Postprint: Study on Individual Biomass Allocation and Variation Patterns of Picea schrenkiana in the Tianshan Mountains

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Abstract

To investigate the allocation patterns and variation trends of biomass in individual organs of Tianshan Picea schrenkiana forests, extensive field measurements were conducted in the study area. Using existing estimation equations for Picea schrenkiana forests, we analyzed the allocation and variation patterns of biomass across various organs (stem, branch, leaf, bark, root) in Tianshan Picea schrenkiana forests. The results showed that: (1) The average biomass of Picea schrenkiana forests in the study area was 388.74 $t \cdot hm^{2}$. Among tree organs, stem, branch, root, leaf, and bark accounted for 43.65%, 28.60%, 13.49%, 11.08%, and 3.18% of the biomass, respectively. (2) The percentage of biomass in each diameter class was: 33.53% (40-50 cm), 20.13% (20-30 cm), 19.59% (30-40 cm), 18.19% (50-60 cm), and 2.05% (10-20 cm). The allocation of tree biomass across different height classes was: 48.78% (20-30 m) > 35.27% (10-20 m) > 14.70% (30-40 m) > 1.25% (0-10 m). The allocation ratio of aboveground to belowground biomass was 87.54% and 12.46%, corresponding to 340.30 $t \cdot hm^{2}$ and 48.44 $t \cdot hm^{2}$, respectively. (3) With increasing altitude, the biomass of Tianshan Picea schrenkiana forests exhibited a "unimodal" pattern, reaching a maximum of 611.58 $t \cdot hm^{2}$ at 2,100-2,400 m. The proportion of stem and bark biomass decreased with altitude, branch biomass gradually increased, while leaf and root biomass showed a trend of first decreasing then increasing. The biomass of diameter classes 20-30 cm, 30-40 cm, and 50-60 cm all displayed unimodal variation trends with altitude, peaking at 2,100-2,400 m. Different tree height classes of Picea schrenkiana forests showed distinct trends in biomass with increasing altitude. The biomass of Tianshan Picea schrenkiana forests and mean annual precipitation both decreased with increasing longitude and latitude, and the stand biomass in the study area showed an overall decreasing trend from west to east. Stand density, altitude, and precipitation jointly determined the magnitude and variation patterns of forest biomass, with 2,100-

2,400 m being the most suitable habitat for Picea schrenkiana forest growth in this study area. These results provide fundamental data for the restoration and reconstruction of Picea schrenkiana forest ecosystems and are of significant importance for integrated management and ecological health assessment in the study area.

Full Text

Preamble

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2. Methods

2.1 Study Area

In July-August 2018, we established sampling plots in the Picea schrenkiana forest region of the Tianshan Mountains across an elevation gradient of 1500–2800 m. A total of 78 circular sampling plots, each with a 10 m radius, were established following established protocols for forest biomass assessment. Within each plot, all trees were measured for diameter at breast height (DBH) and height. Using established biomass estimation equations for P. schrenkiana forests, we analyzed the distribution and variation patterns of biomass across different tree organs.

The biomass allocation analysis revealed the following patterns: (1) Among tree organs, biomass distribution followed the descending order: stems (43.65%) > branches (28.60%) > roots (13.49%) > leaves (11.08%) > bark (3.18%). (2) For diameter classes, biomass distribution was: 33.53% (40–50 cm), 20.13% (20–30 cm), 19.59% (30–40 cm), 18.19% (50–60 cm), and 2.05% (10–20 cm). (3) For height classes, biomass distribution was: 48.78% (20–30 m) > 35.27% (10–20 m) > 14.70% (30–40 m) > 1.25% (0–10 m). (4) Aboveground biomass accounted for 87.54% (340.30 t · hm^{2}) while belowground biomass accounted for 12.46% (48.44 t · hm^{2}).

Elevation significantly influenced biomass distribution, with a hump-shaped pattern observed along the altitudinal gradient. Biomass peaked at 2100–2400 m (611.58 t · hm^{2}), while minimum values occurred at 1500–1800 m (171.38 t · hm^{2}). The 1800–2100 m zone showed intermediate values (402.05 ± 291.58 t · hm^{2}), and the 2400–2800 m zone showed 369.97 ± 205.09 t · hm^{2}. The proportions of stem and bark biomass decreased with increasing elevation, branch biomass increased gradually, while leaf and root biomass showed a pattern of initial decrease followed by increase. Trees in the 20–30 cm, 30–40 cm, and 50–60 cm DBH classes exhibited hump-shaped curves along the elevation gradient, all peaking at 2100–2400 m. The biomass of trees in the 10–20 m height class increased gradually with elevation, while the 20–30 m height class showed an initial increase followed by decrease, reaching maximum at 2100–2400 m.

Spatial analysis revealed a decreasing trend in forest biomass from west to east across the study area. Multiple factors including forest density, elevation, and precipitation jointly determined the biomass magnitude and its variation patterns. The elevation zone of 2100–2400 m represents the most suitable habitat for P. schrenkiana forest growth in this region.

Abstract: The Tianshan Mountains are an important water source in Xinjiang, China. The Picea schrenkiana forest is the dominant species of Xinjiang' s mountain forests. This study takes P. schrenkiana forest as the research object, and discusses the distribution and variation of the biomass of P. schrenkiana forest in various organs (stems, branch, leaves, bark, roots), which will provide data support for the integrated forest management in the study area and be of great significance for the protection, restoration and development of P. schrenkiana forest of the Tianshan Mountains. A total of 78 sampling plots with a radius of 10 m were setup from the elevation of 1500-2800 m with P. schrenkiana (Schrenk' s spruce) forest of Tianshan Mountains, and all trees in the plots was measured. According to the established biomass estimation equations of P. schrenkiana forest, this study analyzed the distribution and variation of the biomass of P. schrenkiana forest in the Tianshan Mountains. The results show as follows: (1) The mean value of biomass of P. schrenkiana forest in the study area was 388.74 t • hm ^{2}, and the stems, branches, roots, leaves and bark accounted for 43.65%, 28.60%, 13.49%, 11.08% and 3.18% of the biomass, respectively. The proportion of stems is the largest, and the proportion of bark is the smallest; the percentage of biomass in each diameter class is: 33.53% (40-50 cm), 20.13% (20-30 cm), 19.59% (30-40 cm), 18.19% (50-60 cm) and 2.05% (10-20 cm); the proportion of tree biomass in different tree height scales is forming a descending order list as follows: 48.78% for the height range from 20 m to 30 m, 35.27% for the height range from 10 m to 20 m, 14.70% for the height range from 30 m to 40 m and 1.25% for the height range from 0 m to 10 m; the distribution percentage of aboveground biomass and belowground biomass is: 87.54% (340.30 t • hm ^{2}) and 12.46% (48.44 t • hm ^{2}), respectively. (2) There was a hump-shaped curve by which the biomass of P. schrenkiana forest reached its peak value of 611.58 t • hm ^{2} at the elevation of 2100-2400 m. The minimum value of biomass at 1500-1800 m was 171.38 t • hm ^{2}, and the value of biomass at 1800-2100 m was 402.05±291.58 t • hm ^{2}, and the value of biomass at 2400-2800 m was 369.97±205.09 t • hm ^{2}. The proportions of stems and bark biomass were decreased along with the increase of elevation, the biomass of branches was increased gradually, and the biomass of leaves and roots was decreased first and then increased. The biomass of P. schrenkiana with diameters being 20-30 cm, 30-40 cm and 50-60 cm displayed a hump-shaped curve with the increase of elevation, and reached its peak value at the elevation of 2100-2400 m. The biomass of P. schrenkiana with a tree height of 10-20 m was gradually increased with the increase of elevation, and the biomass of P. schrenkiana with a tree height of 20-30 m was increased first and then decreased, reaching a maximum value at the altitude of 2100-2400 m. The biomass of the forests showed a decreasing trend from the west to the east in the study area. The forest density, elevation and precipitation jointly determined the size of forest biomass and its variation. The places at the elevation of 2100-2400 m are the most suitable places for growing P. schrenkiana forest in this study area.

Keywords: Picea schrenkiana forest; individual biomass; allocation; organs; environmental factors

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References

[1] Brown S, Lugo AE. The storage and production of organic matter in tropical forests and their role in the global carbon cycle [J]. Biotropica, 1982, 14(3): 161-187.

[2] Field CB, Kaduk J. The carbon balance of an old-growth forest: Building across approaches [J]. Ecosystems, 2004, 7(5): 525-533.

[3] Clark DA. Sources or sinks? The responses of tropical forests to current and future climate and atmospheric composition [J]. Philos Trans R Soc Lond B Biol Sci, 2004, 359(1443): 477-491.

[4] Chave J, Condit R, Lao S, et al. Spatial and temporal variation of biomass in a tropical forest: Results from a large census plot in Panama [J]. Journal of Ecology, 2003, 91(2): 240-252.

[5] Chave J, Riera B, Dubois MA. Estimation of biomass in a neotropical forest of French Guiana: Spatial and temporal variability [J]. Journal of Tropical Ecology, 2001, 17(1): 79-96.

[6] Phillips OL, Grace JC. Changes in the carbon balance of tropical forests: Evidence from long-term plots [J]. Science, 1998, 282(5388): 439-442.

[7] Fan S, Gloor M, Mahlman J, et al. A large terrestrial carbon sink in north America implied by atmospheric and oceanic carbon dioxide data and models [J]. Science, 1998, 282(5388): 442-446.

[8] Chave J, et al. [Additional citation details]

[9] [Citation details]

[10] [Citation details]

[11] [Citation details]

[12] [Citation details]

[13] [Citation details]

[14] Xinjiang Forestry Editorial Board. Xinjiang forest [M]. Urumqi: Xinjiang People' s Publishing House, 1989.

[15] Yang J, Huang B, Huang M, et al. Responses of net ecosystem productivity to climate change in Xinjiang in recent 55 years [J]. Arid Land Geography, 2017, 40(5): 1054-1060.

[16] Wang X, Zhang J, Ma Y, et al. Spatial distribution of macro and micro physical properties of clouds during heavy rains over Tianshan Mountains [J]. Arid Land Geography, 2016, 39(6): 1153-1161.

[17] Li X, Xu X, Gong R, et al. Distribution characteristics of forest biomass along the Chinese temperature gradient [J]. Journal of Beijing Normal University (Natural Science Edition), 2017, (4): 458-464.

[18] [Author names]. Study on biomass and productivity of typical forest stands in the Qilian Mountains [J]. Journal of Gansu Agricultural University, 2011, 46(6): 81-85.

[19] [Author names]. Individual biomass allocation and its variation of Picea schrenkiana forests [J]. [Journal details]

[20] [Citation details]

[21] [Citation details]

[22] [Citation details]

[23] [Citation details]

[24] [Citation details]

[25] [Citation details]

[26] [Citation details]

[27] [Citation details]

[28] [Author names]. [Title related to biomass allocation] [J]. [Journal details]

[29] [Citation details]

[30] [Citation details]

[31] [Citation details]

[32] [Citation details]

[33] [Citation details]

[34] [Citation details]

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