Effects of Thinning Intensity on the SBE in Different Types Stand

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With 5 main types of stand in Nanjing WuXiangsi National Forest Park being objects of research, the diversity of the scenic beauty values of different thinning intensities were explored, and then the multivariate linear model of scenic beauty values and landscape elements was established. The result indicates: (1) The SBE can be greatly improved by thinning especially high-intensity; (2) Main factors of landscape quality of different stands in the study area are density, Diameter at Breast Height (DBH), canopy density etc.; (3) Better permeability, bigger DBH and tree height do improve SBE, while higher stand density and canopy density will harm scenic beauty, so we should consider the positive and negative influences of tending measures when we construct scenic forest.

Keywords: Ecological Scenic Forest, Thinning Intensity; Scenic Beauty Estimation; Estimation model

Introduction

Ecological landscape forest is one kind of forest that have high aesthetic value, and to meet the recreational needs of the people [1]. Forest park in China are mostly originated from state-owned forest farms, pay less attention to the landscape maintenance of forest for a long time. The forests in the forest park at present have many issues such as the landscape is monotonous, simple stand structure etc [2]. Therefore, how to improve the quality of landscape ecological forest is a problem to be solved.

Moreover, according to the results of forest classification operations, the majority of timber forests need to be changed into no-timber forests in China [3]. At present, a large number of scholars had applied SBE method to evaluate different types of ecological landscape forest in various regions, and established the relevant landscape model [4-8]; Some academics have studies the impaction of tending measures to forest beauty [9-11], but there was a little research about the impaction of different thinning intensities to the scenic beauty of different forest stands. Therefore, the purposes of this article is to understand the impaction of thinning to the scenic beauty of ecological landscape forest, and provide some data for the construction and management of ecological landscape forest.

Materials and Method

The research sites is in WuXiangsi National Forest Park, which located in 40km away from the downtown of Nanjing, total area is about 1 333 hm^2, with an average altitude about 100m. The soils of forest park belong to "yellow brown soil", the thickness of soils was 10~100cm with slightly acidic. Climate belong to transition zone of subtropical and temperate, annual average temperature was 15.5°C, average annual sunshine 2 146h, average annual precipitation 1 005mm, and frost-free period 220d[12].

dominated on plantations and secondary that closing hillsides to facilitate forestation in the forest park, the forest in beside of WuXiang temple age at 100a above, and consist in the elm, beech trees and other deciduous broad-leaved forest, It can be as a goals for transformation of forest park stand.

We selected five types of stands in forest park based on the standard investigation, and comprehensive consideration of site conditions and other factors such as soil thickness, slope and the rate of bare rock. design of four thinning intensities zone on the same slope, namely the zone of control, the zone of weak degree thinning (20-30%), the zone of moderate thinning (40-50%), and the zone of intensity thinning (60-70%), as fixed plots. Thinning intensity was the ratio of the timber number of thinning. The thinning was done from February to June of 2007.

In order to make photos more closer to the actual situation of the landscape, we followed the following specifications when shooting: ①avoid taken into account non-forest structure factor, such as streams, roads, equipment etc; ②as far as possible in the conditions of the forest under the shooting, do not use flash; ③photographer should upright shoot, and the lens position and eyes in general high, the direction of the lens should parallel to the slope; ④choose the time shooting between 8:00 to 16:00 to ensure a well-lit and does not produce too many shadows; ⑤all horizontal shooting instead of vertical shooting, the angle and distances of shooting was same; ⑥all select Canon PowerShot Pro1 digital camera to shoot; ⑦shoot l sheet photos in the center of each plot to four directions, and then shooting from four edges to the center of plot. If the the landscape have strong heterogeneity, should increasing the number of photographs.

The site factors need to survey in plot include the soil thickness, elevation, slope, aspect, the proportion of litter cover, the rate of bare rock etc; community structure factor include canopy density, stand density, the DBH and height of tree, average height of shrub layer, Margalef diversity index, Pielou evenness index etc, all indicators was measured by conventional forest resources investigate methods.

Studies have shown that there were no significant differences between the result of on-site and laboratory evaluation, different judges was consistency in the aesthetic attitude [4,13]. The judge use 10-point scale, values greater represents the higher of landscape quality, vice versa. selected photos were made into slides, to slide numbers after arranged in random order, prevent similar landscapes consecutive recurrence so increase judge's perception sensitivity, and record the serial of each slide. We selected 4 or 5 photos to evaluate per sample, and its average value was the beauty scale value of plots. We made a brief description to judge before judge, and reference Daniel's "standardized instructions"[4]. 90 undergraduate and graduate students were organization and undertake a professional judge, who major in forestry, ecology, gardening etc, received 82 valid responses judging table. Major steps of judge can be seen in literature [8], application SPSS software to analysis data.

Daniel etc. proposed the method of classic normal unilateral quantized calculation SBE value (referred to as normal SBE), but found that more shortcomings after analysis. In this paper, we use the method of weighted summation (referred to as the weighted SBE), the calculation formula was:

$$S_i = 10 \bullet \sum_{j=1}^{10} (\frac{n_{ij}}{N} \bullet j)$$

In the formula: S_i was the scenic beauty value of the photo i; N was the total number of evaluate; n_{ij} was the person number of scoring j points to photo number i. we comparative analysis the landscape beauty calculation methods above two method use 150 samples, and results show that there were equal reliability between the scenic beauty method of weighted and normal.

Results

Classification and statistics the SBE of landscape evaluation samples of five typical forest of four thinning intensities, the results shown in Figure 1.

On the whole(Figure 1), the scenic beauty of thinning forest higher than the control area, but intensity thinning can substantial increase scenic beauty of forest. from different types forest of view, the beauty degree change rule was not entirely consistent in different thinning intensities: pine forest, pine oak mixed forest and Chinese fir oak mixed forest showed similar changes with the mean of overall trend, namely, the intensity thinning area have highest beauty, the beauty of the area of weak and moderate thinning was no significant difference; compared with the control zone, sharpest raise of beauty degree in the Quercus mixed forest was weak thinning area, there was no significant difference between moderate thinning and intensity of thinning; while, the beauty of three degree thinning of Chinese fir was little difference.

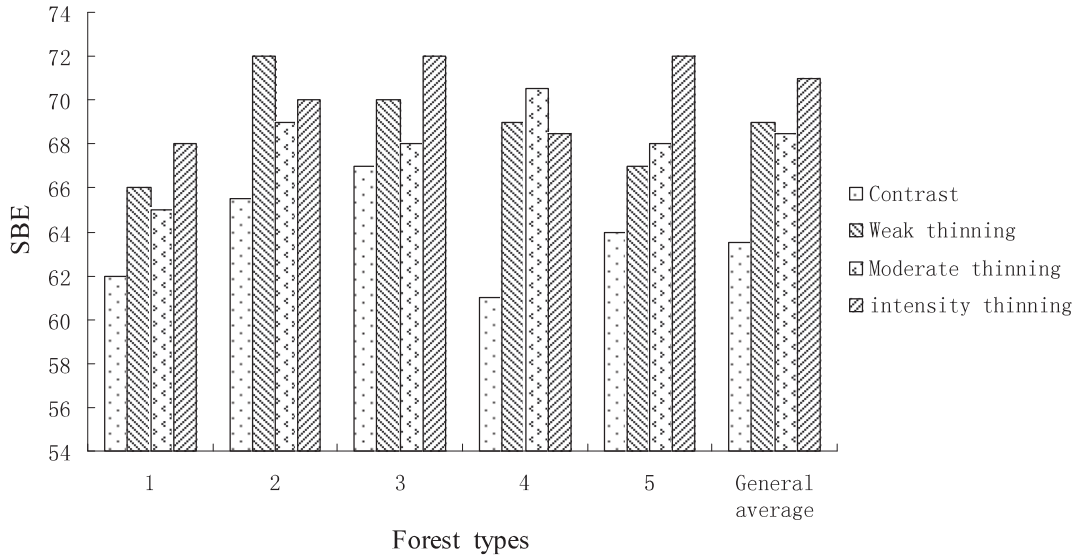

Fig.1 SBE of different thinning intensity

(**Note:**1 represent pine; 2 represent the mixed forest of sawtooth oak and Chen oak; 3 represent the mixed forest of pine and oak; 4 represent fir; 5 represent the mixed forest of fir and oak)

From the improve amplitude of beauty in different forest of view: Compared with the control area, the smallest improve in the weak degree of thinning was pine oak mixed forest, it was 3%, the largest improve was Chinese fir pure forest, it was 14%; the smallest improve in the weak degree of thinning was pine oak mixed forest, it was 1%, the largest improve was Chinese fir pure forest, it was 16%; meanwhile, the improve amplitude of beauty in intensity thinning areas were more than 7%, and a maximum was Chinese fir pure forest, it was 15%. predictably, intensity thinning can enhance the degree of forest beauty compared to weak and moderate thinning in the plot.

In order to understand the effect of thinning measures, we made paired T test to the scenic beauty of four intensities thinning samples, results show that: the difference of stand beauty between three intensities thinning zone and control zone achieve a very significant level, the difference of stand beauty between intensities thinning zone and weak, moderate thinning area achieve a very significant level, while the differences between weak thinning areas and moderate thinning zone are not significant. from this,

we can see that the difference of stand beauty between thinning area and control area was caused by the thinning, the thinning can effectively improve the beauty degree of forest. but from the absolute terms of scenic beauty of view, the weak, moderate and intensity degree of thinning area respectively were 68.5,68.0 and 70.0, and still a large gap compared to the mixed forest stands (SBE =75.3) in the park. the reason of differ beauty under different thinning intensities and the effects mechanism of thinning on the scenic beauty to be the next step.

16 factors were investigated, such as the slope, bare rock ratio, Margalef index, Pielou index, the average DBH of tree etc, and then analysis associated to stand-weighted SBE and its of 16 factors, remove the factor that correlation less than 0.1, and then stepwise regression analysis that make retain factors as independent variables, make the weighted SBE as the dependent variable, establishment the regression model between scenic beauty and impact factors:

$$y=53.395-0.022x_1+18.138x_2-11.391x_3+7.508x_4+0.453x_5-3.628x_6+0.043x_7$$

$P=0.042<0.05$ in the model using F test, and have significant statistical significance, in formula: y-weighted SBE, x1-stand density, x2-Pielou index, x3-canopy density, x4- health situation in forest, x5- average height of tree, x6-transparent degree, x7-average DBH, the standardized regression coefficients of per factor as follows: -0.510,0.224, -0.401,0.357,0.113, -0.396,0.470. the size of various factors contribution to scenic beauty can be obtain by comparing the absolute value of regression coefficients after standardization of various factors: the most influential to forest beauty is stand density, followed by the average DBH of tree, while the least impact is the average height of trees. according to survey data after thinning, shows that stand density and canopy density decreased in post-thinning, the average DBH of tree, transparent, the average height of tree was increased, regression model agreement with this trend.

Discussion

Different methods and intensity of thinning both affects on the stand beauty during the process of stand tending and management. Robert's studies shown that the measures of massive clear-cutting and thinning have a negative impact on scenic beauty of forest, the scenic beauty of rules massive clear-cutting lower than the irregular thinning, the greater of intensity of thinning, the lower of forest beauty degree[15]; Liisa Tyrväinen evaluate the simulated landscape of different treatments, the results show that the stands of shrub layer tending and adopt thinning measures have highest beauty, the scenic beauty of stand of do not take tending measures was least, but the impact magnitude of different tending measures on beauty of various stands was different[16]; Ribe, Axelsson etc. think that people are prefer the stands of tending and no traces of artificial[17-18]; the result of this study shows that the scenic beauty of forest increasing along with the intensity of thinning, which May be due to the forest of study have a higher density, and the permeability of understory was poor, stand density reducing with increased of thinning intensity, improved the shrub layer permeability and accessibility of forest, and thus the forest scenery increasing significantly[19-20].

There are many factors that affect the beauty of stands, Jia Liming as the object to pine forest in Beijing and the result of studies shown that the main factors affect the beauty of forest was shrub layer cover, canopy density, the average higher under the first live branch etc[5]. Ouyang Xunzhi etc. think that the trunk straight, richly varied colors help to improve the scenic beauty, while too high or too low of the forest density, shrub layer cover and the height of shrub layer will have a negative impact to landscape quality[6]. Zhang Zhidu etc. discusses the impact of canopy density to beauty of forest,

think that the appropriate canopy density of arborvitae and pseudoacacia forest was 0.6-0.7[21]. summarized previous studies showed that: in a certain range, the scenic beauty increased with the reduction of stand density and increasing of average DBH; the longer of perspective distance in forest, the higher of forest beauty; higher canopy density help to raise the beauty of forest; dense shrub layer will reduce the beauty of forest; the presence of logging residues reduces the forest's scenic beauty; the scenic beauty of mixed forest high than pure forest; the greater of forest age, the higher of scenic beauty[16,19-20,22-25].

From the regression model in this study of view, the scenic beauty of forest decrease with increasing of stand density and canopy density, increasing with the increases of DBH, transparent degree, uniformity and average height of tree, and increasing with the improve of forest health conditions. Stand density, average DBH and other factors consistent with the conclusions of predecessors, the factors of canopy density consistent with the research results of Jia Liming. In addition, we think that any impact factor only applies to the correlation of scenic beauty within a certain range; it will become a limiting factor after exceeding a certain range. Many factors can't established completely linear relationship with the scenic beauty, the relationship between scenic beauty and per factors to be further investigation use other methods.

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