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Value measurement and case study of development of traditional Chinese medicine resources and the protection of biodiversity

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Abstract. China has rich traditional medicine resources. However, with economic development, the excessive exploitation and utilization of traditional Chinese medicine resources has driven many species to the verge of extinction. However, in recent years, the protection of such resources through advocacy, research, and law enforcement has increased, and populations of some important species have been recovered. Nevertheless, the overall diversity of traditional Chinese medicine resources has faced a notable crisis. Therefore, the development of diverse traditional Chinese medicine resources can improve people's understanding of the importance of these resources, and also play a role in the rational allocation and utilization of such resources, thereby protecting the biological diversity of traditional Chinese medicine resources.

1 Over exploitation of traditional Chinese medicine resources hinders conservation of biodiversity

Due to the rapid development of China's economy and the improvement of the health awareness of its population, traditional Chinese medicine resources are in demand in healthcare, and in prevention and treatment of diseases due to their effectiveness . Both the domestic, and foreign demand for traditional Chinese medicine has rapidly increased. Driven by economic interests, enterprises have sprung up that excessively utilize traditional Chinese medicine resources, causing destruction of the ecological environment and reducing and even depleting these resources in the wild. It has been reported that more than 100 such resources, such as liquorices, notopterygium root, Vitex trifolia, Cistanche, Pinellia ternate, shikonin, etc., are now too scarce to meet medicinal needs. Due to the scarcity of wild resources, the availability of more than 30 types of plants, such as crescent wild lotus, Dysosma versipellis, Magnolia officinalis, Eucommia, wild ginseng, etc., cannot be guaranteed to meet the demand for commodities[1]. The biological diversity of traditional Chinese medicine is decreasing, and the harmonious relationship between humans and nature has been reduced or even lost, causing a loss of biological diversity in the traditional Chinese medicine.

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2 Evaluation and measurement of the ecological value of traditional Chinese medicine resources

2.1 International experience

Traditional Chinese medicine resources form an aspect of animal and plant resources in general; thus, we can use methods for evaluating the ecological values of animal and plant resources to evaluate the ecological values of traditional Chinese animal and plant medicinal resources.

There are a number of studies on the measurement of the ecological value of animal and plant resources in general. Drumarx used the cost of expenditure in the assessment of the value of wildlife over several decades; travel costs, conditions, and other parameters were measured in the assessment of the application and development of ecosystem services[2]. Costanza[3] used a physical quality evaluation method, energy analysis method, market value method, and opportunity cost method, calculated for global ecosystem services and capital asset value; this study formed the basis for many further studies. In the measurement and evaluation of the ecological value of traditional Chinese medicine resources, Han Song and Lin Wei-wei established index systems and measurement methods for the measurement of the ecological value of wild animal and wild plant resources; these methods are referenced in this paper. Han Song considered the ecological value of wildlife resources based on wild animals that are involved in maintaining the integrity of the food chain value as the value of biodiversity. He designed a specific evaluation index system, using the opportunity cost method and an alternative cost method to calculate the ecological value of wild animal resources[4]. Lin Wei-wei divided the ecological value of resources into water conservation, solid soil, carbon sequestration, and storage nutrition substance-specific indicators, and used the shadow price method to calculate the ecological value of wild plant resources [5].

2.2 System for classification and evaluation of ecological value of traditional Chinese medicine resources

Traditional Chinese medicine resources form an organic part of the natural ecosystem, and its ecological value is mainly reflected in the maintenance of ecological balance[6]. the ecological value of traditional Chinese medicine resources is mainly reflected in three factors:

First, traditional Chinese medicine animal resources that maintain the integrity of the food chain, the smooth progress of the nutrient cycle. Second, as part of a natural ecological system, traditional Chinese medicine plant resources play a role in natural ecological functions. Third,Traditional Chinese medicine resources contribute to this biological diversity, and thus maintaining biodiversity is one of the ecological values of traditional Chinese medicine resources.

Therefore, the ecological value of traditional Chinese medicine resources is equal to sum of the ecological value of the animal resources, the ecological value of the plant resources and the maintenance of biological diversity of traditional Chinese medicine resources, which can be expressed as:

$$VTCM = VMB + VFB + VDB \quad (1)$$

Where V_{TCM} is the ecological value of traditional Chinese medicine resources; VFB is the value of traditional Chinese medicine animal resources in maintaining the integrity of the food chain; VAB is the ecological service function value of traditional Chinese medicine plant resources, and VDB is the value of traditional Chinese medicine resources in maintaining biodiversity.

2.3 Measurement of ecological 1value of traditional Chinese medicine resources

2.3.1. Ecological value of animal resources

2.3.1.1 Value of animal resources in maintaining the integrity of the food chain

Wild animal resources in Chinese herbal medicine maintain the integrity of the food chain, thereby maintaining the smooth circulation of nutrients. This value includes the biological control value, seed transmission value, improving the soil value, and purifying the environment value. It can be measured as follows:

$$VFB = VFB_1+VFB_2+VFB_3+VFB_4 \quad (2)$$

Where VFB_1 is the biological control value; VFB_2 is the seed dispersal value; VFB_3 is the improving soil value; and VFB_4 is the purification of the environmental value.

(1)The biological control value:

Wildlife resources add benefit to human life; certain birds and mammals, and even certain pests and rodents are the main food items to humans.Thus, the ecological value of wild animal resources can be used to indicate the cost of prevention and control of pests, and can be calculated as follows:

$$VFB_{1i} = \sum K_j \cdot Q_{ij}/q_j \quad (3)$$

where VFB_{1i} is the i species of wild animals in biological control income; K_j is the costs of control in a unit area of J species of insect pests; Q_{ij} is the number of J species of harmful animals eaten by i species of wild animals on average every year; and q_j is the j types of harmful animals each year, indicating the density of harm.

(2)The spread of seeds value

Some wild animals seeds for food, and thus the wild animals have a significant effect on seed propagation. Animals such as squirrels, jays, crossbills, rodents, and other animals who store pine nuts for food, and as a food storage habit, are conducive to seed dispersal and planting. This value can be calculated as follows:

$$VFB_{2i} = H_i \cdot M \quad (4)$$

Where VFB_{2i} is the seed transmission yield of wild animal resources; H_i is the area of i species of wild animals; and M is the annual planting cost per unit area.

(3)Improving the value of the soil

Wild animals improve the value of the soil, as mainly reflected in two aspects. First, wild animal manure can improve soil fertility, promote soil fertility (which assumes a moderate amount of feces from wild animals, and no soil fertility damage). Second, they improve soil permeability and ventilation, and is calculated as follows:

$$VFB_{3i} = VFB_{31i}+ VFB_{32i} = (NI_i \cdot P_{NI} + PH_i \cdot P_{ph} + PO_i \cdot P_{po})\, Q_{di} + FL \cdot Q_{hi}/q_{hi} \quad (5)$$

Where VFB_{3i} is the i type of wild animal that improve soil yield; VFB31i is the i type of wild animal that improves the monetary value of soil fertility; VFB32i is the i type of wild animal that improves the monetary value of the soil permeability and gas permeability; NIi is the nitrogen content per kilogram of feces of i type of wild animal; PNI is the average cost of industrial nitrogen; PHi is the i type of phosphorus content per kilogram of wild animal feces; Pph is the average cost of industrial production of elemental sulfur; POi is the i species of wild animal feces content per kilogram of potassium; Ppo is the average cost of the industrial production of potassium; Qdi is the i type of the amount of manure produced annually by wild animals; FL is the cost per unit area of arable land; Qhi is the i species of wild animal in the number of mining caves; and qhi is the density of i species of wild animals excavated in the cave.

2.3.1.2 Animal resources for maintaining the value of biodiversity

A review of the literature showed that the opportunity cost method was the best method for evaluating forest biodiversity; in this study, cost measurement was chosen to evaluate the Chinese medicine resources that maintain the value of biodiversity.

Wildlife survival depends on habitat; once habitat is destroyed, wildlife resources will also cease to exist. The opportunity cost is the same as habitat resource opportunity costs, and consists of two parts: the habitat resources for the construction projects, requiring the community to give up their benefits, and for construction projects leaving the community to increase wear and tear. This includes income that depends on wildlife resources and the protection of other wildlife. Such investments are measured using the following formula:

$$VBD_{1i} = \sum Q_{Bij} P_{Bj} + INV_i \quad (6)$$

Where VBD1i is the i species of wild fauna that maintain the value of biodiversity; QBij is the i type of wild animals and plants that occupy j types of resources annually; PBj is j type of average market prices of resources; INVi is i type of investment in wildlife conservation.

2.3.2 Plant resources ecosystem roll functions

Plant resources with ecological roles, including water conservation value, carbon sequestration value, oxygen value, and soil conservation value, can be expressed by the formula:

$$VFB = VFB_1 + VFB_2 + VFB_3 + VFB_4 \quad (7)$$

Water conservation value

The water conservation value of Chinese medicinal plant resources can be divided into the storing precipitation value and the purifying water quality value. The specific calculation method is as follows:

1) Storing precipitation value: Wild plant resources play the important role of capturing precipitation in ecosystems, which increases the effective amount of water and regulates runoff. Storing precipitation is a method for maintaining water balance, as calculated by the formula below:

$$W = (P - E) \cdot A \quad (8)$$

Where W is the stored precipitation (m^3/a); P is the average annual rainfall (mm/a); E is the average annual evaporation (mm/a); and A is the area of Chinese medicine plant resources (hm^2).

2) Water purification value: Plant resources are involved in absorption, adsorption, precipitation decomposition of harmful substances, and improvement of water quality. The value of water purification plant resources can be calculated using the alternative engineering method as follows:

$$VS = C \cdot K \quad (9)$$

Where VS is the water purification value (yuan); C is the intercepted precipitation (m^3/a); K is the unit per volume of water purification costs, which is 0.9885 yuan/m^3.
Therefore, the value of water conservation by plant resources is expressed as:

$$VFB_1 = W + VS = (P - E) \cdot A + C \cdot K \quad (10)$$

Carbon fixation value

Through photosynthesis, plants convert solar energy into chemical energy and synthetic organic materials. The fixation of absorbed CO_2 in the plant body can be calculated using the equation of photosynthesis—$6CO_2 + 12H_2O \rightarrow (CH_2O) + 6O_2 + 6H_2O$—as 1.639 g CO_2 per gram of dry matter. The calculation of pure carbon fixed in plants can be calculated by the following formula:

$$C_c = 0.2729 C_g \quad (11)$$

Where C_c is the fixed carbon content (t/a), and C_g is the fixed CO_2 (t/a).

Oxygen production value

O_2 and CO_2 emissions of a fixed amount are calculated in the same manner; per 1 g of dry matter 1.19 g O_2 can be released, the economic value of O_2 released can be calculated using the reforestation cost method and the price of industrial oxygen substitution method.

Soil conservation value

There are many methods for assessing soil conservation by plants. Taking into account the feasibility of the operation, we selected an alternative engineering method. The basic steps for assessment are as follows: first, we calculated the amount of plant and soil conserved and converted this into land area multiplied by the appropriate engineering reclamation costs, to obtain the value of plant and soil conservation. Second, we calculated the loss of N, P, K, organic matter content in the soil taken away; then, if this is equated to the appropriate amount of commercial fertilizer, and multiplied by the average market price of fertilizer, it is possible to calculate the value of fertilizer plants [7].

2.3.3 Special value of the biological diversity of traditional Chinese medicine resources

The ecological value of traditional Chinese medicine resources and the ecological value of plant and animal resources in general, also have its own value, such as pest control, providing natural medicines for other organisms, and the number of species needed to maintain stability.

Ginkgo is a good example; its fruit used not only for treating phlegm, cough, lungs, and is used as a diuretic, and the ginkgo tree plays a role in ecological water conservation, soil conservation, etc., but also prevents pests and diseases, and plays a role in crop protection[8]. Studies have found that ginkgo leaves are able to protect against the invasion of pathogens and can secrete an antibacterial insecticidal substance[9]. In addition, more importantly, the value of traditional Chinese medicine resources in biodiversity is reflected in its role in human health, disease prevention, strategic resources, public health, and as a human resource library for overcoming health disorders. For instance, extracts from the annual stems and leaves of the Artemisia plants have anti-malarial effects. Extracts from Ginkgo biloba can be used to treat cardiovascular disease.

3 Case analysis of biodiversity conservation and development of traditional Chinese medicine

Bletilla is a typical traditional Chinese medicine plant from the western region; this orchid's dry tubers stops bleeding, reduces swelling, and promotes tissue regeneration. However, Bletilla seeds are very small and have no endosperm[10]; it is difficult to germinate and grow this plant under natural conditions, seedling cultivation is more difficult, and is only achieved by plant breeding[11]. Moreover, the plant has a long breeding cycle and low reproductive efficiency. It is difficult to meet the high demand for cultivation of this plant, and thus the current market supply mainly depends on wild Bletilla. In 2006, the dosage of Bletilla medicinal goods reached 1000 tons; the total market demand broke through 1500 tons in 2007. Because the market demand for Bletilla has increased markedly, the wild resources decline year by year. According to reports, the Bletilla output for 2007 was about 300 tonnes in Guizhou, 500 tons in Yunnan, about 100 tons of Guangxi, and the total output of the western region was about 900 tons[12]. In terms of the market price, in the 1980s, the basic price of Bletilla was ¥ 4~6 per kg. The price began to rise in 1991, and reached ¥ 35~42 per kg in 2005~2006, and in 2014~2015, the market price had risen to ¥ 450~680 per kg. Westerners played a role in stimulating economic interests in the over-exploitation of wild Bletilla. It is predicted that wild Bletilla resource reserves is declining at a rate of 10%~15%. In 2007, Guizhou resources declined by about 40% or more, so that it is now difficult to find wild mountain Bletilla.

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