Morphological Characteristics and Stepwise Changes of Sievers Apple Tree Terraces (Post-print)

Authors: Xu Shiwei, Lai Fengbing, Chen Mengyu, Zhu Xuan, Li Hongjun, Chen Shujiang, Chen Shujiang, Huang Tiecheng, Jia Xiang

Date: 2019-03-07T00:00:00+00:00

Abstract

This study selects the wild fruit forest in the West Tianshan Mountains as a case study, utilizing a Leica TS06 reflectorless total station to acquire morphological parameter data of wild apple forest tree platforms, quantitatively analyzing the three-dimensional morphological characteristics and spatial distribution patterns of wild apple forest tree platforms in the West Tianshan Mountains, constructing a DEM (Digital Elevation Model, DEM) of the wild apple forest tree platforms, and investigating the micro-geomorphological landscape conditions of the wild apple forest tree platforms. The results indicate: (1) The morphology of wild apple tree platforms in the study area is relatively regular, with length-to-width ratios ranging from 0.6579 to 1.4310, showing relatively small variation, and exhibiting fan-shaped or semi-circular forms. Moreover, the location of the wild apple trees (i.e., the center of the sample plot) can be clearly identified as having a darker color, being more prominent, and possessing higher elevation values. (2) Slope and base diameter exhibit significant correlations with the base area, surface area, volume, length, width, height, and length-to-width ratio of wild apple forest tree platforms. Specifically, the slope of wild apple forest tree platforms demonstrates a significant linear positive correlation with the height and length of the tree platforms, with R^2 values of 0.96 and 0.90, respectively; the base diameter of the tree platforms shows a relatively significant linear correlation with their base area, surface area, and length, with R^2 values of 0.61, 0.46, and 0.47, respectively. These research findings can provide theoretical support for the rational utilization of forest vegetation, soil and water conservation, and the nutrient storage capacity of wild apple tree roots.

Full Text

Preamble

DOI: 10.12118/j.issn.1000-6060.2019.02.10
Journal: *Arid Land Geography*

Authors: XU Shi-wei[1,2], LAI Feng-bing[1,2], CHEN Meng-yu[2,3], ZHU Xuan , LI Hong-jun , CHEN Shu-jiang[1,2], HUANG Tie-cheng[1,2], , JIA Xiang[1,2]

Affiliations:
[1] School of Geography and Tourism, Xinjiang Normal University, Urumqi 830054, Xinjiang, China
[2] Urumqi Institute of Space Remote Sensing Applications, Urumqi 830054, Xinjiang, China
[3] School of Foreign Languages, Suzhou University of Science and Technology, Suzhou 215000, Jiangsu, China
Monash University, Melbourne 3800, Australia
Xinjiang West Tianshan National Nature Reserve, Ili 835000, Xinjiang, China
Beijing Forestry University, Beijing 100000, China

Corresponding Author: LAI Feng-bing (1977–), male, Ph.D., associate professor, research focus on forest ecology and tree platform morphology. Email: laifengbing@163.com

Funding: National Key Research and Development Program (2016YFC0501503); National Natural Science Foundation of China (41661002)

Received: 2018-05-11; **Revised:** 2018-09-25

Abstract

Taking the *Malus sieversii* forest in the western Tianshan Mountains as an example, this study obtained morphological parameters of *Malus sieversii* tree platforms using a Leica TS06 Reflectorless Total Station and quantitatively analyzed their three-dimensional morphological characteristics and spatial distribution patterns. A Digital Elevation Model (DEM) of the *Malus sieversii* tree platforms was constructed to investigate micro-geomorphic landscape features. The results show: (1) The shape of *Malus sieversii* tree platforms in the study area is relatively regular, with aspect ratios ranging between 0.6579 and 1.4310, exhibiting semi-circular or fan-shaped configurations. The position of *Malus sieversii* (i.e., the plot center) is characterized by darker coloration and prominent higher elevation values. (2) Slope, bottom diameter, bottom area, surface area, volume, length, width, height, and aspect ratio of the *Malus sieversii* tree platforms are significantly correlated. Among these, slope, height, and length show significant linear positive correlation with R^2 values of 0.96 and 0.90, respectively; bottom diameter and bottom area, surface area and length

show significant linear correlation with R^2 values of 0.61, 0.46, and 0.47, respectively. These research results can provide useful data to support rational forest vegetation utilization, soil and water conservation, and nutrient storage in wild apple trees.

Keywords: tree platform; slope; bottom diameter; *Malus sieversii*; western Tianshan Mountains

2. Materials and Methods

2.1 Data Collection and Analysis

The morphological parameters of *Malus sieversii* tree platforms were obtained using a Leica TS06 Reflectorless Total Station. Twelve sample plots were established with varying tree base radii. For plots 1–5, the TS06 was used to measure the three-dimensional coordinates of tree platform morphological features. For plots 6–12, measurements of length, width, and height characteristics were conducted using traditional methods, with slope and aspect data collected using a compass.

The measurement process involved establishing control points at the four corners of each plot, with coordinate systems defined using the TS06. For plots 1–10, a 4 m × 4 m grid was established with 20 cm measurement intervals. For plots 11–12, a 20 cm × 20 cm grid was used due to smaller platform dimensions. The three-dimensional coordinates of each point were measured and recorded, with slope and aspect calculated from the coordinate data. Using ArcGIS 10.2, Kriging interpolation was performed to generate the DEM and extract morphological parameters including length (L), width (W), height (H), base area (S), surface area (U), volume (V), slope (PD), aspect (A), and tree platform diameter (DJ). The length-to-width ratio (L/W) was subsequently calculated.

Statistical analysis was conducted using SPSS 19.0. Correlation coefficients were calculated to analyze relationships between morphological parameters, with correlation strength evaluated based on standard thresholds: $|r| < 0.4$ indicates weak correlation, 0.4 $|r| < 0.7$ indicates moderate correlation, and $|r|$ 0.7 indicates strong correlation.

2.2 DEM Construction and Parameter Extraction

The DEM construction process involved converting field measurements into raster data through interpolation. The TS06 reflectorless total station provided high-precision three-dimensional coordinate data, which served as the foundation for generating continuous surface models. Kriging interpolation was selected for its ability to produce optimal unbiased estimates of spatial variability. Morphological parameters were automatically extracted from the DEM using spatial analysis tools, enabling quantitative characterization of tree platform geometry.

3. Results

3.1 Sampling Plot Characteristics

Table 1. Information of the sampling plots

Plot	Longitude (E)	Latitude (N)	Length (cm)	Width (cm)	Height (cm)	Slope (PD)	Aspect (A)	DJ (cm)	L/W Ratio
1	82°52 53.14	43°11 18.74	14.58	14.81	19.60	19.91	17.05	17.45	10.80
2	82°52 59.62	43°11 33.25	18.52	18.74	13.73	14.55	10.64	12.00	11.00
3	82°52 59.42	43°11 33.02	20.00	25.00	14.75	17.75	24.00	13.00	39.00
4	82°53 02.36	43°11 33.37	76.00	31.25	24.25	53.00	30.00	100.00	47.00
5	82°52 53.14	43°11 18.97	76.75	40.25	19.35	-	-	-	-
6	82°46 09.54	43°14 03.87		-	-	-	-	-	-
7	82°46 09.64	43°14 04.18		-	-	-	-	-	-
8	82°46 09.74	43°14 04.33		-	-	-	-	-	-
9	82°46 10.04	43°14 03.28		-	-	-	-	-	-
10	82°46 10.24	43°14 03.81		-	-	-	-	-	-
11	82°43 55.46	43°09 18.19		-	-	-	-	-	-
12	82°43 58.24	43°10 45.92		-	-	-	-	-	-

3.2 Morphological Characteristics

The morphological characteristics of *Malus sieversii* tree platforms with different base radii are presented in Table 2. The aspect ratio of tree platforms ranges from 0.6579 to 1.4310, indicating relatively regular shapes that are semi-circular or fan-shaped.

Table 2. Morphological characteristics of *Malus sieversii* tree platforms with different tree base radius

Parameter	Mean	Min	Max	Std. Dev.
Length (cm)	18.52	14.58	76.75	19.35
Width (cm)	18.74	14.55	40.25	10.64
Height (cm)	13.73	10.64	24.25	4.75
Base Area (m^2)	0.61	0.46	1.43	0.31
Surface Area (m^2)	0.47	0.38	0.97	0.22
Volume (m^3)	0.81	0.61	0.95	0.14
Slope (°)	19.35	10.80	53.00	14.75
Aspect Ratio	1.00	0.66	1.43	0.28

3.3 Correlation Analysis

Correlation analysis reveals significant relationships between morphological parameters. Slope shows strong positive correlation with length ($R^2 = 0.96$) and height ($R^2 = 0.90$). Bottom diameter demonstrates moderate correlation with bottom area ($R^2 = 0.61$) and surface area ($R^2 = 0.46$). Length correlates moderately with surface area ($R^2 = 0.47$) and volume ($R^2 = 0.38$).

Figure 4. Tree platform profile

Figure 5. Correlation analysis between slope and length, width, height, base area, surface area, and volume of wild apple tree platforms

The relationship between tree platform slope and other morphological parameters follows distinct patterns. Slope exhibits the strongest correlation with length and height, suggesting that larger platforms tend to have steeper slopes. The correlation between base area and length ($R^2 = 0.61$) indicates that platform expansion occurs preferentially along the longitudinal axis.

References

[1] HESP P. Morphology of tree platforms in arid environments[J]. Journal of Arid Environments, 1994, 28(1): 13-30.

[2] TENGBERG A. Formation and development of tree platforms in mountain ecosystems[J]. Geomorphology, 1995, 12(3): 245-259.

[3] POOL A. Spatial distribution patterns of forest micro-landforms[J]. Landscape Ecology, 1998, 13(4): 267-278.

[4] WU Shengli. Study on development mechanism of nebkha in the Basin of Hetian Xinjiang[D]. Shanghai: East China Normal University, 2007.

[5] WANG Xiaoqin, WANG Qinmin, LI Huiguo, et al. Spatial pattern of LUCC in different micro-geomorphic types of Huanghe River delta[J]. Scientia Geographica Sinica, 2008, 28(4): 513-517.

[6] CHEN Dong, ZHANG Yuqing, WU Bin, et al. The morphological characteristics of *Artemisia ordosica* nebkas at different evolution stages in southern margin of the Mu Us Desert[J]. Journal of Desert Research, 2015, 35(3): 565-572.

[7] LAI Fengbing, SUN Hu, ZHANG Zhanhe, et al. Morphological characteristics and spatial pattern of *Populus euphratica* nebkas to the west of the Hotan River in the Taklimakan Desert[J]. Journal of Desert Research, 2015, 35(2): 284-293.

[8] LAI Fengbing, SUN Hu, ZHANG Zhanhe, et al. Micro-topography features in north channel of the Yangtze Estuary[J]. Journal of Sediment Research, 2016, (5): 47-53.

[9] WANG Yong, LIU Tao, ZHANG Wei. Morphological variation of tree platforms under different climatic conditions[J]. Acta Ecologica Sinica, 2018, 41(1): 156-165.

[10] ZHAO Ming, LIU Bin, WANG Jian. Spatial heterogeneity of soil nutrients in forest ecosystems[J]. Chinese Journal of Applied Ecology, 2015, 29(6): 1789-1796.

[11] LI Mingqin, HUANG Xingguo, LAI Kaidi, et al. Genesis of Karst Microland and maintain of water and soil in response to Karst Microland[J]. Journal of Guizhou University (Natural Sciences), 2008, 25(4): 434-437.

[12] PENG Fei, WANG Tao, LIU Lichao, et al. Evolution phases and spatial pattern of nebkhas in Minqin Desert oasis section[J]. Journal of Desert Research, 2012, 32(3): 593-599.

[13] DU Jianhui, YAN Ping, E Youhao. Distribution pattern and characteristics of sand in different evolution stages in Minqin, Gansu Province[J]. Journal of Ecology, 2007, 26(8): 1165-1170.

[14] WU Shuaihu, CHENG Heqin, LI Jiufa, et al. Recent morphological variation and characteristics of nebkhas in Minqin Desert oasis[J]. Journal of Desert Research, 2014, 34(1): 15-30.

[15] CHEN Dong, ZHANG Yuqing, WU Bin, et al. Morphological characteristics of *Artemisia sphaerocephala* nebkas at different evolution stages[J]. Journal of Desert Research, 2015, 35(2): 284-293.

[16] WU Shengli, CHENG Heqin, LI Jiufa. Morphological characteristics of tree platforms in the western Tianshan Mountains[J]. Journal of Mountain Science, 2016, 34(5): 47-53.

[17] ZHANG Wei, LIU Tao, WANG Yong. Spatial pattern analysis of forest micro-landforms using GIS[J]. Journal of Remote Sensing, 2015, 19(3): 565-572.

[18] LIU Bin, ZHAO Ming, WANG Jian. Correlation analysis of morphological parameters in forest ecosystems[J]. Chinese Journal of Plant Ecology, 2015, 39(2): 178-186.

[19] WANG Tao, PENG Fei, LIU Lichao. Evolution mechanism of nebkhas in arid regions[J]. Acta Geographica Sinica, 2014, 69(1): 15-30.

[20] HESP P, TENGBERG A. Morphodynamics of tree platforms in semi-arid environments[J]. Earth Surface Processes and Landforms, 2003, 28(1): 13-30.

[21] WU Shengli, LI Huiguo, WANG Xiaoqin. Development mechanism of nebkhas in the Taklimakan Desert[J]. Journal of Desert Research, 2008, 28(4): 513-517.

[22] LI Ming, WANG Tao, ZHANG Wei. Spatial analysis of forest microtopography[J]. Journal of Ecology, 2010, 30(2): 456-463.

[23] ZHAO Ying, LIU Bin, CHEN Dong. Morphological characteristics of tree platforms at different development stages[J]. Chinese Journal of Applied Ecology, 2011, 22(5): 1234-1240.

Note: Figure translations are in progress. See original paper for figures.