Study on Forest Site Classification of Southern Xiaoxing'an Mountain in Northeast of China

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ABSTRACT: The principal component analysis and cluster analysis methods were used to classify the forest site type of the southern Xiaoxing'an mountain forests. The collected data sets are including vegetation types, topography, forest growth, soil and meteorological factors. Through principal components analysis，the slope position, slope degree, soil depth and soil type are selected as leading factors to classify site type district. By cluster analysis, the forest sites of the southern Xiaoxing'an mountain are classified into 10 site groups and 35 site types. The site type classification results can be used to provide technical supports for the forest management of the Xiaoxing'an mountain forests as well as the forest right system reform for Yichun Forestry Administrative Bureau.

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INTRODUCTION

Classification of forest site is the essential work of achieving the forest classification management. It has important practical and long-term strategic meanings for adjusting the structure of forests, increasing forest productivity, selecting appropriate afforestation tree species for fast-growing and high-yield plantations, increasing wood yields to ease the relationship between supply and demand, restoring forests, enhancing the availability of forest resources as well as playing the ecological function of forests.

Recently, using multiple factors to do the forest site classification is becoming more and more popular. Based on survey data of forest sample plots and using a comprehensive multi-factor such as landforms, local topography and soil factor as an indicator, the forest land of Susong County was divided to 21 site types (Zhang, 2004). The multiple factors such as soil texture, slope position and slope degree were used to classify the major introduction area of Sichuan Eucalyptus grandis into 17 site types (Ting et al., 2005). Based on field investigation and the comparison of the dominant site factors (e.g. altitude, slope aspect, slope degree, slope position, soil thickness), the Xuancheng limestone mountain natural forest land is divided into 7 site types (Qiang, 2006). According to the field survey of terrain, soil and vegetation of the tidal Kansai ditch, the factors of altitude, slope aspect, landform, soil thickness and soil texture were considered as the leading factors to classify the Kansai channel into 14 site types (He et al., 2008).

Soil is the foundation of tree growth and is one of the most important features of forest site. The Resources Division of Ministry of Forestry (1986) applied soil thickness and texture to classify Wuxiang's land type. Based on soil and topographic factors, Liu (2005) separated Liaodong mountain to 12 different site types and then selected the tree species which are most suitable for each specific site type.

Our study region is southern areas of Xiaoxing'an mountains in northeastern China. Based on the survey of forest growth, topography, vegetation, soil and meteorological factors, the principal component analysis and clustering analysis methods were used to classify the forest site type of the southern Xiaoxing' an mountain forests. Results can be used to provide technical supports for the forest management of the Xiaoxing' an mountains forests as well as the forest right system reform for Yichun Forestry Administrative Bureau.

MATERIAL AND METHODS

Study site

Xiaoxing ' an mountain is located at the north part of Heilongjiang province, China. The latitude is from 46 ° 28 ' to 49 ° 21 ' and the longitude is from 127 ° 42 ' to 130 ° 14 '. This area is belonging to the temperate continental monsoon climate zone. The four seasons are distinct with long, cold and dry winter; short spring and fall as well as warm and moist summer. Annual average temperature is between -1 ° C and 1 °C. The coldest month is January with temperature between -20 ° C and -25 ° C and the hottest month is July with temperatures from 20 ° C to 21 ° C and the extreme maximum temperature is 35 ° C. The annual activity accumulated temperature (≥ 10 ° C) is about from 1,800 to 2,400 degrees centigrade and the frost-free period lasts from 90 days to 120 days. The annual sunshine is about 2,355 to 2,400 hours. The annual precipitation is 550 and 670 mm, which is mainly concentrated in summer. The moisture index is from 1.13 to 0.92. The study region is belong to humid region.

Xiaoxing ' an mountain areas have the world's largest virgin forest of *Pinus koraiensis*, known as "The Home Of Korean Pine". There are 2.8 million hectares of forest land and the forest cover is 72.6% with total standing volume of 240 million cubic meters. The main forest type is Korean pine-broad-leaf mixed forest. Main tree species are Korean pine (*Pinus koraiensis*), Spruce (*Picea spp.*), Fir (*Abies nephrolepis*), Scotch pine (*Pinus sylvestris var mongolica*), Ash (*Fraxinus mandshurica*), Amur Corktree (*Phellodendron amurense*), Manchurian walnut (*Juglans mandshurica*), Poplar (*Populus spp.*). The timber production is 2.145 million cubic meters in 1998. At the same time, every year more than 1 million cubic meters of felling, bucking, processing residues can provide adequate raw materials for other wood utilization.

Data collection

The secondary resources database of southern Xiaoxing ' an mountains including a total of 20 Forestry Bureaus in Yichun area and the Songhua River region were collected. There are 331 permanent forest sample plots. The variables are including elevation, slope, aspect, slope position, vegetation, and soil types and so on. In addition, the vegetation, soil, weather and stand growth data were also obtained for Xiaoxing ' an mountains area and the corresponding database was created.

Methods

Due to the topography, climate, soil and zonal vegetation spatial variations, there are clearly regional differences in Xiaoxing ' an mountains leading to the different forest composition, forest potential productivity as well as forest development stages. Thus, during the process of forest site classification, in order to avoid subjective and biased classification, multiple approaches were applied to archive the results which can reflect the real variations of forest land types in the study areas. The study first uses principal component analysis on the data of 331 permanent sample plots of 20 forestry bureaus in southern Xiaoxing' an mountains. The variables used are including altitude, slope, aspect, slope position and so on. The dominant components were selected and then cluster analysis was applied to classify the 331 plots to different site types.

Dominant factor selection and quantification

The forest site classification factors mainly have two kinds. One kind is the climate index and is invisible. Another one is the geographical indicator and is tangible, such as geomorphology, altitude, soil type, plant community characteristics, and so on. In this study, the topographic factors including altitude, slope direction, slope degree and position as well as soil factors such as soil thickness and type were considered as dominant factors and applied to classify Xiaoxing' an mountains forest site types.

The selected classification factors include both quantitative and qualitative factors. As we known, the qualitative factors are not able to directly be used in statistical analysis. Therefore, the qualitative factor to different levels is need to categorize. In other words, the qualitative factors will be quantified and assigned values according to their categories/classifications. Based on the terrain of Xiaoxing ' an mountain terrain and field surveys, the categories of qualitative factors used are shown as follows:

(1) Altitude: ≤ 800 m, ＞800 m.

(2) Aspect: sunny (South, Southwest, West and Northwest), shady (South-East, East, North East, North).

(3) Slope: ≤ 5 ° (moderate slope), 6~15 ° (slope), 16~25 ° (steep slope), ≥ 26 ° (acute and steep slope).

(4) Slope position: according to contour map and altitude, the slope position is classified as up (hillside high above two-thirds), center (relative height between 1/3~2/3), down (relative height below one-third).

(5) Soil thickness: ≤50 cm (thin-layer soil), ＞ 50 cm (thick-layer). Soil thickness is the actual thickness of A+B (AB) layers.

(6) Soil texture: dark brown, brown and meadow.

The detail information about site qualitative factor classification is shown in Table 1.

Table 1. The classification of site qualitative factors.

Site factor	Classification criteria			
	1	2	3	4
Altitude	≤800 m		＞800 m	
Slope degree	≤5°	6°～15°	16°～25°	＞25°
Slope direction	Sunny		shady	
Slope position	Up	centre	down	
Soil thickness	≤50cm		＞50cm	
Soil type	dark brown	brown	meadow	

RESULTS AND DISCUSSIONS

Principal component analysis

The SPSS 16.0 software package was used to do the principal component analysis for the 331 permanent sample plots. The correlation coefficient matrix r, the principal component eigenvectors, eigenvalues and the component contribution rates are calculated. The results are shown in table 2 and table 3.

Table 2 Total variance explained.

Component	Initial Eigenvalues			Extraction Sums Of Squared Loadings		
	Total	Variance%	Cumulative%	Total	Variance%	Cumulative%
1	1.537	25.620	25.620	1.537	25.620	25.620
2	1.096	18.275	43.894	1.096	18.275	43.894
3	1.004	16.727	60.621	1.004	16.727	60.621
4	.967	16.109	76.731			
5	.797	13.290	90.021			
6	.599	9.979	100.000			

In Table 2, the first three largest eigenvalues are 1.537, 1.096 and 1.004 respectively and are all greater than 1. Thus, the cumulative variance contribution of the first three principal components is 60.621%, which indicates that the first three principal components can represent the 60.621% information of the original variables. Therefore, the first 3 principal components have been used for the site classification of the southern Xiaoxing' an mountain areas.

Table 3 Eigenvectors.

	Component		
	1	2	3
Slope direction	.610	-.487	-.152
Slope degree	-.743	.149	.086
Slope position	.665	.262	.138
Altitude	-.355	-.301	.166
Soil type	.131	-.066	.962
Soil thickness	.164	.821	-.012

As can be seen from Table 3, slope position and slope degree in the first principal component have the largest positive and negative coefficients of 0.610 and -0.743, respectively. Thus, the first principal component is a reflection of the slope position and degree. In the second principal component, the soil thickness coefficient is 0.821, which indicating the second principal component is a reflection of the thickness of soil layer index. In the same way, the third principal reflects the soil type.

According to table 3, we can obtain the following three principal components:

$$Y_1=0.610X_1-0.743X_2+0.665X_3-0.355X_4+0.131X_5+0.164X_6$$

$$Y_2=-0.487X_1+0.149X_2+0.262X_3-0.301X_4-0.066X_5+0.821X_6$$

$$Y_3=-0.152X_1+0.086X_2+0.138X_3+0.166X_4+0.962X_5-0.012X_6$$

Site type group classification

Based on the principal component analysis, summarized the data of the field survey, the characteristics of the relationship between the topography of the area, the soil, the site conditions and tree growth, vegetation distribution rule, limiting factors, and so on. The two indicators which are slope position and slope in the first principal component were used as the classification basis of area and site type group in southern Xiaoxing' an mountain. The Xiaoxing ' an mountain site district was classified into two distinct site type districts according the cluster analysis method. The two site type districts are the low mountain and hill site type district and, the hill and rolling hill site type district. According to the variation between classification variables, combined with the results of cluster analysis, the above two site type district to 8 and 2 distinct site type groups respectively (Table 4) is classified.

Table 4 Site type groups

Site type district	Site type group	Num.	Classification variables
Low mountain and hill	Subalpine	1	> 800 m mountain
	Top mountain	2	Wide ridge with round top mountain
	Middle slope	3	16 ° ~ 25 ° slope
	Lower slope	4	16 ° ~ 25 ° downhill
	Middle slope	5	6 ° ~ 15 ° slope
	Under gentle slope	6	6 ° ~ 15 ° downhill
	Valley forest	7	<5 ° foothills
	Valley meadows shrub	8	Meadow , shrub in the valley <5 °
Hill and rolling hill	Hill	1	> 25 ° uphill
	Rolling hill	2	16 ° ~ 25 ° uphill

Site type classification

Site type group to site type within each site type group is further classified. According to the results of the principal components analysis and site type group classification, soil thickness and type were considered as leading factors for site type classification. By cluster analysis for each site type group, each site type group to different site types is classified. Here, the cluster analysis results for the valley forest site type group and rolling hill site type group were showed in Figure 1 and Figure 2 respectively. The SPSS 16.0 software package was used to carry out cluster analysis. The distance between classes was calculated as the sum of squares of deviations, which is one of the mostly common used methods for distance measurement for cluster analysis. Basically, the subjects within the same class will have smaller sum of squares of deviations than the subjects between different classes.

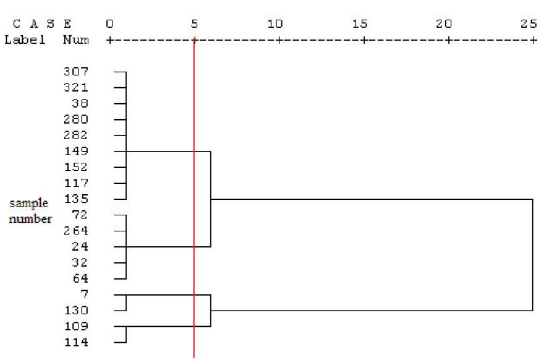

Fig. 1 The pedigree for the valley forest site type group

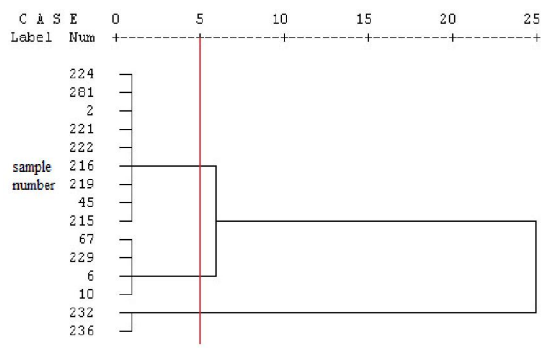

Fig. 2 The pedigree for the rolling hill site type group.

In the clustering result, the appropriate threshold value of sum of squares of deviations/distance should be selected. A large threshold value will lead to fewer classes, which may not reflect the detail differences between site types. While, a small threshold value will produce more detail classes and thus, the classification results may not useful in practice. The threshold value of 5 was selected and applied to do the cluster analysis. In addition, the field survey data was also considered to adjust the classification results. The final site type classification results were showed in Table 5.

Table 5 Site type classification for southern Xiaoxing ' an mountain.

Site type district	Site type group	Site type
Low mountain and hilly	Subalpine	Thin layer of dark brown soil
		Thin layer of brown soil
		Thick layer of dark brown soil
		Thick layer of brown soil
	Top mountain	Thin layer of dark brown soil
		Thin layer of brown soil
		Thick layer of dark brown soil
		Thick layer of brown soil
	Middle slope	Thin layer of dark brown soil
		Thin layer of brown soil
	Lower slope	Thin layer of dark brown soil
		Thin layer of brown soil
		Thick layer of dark brown soil
		Thick layer of brown soil
	Middle slope	Thin layer of dark brown soil
		Thin layer of brown soil
		Thick layer of dark brown soil
		Thick layer of brown soil
	Under gentle slope	Thin layer of dark brown soil
		Thin layer of brown soil
		Thick layer of brown soil
	Valley forest	Thin layer of dark brown soil
		Thin layer of brown soil
		Thick layer of dark brown soil
		Thick layer of brown soil
	Valley meadows shrub	Thin layer of dark brown soil
		Thin layer of brown soil
		Thin meadow soil
		Thick layer of dark brown soil
		Thick layer of brown soil
Hill and rolling hill	Hill	Thin layer of dark brown soil
		Thin layer of brown soil
	Rolling hill	Thin layer of dark brown soil
		Thin layer of brown soil
		Thick layer of brown soil

CONCLUSIONS

The data sets from secondary resources database and filed survey were used. At initial step, the classification variables of altitude, slope, direction of slope and slope position were selected for terrain factor and, soil thickness and type were considered for soil factor. The qualitative variables were quantified and assigned values according to their categories.

The principal component analysis was carried out to 331 permanent sample plots using SPSS 16.0 software package. According to the results of correlation coefficient matrix r, the eigenvector, eigenvalue and contribution rate of each component, the variables of slope position, slope degree, soil thickness and type were decided as leading factors of site type district classification and used to classify the southern Xiaoxing ' an mountain to two site type districts including low mountain and hill soil type district as well as hill and rolling hill soil type districts. According to the variations between classification variables, the above two site type district to 8 and 2 distinct site type groups is classified respectively

Based on the principal component analysis, clustering analysis for each site type group is done. The filed survey data was also used to adjust the classification results of site type group. Through the cluster analysis, the detail site type classification is obtained for each site type group. The site type classification results in this study can be used to provide technical supports for the forest management of the Xiaoxing' an mountains forests as well as the forest right system reform for Yichun Forestry

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REFERENCE

1. Bailey, R. G. et al. 1978. Natural of land and resource classification – a review. For 76: 650-655.
2. Carmen, W. H.1975. Forest site quality evaluation in the United States. Adv. Agron 27:207-269.
3. Danial, T. W. et al. 1979. Principles of silviculture. Ed. 2. McGraw-Hill: 251-254.
4. Daubenmire, R. F. 1979. The use of vegetation in assessing the productivity of forest land. Bot Rev 42(2): 115-143.
5. Guan, L.P., Wang, D.W. 2006. Application of geography information system in forest classification management. Shelter technology (1): 71-72.
6. He, M.Y. 2008. Tide none of xigou eco-economic protection forest site type Division. Research on soil and water conservation 15 (5): 158-161.
7. Johnston, D. R., Breadlly, R. T. 1967. Forest management tables, Commonwealth Forest Review 42(3):113.
8. Killiam, W. 1981. Site classification system used in forestry. Processing of the Wordshop on land Evaluation for Forestry: 134-151.
9. Killiam, W. 1981. Site classification system used in forestry. Processing of the Wordshop on land Evaluation for Forestry: 134-151.
10. Killiam, W. 1981. Site classification system used in forestry. Processing of the Wordshop on land Evaluation for Forestry: 134-151.
11. Liu, C. 2005. Water source forest habitats in Liaodong mountain areas, suitable land and tree. Liaoning forestry science and technology (4): 15-17.
12. Lei, H.Z., Yang, Q., Jiao f. 2000. Soil erosion and land use in hilly and gully regions on the loess plateau. Research on soil and water conservation 7 (2): 49-53.
13. Lai, T., Zhang, J. 2005. Sichuan Introduction and Plantation of Eucalyptus grandis site type divided. Sichuan Agricultural University 23 (3) :318 -322 .
14. Lacate, D. S. 1969. Guidelines for bio-physical land classification, Publ. No. 1264, Canada For. Serv. Ontario, Canada 61.
15. Pfister, R. D. etal. 1977. Forest habitat types of Montana. USDA For. Serv. Gen. Tech. Report INT-34. Intermountain For. And Rge. Exp. Sta., Ogdan, Utah :174.
16. Qiang, Y. H. 2006. Preliminary study on site classification of limestone mountain in xuancheng City. Modern agricultural science and technology (12): 19-22.
17. Spurr, H. B., Barnes. V. 1980. Forest ecology. Ed. 3 Jogn Wiley and Sons 297-336.
18. Liang, S. L., Li, G., Yong, P. 2009. Northwest Shanxi loess hilly established area of site type division. Shanxi Forestry Science 38 (1) :5 -7 .
19. Whittaker, R. H. 1978. Classification of plant commynity. The Hagus: 82-110,287-400.
20. "Writing group of forest site classification." China forest site classification [M]. China Forestry Publishing House.1986. Chinese
21. Ye, L. 2006. Larch plantation site quality evaluation. Forest survey design 2: 49-52 .
22. Wang, Y. G., Wang K. 1996. On China's forest site classification and characteristics of forest site types of two studies in China, and its significance. Central South forest inventory and planning 3 (15): 46-49.
23. Yu, Q. F., Tang, D. R. 2003. Forest site classification based on remote sensing and geographic information system. Journal of Northwest Forestry University 18 (2): 87-90.
24. Zhuang, L.W., Yang, K. 1999. On east slope of daxing' an mountain forest site classification. Inner Mongolia forestry investigation and design (1): 11-14.
25. Zhang W. R. 1997. Forest site in China. Science Press.
26. Zhang, Y. M., He, R. Z., Guo,B. S. 2005. Forest site classification based on RS and GIS. Journal of Northwest forestry University 20 (4): 147-152.
27. Zhang, F. L. 2004. The division and evaluation of forest site types in Su County. Anhui forestry science and technology 2：10-11.
28. Zhu, H. 2008. Red spruce plantation site classification and quality evaluation. Northeast Forestry University 36 (5) :4- 6 .

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