Population Age Structure and Population Dynamics of Malus sieversii: A Postprint

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Abstract

Xinjiang wild apple is a Tertiary relict species whose population size and distribution area are currently declining, placing it on the brink of extinction. This study elucidates its population age structure and future development trends through analysis of life tables, survival curves, and time series prediction of population size for populations in different habitats. The results indicate that Xinjiang wild apple populations contain virtually no age class 1 juveniles, with only the Xinyuan County Improved Farm population possessing a small number of age class 2 individuals. The dominant age classes in most populations are 4 and 5, while those in the Xinyuan County Balian population have already reached classes 6 and 7, with old-aged individuals constituting the majority across all populations. The survival curves of different populations generally conform to the Deevey-II type, with mortality rates being similar across age classes. As most populations are already in middle age classes, the dominant age classes of various populations are projected to shift backward after 20, 40, and 60 years, with aging phenomena becoming more pronounced. It is recommended that germplasm resource banks for Xinjiang wild apple be established, artificial seedling cultivation be implemented, and supplementary planting be conducted for various populations to promote development toward uneven-aged forest stands. Furthermore, artificial tending and management measures should be intensified, including thinning of overly dense shrubs and herbs and control of pests and diseases, to create favorable conditions for seedling establishment.

Full Text

Abstract

Malus sieversii is a Tertiary relict species that now faces extinction due to continuous population decline and range contraction. This study analyzed life tables, survival curves, and time series of *M. sieversii* to illuminate age composition and population development trends. Results showed almost no seedlings in

the first age class across all populations, with only a few individuals surviving in the second age class at the Agricultural Improvement Station in Xinyuan County, Xinjiang. The dominant age classes in most populations were the 4th and 5th, extending to the 6th and 7th in the Balian population. In short, mid- and old-aged individuals dominated all populations. The survival curves of *M. sieversii* populations tended toward Deevey-II type. Predictions indicated that the dominant age classes in all populations would become substantially more aged after 20, 40, and 60 years. We suggest establishing a genetic resources center for *M. sieversii*, growing and transplanting seedlings, and strengthening population management.

Keywords: *Malus sieversii*; static life table; time series; age composition; population dynamic status

1. Methods

1.2 Plot Setup and Data Collection

We established 16 permanent sample plots of 50 m × 50 m each. Each plot was subdivided into three 5 m × 5 m subplots and three 1 m × 1 m subplots for comprehensive sampling. For each *M. sieversii* individual, we measured height, diameter at breast height (DBH), and crown width. A total of 108 *M. sieversii* individuals were surveyed across all plots. The relationship between height (x) and crown width (y) was described by the linear equation: $y = 1.966x + 17.31$.

1.3 Time Series Analysis

The time series model was defined as: $t = M(1)X_t - X(t-n)$, where $M(1)$ represents the moving average, t is the time period, n is the time lag, and X_t is the observed value at time t. We analyzed age class transitions at 20-year, 40-year, and 60-year intervals, with 10-year age classes as the basic unit. This approach allowed us to predict population structure changes over time [26–27] .

1.5 Statistical Analysis

Statistical analysis was performed using standard ecological software. The height-crown width relationship showed a significant positive correlation: $r = 0.676$ ($P < 0.001$).

2. Results

2.1 Age Structure Characteristics

The age structure analysis revealed that 17.64% of the population comprised mid-aged individuals. Age classes 3, 4, and 5 dominated the population structure. Notably, the 10-year age class contained virtually no seedlings, and the 10–20-year class had very few saplings. The maximum recorded age was 128 years, with an average age of 19 years across all populations (Fig. 2).

Population 1 consisted primarily of age classes 4 and 5, accounting for 77.50% of individuals. Population 2 was dominated by age classes 3 and 4 (77.36%). Population 3 showed age classes 5 and 7 as dominant (71.43%). In Population 4, age classes 4 and 5 represented 86.10% of individuals. Population 5 had age classes 4 and 5 comprising 87.76% of individuals. Population 6 showed age classes 4 and 5 at 88.57%, while Population 7 had 85.71% in these classes (Fig. 2).

2.2 Life Expectancy

The mean life expectancy varied significantly across age classes (Table 3). Younger age classes generally showed higher mortality rates, while older classes exhibited more stable survival patterns.

2.3 Survival Curves

The survival curves for all populations followed a Deevey-II pattern, indicating relatively constant mortality rates across age classes (Fig. 2). This pattern suggests that environmental factors rather than age-specific senescence primarily regulate population dynamics.

3. Discussion

3.1 Population Dynamics

The lack of seedlings and scarcity of young individuals indicate severe recruitment limitations across all *M. sieversii* populations. This regeneration bottleneck threatens long-term population viability. The dominance of mid- and old-aged individuals reflects historical recruitment events and suggests that current conditions are unfavorable for seedling establishment and survival [28] .

3.2 Conservation Implications

The predicted aging of dominant age classes over 20-, 40-, and 60-year horizons underscores the urgent need for intervention. Without active management, these populations will continue to decline. Establishing a genetic resources center and implementing seedling transplantation programs are critical for species preservation. The significant correlation between height and crown width ($r = 0.676$, $P < 0.001$) provides a useful metric for monitoring individual health and growth rates in restoration efforts.

Table 3 The mean expectation of life of *Malus sieversii* populations

Age Class	Population 1	Population 2	Population 3	Population 4	Population 5	Population 6	Population 7
1	-	-	-	-	-	-	-
2	16.50	9.50	0.59	1.26	0.98	0.61	0.50
3	48.50	2.81	0.62	0.98	0.59	0.50	-
4	20.50	22.75	0.58	4.00	1.83	3.50	0.50
5	-	32.50	0.67	1.50	1.10	2.50	0.50
6	-	17.50	1.21	1.53	1.07	1.07	0.83
7	-	13.17	1.15	4.83	1.00	1.33	0.83
8	-	19.50	2.03	1.72	1.03	0.79	1.17
9	-	18.50	4.00	1.15	0.83	6.50	1.50
10	-	-	-	2.50	0.75	0.50	2.50
11	-	-	-	-	0.60	0.50	-
12	-	-	-	-	1.37	1.67	-
13	-	-	-	-	5.67	1.59	-
14	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-

Note: 1-16 represent age classes; see Fig. 1 for details.

References: [1] Chen Zhiyang, Yang Ning, Yao Xianmin, et al. Life history and spatial distribution of a *Taiwania flousiana* population in Leigong Mountain, Guizhou Province, China〔J〕. *Acta Ecologica Sinica*, 2012, 32(7): 2158-2165. [4] Wang Lei, Cui Dafang, Lin Peijun, et al. Types of wild apples planted in Xinjiang〔J〕. *Journal of Xinjiang Normal University (Natural Science Edition)*, 1998, 17(1): 37-46. [6] Lin Peijun, Cui Nairan, Wang Lei. The Wild Fruit Forest Resources in Tianshan Mountains: Comprehensive study on Ili Wild Fruit Forest〔M〕. Beijing: China Forestry Publishing, 2000. [9] Li Bo. Ecology〔M〕. Beijing: Higher Education Press, 2000: 46. [10] Li Bo. Ecology〔M〕. Beijing: Higher Education Press, 2000: 46. [11] Standard Methods for Observation and Analysis in Chinese Ecosystem Research Network—Survey, Observation and Analysis of Terrestrial Biocommunities〔M〕. Beijing: Standard Press of China, 1996: 20-81. [12] Chen Xing. Wild apple resources in Ili, Xinjiang〔J〕. *Arid Zone Research*, 2009, 36(3): 447-452. [13] Dong Ming, Wang Yifeng, Kong Fanzhi. Standard Methods for Observation and Analysis in Chinese Ecosystem Research Network〔M〕. Beijing: Standard Press of China, 1996: 20-81. [14] Zhang Yanmin, Feng Tao, Zhang Chunyu, et al. Advances in research of the *Malus sieversii* (Ledeb.) Roem.〔J〕. *Acta Horticulturae Sinica*, 2009, 36(3): 447-452. [15] Tian Runwei, Cai Xinbin, Liu Liyan, et al. Characteristics of the age structure of *Malus sieversii* populations〔J〕. *Nonwood Forest Research*, 2016, 34(3): 163-168. [16] Jiang Hong. Study on Population Ecology of *Picea asperata*〔M〕. Beijing: China Forestry Publishing House, 1992: 33-78. [19] Zhu Ning, Zang Runguo. Population ecology of *Acanthopanax senticosus* population structure〔J〕. *Chinese Journal of Applied Ecology*, 1993, 4(2): 113-119. [21] Wang Zehua, Qin Wei,

Yan Juanjuan, et al. Study on the relationship between physiological response and cold hardiness of *Malus sieversii* in different populations〔J〕. *Nonwood Forest Research*, 2016, 36(4): 811-817. [23] Xie Zongqiang, Chen Weilie, Lu Peng, et al. The demography and age structure of *Malus sieversii*〔J〕. *Journal of Plant Ecology*, 1999, 19(4): 523-528. [26] Chen Xing. Wild apple resources in Ili, Xinjiang〔J〕. *Arid Zone Research*, 2009, 36(3): 447-452. [27] Dong Ming, Wang Yifeng, Kong Fanzhi. Standard Methods for Observation and Analysis in Chinese Ecosystem Research Network〔M〕. Beijing: Standard Press of China, 1996: 20-81. [28] Wang Lei, Cui Dafang, Lin Peijun, et al. Types of wild apples planted in Xinjiang〔J〕. *Journal of Xinjiang Normal University (Natural Science Edition)*, 1998, 17(1): 37-46. [29] Jiang Hong. Study on Population Ecology of *Picea asperata*〔M〕. Beijing: China Forestry Publishing House, 1992: 33-78. [31] Su Zhi-hao, Li Wen-jun, Cao Qiu-mei, et al. Age composition and quantitative dynamic status of *Malus sieversii* populations〔J〕. *Arid Zone Research*, 2018, 35(1): 156-164.

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