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RESEARCH ARTICLE

Li Shidong, Shen Guofang, Zhai Mingpu, Li Junqing

Quantitative site classification in the key county in the conversion of farmland to forests project

Abstract According to the requirements of the conversion of farmland to forests project (CFFP), we investigated the vegetation factors and environmental factors from more than 6,105 sub-compartments in Liangcheng County, Inner Mongolia by using the Matlab, analytic hierarchy process (AHP), and the hierarchical cluster method (HCM). The site conditions were classified quantitatively. The results show that CFFP at this site comprises five site-type groups and 19 site types. A quantitative site classification system method has been established in this paper.

Keywords the conversion of farmland to forests project (CFFP), site classification, quantitative, site types

1 Introduction

Site classification is the foundation and pre-condition for the conversion of farmland to forests project (CFFP). The ancient Chinese could already identify site conditions at ease and carry out forestry production in accordance with these conditions. The modern Chinese site classification began from the 1950s. The Ministry of Forestry had carried out large-scale classification and assessment on forest types since 1954 and the classification on site conditions and types in afforested areas since 1958. The neoteric western study on forest site classification began from the eighteenth century. At that time, German foresters identified the forestland productivity by formulating the stand yield statement. And later, some results came out successively both in and outside China. It is easy to know from the history of site classification that the major approaches of site classification include vegetation factor approach, environmental factor approach, etc. and its major methodologies include qualitative classification and integrated classification of both qualitative and quantitative methods (Ren and Yang, 1961; Bailey, 1985; Li, 1987; Denton and Barnes, 1988; Huang, 1989; The compiling staff of *The Site Classification of Chinese Forest*, 1989; Liu and Liu, 1994; The compiling staff of *The Site Types of Chinese Forest*, 1995; Zhang, 1997a, 1997b; Fu et al., 2000). CFFP is the foundation and start point for the Great Development of the West. It involves extensive regions and areas with different natural, economic, and social conditions in China. With the investment much more than that of the world-famous Three Gorges Project, CFFP is the ecological forestry project that is invested the most in China, even in relation to the whole world. The complete success of such a large-scale, extensively involving and hugely invested project could be guaranteed only based on and supported with improved scientific and technological system and developed site classification. It calls for learning from the well-rounded international experience and selecting an own scientific road with attention to ecological, economic, and social benefits. Therefore, according to the practical need for the CFFP in China, we divided the 1,897 counties of 25 provinces, regions, and cities covered in the project into four levels, i.e. zones, sub-zones, localities, and plots (Li and Zhai, 2004). Taking Liangcheng County in Inner Mongolia as an example, the study adopts the integrated multi-factor approach, combining vegetation factors and environmental factors, and applies modern mathematic and information technologies to classify site conditions with quantitative assessment on the degree that the conversion of farmland and the barren hills and lands are suitable for afforestation in the CFFP areas.

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Li Shidong, Shen Guofang, Zhai Mingpu, Li Junqing
College of Resources and Environment,
Beijing Forestry University, Beijing 100083, China
E-mail: eastworld@sohu.com

Li Shidong
Institute of Geographic Sciences and Natural Resources Research,
Chinese Academy of Sciences,
Beijing 100101, China

2 Principles and basis of site classification

2.1 Principles

The principles for the site classification in the study mainly include regional differentiation, general view, dominant factors, and sustainable development (Omernik, 1987; Klijn and Haes, 1994; Host, 1996).

2.2 Basis

The sources of the data for site classification are the results of the investigation of compartments and sub-compartments in the CFFP area. Besides, some literatures on division and site classification from *Vegetation of China, Forests of China, Forest Site Classification in China* and *Forest Site Types in China* and a great deal of on-the-spot study results are also consulted (The editorial committee of *Vegetation of China*, 1983; Ren and Bao, 1992; The editorial committee of *Forests of China*, 1996; Fu et al., 2001).

3 Methods and approaches of site classification

3.1 Overall plan

Generally, there are two major methods of site classification, including qualitative and quantitative methods. This study adopts the upside-down quantitative analysis based on Matlab, analytic hierarchy process (AHP), and hierarchical cluster method (HCM) for the site classification. In the light of the practical characteristics and project needs of CFFP, two levels of site classification systems are adopted, namely site-type groups and site types.

3.2 Establishment of classification factor system

The study establishes the classification factor system by adopting frequency statistics analysis, expertise collection, and stepwise regression, and applying the latest integrated multi-factor approach, combining vegetation factors and environmental factors. The concrete steps are as follows:

Study-related national and international literatures and conduct frequency statistics analysis on division factors. In the light of the objectives and principles of division and the characteristics of the sites studied, select factors from the three aspects of nature, economy, and society and establish a pre-collection of factors at different division levels.

Use stepwise regression to establish related coefficients of pre-selected factors and dominant factors and select indexes.

Use AHP and decide the index factors under analysis operation, based on the scores by the experts.

Establish the CFFP classification factor system. Decide that the major factors are soil types, aspects (sunny, half-sunny, shady, or half-shady), slope position (ridge, upper slope, middle slope, down slope, or flat), slope degree, elevation, major vegetation, and vegetation coverage (Table 1).

Table 1 Indexes of CFFP site classification and their weight

Indexes	Aspect	Slope degree	Slope position	Elevation	Soil types	Major vegetation	Vegetation coverage
Weight	0.225	0.192	0.114	0.097	0.241	0.073	0.058

3.3 Establishment of database

Seven-factor data of all related compartments and sub-compartments in Liangcheng County have been collected. A database of 6,105 sub-compartments and over 4,000 raw data has been established.

3.4 Factor quantification

Since most of the factors for site classification such as aspect, slope position, soil type, and major vegetation, are qualitative ones, they must be quantified. The study uses quantitative theories to quantify the survey data of each sub-compartment.

3.5 Data standardization

Based on the factor quantification, (0,1) method is used to standardize each factor datum to make the factors comparable. At the same time, the weight is assigned into each factor (Table 2).

3.6 Systematic clustering

In the basic unit of sub-compartment and based on Matlab, the data analysis and systematic clustering (see Table 3) have been conducted for over 6,100 sub-compartments involved in CFFP for quantitative classification.

3.7 Denomination for site classification

Integrated with characteristics of the CFFP in China, two levels of denomination systems for site classification have been settled. Denomination for site-type groups uses the soil type + site-type group. As for site types it uses aspects or slope + soil type + site types.

Table 2 Partial data analysis of CFFP site classification

Compartment	Unit code	Aspect	0–1 value	Weight value	Slope degree	0–1 value	Weight value	Slope position	0–1 value	Weight value	Eleva-tion	0–1 value	Weight value	Soil	0–1 value	Weight value	Vegeta tion	0–1 value	Weight value	Coverage	0–1 value	Weight value
11	26	1	0.10	2.25	3	0.50	9.60	3	0.50	5.70	1,550	0.25	2.45	1	0.10	2.41	1	0.10	0.73	10	0.10	0.58
25	17	1	0.10	2.25	3	0.50	9.60	2	0.33	3.80	1,600	0.26	2.53	1	0.10	2.41	1	0.10	0.73	30	0.30	1.74
25	19	1	0.10	2.25	3	0.50	9.60	3	0.50	5.70	1,600	0.26	2.53	1	0.10	2.41	1	0.10	0.73	30	0.30	1.74
25	18	1	0.10	2.25	3	0.50	9.60	2	0.33	3.80	1,680	0.27	2.66	1	0.10	2.41	1	0.10	0.73	40	0.40	2.32
16	12	1	0.10	2.25	3	0.50	9.60	3	0.50	5.70	1,600	0.26	2.53	1	0.10	2.41	2	0.20	1.46	10	0.10	0.58
16	13	1	0.10	2.25	3	0.50	9.60	3	0.50	5.70	1,650	0.27	2.61	1	0.10	2.41	2	0.20	1.46	10	0.10	0.58
18	7	3	0.30	6.75	3	0.50	9.60	3	0.50	5.70	1,670	0.27	2.64	1	0.10	2.41	2	0.20	1.46	20	0.20	1.16
21	8	1	0.10	2.25	3	0.50	9.60	3	0.50	5.70	1,700	0.28	2.69	1	0.10	2.41	2	0.20	1.46	10	0.10	0.58
23	17	1	0.10	2.25	3	0.50	9.60	3	0.50	5.70	1,900	0.31	3.01	1	0.10	2.41	2	0.20	1.46	10	0.10	0.58
55	27	1	0.10	2.25	2	0.33	6.40	3	0.50	5.70	1,650	0.27	2.61	1	0.10	2.41	4	0.40	2.92	10	0.10	0.58
63	6	3	0.30	6.75	3	0.50	9.60	3	0.50	5.70	1,200	0.20	1.90	1	0.10	2.41	4	0.40	2.92	10	0.10	0.58
5	10	3	0.30	6.75	3	0.50	9.60	3	0.50	5.70	1,300	0.21	2.06	1	0.10	2.41	4	0.40	2.92	20	0.20	1.16
10	6	3	0.30	6.75	3	0.50	9.60	3	0.50	5.70	1,300	0.21	2.06	1	0.10	2.41	4	0.40	2.92	10	0.10	0.58
2	15	3	0.30	6.75	3	0.50	9.60	3	0.50	5.70	1,400	0.23	2.22	1	0.10	2.41	4	0.40	2.92	10	0.10	0.58
6	7	6	0.60	13.5	3	0.50	9.60	3	0.50	5.70	1,400	0.23	2.22	1	0.10	2.41	4	0.40	2.92	10	0.10	0.58
8	4	6	0.60	13.5	3	0.50	9.60	3	0.50	5.70	1,450	0.24	2.29	1	0.10	2.41	4	0.40	2.92	12	0.12	0.70
1	21	1	0.10	2.25	3	0.50	9.60	3	0.50	5.70	1,500	0.24	2.37	1	0.10	2.41	4	0.40	2.92	30	0.30	1.74
1	22	1	0.10	2.25	3	0.50	9.60	3	0.50	5.70	1,500	0.24	2.37	1	0.10	2.41	4	0.40	2.92	20	0.20	1.16
14	10	1	0.10	2.25	3	0.50	9.60	3	0.50	5.70	1,500	0.24	2.37	1	0.10	2.41	4	0.40	2.92	10	0.10	0.58
14	11	1	0.10	2.25	3	0.50	9.60	3	0.50	5.70	1,500	0.24	2.37	1	0.10	2.41	4	0.40	2.92	10	0.10	0.58
32	7	1	0.10	2.25	3	0.50	9.60	3	0.50	5.70	1,500	0.24	2.37	1	0.10	2.41	4	0.40	2.92	20	0.20	1.16
1	10	3	0.30	6.75	3	0.50	9.60	3	0.50	5.70	1,500	0.24	2.37	1	0.10	2.41	4	0.40	2.92	12	0.12	0.70
1	12	3	0.30	6.75	3	0.50	9.60	3	0.50	5.70	1,500	0.24	2.37	1	0.10	2.41	4	0.40	2.92	10	0.10	0.58
1	20	3	0.30	6.75	3	0.50	9.60	3	0.50	5.70	1,500	0.24	2.37	1	0.10	2.41	4	0.40	2.92	30	0.30	1.74
2	4	3	0.30	6.75	3	0.50	9.60	3	0.50	5.70	1,500	0.24	2.37	1	0.10	2.41	4	0.40	2.92	10	0.10	0.58
2	13	3	0.30	6.75	3	0.50	9.60	3	0.50	5.70	1,500	0.24	2.37	1	0.10	2.41	4	0.40	2.92	10	0.10	0.58
2	14	3	0.30	6.75	3	0.50	9.60	3	0.50	5.70	1,500	0.24	2.37	1	0.10	2.41	4	0.40	2.92	10	0.10	0.58
2	20	3	0.30	6.75	3	0.50	9.60	3	0.50	5.70	1,500	0.24	2.37	1	0.10	2.41	4	0.40	2.92	10	0.10	0.58
2	24	3	0.30	6.75	3	0.50	9.60	2	0.33	3.80	1,500	0.24	2.37	1	0.10	2.41	4	0.40	2.92	10	0.10	0.58

*Data obtained from Manhanshan Forest Farm.

Table 3 Part of results of system clustering for the CFFP in Liangcheng County

Site types	Included unit code
1-1 (144)	**Changhanying**: Wangsanshun: 1-14, 1-21, 1-10, 1-6, 1-27, 1-17, 1-13, 1-12, 1-4, 1-30, Baoquanzhuang: 2-7, 2-10, 2-5, 2-4, 2-37, 2-33, Changhanying: 3-6, 3-7, 3-9, Dakoukou: 4-4, 4-15, 4-35, 4-21, 4-34, 4-41, 4-37, 4-43, 4-27, Shengchengwo: 5-31, 5-28, 5-5, 5-13, 5-20, 5-4, Naobaoping: 6-11, 6-18, 6-20, 6-5, 6-26, 6-24, 6-31, Dongchanghanying: 7-1, touhao: 8-16, 8-12, Sihao: 9-24, 9-3, 9-16, 9-34, 9-17, 9-29, 9-25, Tiepu: 10-15, 10-11, 10-9, 10-10, Beishuiquan: 11-18, Shiyihao: 13-26, 13-39, 15-1; **Houying**: Shuangshan: 3-20; **Maihutu**: Sansheng: 1-2, Qianyi: 2-1, 2-6, 2-3, 2-5; **Sansumu**: Yuanzigou: 3-19, 3-2, 3-45, 3-36, Yuchang: 4-1, Guanweihui: 5-2, 5-3, 5-4, 5-5, 5-6, 5-7, 5-8, 5-9, 5-10, Jiaotongju: 6-1, 6-2, 6-3, 6-4, Suyi: 7-19, 7-3, 7-6, 7-7, 7-5, 7-11, 7-12, 7-13, 7-14, 7-15, 7-16, 7-17, 7-18, Sansumu: 8-5, 8-9, 8-3, 8-8, 8-16, 8-17, 8-18, 8-19, 8-20, 8-21, 8-22, Xiying: 9-5, 9-22, 9-7, Yuanshan: 10-40, 10-41, 10-42, 10-43, 10-44, 10-45, 10-1, 10-2, 10-3, 10-6, 10-5, 10-4, Songshugou: 11-9; **Shijiuhao**: Laguigou: 2-26, Xinwo: 3-23, Dawa: 4-33, 4-74, 4-37, 4-66, 4-40, 4-63, 4-26, 4-50, Shijiuhao: 5-28, 5-62, 5-47, Shiqihao: 6-14, 6-15, 6-1, Shiwuhao: 7-34, 7-16, 7-29, 7-42; **Xianghuangdi**: Xixiang: 6-27
1-2 (121)	**Caozhanman**: Zhouquan: 3-4, Jiuhao: 4-2, 4-7, 4-1, 4-12, 4-10, 4-9; **Chengjiaying**: Dayuanshan: 1-17, 1-29, 1-20, 1-30, 1-13, 1-27, 1-21, 1-16, 1-26, 1-1, 1-5, 1-22, 1-28, Daxingwo: 2-24, 2-18, 2-13, 2-9, 2-22, 2-1, 2-4, Zuoweiwo: 4-20, 4-18, 4-3, 4-5, Caiyuanzi: 5-9, 5-13, 5-16, 5-21, 5-24, 5-19, 5-3, 5-17, 5-18, 5-5, 5-23, 5-6, 5-20, 5-25, donggoumen: 6-3, 6-14, 6-4, 6-7, 6-5, 6-12, 6-6, 6-13, 6-8, Chengjiaying: 7-9, 7-8; **Daihailinchang**: 2-10, 3-22, 4-8; **Chunxianwo**: Mengxianwo: 1-13; **Liusumu**: Changqidong: 2-19, Wujuwo: 3-23, 3-9, 3-11, 3-44, Yangpowo: 6-7; **Manhanshanlinchang**: 12-28, 36-3; **Xianghuangdi**: Xiaozhao: 2-52, 2-34, 2-35, 2-36, Jiuguquan: 3-18, 3-7, 3-6, 3-8, 3-9, 3-3, Xingshuba: 4-9, 4-3, Qichougou: 5-20, 5-5, 5-1, 5-23, 5-9, 5-10, 5-18, Anzishan: 7-1, Mafangtan: 8-17, 8-19, Gonggouyan: 9-14; **Rongxing**: Taipingwo: 1-5, 1-38, 1-14, 1-17, 1-22, 1-26, 1-39, 1-13, Yangpowo: 2-11, 2-17, 2-15, 2-10, Duonasu: 3-10, 3-26, 3-20, 3-4, 3-13, 3-34, 3-18, 3-33, 3-8, 3-22, Xiaodonggou: 4-12, 4-26, 4-15, 4-2, Hanjiapeng: 8-10, Rongxing: 9-2, Beipeng: 13-34, 13-14

Note: In the bracket is the number of sub-compartments.

4 Results of site classification

There are five site-type groups and 19 site types in Liangcheng County (Table 4). Table 5 shows the characteristics of site-type groups and Table 6 presents the characteristics of site types.

Table 4 Results of CFFP site classification in Liangcheng County

Site type groups	Site types
1 Forest meadow soil site-type group (1656)	1-1 Gentle slope grey forest soil site type (144)
	1-2 Even slope meadow swamp soil site type (121)
	1-3 Gentle slope forest soil site type (550)
	1-4 Even slope meadow soil site type (841)
2 Aeolian saline-alkali sandy soil site-type group (385)	2-1 Gentle slope sandy soil site type (137)
	2-2 Even slope sandy soil site type (128)
	2-3 Even slope saline-alkali soil site type (120)
3 Dark brown soil and light brown soil site-type group (1612)	3-1 Sunny and half-sunny dark brown soil site type (694)
	3-2 Shady and half-shady dark brown soil site type (364)
	3-3 Sunny and half-sunny light brown soil site type (14)
	3-4 Shady and half-shady light brown soil site type (251)
	3-5 Even slope dark brown soil site type (116)
	3-6 Even slope light brown soil site type (173)
4 Loess site-type group (1568)	4-1 Sunny and half-sunny Loess site type (1199)
	4-2 Shady and half-shady Loess site type (178)
	4-3 Even slope Loess site type (191)
5 Chestnut soil site-type group (901)	5-1 Sunny and half-sunny chestnut soil site type (657)
	5-2 Shady and half-shady chestnut soil site type (184)
	5-3 Even slope chestnut soil site type (60)

Note: In the bracket is the number of sub-compartments.

Table 5 Characteristics of site-type groups of CFFP site classification in Liangcheng County

Site type group	Aspects	Soil types	Elevation /m	Average slope degree/(°)	Slope position	Major vegetation	Vegetation coverage /%
1	Flat and various aspects	Forest meadow soil	1,000–2,042	9	Mainly flat	Arbor, shrub and grass	32
2	Flat and various aspects	Aeolian saline-alkali sandy soil	1,100–2,102	7	Mainly flat	Shrub and grass	14
3	Various aspects	Dark brown soil and light brown Soil	1,165–2,200	14	Flat to ridge	Arbor, shrub and grass	22
4	Various aspects	Loess	1,100–2,196	12	Flat to ridge	Arbor, shrub and grass	22
5	Various aspects	Chestnut soil	1,100–2,071	12	Flat to ridge	Arbor, shrub and grass	24

Table 6 Characteristics of the site type of CFFP site classification in Liangcheng County

Site type	Aspect	Soil type	Elevation /m	Average slope degree /(°)	Slope position	Major vegetation	Vegetation coverage /%
1-1	No obvious aspect	Forest soil	1,000–1,456	12	Mainly flat	Arbor, shrub and grass	25
1-2	No obvious aspect	Meadow Soil	1,114–1,621	7	Mainly flat	Arbor, shrub and grass	25
1-3	No obvious aspect	Forest Soil	1,215–1,675	13	Mainly flat	Shrub and grass	4
1-4	No obvious aspect	Meadow Soil	1,385–2,042	6	Mainly flat	Shrub and grass	45
2-1	No obvious aspect	Aeolian sandy soil	1,528–2,102	11	Mainly flat	Shrub and grass	14
2-2	No obvious aspect	Aeolian sandy soil	1,121–1,482	5	Mainly flat	Shrub and grass	14
2-3	No obvious aspect	Saline-alkali soil	1,100–1,361	4	Mainly flat	Shrub and grass	14
3-1	Sunny and half-sunny	Dark brown soil	1,380–1,763	17	Down slope to ridge	Shrub and grass	27
3-2	Shady and half-shady	Dark brown soil	1,509–2,200	16	Down slope to ridge	Arbor, shrub and grass	16
3-3	Sunny and half-sunny	Light brown soil	1,489–1,897	18	Down slope to ridge	Shrub and grass	10
3-4	Shady and half-shady	Light brown soil	1,301–1,694	15	Down slope to ridge	Arbor, shrub and grass	39
3-5	No obvious aspect	Dark brown soil	1,165–1,255	4	Mainly Flat	Arbor, shrub and grass	39
3-6	No obvious aspect	Dark brown soil	1,165–1,243	6	Mainly Flat	Arbor, shrub and grass	27
4-1	Sunny and half-sunny	Loess	1,411–2,196	19	Down slope to ridge	Arbor, shrub and grass	30
4-2	Shady and half-shady	Loess	1,286–1,643	17	Down slope to ridge	Arbor, shrub and grass	29
4-3	No obvious aspect	Loess	1,100–1,181	3	Mainly Flat	Arbor, shrub and grass	18
5-1	Sunny and half-sunny	Chestnut soil	1,175–2,071	11	Down slope to ridge	Arbor, shrub and grass	24
5-2	Shady and half-shady	Chestnut soil	1,151–1,634	13	Down slope to ridge	Arbor, shrub and grass	47
5-3	No obvious aspect	Chestnut soil	1,100–1,247	4	Mainly flat	Arbor, shrub and grass	29

Based on site classification and focusing on different site types (groups), Liangcheng uses different forest types, tree species, collocation modes, and technical measures. It conducts suitable practices in the light of the local conditions, adopts effective prevention for the local adverse conditions, and plants the right tree species for the county. It has achieved good ecological, economic, and social benefits. The authors carried out a study on the optimal modes,

aiming at the sunny and half-sunny chestnut soil site type of the fifth site-type group and got an optimal mode with *Prunus armeniaca, Hippophae rhamnoides,* and *Medicago sativa* and put forward its systematic simulation model, matching techniques, and mode mechanism.

References

Bailey R.-G., Ecological regionalization in Canada and the United States, Geoforum, 1985, 6(3): 265–275

Denton S.-R. and Barnes B.-V., An ecological climatic classification of Michigan: a quantitative approach, Forest Sci., 1988, 34(1) :119–138

Fu B.-J., Liu G.-H. and Meng Q.-H., The ecology regionalization and development strategy of west of China, Arid Land Geogr., 2000, 23(4): 289–296 [傅伯杰，刘国华，孟庆华，中国西部生态区划及其区域发展对策，干旱区地理，2000, 23(4): 289–296]

Fu B.-J., Liu G.-H., Chen L.-D., Ma K.-M. and Li J.-R., Scheme of ecological regionalization in China, Acta Ecol. Sin., 2001, 21(1): 1–6 [傅伯杰，刘国华，陈利顶，马克明，李俊然，中国生态区划方案，生态学报, 2001, 21(1): 1–6]

Host G.-E., A quantitative approach to developing regional ecosystem classifications, Ecol. Appl., 1996, 6(2): 608–618

Huang B.-W., The comprehensive regionalization compendium of Chinese nature. Collect. Geogr. Publ., 1989, 21: 10–20 [黄秉维，中国综合自然区划纲要，地理集刊，1989，21: 10–20]

Klijn F. and Haes A.-U., A hierarchical approach to ecosystem and its implications for ecological land classification, Landscape Ecol., 1994, 9(2): 89–104

Li S.-D. and Zhai H.-B., Comprehensive regionalization of the conversion of farmland to forests in China. J. Mt. Sci., 2004, 22(5): 513–520 [李世东，翟洪波，中国退耕还林综合区划，山地学报, 2004, 22(5): 513–520]

Li W., The discussion on the issue of nature geography regionalization. Acta Geogr. Sin., 1987, 42(4): 376–380 [李万，自然地理区划问题探讨，地理学报，1987, 42(4): 376–380]

Liu Z.-D. and Liu Z.-W., Study on biomass of *hippophae rhamoides* L. and *caragana microphylla* L. on loess plateau, Acta Agr. Boreal.-occidental. Sin., 1994, 3(2): 92–96 [刘占德, 刘增文, 沙棘柠条的生物量及立地因子分析，西北农业学报，1994, 3(2): 92–96]

Omernik J.-M., Ecoregions of the conterminous United States, Annals of the Association of American Geographers, 1987, 77(1): 118–125

Ren M.-E. and Bao H.-S., The Natural Region, Development and Renovation of China, Beijing: Science Press. 1992 [任美锷，包浩生，中国自然区域及开发整治，北京：科学出版社，1992]

Ren M.-E. and Yang R.-Z., The issue on Chinese nature regionalizationl. Acta Geogr. Sin., 1961, 27: 66–74 [任美锷，杨纫章，中国自然区划问题，地理学报，1961，27：66–74]

The compiling staff of *The Site Classification of Chinese Forest*, The Site Classification of Chinese Forest, Beijing: China Forestry Publishing House, 1989 [《中国森林立地分类》编写组，中国森林立地分类，北京：中国林业出版社，1989]

The compiling staff of *The Site Types of Chinese Forest*, The Site Types of Chinese Forest, Beijing: China Forestry Publishing House, 1995 [《中国森林立地类型》编写组，中国森林立地类型，北京：中国林业出版社，1995]

The editorial committee of *Chinese Forest*. Chinese Forest, Beijing: China Forestry Publishing House, 1996 [中国森林编辑委员会，中国森林，北京：中国林业出版社，1996]

The editorial committee of *Chinese Vegetation*. *Chinese Vegetation*, Beijing: Science Press, 1983 [中国植被编辑委员会，中国植被，北京：科学出版社，1983]

Zhang S.-Y., A study on main factors of forest site type in suitable forest region of dry-hot river valley in Yuanmou. J. Southwest For. Coll., 1997,17(2): 8–18 [张尚云, 元谋干热河谷宜林地段划分立地类型主导因子研究, 西南林学院学报, 1997, 17(2): 8–18]

Zhang W.-R., The Site Types of Chinese Forest, Beijing: Science Press, 1997 [张万儒，中国森林立地类型，北京：科学出版社，1997]