ELSEVIER

Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Earth and Planetary Science 2 (2011) 315 – 320

Procedia
Earth and Planetary Science

The Second International Conference on Mining Engineering and Metallurgical Technology

High Gradient Effects of Forest Biomass Energy in Mountainous Region—A Case of Meili Snow Mountain

Qingzhong Ming[a, b*], Shurong Guo[a], Yuanmei Jiao[a, b]

[a]*College of Tourist and Geography, Yunnan Normal University. Kunming, 650500, China;*
[b]*Key Laboratory of Plateau Geographical Process and Environmental Change, Yunnan Provience, Kunming, 650500, China*

Abstract

Integrated using methods of forest biomass and productivity, Geographic Information System, and biogeographic statistics, this paper is quantified the reserves of forest biomass energy, and its relationship to elevation, slope degree and slope aspects. The results indicate: the forest biomass energy in eastern Meili Snow Mountain have significant spatial heterogeneity and correlation, in which the forest biomass energy is increasing with elevation in between 2000 to 3900 meters above sea level, and is decreasing while the elevation is higher than 3900 meters; The quantity of forest biomass energy is distributed mainly in between of 25 to 35 slope degree. It has obvious difference among slope aspects, in which eastern, southeastern, and northwestern aspects are relatively centralized. The correlation analysis between forest biomass energy and elevation, slope degree, and slope aspects indicate the negative correlation to elevation and slope aspect, and positive correlation to slope degree with a correlation coefficient of -0.17, -0.86 and 0.30, respectively. Therefore, the forest biomass energy concentrated at the middle belt of the Meili Snow Mountain formed an annular ecological corridor and provided a good living environment for mountainous ecosystems and local peoples.

Keywords: Forest Biomass Energy, Elevation, Slope and Aspect, Effect of High Gradient, Meili Snow Mountain

* Corresponding author. Tel.: +86-871-5941288; fax: +86-871-5941198.
E-mail address: mingqingzhong01@163.com.

1878–5220 © 2011 Published by Elsevier Ltd. Open access under CC BY-NC-ND license.
doi:10.1016/j.proeps.2011.09.049

1. Study area

Meili Snow Mountain, across the Yunnan and Tibet provinces, is situated in the heart of the Hengduan Mountains and located in the Lancang river valley and the Nu river valley, it has high altitudes and complex topography (Figure 1). It is reflecting the relatively high biodiversity and the differences of climate of the area, because of the great highness, the disparity in precipitation and temperate and topography. The vertical belts of the vegetation preserved intact and formatted variety types of forest vegetation, which are mainly composed of the cold-temperate coniferous. It is also has obvious vertical distribution. That is, from 2700 to 4000m above sea level, the vegetation of the upper part of the mountain is made up of a whole cold-temperate coniferous forest; the lower is compose of cold-temperate broad-leaved forest, cold-temperate bamboo. And the vegetations composed principally of warm coniferous forest and warm-temperate broad-leaved forest in the areas with altitudes of below 2700m. This is in fact an ideal spot to distribution patterns of vegetation, terrain factors and the relationship between the effects of high gradient mountain under natural conditions.

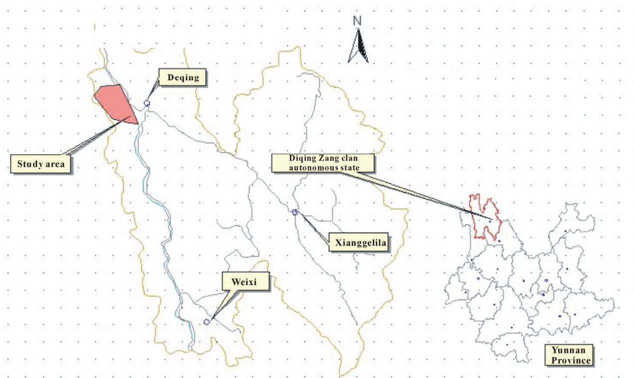

Figure 1 Location of study site

2. The relation between forestry volume, biomass, biomass energy resource and geographic factors

Based on the data of forest resource from Deqin County planning survey results in 2006, we calculated the volume per unit area of all types forest. Application of biomass-based volume estimation model (BEF) and the parameters of related transformation, we obtained forest biomass and forest productivity in the unit area of all types forest, and the theoretical potential and the annual production of biomass energy per unit area of each forest type were calculated, according to the average calorific value of plant and national standard calorific value of coal [1].

2.1. The relation between forestry volume, biomass, biomass energy resource and elevation class

We obtained the distribution of different elevation levels by using the statistical data of the elevation level and forest vegetation layers, which extracted from the DEM. The ideas of "Yunan Forest" think that the timberline is about 4200m above sea level in northwestern Yunnan. However, the timberline of high mountains is the transition zone between the canopy forest and tree line, and is also the ecosystem transition zone including tree islands and the elfin forest [2]. In this study, the area of sixth elevation level

(4380-4850m), has distributed 2.34ha Abies forest and the total accumulation is 618 M^3. It is tree island formatted in local micro-climate under the complex topography.

The forest reserves, forest biomass, and biomass energy resources of the different altitude level increased gradually from level 1 to level, after that it is shown the sharp decline. Forest productivity and biomass productivity in the third level is to reach the maximum elevation. In terms of the biomass reserves of forest ecosystem per unit area, it takes on the trend, which are growing from low altitude to high (Figure 2). The above discussions are not included the alpine meadow and shrub.

2.2. The relation between forestry volume, biomass, biomass energy resource and slope degree

We translated terrain digital elevation model of TIN Form into the GRID format, and the different slopes of GRID layer are classified into five types as follows: 0º-15º in grade Ⅰ; 15º-25º in grade Ⅱ; 25º-35º in grade Ⅲ; 35º-45º in grade Ⅳ; >45º in grade Ⅴ。Using gradient and forest vegetation layers to partition the statistics data, we get the distribution of the total land and forest distribution area in the different slope degree.

From biomass reserves per unit area of forest ecosystems of view, the change regularity of the slope are shown in Figure 3. And we can see, the biomass reserves per unit area in every grade are basically consistent about 70t/ha. However, in the slope from 35-45º, the biomass Reserves per unit area was significantly higher than the other slope, it is up to 170t/ha.

It is well known that the slope is related with Soil depth, soil moisture conditions and the soil characters of forest. And low slope is beneficial to water and soil conservation, high slope is prone to erosion soil. But the slope of the soil is too low to develop gley and isn't detrimental to plant growth. General speaking, the slope of the mountain is not distinct on the spatial distribution of biomass reserves than altitude and slope aspect for it [3, 4]. This occurs because biomass reserves are likely suffered from human activities. In the area of gentle slope and good slope conditions, the higher level of human use caused ecosystem retrogression. With the slope raised, the scopes of man's use of site conditions are progressively difficult and led the biomass reserves to increase gradually.

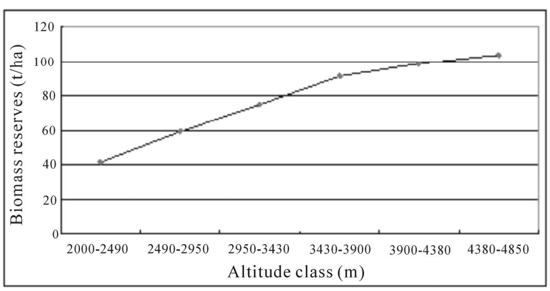

Fig.2 Forest biomass reserves per hectare in different altitude class

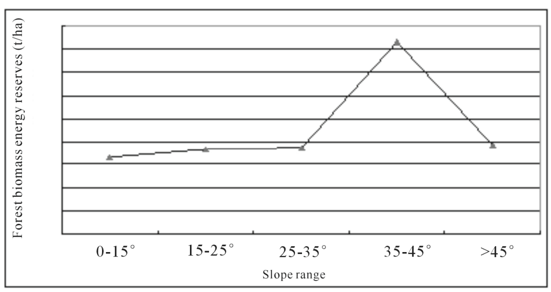

Fig.3 Forest biomass energy reserves per hectare in different slope range

2.3. The relation between forestry volume, biomass, biomass energy resource and slope aspect

Based on the slope aspect map from TIN by using Arcview3.2, the slope aspect can be divided into nine grades, such as flat，north, northeast, east, southeast, south, southwest, west and northwest. We collected and analyzed the statistic data of the slope aspect layer and all types of forest layers of the grid format by using the default class of the slope aspect, and gained the distribution of each evaluation factor in different slopes, except the flat.

By the above statistical analysis, the total forest volume, biomass, resources of biomass quantity, forest productivity and annual productivity of biomass resources in each slope aspect of the study area are gradually decreasing from north, southeast, east, northeast, south, northwest, southwest to west. And the distribution of the general trend is the larger the area of forest, the value of statistical indicators of the forest is greater. However, the different light, humidity, heat and airflow of plant growth necessary, which decided by the different slope aspects, are affecting the biomass reserves of forest plants. In general, the southern, southeast and southwest slope can obtain greater the sun heat, and vice versa. The change law of biomass reserves of forest ecosystem was correlated with the thermal condition gradients.

3. Discuss

3.1. The relation between forestry volume, biomass, biomass energy resource and slope aspect

The study data are often more than one variable data during analysis and conducting data, these variables are correlative dependence and interplay, and the relationship can be divided two types. One is function, the other is correlation. According to the basic assumption of statistical biogeography, the biological or ecological phenomena in any space exist the spatial correlation. On the basis of the regional maps of forest type and digital elevation model (DEM), with the statistics in the above indexes (such as the elevation, slope degree, biomass and biomass resources of slope aspect), the correlation between topographic conditions (altitude, slope, aspect) and the statistics indexes of forest have been discussed (Table 2).

Table 2 Correlation coefficient between forest index and terrain factor

	Stock Volume	Biomass	productivity	Reserves of biomass	Biomass productivity
Elevation	-0.13	-0.17	-0.40	-0.17	-0.40
Slope degree	0.31	0.30	0.27	0.30	0.28
Slope aspect	-0.86	-0.9	-0.87	-0.86	-0.87

From Table 2 we can see that the results show a good correlation exists between stock volume, biomass, forest productivity, biomass resources, biomass productivity and topographic conditions. From the Correlation coefficient of view, we also found that the Correlation coefficient is smaller between topographic conditions and the forest statistical indexes, it reflected that the altitude and gradient has little effect on the spatial variation of biomass reserves. On the contrary, the obvious correlation coefficient between slope aspect and biomass reserves suggests that the slope aspect has significant effect on the spatial variation of biomass reserves. Currently, the effect topography factors on the ecological spatial characteristics of plant communities are not clear. It is universally acknowledged that topographical factors can interpret the ecological spatial characteristics of vegetation about 7% -15% [5]. And there are two quite distinct fronts of the point on the scale effect of topographical factors [6]. As far as this study is concerned, the impact of altitude and slope degree on biomass reserves is smaller than that of slope aspect.

3.2. The relation between forestry volume, biomass, biomass energy resource and slope aspect

In mountain areas, with the altitude and elevation changes, it is often produce the ladder change phenomena of nature and human, that is the high gradient effect of mountain [7]. The high gradient effect of mountain is the synthetic effects, and the high gradient effect of biomass is a specific embodiment which can represent the high gradient effect of mountain.

This paper, by forest ecosystems of east slope of Meili Snow mountain study, the correlation between the spatial distribution and biomass-energy resources in the forest ecosystems was analyzed. Research indicates that biomass-energy resources in the forest ecosystems of Meili Snow mountain has changed with the altitude variation (Figure 5). From 2000 to 3900m, the forest biomass resources increased with the increasing altitude, and the forest biomass resources declined sharply above 3900m. The figure has the single apex and similar to the mid-altitude bulge of species diversity of plant communities which called from Whittaker and Niering.

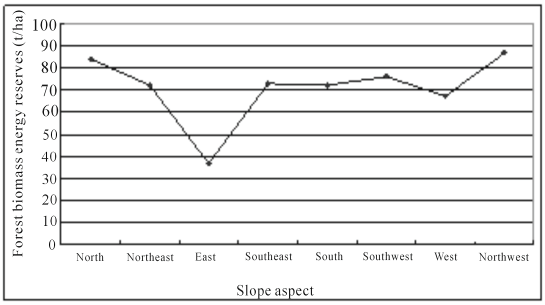

Figure 4 Forest biomass energy reserves per hectare in different aspect range

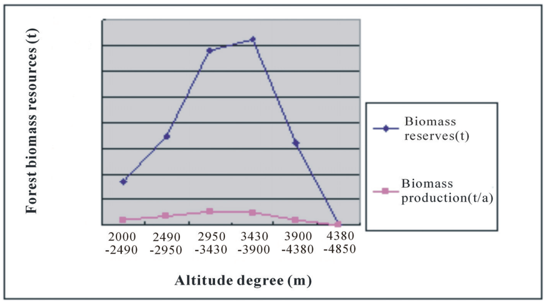

Fig.5 Gradient change of forest biomass resources by altitude

It is also denoted from Figure 5 that the number of biomass resources in slope degree of 25-35º is up to the maximum. Furthermore, the numbers of biomass resources in different slopes were difference obviously and ranged mostly from east, southeast to northwest slope. The analyzed results illuminate that the number of biomass resources was related to the topographic factors (altitude, slope degree, slope aspect), the correlation coefficients are-0.17， -0.86 and 0.30 respectively.

This change is consistent with the high gradient effects and climate change of whole Hengduan mountain. Precipitation in mountainous areas is shown an increased trend with elevations increasing, until up to the maximum. From a certain height, the precipitation is decreased with increasing altitude essentially (Figure 6).

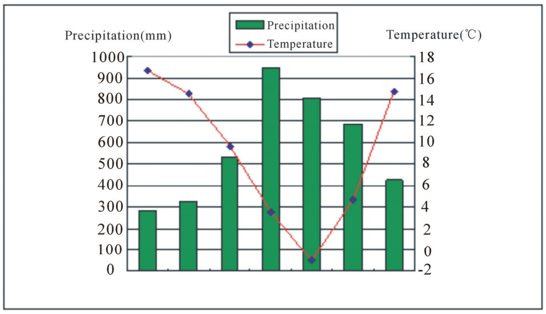

Fig.6 Precipitation and temperature of Hengduan Mountains[6]

The temperature of mountain is decreased about 0.5-0.7℃/100m with the increase of altitude. Based on the water and thermal gradient effect, the mountainous has appeared vertical climate zone. Moreover, the vegetation types, composition, community structure, biomass reserves, productivity are also restrict by the water and thermal gradient effect.

In the eastern slope of Meili Snow Mountain, from low to high elevations it distribute several natural vegetation zone, such as subtropical shrub belt, conifer belt, cold temperate coniferous forest, alpine meadow, alpine scrub to alpine scree. The productivity of various types of vegetation existed obvious difference, and these led to zonal distribution of biomass reserves and the significantly high gradient effect of biomass energy resources of forest ecosystem.

4. Conclusion

Mountain have significant spatial heterogeneity and correlation, in which the forest biomass energy is increasing with elevation in between 2000 to 3900 meters above sea level, and is decreasing while the elevation is higher than 3900 meters; The quantity of forest biomass energy is distributed mainly in between of 25 to 35 slope degree. It has obvious difference among slope aspects, in which eastern, southeastern, and northwestern aspects are relatively centralized. The correlation analysis between forest biomass energy and elevation, slope degree, and slope aspects indicate the negative correlation to elevation and slope aspect, and positive correlation to slope degree with a correlation coefficient of -0.17, -0.86 and 0.30, respectively.

Acknowledgements

This study was supported by State Key Program of National Natural Science of China (Grant No. U0933604, 40872118); The Grant from Candidates of Young and Middle Aged Academic Leader of Yunnan Province; Key program of science and technology development of Yunnan Province in 2009; Key program of Chinese Ministry of Education (207102).

Reference:

[1] Ming QingZhong, Guo ShuRong, Jiao YuanMei. High Gradient Effects of Forest Biomass Energy in Mountainous Region—Research Methods. Journal of Mountain Science, 2011

[2] Wang Zhengquan. Geostatistics and its Application in Ecology. Beijing, Science Press, 1999, 2.

[3] Yang Juan, Yuan Weigao, Jiang Bo, et al. Effect of Environment on Biomass of Major Ecological Forest in Zhejiang. Journal of Zhejiang Forest Science and Technology, 2007,27(20):20-29.

[4] Xu Zhigao, Wang Xiaoyan, Lei Ruide. Biomass Changing Tendency Analysis of Qinling Huoditang Forest Landscape which Based on GIS. Central South Forest Inventory and Planning, 2003,22(4):14-17.

[5] Shen Zehao, Zhang Xinshi. The Spatial Pattern and Topographic Interpretation of the Forest Vegetation at Dalaoling Region in the Three Gorges.Acta Botanica Sinica, 2000,42(10):1089-1095.

[6] Shen Zehao, Fang Jingyun, Liu Zengli,et al. Patterns of Biodiversity Along the Vertical Vegetation Spectrum of the East Aspect of Gongga Mountain. Acta Phytoecologica Sinica, 2001,25(6):721-732.

[7] Ming Qingzhong. The Landform Development and Environmental Effects of Three Parallel Rivers. Beijing, Science Press, 2006, 7.