Advance Journal of Food Science and Technology 5(9): 1163-1167, 2013
DOI:10.19026/ajfst.5.3076
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: May 12, 2013 Accepted: June 25, 2013 Published: September 05, 2013

Research Article

Evaluation on *Phyllostachys Pubescens* Forest Ecosystem Services Value in Suichang County

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Abstract: In order to reflect the ecological benefits of Moso bamboo forest (*Phyllostachys pubescens*), based on the method of "The assessment of Forest Ecosystem Services in China", assessing Moso bamboo forest ecosystem services value in Suichang County. Moso bamboo forest ecosystem services value are divided into six groups: water storage, soil conservation, C fixation and O_2 release, nutrients accumulation, environment purification, biodiversity conservation in this study. Chinese Fir Plantation as the control was to compare. The results showed that: (1) The total value of Moso bamboo forest ecosystem services in Suichang County was 1260.40 million yuan/a, services values of water storage, soil conservation, C fixation and O_2 release, nutrients accumulation, environment purification, biodiversity conservation were respectively 741.00 million yuan/a, 81.00 million yuan/a, 331.00 million yuan/a, 21.6 million yuan/a, 32.2 million yuan/a ,53.6 million yuan/a. (2) The total value of Moso bamboo forest ecosystem services in Suichang County has increased 302.80 million yuan/a, the growth was about 31.62%. (3) In the six groups, all of Moso bamboo ecosystem services value more than the same area of Chinese Fir forest plantation. These provide a reference basis for the similar region to evaluate Moso bamboo ecosystem services value, demonstrating the important contribution of Moso bamboo to the forest ecosystem of Suichang County's sustainable development.

Keywords: Chinese fir forest, ecosystem services value, evaluation, moso bamboo forest (*phyllostachys pubescens*), suichang county

INTRODUCTION

The forest ecosystem service function refers to the forest ecosystems and ecological processes that formed and maintained by the natural environmental conditions and their effectiveness for human survival and the forest ecological system has special ecological significance to maintain the natural ecological system pattern, function and process. Therefore, objective evaluation of forest ecosystem services function is of great significance to the study of forest resources protection and science (Daily, 1997; Zhao *et al*., 2004). Forest ecosystem as the most complicated ecosystem on land and evaluation for its service function has become a hot global research in recent years. Internal research of soil and water conservation since the 1980s (Guo *et al*., 2008). The study on the forest ecosystem services function mainly in natural forest and ecological forest at present (Zhang *et al*., 2011; Zhao *et al*., 2012; Wang *et al*., 2012a, b, c), less in Moso bamboo forest. It is the one of the bamboo and provided with economic, ecological, social benefits (Jin, 2006; Pan *et al*., 2010). Generally there is no literature, evaluation on Moso bamboo forest ecosystem service function value mainly focused on the single service function of ecological system in the territory of Zhejiang and there is not the comprehensive evaluation. The author tried to make an investigation on 9 indicators of 6 ecosystem services in Moso bamboo forest. In order to get the total value of ecosystem services and survey for 6 ecosystem services value which one has the highest benefits in Suichang county. It provided a reference basis for the similar region to evaluate and analysis Moso bamboo forest ecosystem services value.

MATERIALS AND METHODS

Study sites: Suichang county is located in the southwest of Zhejiang Province, located in the source of the Oujiang and the Qian Tang River and Wuyi,

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Songyang County in the East, Longquan City and Pucheng County in the south, Jiangshan City in the west, Quzhou City in the northwest, Longyou, Jinhua City in the north. Between east longitude 118°41′-119°30′ north latitude 28°13′-18°49′. Suichang county is a typical mountainous county, because of mountains are greater than the sum of low mountains, hills, plains and known as "9 hills half water half minutes of cropland", its elevation in 153-1724.2 m. There has a pleasure climate that is subtropical monsoon type and climate differences are distinct in mountains. Average annual precipitation is 1510 mm, annual average temperature of 16.8°C relative humidity 80%, red soil and yellow soil in the main. The total land area is 254000 hm^2, forest area of 209000 hm^2, forest coverage rate of 82.3% in the Suichang County. Moso bamboo forest area is 17900 hm^2, accounted for 8.54% in the main forest types.

Data sources:

- Forestry Bureau in Suichang County investigated and monitored data and collected Moso bamboo forest data in the surrounding cities
- According to specifications for assessment of forest ecosystem service function (LY/T 1721-2008) by forestry industry standard of the people's Republic of China (SFB, 2008). We used its 11 public data which issued by the relevant authority

Evaluate forest ecosystem services value method: Evaluation on Moso bamboo forest ecosystem services value in Suichang County, mainly referring to "Specifications for assessment of forest ecosystem service function" (LY/T 1721-2008) and "The assessment of forest ecosystem services in China "(SFB, 2008), included six ecosystem service function such as water storage, soil conservation, C fixation and O_2 release, nutrients accumulation, environment purification, biodiversity conservation, a total of 9 indicators. Besides, the anion index to reflect environment purification. Forest ecosystem services of annual total value by 6 the value of ecosystem service function is showed as a sum.

Water storage: The value of water storage consisted of the value of forest adjust water and purify water:

- The value of forest adjust water:

$$U_A = 10\ CA\ (V_1+V_2+V_3) \quad (1)$$

- The value of forest purify water:

$$U_P = 10\ KA\ (V_1+V_2+V_3) \quad (2)$$

The value of forest water storage:

$$U = U_A+U_P$$

where,

V_1 : The canopy interception water storage capacity (mm/a)
V_2 : The litter lays water storage capacity (mm/a)
V_3 : Non capillary porosity water storage capacity (mm/a)
A : Area (hm^2)
C : The cost of reservoir capacity (Public data is 6.110 yuan/m^3)
K : The cost of water purification (Public data is 2.09 yuan/t)
U : The value of forest water storage (yuan/a)
U_A : The value of forest adjust water (yuan/a)
U_P : The value of forest purify water (yuan/a)

Soil conservation: Forest soil conservation consisted of forest soil fixing and forest fertility conservation:

- The value of forest soil fixing:

$$U_S = AC(X_2-X_1)/\rho \quad (3)$$

- The value of forest fertility conservation:

$$U_F = A(X_2-X_1)\ (NC_1/R_1+PC_1/R_2+KC_2/R_3+MC_3)$$

where,

U_S : The annual value of forest soil fixing (yuan/a)
X_1 : Soil erosion modulus (t/hm^2/a)
X_2 : Non forest land soil erosion modulus (t/hm^2.a)
A : Area (hm^2)
C : The costs of earthwork excavation and transportation (Public data is 12.6 yuan/m^3)
ρ : Soil bulk density (t/m^3)
U_F : The annual value of forest fertility conservation (yuan/a)
N : Soil N content (%)
P : Soil P content (%)
K : Soil K content (%)
M : Soil organic matter mass fraction (%)
R_1 : Diammonium phosphate N content (%)
R_2 : Diammonium phosphate P content (%)
R_3 : Potassium chloride K content (%)
C_1 : The price of Diammonium phosphate (Public data is 2400 yuan/t)
C_2 : The price of Potassium chloride (Public data is 2200 yuan/t)
C_3 : The price of organic matter (Public data is 320 yuan/t)

C fixation and O_2 release:

- The value of forest C fixation:

$$U_c = AC_c (1.63R_cB + F_c) \quad (4)$$

- The value of forest O_2 release:

$$U_{o2} = 1.19C_{o2}AB \quad (5)$$

where,
U_c : The annual value of forest C fixation (yuan/a)
B : Forest net productivity (t/hm^2.a)
F_c : Per unit area of forest carbon sequestration in soil (t/hm^2.a)
C_c : The price of C fixation (Public data is 1200 yuan/t)
R_c : Carbon content in carbon dioxide (Public data is 27.27%)
A : Area (hm^2)
U_{o2} : The annual value of forest O_2 release (yuan/a)
C_{o2} : The price of O_2 (Public data is 1000 yuan/t)

Nutrients accumulation: The calculation of nutrients accumulation value converted into potassium chloride fertilizer and Diammonium phosphate fertilizer method. The value of forest nutrients accumulation:

$$U_N = AB (N_NC_1/R_1+P_NC_1/R_2+K_NC_2/R_3) \quad (6)$$

where,
U_N : The value of forest nutrients accumulation (yuan/a)
B : Forest net productivity (t/hm^2.a)
N_N : Forest N content (%)
P_N : Forest P content (%)
K_N : Forest K content (%)
R_1 : Diammonium phosphate N content (Public data is 14%)
R_2 : Diammonium phosphate P content (Public data is 15.01%)
R_3 : Potassium chloride K content (Public data is 50%)
C_1 : The price of Diammonium phosphate fertilizer (Public data is 2400 yuan/t)
C_2 : The price of potassium chloride fertilizer (Public data is 2200 yuan/t)
A : Area (hm^2)

Environment purification: The value of anion is to reflect the value of environment purification. According to the negative oxygen ion generator in Taizhou Kelida electronic limited company of Zhejiang province infer anion life is 10 min, each producing 1018 anion for the cost of 5.8185 yuan (The range of 30 m^2, Power 6W, Anion concentration of 100000/cm^3, Life is 10 a, The price is 65 yuan one, Model for the KLD 2000:
The annual value of anion:

$$U_a = 5.256\times5.8158/1018\times AH (Q_a-600)/L \quad (7)$$

where,
U_a : The annual value of forest anion (yuan/a)
Q_a : The concentration of forest anion (cm^{-3})
L : The anion life (min)
H : Forest height (m)
A : Area (hm^2)

Biodiversity conservation: Selection of species conservation index is to reflect forest biodiversity conservation. Using the Shannon-Wiener index is to calculate the value of biodiversity conservation.
The annual value of forest biodiversity conservation:

$$U_B = S_BA \quad (8)$$

where,
U_B : The annual value of forest biodiversity conservation (yuan/a)
S_B : Unit area the cost of species loss (yuan/hm^2.a)
A : Area (hm^2)

RESULTS

According to the above method (SFB, 2008), the research results showed that Moso bamboo forest five years before and after comparison of ecosystem services value in Suichang County (Table 1).

Water storage: Effects of forest water storage has three factors (that is he canopy interception, litter water storage, soil storage capacity) (Xiao *et al*., 2009), by measuring the three levels of water capacity was Moso bamboo forest the amount of water conservation in Suichang County. Due to large bamboo forest distribution area rainfall and high density, wide spreading, multiple levels and bamboo forest canopy interception efficiency is better (Ma and Liu, 2009). Moso bamboo forest canopy interception amount 252.51 mm/hm^2, slightly higher than the same type research (Li *et al*., 2011; Wang *et al*., 2008; Huang *et al*., 2009). The Moso bamboo forest litter water volume is 4.13 mm/hm^2, soil water storage capacity of 248.89 mm/hm^2. According to Eq. (1) (2) calculated that the annual value of forest adjust water and purify water were respectively 552.00 million yuan and 189.00 million yuan. In that way, the annual value of Moso bamboo forest water storage was 741.00 million yuan.

Soil conservation: Bamboo has a strong root system network, make bamboo forest soil structure is good, make soil erosion resistance performance enhancements (Ma and Liu, 2009) and rich litter layer can avoid rain splash erosion and runoff (Wang and Chen, 2010). Due to soil organic matter accumulation effect is greater than decomposition effect and thus Moso bamboo

Table 1: Moso banboo forest five years before and after comparison of ecosystem services value

Ecosystem services	2010/million yuan/a	2005/ million yuan/a	Growth rate/%
Water storage	741.000	505.9	46.47
Soil conservation	81.0000	68.20	18.77
C fixation and 0_2 release	331.000	281.9	17.42
Nutrients accumulation	21.0000	18.30	18.03
Environment purification	32.0000	30.60	5.230
Biodiversity conservation	53.0000	52.70	1.710
Total	1260.40	957.6	31.62

Table 2: Classification and the magnitude of value of the Shannon-Wiener index

Rank	Shannon-wiener index	Price (yuan/hm^2.a)
I	N≥6	50000
II	5≤N≤6	40000
III	4≤N≤5	30000
IV	3≤N≤4	20000
V	2≤N≤3	10000
VI	1≤N≤2	5000
VII	N≤1	3000

forest has stronger ability of soil conservation (Jiang *et al*., 2008). According to Eq. (3) calculated that the annual value of forest soil fixing and fertility conservation were respectively 7.50 million yuan and 73.50 million yuan. In that way, the annual value of Moso bamboo forest soil conservation was 81.00 million yuan.

C fixation and O_2 release: The particularity of bamboo root makes Moso bamboo forest area each year to increasing at the rate of 3%. Moso bamboo forest not only can absorb carbon dioxide, still can release 35% more oxygen than other plants. This means that the bamboo forest carbon sinks is a constantly expanding, has high value of carbon fixation oxygen release (Zhou *et al*., 2010). According to Eq. (4), (5) calculated that the annual value of forest carbon fixation and oxygen release were respectively 113.00 million yuan and 218.00 million yuan. In that way, the annual value of Moso bamboo forest carbon fixation and oxygen release were 331.00 million yuan.

Nutrients accumulation: According to the increase NPK content of Moso bamboo forest and Eq. (6) calculated that the annual value of forest nutrients accumulation was 21.60 million yuan.

Environment purification: According to the anion quantity of Moso bamboo forest and Eq. (7) calculated that the annual value of forest environment purification was 32.20 million yuan.

Biodiversity conservation: The Shannon-Wiener index of Moso bamboo forest in Suichang County was 0.28 and its rank was VII. According to Eq. (8) and Table 2 calculated that the annual value of forest biodiversity conservation was 53.60 million yuan.

The change trend of ecosystem services value:

- Moso bamboo forest ecosystem services value in Suichang County was 1260.40 million yuan and up 31.62% over five years ago (Table 1). By Moso bamboo forest five years of growth, the 6 ecosystem services value has increased, one of the biggest growth for water storage function, accounting for 43.18% of the total growth. Function of water storage efficiency is the fastest and Moso bamboo forest growth has promoting effect on it in the local Moso bamboo forest ecosystem service function. At the same time, the local Moso bamboo forest six ecosystem services value increase with forest stand growth, expanding forest land area.
- Research in Chinese fir forest on the same test with the region at the same time, the local Chinese fir forest ecosystem services value is higher than the Moso bamboo forest there, this is due to the area of Chinese fir forest area is more than Moso bamboo

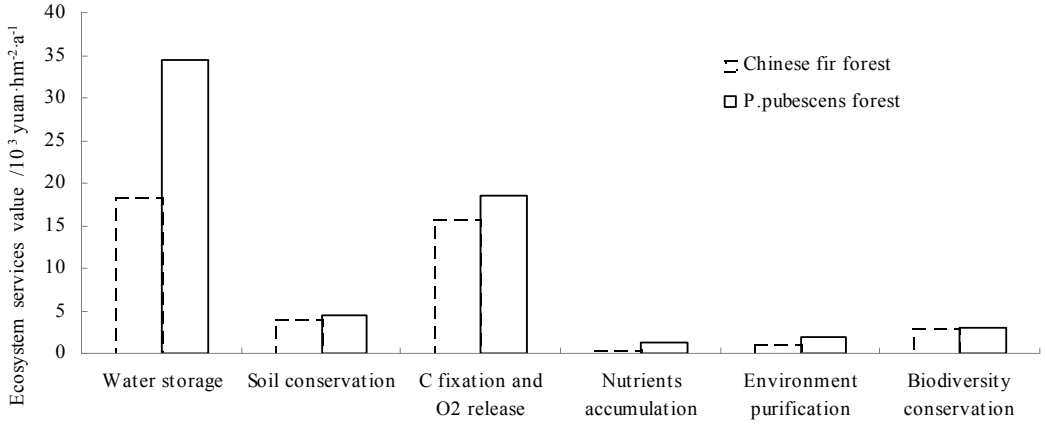

Fig. 1: The comparison of P. pubecens and Chinese fir forest ecosystem services value in Siuchang county

forest area. As is showed in the Fig. 1, unit area Moso bamboo forest ecosystem services value of water storage, soil conservation, C fixation and O_2 release, nutrients accumulation, environment purification, biodiversity conservation were Chinese fir forest ecosystem services value of 1.89, 1.09, 1.18, 2.28, 1.56 and1 times, respectively.

CONCLUSION

- Our calculations show that the value of water storage was far great than the others and its value was respectively C fixation and O_2 release, soil conservation, biodiversity conservation, environment purification, nutrients accumulation value of 2.24, 9.15, 13.82, 23.01, 34.30 times, respectively. This shows that water storage value in the value of ecosystem services was an important role in the local Moso bamboo forest.
- The sum of water storage and C fixation and O_2 release value account for more than 85% Moso bamboo forest ecosystem services value in Suichang County. Both of this was 5.69 times the sum of the others. Hence, increases in Moso bamboo forest production will protect the Qiantang River and Oujiang River and likely be good for ecological tourism.
- Unit area Moso bamboo forest was more than Chinese fir forest in six ecosystem services value, demonstrating the ecosystem services value of local Moso bamboo forest was better than Chinese fir forest. Reflect the greatest advantage in terms of nutrients accumulation value.

ACKNOWLEDGMENT

The authors thank the National Natural Science Foundation of China (31270497, 30972397) for support.

REFERENCES

Daily, G., 1997. What Are Ecosystem Services? In: Daily, G. (Ed.), Natures Services: Societal Dependence on Natural Ecosystems. Island Press, Wahsington, DC, pp: 1-10.

Guo, H., B. Wang, X.Q. Ma, G.D. Zhao and S.N. Li, 2008. Evaluation of ecosystem services of Chinese pine forests in China. Sci. China Ser. C, 51(7): 662-670.

Huang, J., J.Y. Zhang, J.C. Zhang, *et al*., 2009. Eco-hydrological effects of secondary bamboo forest (*Phyllostachyse dulis*) canopy and its influence factors in North subtropics. Bull. Soil Water Conserv., 29(1): 23-27.

Jiang, J.M., W.S. Zhu, G.H. Liu, F. Shi-Ming and C. Xiu-Ming, 2008. Soil fertility in a Phyllostachys pubescens forest of southern Sichuan. J. Zhejiang Forest. Coll., 25(4): 486-490.

Jin, A.W., 2006. Modern Phyllostachys Edulis Cultivation and Propagation: Problems and Methods. China Agricultural Press, Beijing.

Li, H.F., X.W. Liu, J.Y. Wang, T. Dongming, L. Guangping, *et al*., 2011. Study on water conservation function Moso bamboo forest in Mao'er mountain, Guangxi. Guizhou Forest. Sci. Technol., 39(2): 22-25.

Ma, J.G. and Y.Q. Liu, 2009. The summary of study on the water and soil conservation benefit of bamboos. J. Yunnan Univ., 31(S1): 350-354.

Pan, C.X., X.T. Li and Y.L. Lv, 2010. Resources and biomass of phyllostachys heterocycla cv. pubescens in Anji. J. ZheJiang For. Sci. Tech., 30(1): 82-84.

SFB (State Forestry Bureau), 2008. Specifications for Assessment of Forest Ecosystem Service Function (LY/T 1721-2008) [S]. Standards Press of China, Beijing.

Wang, S.L. and C.Y. Chen, 2010. Forest Litter Ecology. Science Press, Beijing.

Wang, Y.H., W.F. Song and C.J. Li, 2008. Study on crown interception effect of different forest canopies. Subtrop. Soil Water Conserv., 20(3): 5-10.

Wang, Y.Z., X.Z. Feng and Y.N. Qu, 2012a. Evaluation on forest ecosystem services value in Lao Mountain. Shandong Forest. Sci. Technol., 199(2): 57-59.

Wang, S.L., X.D. Liu, J.H. Wang, *et al*. 2012b. Evaluation on forest ecosystem services value in Gansu province. J. Arid Land Resour. Environ., 26(3): 139-145.

Wang, Z.J., P. Li, Y.F. Wang, *et al*., 2012c. Service function valuation and analysis forest ecosystem in Nanyang. J. Chin. Urban Forest., 10(2): 29-31.

Xiao, J.W., W.X. Kang and S.H. Yin, 2009. Natural purification function of urban forest in Changsha and evaluation on it's value. J. ZheJiang For. Sci. Tech., 29(6): 71-75.

Zhang, Q.L., L. Chun, T. Wu, *et al*., 2011. Evaluation for forest ecosystem service functions of Manhan mountain in Inner Mongolia. J. Central South Univ. Forest. Tech., 31(12): 43-48.

Zhao, T.Q., Z.Y. Ouyang, H. Zheng, *et al*., 2004. Forest ecosystem services and their valuation in China. J. Nat. Resour., 19(4): 480-491.

Zhao, Z.B., K.G. Li, G.J. Zeng, *et al*., 2012. Evaluation of forest ecosystem services values in Qin Huangdao. J. Arid Land Resour. Environ., 26(2): 31-35.

Zhou, G.M., P.K. Jiang and Q.F. Xu, 2010. Bamboo Forest Ecosystem Carbon Fixation and Transformation. Science Press, Beijing.