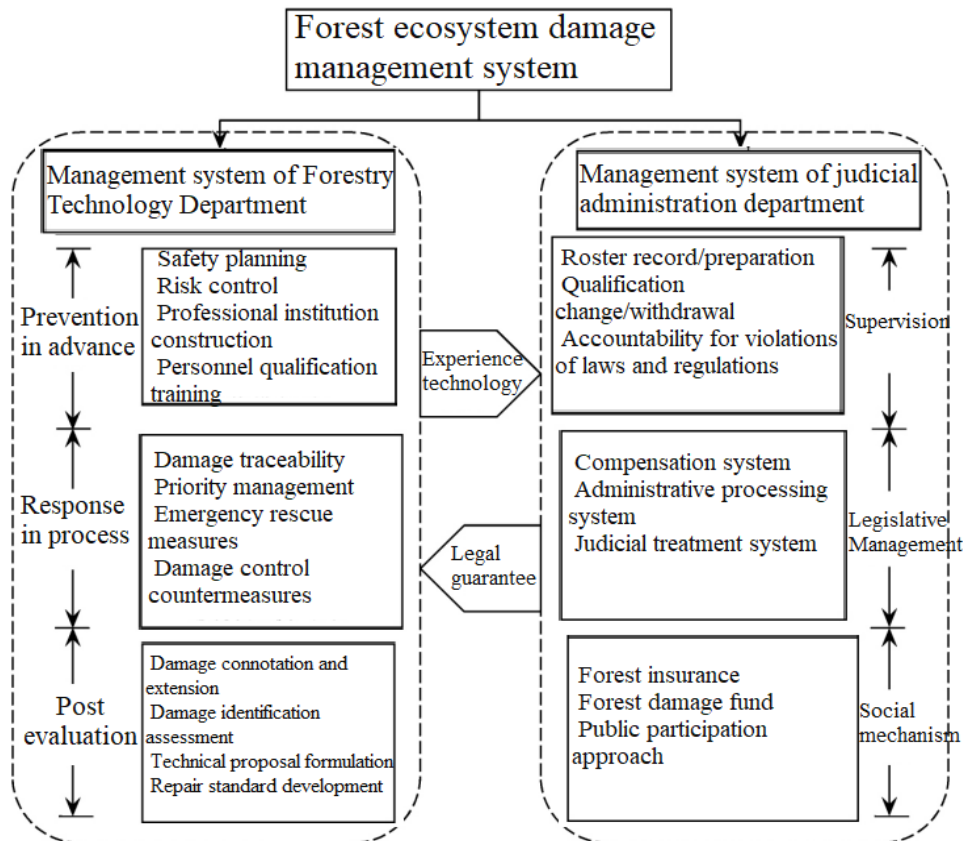


Figure 2. Management system of forest ecosystem damage.

4.1 Management system of forestry technology departments

(1) Prevention in advance. It is mainly to re-

duce the probability of damage through safety planning for possible forest ecosystem damage, such as layout, site selection and other management of con-

struction land occupation, and timely monitoring of industrial pollution that may constitute forest ecosystem damage; at the same time, carry out the ability training of relevant personnel in the identification industry, accelerate the construction of forest ecosystem damage identification and assessment institutions, clarify their establishment conditions and application procedures, and supervise the unity of their standards and methods for identification and assessment, so as to provide guarantee for the professionalism of identification and assessment.

(2) Response in the process. It is mainly through the identification of the source of forest ecosystem damage, to stop the further deterioration of the damage from the source; and make a preliminary assessment of the damage degree of different damaged objects, give priority to the areas with high damage degree or poor resistance to damage, as well as the key damaged objects, and take emergency rescue measures in time; under the premise of comprehensively considering economic and technical constraints, appropriate damage control countermeasures should be formulated to minimize the overall damage of forest ecosystem.

(3) Post evaluation. The evaluation work often faces problems such as unclear definition of loss and difficult to quantify. On the basis of clarifying the connotation and extension of forest ecosystem damage, it is necessary to carry out scientific identification and evaluation, including sorting out the causes and evolution mechanism of ecosystem damage, measuring key factors and indicators, defining baseline and damage category, and standardizing and unifying the calculation method of ecosystem damage; at the same time, after the forest ecosystem is damaged, there is an urgent need to formulate a reasonable restoration technology scheme to repair its ecological environment; on the basis of the determination of the technical scheme, it is necessary to formulate scientific restoration standards to measure whether the restoration of forest ecosystem meets the requirements and provide technical support for the post restoration work.

4.2 Management system of judicial administration departments

(1) The supervision and management functions performed by the judicial administration department in the identification and assessment of forest ecosystem damage are mainly to record, roster, ability verification or integrity notification of institutions and personnel engaged in identification and assessment; and change or revoke the qualifications of relevant institutions and personnel according to the actual situation; at the same time, institutions or individuals that violate laws and regulations in the appraisal and evaluation, as well as local governments or leaders in charge with inadequate implementation of laws and policies, imperfect emergency mechanism, and inadequate supervision and management should be held accountable and dealt with.

(2) The formulation of legislation in the field of forest ecosystem damage can increase human consciousness of forest protection and reduce the law enforcement resistance of forestry departments. The legislative content mainly includes the establishment of compensation system, administrative processing system and judicial processing system. The imperfection of the compensation system is one of the reasons for the low cost of forest ecosystem damage. Therefore, it is urgent to establish and improve the forest ecosystem damage compensation system, mainly including the definition and specification of the scope of compensation, the obligor and the responsible person of compensation, the way of compensation and the management of compensation funds. The administrative handling system mainly includes the administrative mediation and administrative relief system suitable for national conditions. The judicial treatment system is a standardized formulation of legal proceedings, including the expansion of the scope of litigation subjects, the clarification of litigation procedures and requirements, and the improvement of legal proceedings support systems such as the construction of evidence support institutions, environmental courts and lawyer groups, so as to provide unified standardized and legalized management for the damage assessment of forest ecosystems.

(3) The socialization mechanism of forest ecosystem damage is mainly based on the relatively

perfect legal norms and management evaluation technology, including the unified administrative and judicial management of establishing forest insurance and forest damage fund as the guarantee of forest ecosystem restoration and compensation, as well as the formulation of the “public participation method of forest ecosystem damage compensation” for the purpose of expanding public participation in forest damage compensation. Starting from the social sharing mechanism, we can ensure that individuals or enterprises and institutions can get effective relief and compensation when they suffer from forest ecosystem damage through a variety of financial channels; by clarifying the relevant responsibilities and rights of the public, strengthening public participation, and further ensuring the fairness, impartiality and openness of forest ecosystem damage compensation.

5. Conclusion

Ecosystem damage assessment is the main part of ecological environment damage assessment. The establishment of ecosystem damage assessment index system is of great significance to the quantification, standardization and scientization of forest ecosystem damage assessment technology. Starting from the meaning of forest ecosystem damage, this paper further divides the damaged objects of ecosystem damage into personal safety, human activities and forest ecosystem functions, and combs and clarifies their damaged categories; according to the four principles of scientificity, systematization, comparability and operability, the forest ecosystem damage assessment index system is established, including four first-class indexes of personal safety damage, human activity damage, forest ecosystem function damage and other damage, 14 second-class indexes of physical damage, mental damage, economic forest fruit loss and 22 third-class indexes, and the quantitative method of each index is clarified; on this basis, this study analyzes the management system of forest ecosystem damage assessment from the forestry technology department and the judicial administration department respectively, so as to provide a reference basis for the scientific assessment of forest ecosystem damage and the

formulation of management system, mechanism and legal system.

In general, the construction of this index system is a beneficial attempt for the damage assessment and management of forest ecosystem. Its grasp of the damaged object and the damaged process helps to accurately and comprehensively reflect the basic status of forest ecosystem damage, and also provides a theoretical basis and reference basis for damage management. However, the damage assessment of forest ecosystem is a process of gradual refinement. In view of the differences of assessment indicators between different functional divisions of forest ecosystem, it needs to be further improved; at the same time, forest ecosystem damage assessment indicators need not only the construction of the index system, but also the further improvement of work such as damage baseline confirmation, which is also the research direction that needs to be improved in the future.

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Conflict of interest

The authors declared no conflict of interest.

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