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 O2 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 O2 release, nutrients accumulation, environment purification, biodiversity conservation were respectively 741.00 million yuan/a, 81.00 million yuan/a, 21.6 million yuan/a, 23.2 million yuan/a, 331.00 million yuan/a, 353.6 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,
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 1538-1724.2 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 hm², forest area of 209000 hm², forest coverage rate of 82.3% in the Suichang County. Moso bamboo forest area is 17900 hm², 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

### Evaluating forest ecosystem service 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 O₂ 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:
  \[ U_A = 10CA(V_1 + V_2 + V_3) \]  
- The value of forest purify water:
  \[ U_P = 10KA(V_1 + V_2 + V_3) \]

### Soil conservation: Forest soil conservation consisted of forest soil fixing and forest fertility conservation:
- The value of forest soil fixing:
  \[ U_S = \frac{AC(X_2 - X_1)}{\rho} \]  
- The value of forest fertility conservation:
  \[ U_F = A(X_2 - X_1)(NC_1/R_1 + PC_1/R_2 + KC_2/R_3 + MC_3) \]

### C fixation and O₂ release:
- 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 (hm²)
- \( C \): The cost of reservoir capacity (Public data is 6.110 yuan/m³)
- \( K \): 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)
• The value of forest C fixation:

\[ U_c = AC_c (1.63R+B + F_c) \quad (4) \]

where,
- \( U_c \): The annual value of forest C fixation (yuan/a)
- \( B \): Forest net productivity (t/hm².a)
- \( F_c \): Per unit area of forest carbon sequestration in soil (t/hm².a)
- \( C_c \): The price of C fixation (Public data is 1200 yuan/t)
- \( R \): Carbon content in carbon dioxide (Public data is 27.27%)
- \( A \): Unit area (hm²)
- \( U_{o2} \): The annual value of forest O₂ release (yuan/a)
- \( C_{o2} \): The price of O₂ (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:

\[ U_N = AB (N_2C_1/R_1 + P_2C_1/R_2 + K_2C_1/R_3) \quad (6) \]

where,
- \( U_N \): The value of forest nutrients accumulation (yuan/a)
- \( B \): Forest net productivity (t/hm².a)
- \( N_2 \): Forest N content (%)n
- \( P_2 \): Forest P content (%)
- \( K_2 \): Forest K content (%)
- \( R_1 \): Diammonium phosphate N content (Public data is 14%)n
- \( R_2 \): Diammonium phosphate P content (Public data is 15.01%)n
- \( R_3 \): Potassium chloride K content (Public data is 50%)n
- \( C_1 \): 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 (hm²)

**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 m³, Power 6W, Anion concentration of 100000/cm³, Life is 10 a, The price is 65 yuan one, Model for the KLD 2000: The annual value of anion:

\[ U_a = 5.256 \times 5.8158/1018 \times AH (Q_2 \times 600)/L \quad (7) \]
Table 1: Moso bamboo forest five years before and after comparison of ecosystem services value

<table>
<thead>
<tr>
<th>Ecosystem services</th>
<th>2010/million yuan/a</th>
<th>2005/million yuan/a</th>
<th>Growth rate/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water storage</td>
<td>741.000</td>
<td>505.9</td>
<td>46.47</td>
</tr>
<tr>
<td>Soil conservation</td>
<td>81.0000</td>
<td>68.20</td>
<td>18.77</td>
</tr>
<tr>
<td>C fixation and O₂ release</td>
<td>331.000</td>
<td>281.9</td>
<td>17.42</td>
</tr>
<tr>
<td>Nutrients accumulation</td>
<td>21.0000</td>
<td>18.30</td>
<td>18.03</td>
</tr>
<tr>
<td>Environment purification</td>
<td>32.0000</td>
<td>30.60</td>
<td>5.230</td>
</tr>
<tr>
<td>Biodiversity conservation</td>
<td>53.0000</td>
<td>52.70</td>
<td>1.710</td>
</tr>
<tr>
<td>Total</td>
<td>1260.40</td>
<td>957.6</td>
<td>31.62</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Rank</th>
<th>Shannon-wiener index</th>
<th>Price (yuan/hm²·a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>N≥6</td>
<td>50000</td>
</tr>
<tr>
<td>II</td>
<td>5≤N≤6</td>
<td>40000</td>
</tr>
<tr>
<td>III</td>
<td>4≤N≤5</td>
<td>30000</td>
</tr>
<tr>
<td>IV</td>
<td>3≤N≤4</td>
<td>20000</td>
</tr>
<tr>
<td>V</td>
<td>2≤N≤3</td>
<td>10000</td>
</tr>
<tr>
<td>VI</td>
<td>1≤N≤2</td>
<td>5000</td>
</tr>
<tr>
<td>VII</td>
<td>N≤1</td>
<td>3000</td>
</tr>
</tbody>
</table>

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 O₂ 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.
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 and 1 times, respectively.

**CONCLUSION**

- Our calculations show that the value of water storage was far greater 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.

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