Structural characteristics of mixed plantation of pinus massoniana and oak in danjiangkou reservoir area

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Abstract. In this paper, the frequency distribution of DBH and DBH of masson pine and oak trees in mixed forest was simulated by using normal distribution, and the relationship between DBH and tree height was fitted by 11 common curve models. The power model can well simulate the relationship between DBH and tree height.

1. Introduction
The structural characteristics of stand are the basis and expression of stand function. The law of stand structure is a theory to solve a series of forest management problems. It is one of the most important links in forest management, for tree growth, forest regeneration, biodiversity and forest succession has a direct impact. Therefore, the problem of forest structure is always the difficulty in forestry research.

Danjiangkou reservoir is an important strategic water resource area in China, which is the source and protection area of water resources in the middle route project. Forest vegetation plays an important role in water conservation and water purification. At present, the common forest types in the reservoir area include: masson pine, oak tree, lateral cypress, citrus, etc. As the main forest type of ecological forest, the masson pine and oak tree are widely distributed in Danjiangkou reservoir area. The study on the forest structure of masson pine and oak mixed plantation can not only understand the current situation of the stand, but also lay a foundation for the further adjustment of the stand structure and give full play to its role in water conservation and water purification.

2. Overview of the research area
This study is located in longkou forest farm of danjiangkou city (110°48' ~ 111°35' E, 32°14' ~ 32°58' N) in the middle line of the south-to-north water diversion project. The weather is a subtropical semi-humid monsoon climate, and has features as: four distinct seasons, mild climate, sufficient sunlight, rich in heat, rain and heat in the same season, long frost-free period and so on.

The annual average temperature is 15.9℃, the maximum extreme temperature is 41.5℃, and the minimum extreme temperature is 12.4℃. The annual rainfall ranges from 750mm to 900mm, among which January has the least rainfall, June to September has the most. The average annual rainfall is 123d, the annual evaporation is 1979.1mm, the annual sunshine hours are about 2009.6h to 2059.7h, and the frost-free period is 180 to 250d. Landform types are mainly low hills and hills, most of the soil
is yellow brown soil and yellow soil, and the parent material of the soil is developed from limestone, gneiss and so on, with loose texture.

The forest type in the reservoir area consists of plantation and secondary forest. The dominant trees are mainly Pinus massoniana, and the secondary dominant trees include Quercus variabilis, Cupressus funebris, Citrus reancon, etc. Species of undergrowth vegetation were basically similar, among which Ziziphus jujuba, Zanthoxylum bungeanum and Sophora davidii were dominant species. Herb in order along the grass (Ophiopogon bodinieri), presses the grass (Oxalis corniculata), Imperata cylindrica (Imperata cylindrica), winding stone (Trachelospermum jasminoides) etc as the dominant population.

3. Research methods
In September 2018, a typical mixed forest of masson's pine and oak trees was selected in the research area, and 6 20m*20m quadrats were set up to measure the DBH, tree height and crown width of each wood with a measuring scale. Among them, 319 oak trees and 243 masson's pine trees, a total of 562.

SPSS software was used to simulate whether the distribution of DBH and tree height conforms to the normal distribution, and then the relationship between DBH and tree height, DBH and crown width was fitted with different curve models.

| Models        | Equation                               |
|---------------|----------------------------------------|
| Linear        | $Y = \beta_0 + \beta_1 x$             |
| Quadratic     | $Y = \beta_0 + \beta_1 x + \beta_2 x^2$ |
| Compound      | $Y = \beta_0 + \beta_1 x$             |
| Growth        | $Y = e^{\beta_0 + \beta_1 x}$         |
| Logarithmic   | $Y = \beta_0 + \beta_1 \ln(x)$        |
| Cubic         | $Y = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3$ |
| S             | $Y = e^{\beta_0 + \beta_1 / x}$       |
| Exponential   | $Y = \beta_0 e^{\beta_1 x}$           |
| Inverse       | $Y = \beta_0 + \beta_1 / x$           |
| Power         | $Y = \beta_0 (x^{\beta_1})$           |
| Logistic      | $Y = 1 / (1 + e^{\beta_0 \beta_1 x})$ |

4. Results analysis

4.1 Tree height and DBH distribution of mixed forests were fitted

![Histogram of DBH and Tree Height](image1)

![Histogram of DBH and Tree Height](image2)
Figure 1. H and DBH frequency of mixed forest

As can be seen from figure 1, the DBH and tree height of oak and masson pine were well in line with the normal distribution. The mean DBH of masson pine was 15.24±3.9 cm, the skewness was 0.48±0.15, the maximum DBH was 30.2 cm, and the minimum DBH was 6.6 cm. The mean tree height was 10.19±2.17 m, and the skewness was 0.58±0.15. Kurtosis is 0.07±0.31, the maximum value of tree height is 16.7 m, and the minimum value is 6.3 m. The mean DBH of oak was 10.1±3.2 cm, skewness 0.2±0.14, kurtosis 0.56±0.27, the maximum DBH and the minimum DBH were 20.4 cm and 3.3 cm respectively. The mean tree height was 8.91±2.69 m, and the skewness was 0.58±0.13. Kurtosis is 0.13±0.27, the maximum value of tree height is 17.3 m, and the minimum value is 3 m.

4.2 Relationship between tree height and DBH in mixed forest

Figure 2. Curve fitting of tree height and DBH of masson pine and oak mixed forest

It can be seen from figure 2 that the fitting effect of the curve of height and DBH of pine in horsetail is not very well, R2<0.2. The curve fitting effect of tree height and DBH of the oak tree was ideal, and the power model was the best one (R2=0.525, P<0.01), β0=1.997, β1=0.645.

5. Discussion

In this paper, normal distribution was used to simulate the frequency distribution of DBH and DBH of oak plantation, and 11 common curve models were used to fit the relationship between DBH and tree height. Diameter and tree height are the most important factors for forest survey, while in field survey, diameter is easy to be measured, with high precision and high speed. Through this study, the relationship function between tree height and DBH is obtained. In the future field investigation, some tree height values can be measured, and the tree height value can be calculated through the research function. Therefore, it is necessary to build a simple and accurate relationship model between tree
height and DBH for more effective forestry management.

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