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Measurement on Monetary Value of Forestry Multifunction—A Case of Danzhai County, Guizhou Province, China

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Abstract Forestry functions of Danzhai County are introduced from the aspects of physical production value, social service value and ecological service value. Quantitative research on monetary value of the functions is conducted by using the Replacement Cost Method (RCM), Classification Valuation Method (CVM) and Travel Cost Method (TCM). Result shows that the value of forestry production is 19 712.6 thousand yuan, and the value of flood control and water conservation is 111 000 thousand yuan, which is 5.63 times of forestry production value. Besides, the value of soil conservation and yield increase is 160 101.5 thousand yuan, which is 8.12 times of the value of forestry production; the value of carbon fixation and oxygen release and air purification is 1 126 624.1 thousand yuan, 57.15 times of the value of forestry production; and the value of the employment and income increase, and the landscape and recreation is 5 380 thousand yuan, which is 0.27 times of the value of forestry production. Due to the important external role of the forestry, government should take into account the multifunction of forestry when making policies in order to promote the effective development of forestry and the sustainable development of agriculture.

Key words Forestry multifunction; Monetary value; Evaluation; China

1 Summary of reserch area

1.1 Basic situation of Danzhai County Danzhai County (107°44' – 108°08' E, 26°05' – 26°26' N) is located in the southeast of Guizhou Province, that is, the west of Autonomous Prefecture of Miao and Dong Minority of Southeast Guizhou. The county is situated in the sloping area of the transitional zone from Guizhou plateau to Guangxi hill, the southern slope of Leigong Mountain of eastern Miaoling mountain ridges, and the upstream watershed of Duliujiang and Qingshuijiang River Systems. Danzhai County is high in east and low in west and tilts to northwest and southeast along the watershed with the shape of diamond, connecting Leishan County in the east. The total area of Danzhai County is 94 029.58 hectares, 40.50 kilometers of east-west width and 39.80 kilometers of north-south length.

Danzhai County has a mild climate, belonging to mid-sub-tropical monsoon moist climate with distinct four seasons, frost-less period of 283 days, abundant rainfall of 1 320.5 millimeters in each year, annual average temperature of 16.3 degrees centigrade, extreme high temperature of 34.80 degrees centigrade, and extreme low temperature of minus 9.5 degrees centigrade. Mountains are the main landform in the county, accounting for 94% of the total area. Forest area of Danzhai County is 54 667.37 hectares, the highest forest coverage (63.75%) in the whole province. Woody plants in Danzhai County, belonging to 519 species, 237 genera and 91 families, and herbs and lianas, belonging to 230 species and 43 families, are named. There are various rare and endangered plant species in Danzhai County. Among the 24 species we already known, a total of 14 species are national protected trees, ac-

counting for 33% of the 42 species in the whole province.

1.2 Significance of value assessment on forest function Concept of agricultural multi-functionality is advanced at the Global Agricultural and Rural Development Conference in the year 1992, emphasizing the multi-function of food security, social stability, cultural heritage, ecological conservation and political security and defining the concept of multi-functionality of agriculture^[1-2]. Multi-functionality of forest is put forward based on multi-functionality of agriculture, mainly referring to the functions of ecological landscape, soil and water conservation, biodiversity, flood prevention and disaster mitigation, decreasing temperature, and freshening air, and the production function. Research shows that value of other forestry functions is many times higher than that of production function^[3].

Usually, development degree of forest is evaluated by the market value of forest products. However, domestic and foreign theory and practice have proved that value of forest resources manifests itself on the values of ecological service, social service and external economy, but not on the economic value of inner industry. Value of this public welfare commodity beyond market can not be fully achieved through the market, and might result in low forestry value and loss of producer's interests. Therefore, compensation for forestry is needed. Value evaluation on forestry functions, especially on the ecological and social services, will provide a strong scientific basis, which changes people's knowledge about forestry, pays attention to the multi-functionality of forestry, protects the ecological environment, and has important significance to the rational allocation of resources and the realization of forestry compensation.

2 Value evaluation on forestry function of Danzhai County

Multi-functionality of forestry has been a hot issue in academic circles in recent years. With the reform of forestry right

system and global warming, value evaluation and application research on forestry multi-functionality have been paid special attention to. It is generally agreed that multi-functionality of forestry is mainly reflected in three aspects, which are physical production value (wood, woodland and forest by-product), social service value (water conservation, climate regulation, environmental purification, maintenance of biological diversity, carbon fixation and oxygen release, soil and water conservation, and flood control), and ecological service value (employment, recreational environment, entertainment, aesthetics, spiritual and cultural heritage). Based on the achievements of previous research, various functions of forestry are summarized and their valuation is conducted combining with the forestry development of Danzhai County. However, since there is no market exchange, it is difficult to accurately calculate the market value of external economy of forest functions. The only way to evaluate is through indirect approaches. Thus, Replacement Cost Method (RCM) is used to evaluate the monetary values of water conservation, flood control, soil and water conservation, carbon fixation and oxygen release, air purification and so on. Meanwhile, Travel Cost Method and Contingent Valuation Method are adopted to assess the functional values of employment income, landscape recreation and so on^[4].

2.1 Functions of water conservation, flood control and disaster reduction Water conservation is an important function of forestry (forest), having the value of water storage, runoff regulation, flood and drought control, and water purification. Value of water conservation can be expressed as precipitation interception by forestry (forest), which redistributes precipitation through canopy, litters and soil interceptions, so as to regulate the spatial and temporal distribution of precipitation and to play the role of flood prevention and disaster reduction.

2.1.1 Interception by canopy.

$$\text{Its equation is } Y_1 = S \cdot L \cdot G, \quad (1)$$

where Y_1 is the canopy interception, S is forest area, L is annual average precipitation, and G is canopy interception rate.

Canopy interception plays an extremely important role in water balance of forest ecosystem, and is of great significance to the attenuation of peak flow and the delay of peak time. Research shows that canopy interception rate of forest vegetation ranges from 11.4% to 34.3% in different climatic zones of northern and southern China^[5]. Based on the actual situation of forestry in Danzhai County, average canopy interception rate is 18.7% and the average precipitation is 1320.5 millimeters. Thus, according to equation (1), canopy interception of forestry is 135 million cubic meters in Danzhai County in the year 2008.

2.1.2 Interception by litters.

$$\text{Its equation is } Y_2 = S \cdot C, \quad (2)$$

where Y_2 is the total water holding capacity of litters, S is forest area, and C is annual average water holding capacity.

Litter plays an important role in water conservation. It reduces the surface runoff during heavy rainfall and ensures the runoff of river in dry season. Substance amount of water conservation is closely related to its property, storage, structure, humidity and decomposition status, which is commonly meas-

ured by the maximum water-holding capacity of forest stand. For the convenience of calculation, let average water-holding capacity of forest stand be 91.51 tons per hectare, total water holding capacity of litters reaches 5 million cubic meters according to equation (2).

2.1.3 Interception by forest soil.

$$\text{Its equation is } Y_3 = S \cdot M, \quad (3)$$

where Y_3 is soil interception, S is forest area, M is average water holding capacity.

Water holding capacity of forest soil depends on soil porosity. Big porosity is conducive to water infiltration, reduces the peak flow, increases the flow of drought period, and enhances the water conservation. Investigation result shows that average moisture content of soil in forest stand is 459.16 tons per hectare in Danzhai County. Thus, soil interception of forest is 251 million cubic meters according to equation (3).

To sum up, Replacement Cost Method (RCM) is suitable for the value evaluation, referring to a new artificial project to replace the original damaged one. Cost of the project is the economic losses caused by the destruction of forest ecosystem. The key of this method is pricing; and unit storage cost of water conservancy engineering is generally used as a valuation standard (average cost of reservoir capacity construction is 0.67 yuan per cubic meter in China from the year 1988 to 1991)^[6]. Therefore, total value of forestry (forest) water conservation reaches 110.61 million yuan in Danzhai County.

2.2 Functions of soil and water conservation and grain production increase

2.2.1 Value of protected land. Total annual land protection of forestry (forest) is usually equal to the difference between potential and actual soil erosion. According to the research on soil erosion modulus in bare land by OUYANG Zhiyun *et al.*, the depth and modulus of middle-degree erosion in bare land in each year are 15–35 millimeters and 150–350 cubic meters per hectare, respectively. According to statistics, soil bulk density of Danzhai County is 1.125 tons per cubic meter; the minimum erosion modulus is 163.6 cubic meters per hectare each year. Thus, the minimum amount of potential soil erosion is 10 676 537.36 tons. It is estimated that annual average erosion modulus in forest (broad-leaved forest, coniferous forest, mixed wood) is 3.47 cubic meters per hectare in Danzhai County and the annual soil loss is 213 407.75 tons. Thus, the difference reaches 9 848 121.70 tons. Taking 0.5 meter as the standard average thickness of soil tillage in China, area of protected land in forestry (forest) is 1 750.78 hectares each year in Danzhai County. Since the average annual income of forestry production is 363.58 yuan per hectare in China, value of protected land in forest in the year 2008 is 461.5 thousand yuan in Danzhai County.

2.2.2 Value of maintaining soil fertility. Soil erosion takes away nitrogen, phosphorus, potassium and organic matter. Contents of organic matter, nitrogen, phosphorus and potassium are 5.8%, 0.18%, 0.03% and 0.08%, respectively, in Danzhai County. According to the minimum protected land in forest (9 848 121.70 tons) in the year 2008, we find out that

the organic matter, nitrogen, phosphorus and potassium have been reduced by 571 191.06, 17 726.62, 2 954.44 and 7 878.50 tons, respectively. If turning them into firewood, urea, calcium superphosphate and potassium chloride, we can calculate that the value of maintaining soil fertility is 154 million yuan in the year 2008 according to market prices.

2.2.3 Value of grain yield increase. Forestry (forest) has significant impact on regional microclimate, which not only regulates forest microclimate, but also has the functions of cooling and insulation. Forestry (forest) can increase the local rainfall to a certain degree, maintain the required temperature and water for normal growth of crop, and promote the increase of local grain yield. According to research, annual loss caused by biological disaster accounts for 10% – 15% of the total grain yield in China^[7]. Due to the function of vegetation and the existence of forest, at least 10% grain yield is saved each year. Grain yield of Danzhai County is 56.4 thousand tons in the year 2008 with the total value of 56 400 thousand yuan. Thus, the value of grain yield increase can reach 5 640 thousand yuan due to forest vegetation.

2.3 Functions of carbon fixation, oxygen release and air purification Photosynthesis in plant is of great importance to the human society, the whole nature, and the balance of global atmosphere. During this process, by absorbing carbon dioxide in the air, plants generate carbohydrate by solar energy and release oxygen at the same time. Forest is the world's largest carbon pool in terrestrial ecosystem. The world's total carbon storage in forest (1 146 gross tons) occupies about 46% carbon in soil and vegetation. Carbon dioxide can be stored in various forms in forest and can mitigate global warming. Its value calculation should mainly include the values of pollutant degradation, atmospheric dust prevention, filtering and adsorption^[8]. It is calculated that the total value of the functions of carbon fixation, oxygen release and air purification reaches 1 126 million yuan in Danzhai County.

2.3.1 Benefits of carbon fixation. Carbon fixation in forestry (forest) is achieved through photosynthesis of green plants, producing carbohydrate by carbon dioxide. And carbon is fixed in plants in the form of organic matter, which becomes an important buffer of atmospheric carbon dioxide, alleviates the growth rate of atmospheric carbon dioxide, and reduces the impact of climate warming. According to relevant researches, production of every one ton of dry matter, or 0.50 ton of carbon, in forestry (forest) needs to absorb 1 184 tons of carbon dioxide^[9]. Investigation on forest resources in Danzhai County indicates that volume of standing trees is 66.48 cubic meters per hectare. Since 0.50 ton of carbon can produce 1 ton the dry matter, if absolute dry weight of wood is 0.46 ton per cubic meter and the cost of carbon dioxide fixation is 273.3 yuan per ton, the carbon storage value of standing trees is 4 596.75 yuan per hectare, according to the valuation standard in the *Forest Environmental Value Assessment of China*. Thus, carbon storage value of forestry (forest) in the whole county is 251 million yuan.

2.3.2 Value of oxygen release. According to the research,

producing every one ton of dry matter in forest needs to release 1 393 – 1 423 kilograms of oxygen, that is, 1 408 kilograms on average. Based on the valuation standard in the *Forest Environmental Value Assessment of China*, the cost of providing oxygen is 369.7 yuan per ton. Thus, the value of oxygen release in forest is 15 918.46 yuan per hectare in Danzhai County; and the total value of oxygen release reaches 870 million yuan in the whole province.

2.3.3 Value of air purification.

(1) Absorb sulfur dioxide. The equation is $W_{so_2} = F \cdot S$, where W_{so_2} is the total sulfur dioxide absorbed by forest, F is the average sulfur dioxide absorbing capacity of different forest types (t/a), and S is area of forest. According to the *National Report on Biodiversity of China*, sulfur dioxide absorbing capacity of forest is 152.13 kilograms per hectare on average; and cost of sulfur dioxide reduction is 0.6 thousand yuan per ton. Thus, the annual total sulfur dioxide absorption of forestry (forest) is 8 316.60 tons in Danzhai County with the total value of 4 989.96 thousand yuan.

(2) Absorb fluorin. The equation is $W_{HF} = H \cdot S$, where W_{HF} is the total fluorin absorbed by forest, H is the average HF absorbing capacity of different forest types (t/a), and S is area of forest. Fluorin in the atmosphere is generally in the form of HF and the biological control of fluoride is an idea measure. According to the measurement on HF absorption of tree by the Beijing Municipal Research Institute of Environmental Protection, annual average HF absorption of various trees is 3.58 kilograms per hectare. Annual HF absorption of forestry (forest) is 195.71 tons in Danzhai County by using Area-Absorptive Capacity Method. According to the tariff standard of 160 yuan per ton, the value generated is 31.3 thousand yuan.

(3) Prevent dust fall. The equation is $W_{fc} = C \cdot S$, where W_{fc} is the total dust fall prevented, C is the average dust prevention capability of different forest types (t/a), and S is area of forest. Trees with large shape and dense foliage can reduce the speed of wind and can let the large particles of dust fall onto the ground due to the weakened wind speed under the action of gravity. According to the survey, dust fall prevention by forest reaches 19.69 kilograms per hectare in Danzhai County. Annual dust fall prevention by forest is 1 076.41 tons in Danzhai County by using Area-Absorptive Capacity Method. According to the tariff standard of 560 yuan per ton, the value generated is 602.8 thousand yuan.

In a word, values of annual sulfur dioxide absorption of forestry (forest), fluorin absorption, and dust fall prevention are 4 989.96 thousand, 31.3 thousand and 602.8 thousand yuan in Danzhai County, respectively. And the total value of air purification reaches 5 624.1 thousand yuan each year.

2.4 Functions of employment increase and landscape recreation As a form of social employment, forestry and forest by-products production needs more and more labor forces with the reform of forest right system in recent years. In the year 2008, forestry and forest by-products production has a total number of 587 employees, and offers 365 job vacancies each year. If the annual average salary of each employee is

12 000 yuan, functional value of employment is up to 4.38 million yuan. With the acceleration of the pace of city life in recent years, pressure on life becomes greater and people has an urgent need to relax and to return to nature, which promote the development of leisure tourism around urban area. Danzhai County has a good ecological environment. Besides, with the application of Xiarong expressway, distance is only 100 kilometres between Guiyang and Danzhai and 30–50 kilometres between Danzhai and Duyun (or Kaili), which significantly promotes the development of leisure tourism based on forest, ecology and natural landscape in Danzhai County. In the year 2008, passenger flow reaches 300 thousand and annual ticket income is 500 thousand yuan. Development of tourism also stimulates the rapid growth of tertiary industry, such as catering industry, transportation and commodity marketing, with a total income over 500 thousand yuan. Therefore, it can be concluded that the value of forestry landscape and recreation is about 1 000 thousand yuan in Danzhai County in the year 2008.

2.5 Productive function of forest and forest by-products Forest stands for living trees, which is an important component of forest resources. Evaluation on forest resources can realize the value preservation and increment of forest assets, bring forestry into the operation system of socialist market economy, and promote the sustainable development of forestry. Under normal circumstances, productive value of forest and forest by-products can be replaced by the growth value of living trees. The equation is $I = M \cdot N \cdot P$, where I is the value of living trees, M is the volume of living trees in each stand (m^3), N is the annual net growth rate of each stand, and P is the price of living trees in forest. Since the total volume of living trees is 3 634.2 thousand cubic meters in Dabzhai County with the annual net increase of 3.94%, total productive value of forest and forest by-products reaches 19 712.6 thousand yuan according to the index of forest price (137.67 yuan per cubic meter) during the accounting of forest resource value in Beijing City.

3 Conclusion

Forestry in Danzhai County has a rich multi-functionality

feature with the multi-functional currency value of 1 422 818 200 yuan, which is 72.18 times of the value of forestry production (19 712.6 thousand yuan). Thus, effective development will greatly promote the development of society and economy in Danzhai County. However, this evaluation result can only reflect the monetary value of forestry multi-functionality to a certain extent due to the limited understanding of forest functions, the externality of the role of forestry (forest) resources, the limited nature of the value assessment method, and the differences in evaluation and pricing standards. There is a certain error between the true value and the result in this research, which should be further studied in future.

References

- [1] FAO (Food and Agriculture Organization of the United Nations). FAO/Netherlands conference on the multifunctional character of agriculture and land[R]. Maastricht, The Netherlands, 1999.
- [2] The Organisation for Economic Co-operation and Development (OECD). Multifunctionality: the policy implications [M]. Paris: OECD Publications, 2003:21–22.
- [3] RAN LR, LU J. Selection of forestry industry developemnet modes for multifunctional utilization of forests[J]. Liaoning Forestry Science and Technology, 2008(1):23–25, 34. (in Chinese).
- [4] SU ZR. The stages and evaluation of forest culture development [J]. Journal of Beijing Forestry University: Social Sciences, 2005 (1):1–7. (in Chinese).
- [5] LIU SR, JIANG YX, SHI ZM, *et al.* A study on the biological diversity in warm temperate forest in China [M]. Beijing: China Science and Technology Press, 1998:1–3. (in Chinese).
- [6] CHENG Y. Mechanism of water resources conservation and recharge of forest and its ecological function value evaluation in Jinyun Mountain [D]. Beijing: Beijing Forestry University, 2007. (in Chinese).
- [7] ZHANG GX. Talk about natural control of pests from harmonious and coexist between the human beings and nature [C]//ZHANG ZL. Integrated control of harmful organism in China. Beijing: China Agricultural Science and Technology Press, 1996. (in Chinese).
- [8] JIANG HY, WANG QB. Contents of estimation on values of service function of forest ecological systems [J]. Liaoning Forestry Science and Technology, 2003(5):27–30. (in Chinese).
- [9] ZHOU XF. Forest ecological functions and management countermeasures [M]. Beijing: China Forestry Press, 1999. (in Chinese).

林业多功能货币价值测度研究——以贵州省丹寨县为例

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摘要 林业是农业的一个重要组成部分, 不仅具有一般农业的基础功能, 还具有丰富而特殊的多功能性。以贵州省丹寨县为例, 在介绍林业功能价值评估意义的基础上, 从林业的实物生产价值(林业及林副产品生产功能)、生态服务价值(涵养水源, 防洪减灾功能; 水土保持, 粮食增产功能; 固碳释氧, 净化空气功能)、社会服务价值(就业增收, 景观游憩功能)3方面介绍了丹寨县林业功能, 并采用国际上比较成熟的替代成本法(RCM)、分类估价法(CVM)和旅行成本法(TCM)对上述功能的货币价值进行数量研究。结论表明, 林业生产价值为1 971.26万元; 涵养水源、防洪减灾功能价值11 100万元, 是林业生产价值的5.63倍; 水土保持、增肥增产功能价值16 010.15万元, 是林业生产价值的8.12倍; 固碳释氧、净化空气功能价值11 2662.41万元, 是林业生产价值的57.15倍; 就业增收、景观游憩价值538万元, 是林业生产价值的0.27倍。鉴于林业重要的外部作用, 建议政府在政策制定过程中考虑到林业丰富的多功能性, 以促进林业的有效开发和农业持续发展。

关键词 林业多功能; 货币价值; 估价