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***Pinus densiflora* var. *ussuriensis* Forest Alliance**

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Pinus densiflora var. *ussuriensis* Forest Alliance

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Abstract

Pinus densiflora var. *ussuriensis* forest is a pine forest type unique to the northeast region of China, with a special habitat, strong barrenness and drought resistance, and normal growth under super-reversible ground conditions, as well as important ecological benefits such as water conservation, improvement of soil conditions, windbreaks and sand fixation, making it an important pioneer tree species for improving ground conditions. The paper through the natural distribution of China's *Pinus densiflora* var. *ussuriensis* forest field survey, combined with literature, the geographical distribution of *Pinus densiflora* var. *ussuriensis* forest, ecological characteristics, community characteristics, species composition and type division of the systematic analysis, the main results:

- (1) According to 11 sample squares survey statistics, the natural *Pinus densiflora* var. *ussuriensis* forest recorded a total of 142 species of vascular plants, belonging to 55 families and 104 genera. Among them, there are 2 species of ferns, 1 species of gymnosperms and 139 species of angiosperms.
- (2) The number of terrestrial herbs in the life type composition of the *Pinus densiflora* var. *ussuriensis* forest is the highest, followed by woody plants, and the proportion of bryophytes is the least.
- (3) The *Pinus densiflora* var. *ussuriensis* forest located at the lake post of Xing Kai Lake is in a period of decline, and if the soil in the area continues to be moisturized, the cluster may eventually evolve into a broad-leaved mixed forest.
- (4) According to the life type and dominant species, the *Pinus densiflora* var. *ussuriensis* forest can be divided into 2 clusters.

Keywords

Pinus densiflora var. *ussuriensis*; species diversity; community characteristics; community classification

Introduction

Vegetation is the result of the long-term development of plant communities in an area (Zhengyi and Editorial Committee of Vegetation of China 1980). In-depth study of vegetation is an important means of understanding the laws of development of the natural environment. Xingkai *Pinus densiflora* forest is an important vegetation type in the cold-temperate zone coniferous forest area, and the species of *Pinus densiflora* var. *ussuriensis* Liou & Z. Wang belongs to the family of gymnosperm, *Pinus densiflora* var. *ussuriensis*, *Pinus densiflora* var. *ussuriensis*, and it is the naturally occurring species of *Pinus densiflora* var. *ussuriensis* in the area of Xingkai Lake.

Pinus densiflora var. *ussuriensis* is a national key wild plant of the second level of protection according to National Key Wild Plants under Protection (2021 Edition) (National Forestry and Grassland Administration, Ministry of Agriculture and Rural Affairs 2021). It is highly resistant to drought and barrenness, and can grow in arid sandy soils where rocks are exposed and other tree species are difficult to survive, and has an important influence on the soil formation process. It is an extremely important pioneer species for improving the standing conditions, and occupies an irreplaceable leading role in maintaining and improving the ecological environment. Investigating the population structure of *Pinus densiflora* var. *ussuriensis* can provide important background information for its conservation.

Materials and Methods

Overview of the study area

The natural distribution area of *Pinus densiflora* var. *ussuriensis* is narrow, with only small intermittent distributions along the shores of Lake Xingkai in Russia, and in the low hills of the Lake Xingkai area and Muling River basin in southeastern Heilongjiang Province, China (Yiliang 1997).

Among them, Xingkai Lake Nature Reserve belongs to Mishan City, Jixi City, Heilongjiang Province, and is located in the southeastern part of Mishan City. The *Pinus densiflora* var. *ussuriensis* forest is mainly located in the large lake post between the large and small Xingkai Lake, which extends from Dangbi Town in the northwestern part of the edge of the lake to Longwangmiao in the southeastern part of the lake, with geographic coordinates of 131°58'30"~133°07'30" "E, 45°01'00"~45°34'30" "N. The region has a unique regional microclimate as a result of the huge body of water of the Lake Xingkai and is a part of the humid semi-humid temperate continental monsoon climate. Spring thawing of the lake absorbs a lot of heat energy, so that the temperature is lower than the same latitude 1 °C ~ 3 °C; autumn lake ice release heat, so that the frost-free period of the area around the lake than inland at the same latitude backward postponed about 15d. The average annual

temperature of 2.9 °C ~ 3.1 °C, the average annual precipitation of 650 ~ 750mm, summer precipitation accounts for about 70% of the year. The southwest wind prevails in the spring and summer in the Xingkai Lake area, with an average annual wind speed of 3.0~4.0m/s, and an average annual number of gusty days of about 38d. The average annual sunshine hours of 2574 hours, the active cumulative temperature of 2250 °C, frost-free period of 147d, xingkai lake winter is extremely cold, in November began to freeze, 15d or so the lake surface all frozen, the lake ice thickness of 0.8 ~ 1.5m, thawed in mid to late April, the surface of the water frozen period of 150d or so (Ze et al. 2022, Ze et al. 2020, Ze et al. 2021).

Muling river basin distribution area is mainly located in the middle and upper reaches of the Muling River in the low hills, the river from the southwest direction of the Muling City, extends to the northeast direction of the city of Jixi and so on, *Pinus densiflora* var. *ussuriensis* in this area is intermittent distribution. All belong to the temperate continental monsoon climate. Dry and windy in spring, mild and rainy in summer, early first frost in autumn, cold and dry in winter. The average annual temperature is 2.8-4.9 °C, the annual evaporation is 1,251.1-1,341.5 mm, and the average annual ≥ 10 °C active cumulative temperature is 2,490.7-2,831.6 °C. The average annual rainfall is about 509.4 ~ 517.3 mm, the average annual relative humidity is 66%, and the rainfall is mostly concentrated in June to September. The annual sunshine hours are 2,280.8 ~ 2,498.2 h, and the frost-free period is about 120 d. The average annual rainfall is 509.4 ~ 517.3 mm, and the average relative humidity is 66%.(Lei and Yu 2013, Jixuan 2020, Xu et al. 1992, Zhaoyuan and Zhenghao 2014).

Sample survey

Three to six 20m×20m tree samples were set up in Xingkai Lake Dahugang, Jixi Heping Forest Farm and Jidong County Southwest Fork Forest Farm, respectively; one 5m×5m shrub sample was set up within the tree sample, and four 1m×1m herbaceous samples were set up in the corners of the trees.

In the tree sample, all woody plants with tree height $\geq 5\text{m}$ were numbered, and each tree was inspected to record its scientific name, tree height, diameter at breast height, height below branches and crown width. In the shrub sample, all woody plants $< 5\text{m}$ in height were numbered and the scientific name, number of plants, cover, mean height, basal diameter, and crown spread were recorded for each species. In the herbaceous sample, the scientific name, multiplicity, cover, and mean height of all herbaceous plants were recorded.

Table 1

Data Analysis

Checking of scientific names

All species occurring in *Pinus densiflora* var. *ussuriensis* forests were checked based on the results of the survey of the sample plots and sample lines according to Flora of China (The Editorial Committee of Flora Reipublicae Popularis Sinicae, Chinese Academy of Sciences 2019), and a list of the species of *Pinus densiflora* var. *ussuriensis* forests in Xingkai was obtained.

Significant value calculations

Species importance values for each stratum were calculated according to the data in the sample recording sheet with the following formula:

Importance value of tree layer = (relative density + relative breast height area + relative height)/3

Shrub layer, herb layer species importance value = (relative density + relative cover + relative height)/3

Cluster classification and nomenclature

Quantitative classification was carried out using the JUICE programme (L and J 2006), and the results of the quantitative classification were corrected to determine a reasonable classification scheme based on records in the literature and reference books as well as experience. Nomenclature was also carried out according to the principles in the revised programme of the Chinese Vegetation Record (CVR) (Ke et al. 2020).

Result

Species composition of *Pinus densiflora* var. *ussuriensis* Forests

Suppl. material 1 A total of 55 families 104 genera and 142 species of vascular plants were investigated in *Pinus densiflora* var. *ussuriensis* Forest. Among them, there are 2 species of ferns, 2 genera of ferns, 2 species of gymnosperms, 2 genera of gymnosperms, and 142 species of angiosperms, 51 genera of angiosperms and 100 genera of ferns. In accordance with the decreasing order of the number of species, the number of species of the family were 10 genera and 16 species of Asteraceae, Rosaceae 9 genera and 12 species, 6 genera and 11 species of Fabaceae, 4 genera and 6 species of Gramineae, 1 genera and 6 species of Violaceae, Caryophyllaceae 4 genera and 5 species, 4 genera and 5 species of Asparagaceae, Cyperaceae 1 genera and 4 species, Ranunculaceae 4 genera and 4 species, Caprifoliaceae 2 genera and 4 species, Rhamnaceae 1 genera and 4 species, Lamiaceae 4 genera and 4 species, Campanulaceae 2 genera and 4 species, Apiaceae 4 genera and 4 species, 3 genera and 3 species of Crassulaceae, 2 genera and

3 species of Rubiaceae, 1 genus and 2 species of Iridaceae, 1 genus and 2 species of Amaryllidaceae, 2 genera and 2 species of Urticaceae, 2 genera and 2 species of Betulaceae, 1 genus and 2 species of Sapindaceae, 1 genus and 2 species of Amaranthaceae, 2 genera and 2 species of Ericaceae, 2 genera and 2 species of Onagraceae, and another 31 families containing only 1 genus and 1 species.

According to the number of species as a percentage of the total, the dominant families accounted for the following proportions of the total: Asteraceae accounted for 11.27%, Rosaceae 8.45%, Fabaceae 7.75%, Gramineae and Violaceae each accounted for 4.23%, and Caryophyllaceae and Asparagaceae each accounted for 3.52%.

The genera with more species in decreasing order were *Artemisia* (6 species), *Viola* (6 species), *Vicia* (5 species), *Carex* (4 species), *Rhamnus* (4 species), *Prunus* (3 species), and *Adenophora* (3 species). Containing two species of 14 genera, respectively, the genus *Iris*, *Allium*, *Polygonatum*, *Deyeuxia*, *Setaria*, *Patrinia*, *Lespedeza*, *Potentilla*, *Acer*, *Silene*, *Chenopodium*, *Galium*, *Aster* and *Lonicera*. The number of oligotrophic genera containing only one species totaled 83. The dominant genera accounted for the following: *Artemisia* and *Viola* each accounted for 4.23%, *Vicia* 3.52%, *Carex* and *Rhamnus* each accounted for 2.82%, and *Prunus* and *Adenophora* each accounted for 2.11%.

Table 2

Lifestyle Composition

Pinus densiflora var. *ussuri* forests have the largest number of terrestrial herbs, accounting for nearly 80% of the total, and the highest proportion of terrestrial herbaceous plants is erect miscellaneous, accounting for about 40% of the total number of species, accounting for more than 50% of the number of herbaceous plants; followed by rhizomes, accounting for about 15% of the total number of species, about 20% of the number of herbaceous plants. Succulents and ferns accounted for the least, only about 1%.

The *Pinus densiflora* var. *ussuriensis* forest has about 20% of woody plants, with only one evergreen tree, the *Pinus densiflora* var. *ussuriensis*. Deciduous shrubs accounted for the highest proportion, with shrubs accounting for about 15 per cent of the total number of species. Deciduous trees are the next highest, accounting for about 6 per cent. Lianas account for less than 1 per cent.

Cluster classification results

***Pinus densiflora* var. *ussuriensis*+*Quercus mongolica* - *Lespedeza bicolor* - *Carex caespitosa* Association**

This community is distributed in the lakeshore between the big and small Xingkai Lakes, at an altitude of 80-100 m. It often grows in the sunny area of the lake-facing slope, with a gradient of 10° ~ 20°.

The community has a clear vertical structure, typical of coniferous forest outcrops. It can be divided into a tree layer, a small tree layer, a shrub layer, and a herb layer.

The tree layer has a cover of about 70%, a diameter at breast height of 15 (3-37) cm, and a height of 13 (5-17) m. It can be divided into two sub-layers: in the large tree layer, *Pinus densiflora* var. *ussuriensis* is the single dominant species, with occasional *Populus davidiana* and *Acer pictum* and other broadleaf species, and an average height of about 14 m. The small tree layer mainly consists of *Quercus mongolica*, with *Acer tegmentosum*, *Acer tegmentosum*, and other species mixed in it.

The shrub layer is relatively sparse, with a cover of about 30 per cent and an average height of about 1 m. The main species are deciduous shrubs such as *Quercus mongolica*, *Lespedeza bicolor*, *Rhamnus arguta*, *Prunus padus*, *Eleutherococcus sessiliflorus*, *Lonicera praeflorens*, *ophora flavescens*, and *Berberis amurensis* in the form of thickets, and young trees of arboreal species of *Pinus densiflora* var. *ussuriensis*, *Acer tegmentosum*, and *Acer pictum*. Occasional clumps of *Juniperus sabina* var. *davurica* are seen.

The herbaceous layer mainly consists of drought-tolerant herbs, such as common *Carex caespitosa*, *Deyeuxia purpurea*, *Polygonatum odoratum*, *Phryma leptostachya* subsp. *Asiatica*, *Carex lanceolata*, *Carex appendiculata*, *Viola acuminata*, *Maianthemum bifolium*, etc. Occasionally, *Vicia amurensis*, *Campanula punctata*, *Artemisia sylvatica* can be seen. Herbs that often grow in wet conditions, such as *Viola collina*, *Glechoma longituba*, *Stellaria radians*, can be seen at higher levels of depression. Invasive plants, such as *Phedimus aizoon*, *Agrimonia pilosa*, *Urtica angustifolia*, are common at the forest edge, with occasional invasive plants, such as *Oenothera biennis* and *Chenopodium ficifolium*, near the road.

Lianas such as *Vitis amurensis*, *Thladiantha dubia*, and *Dioscorea nipponica* are also found in small quantities in the forest and can grow across herbaceous and shrub layers, increasing the complexity of the community structure.

Tables 4, 5, 6

***Pinus densiflora* var. *ussuriensis* - *Rhododendron dauricum* - *Carex callitrichos* Association**

The cluster is distributed in the upper and middle reaches of the Muling River basin in the low hills, slope 40 ° ~ 60 ° or so, altitude 300 ~ 600 m between, in the region of the sunny slopes in the middle and upper arid, barren stony dark brown loam, there are large areas of *Pinus densiflora* var. *ussuriensis* pure forest distribution, is *Pinus densiflora* var. *ussuriensis* forests in the high-elevation of a typical distribution area.

The community has a distinct vertical structure and can be divided into a large tree layer, a small tree layer, a shrub layer, and an herbaceous layer. The tree layer can be divided into two sublayers. The large tree layer is single and neat, almost entirely composed of *Pinus densiflora* var. *ussuriensis*, with a cover of about 70%, a diameter at breast height of 13 (1-60) cm, and a height of 10 (5-17) m. *Quercus mongolica* with straight trunks is occasionally seen, and elm is *Ulmus pumila*. The small tree layer is mainly composed of *Quercus mongolica* with poor growth and much branched trunks, with an average height of about 6 m. The tree layer is mainly composed of *Quercus mongolica* with poor growth and much branched trunks.

The shrub layer is sparse, with low species richness, a cover of about 20%, and an average height of less than 1 m. It consists mainly of *Rhododendron dauricum* and *Lespedeza juncea*, *Lespedeza juncea* and other drought-tolerant deciduous shrubs, with the occasional seedlings of *Maackia amurensis*, *Corylus heterophylla* and broadleaf trees such as birch and Purple linden.

The herb layer is sparse and has low species richness, with only about 15% cover and an average height of about 30 cm. Drought-tolerant plants of the *Carex* and *Iris* form the main outcrop of the herb layer. *Carex callitrichos*, *Iris uniflora*, *Spodiopogon sibiricus*, *Deyeuxia pyramidalis*, as well as *Artemisia argyi*, *Artemisia vestita*, and *Patrinia rupestris* are common. Occasionally, *Gypsophila pacifica*, *Adenophora pereskiiifolia*, *Pyrola asarifolia* subsp. *Incarnata*, *Hylotelephium malacophyllum*, and *Orostachys spinosa* tile pine are seen. One of the growth in the mountain slopes, from the farmland, villages closer to the *Pinus densiflora* var. *ussuriensis* forest can be seen under the *Senecio vulgaris* and *Erigeron annuus* and other invasive plants. No interstory plants were seen in the forest.

Tables 7, 8, 9

Discussion

The 2 clusters of *Pinus densiflora* var. *ussuriensis* forests are in different successional stages and subject to different disturbances.

Pinus densiflora var. *ussuriensis*+*Quercus mongolica* - *Lespedeza bicolor*- *Carex caespitosa* Association located in Dahu Gang, Xingkai Lake, was mainly disturbed from the following three aspects:

1. changes in soil conditions. There are four lake posts on the north shore of Xingkai Lake, according to the formation of the era from early to late, respectively, the barren post, the second post, the sun post and the big lake post, the texture composition of the brownish-red subclay, yellowish-brown sandy clay and clay-sand, earthy-yellow clayey medium-fine sand, and yellowish-white medium-fine sand, respectively, showing the characteristics of successive changes, suggesting that the big lake post may be in the transition stage from arid and infertile medium-fine sand to subclay soil with high humidity and high fertility . A few broadleaf trees such as *Populus amurensis*, *Tilia amurensis*, and *Acer pictum* subsp. *mono*, which prefer humid habitats, have invaded the edge of *Pinus densiflora* var. *ussuriensis*, and the invading broadleaf species are generally small in diameter at breast height (DBH), low in height (LH), and small in age (AGE). If the soil in the area continues to be humid, it will be more favourable for the colonisation and growth of the broadleaf trees, which will change the composition of the forest stand.
2. Bank collapse. *Pinus densiflora* var. *ussuriensis* forests in low altitude areas are concentrated in the large and small lakes of Xingkai Lake between the large lake post, Xingkai Lake lake is vast, windy and high waves, spring and summer lake on the southwest wind is fierce, the average annual wind speed of up to 3 ~ 4 m/s. The lake wind will be the sand and gravel in the lake piled up to the shore, and then by the lake wind handling the formation of the lake post. Over the past 30 years, the water level of Lake Densiflora var. *ussuriensis* has been rising, the inundation range of the lake has changed significantly, the width of the narrowest part of the lake post has been reduced by nearly 50%, and the lake post has been collapsed in many places (Xianhua et al. 2006), and *Pinus densiflora* var. *ussuriensis* often falls to the ground, and the vegetation has been seriously damaged.
3. anthropogenic interference. 2011, "Heilongjiang Xingkai Lake National Nature Reserve Lake Gang Regulations" began to implement (Jixi Daily 2011), but before the publication of this "Regulations", the surrounding excavation and mining, land use and road construction projects, has been distributed in the lake Gang *Pinus densiflora* var. *ussuriensis* caused greater damage.

Among the above disturbing factors, the soil conditions and living environment have been steadily and irreversibly damaged, the soil moisture in the area will continue to increase, and the area of *Pinus densiflora* var. *ussuriensis* forests will gradually shrink, and may ultimately be replaced by broad-leaved mixed forests. To sum up, the cluster is in a period of decline.

The *Pinus densiflora* var. *ussuriensis* - *Rhododendron dauricum* - *Carex callitrichos* Association located in the upper and middle watersheds of the Muling River is in a relatively stable period. The *Pinus densiflora* var. *ussuriensis* is the established species of this cluster, which is distributed in the area with high altitude, poor and arid soil, and directly exposed gravel on the surface, which makes it difficult for other tree species to

survive, so the *Pinus densiflora* var. *ussuriensis* is able to grow and reproduce. And far away from farmland villages, without human interference. Combined with the local climatic characteristics and physical and chemical properties of the soil, *Pinus densiflora* var. *ussuriensis* - *Rhododendron dauricum* - *Carex callitrichos* Association cluster should be the top vegetation in this area. The sparse forest stand, good light conditions and arid soils in this area are favourable for *Pinus densiflora* var. *ussuriensis* seedling regeneration, and the proportion of seedlings and young trees in the forest is as high as 40%, with good growth and unimpeded self-renewal.

Conflicts of interest

The authors have declared that no competing interests exist.

References

- Jixi Daily (2011) Heilongjiang xingkai lake national nature reserve lake post management regulations.
- Jixuan H (2020) Effects of meteorological factors on roasted tobacco production in Jidong County. Northeast Agricultural University
- Ke GU, Jing-Yun FA, Guo-Hong WA, Zhi-Yao TA, Zong-Qiang XI, Ze-Hao SH, Ren-Qing WA, Sheng QI, Cun-Zhu LI, Liang-Jun DA, Dan YU (2020) A revised scheme of vegetation classification system of China. Chinese Journal of Plant Ecology 44 (2): 111-127. <https://doi.org/10.17521/cjpe.2019.0271>
- Lei J, Yu Z (2013) A preliminary study on the conservation project of *Pinus densiflora* var. *ussuriensis* in Jidong County. Protective Forest Science and Technology 4: 83-84 108.
- L T, J H (2006) JUICE: program for management, analysis and classification of ecological data. Release date: 2019-10-10. URL: https://www.sci.muni.cz/botany/juice/JC_man1.pdf
- National Forestry and Grassland Administration, Ministry of Agriculture and Rural Affairs (2021) The List of Key Protected Wild Plants in China. https://www.gov.cn/zhengce/2021-09/07/content_5727413.htm. Accessed on: 2023-4-20.
- The Editorial Committee of Flora Reipublicae Popularis Sinicae, Chinese Academy of Sciences (2019) Flora of China. <http://www.iplant.cn/foc>. Accessed on: 2020-6-18.
- Xianhua Y, Ping G, Yanqiu H (2006) Vertical shore protection of Xingkai Lake. Water Resources Science and Economy 06: 401.
- Xu CY, Li H, Zhang J (1992) Relationship between ecological environment and growth of natural forests of *Pinus terrestris* and *Pinus sylvestris*. Jilin Forestry Science and Technology 3: 1-4.
- Yiliang Z, et al. (1997) 中国东北植被地理. [Vegetation Geography of Northeast China]. Science Press, Beijing. [In Chinese].
- Ze YA, Guodong LI, Huimin DA, Yhe ZH, Jiang XU, Hongye XI (2020) Characterisation of spatial and temporal variation of soil pH in Xingkai Lake Plain, Heilongjiang Province. Geology and Resources 29 (6): 614-620.

- Ze YA, Guodong LI, Huimin DA, Yhe ZH, Hongye XI, Yuchao YI (2021) Geochemical characteristics of soil selenium and potential of selenium-enriched land development in Xingkai Lake Plain, Heilongjiang. *Geological Bulletin* 40 (10): 1773-1782.
- Ze YA, Yhe ZH, Huimin DA, Guodong LI, Kai LI, Jiang XU (2022) Spatial variability of organic carbon in surface soils of the Xingkai Lake Plain. *Physical and Chemical Exploration* 46 (5): 1076-1086.
- Zhaoyuan J, Zhenghao C (2014) Characterisation of Mudanjiang's climate over the past 30 years. *Private Science and Technology* 10: 221.
- Zhengyi W, Editorial Committee of Vegetation of China (1980) 中国植被. [Vegetation of China]. Science Press, Beijing. [In Chinese].

Table 1.
Sample plot information.

Site number	Sample site	Aspect	Slope	Position on slope	Latitude(°N)	Longitude(°E)	Altitude(m)
S1	Mishan - Xingkai Lake Hukang	Southwest	15°	Upper slope	45.3466742	132.3069948	99.6
S2	Mishan - Xingkai Lake Hukang	Southwest	20°	Mid-slope	45.3486517	132.3097488	99.8
S3	Mishan - Xingkai Lake Hukang	Southwest	20°	Upper slope	45.2671735	132.7066088	99.8
S4	Mishan - Xingkai Lake Hukang	Southwest	15°	上坡 Upper slope	45.2755584	132.6909948	101.5
S5	Liuwangkou Tun, Xingkaihu Farm	Southwest	10°	上坡 Upper slope	45.2803	132.6913	92.80
S6	Liuwangkou Tun, Xingkaihu Farm	Southwest	10°	上坡 Upper slope	45.2696	132.7127	83.70
S7	South Fork Forest, Chicken East and West	Southwest	20°	Mid-slope	45.0181379	131.1118699	404.9
S8	South Fork Forest, Chicken East and West	South	35°	Upper slope	45.0250836	131.1221641	337.1
S9	South Fork Forest, Chicken East and West	South	45°	Mid-slope	45.0190816	131.1154875	310.8
S10	South Fork Forest, Chicken East and West	East	50°	Upper slope	44.9974858	131.0928815	413.5
S11	South Fork Forest, Chicken East and West	South	50°	Upper slope	45.0188718	131.1121523	435.8
S12	South Fork Forest, Chicken East and West	South	40°	Upper slope	45.0205656	131.1129329	459.8
S13	Jixi Heping Forest	South	35°	Mid-slope	45.4459644	130.9735044	428.8
S14	Jixi Heping Forest	Southwest	40°	Upper slope	45.4505443	130.9901770	454.5
S15	Jixi Heping Forest	Southwest	50°	Lower slope	45.4147683	130.9575652	325.7
S16	Jixi Heping Forest	Southwest	60°	Mid-slope	45.4150583	130.9562751	328.8
S17	Jixi Heping Forest	Southwest	35°	Mid-slope	45.4275936	130.9750248	341.7

Table 2.
Composition of genera and species of *Pinus densiflora* var. *ussuriensis* forests.

Family	No. of genera	No. of species
Poaceae	4	6
Dennstaedtiaceae	1	1
Polypodiaceae	1	1
Pinaceae	1	1
Cupressaceae	1	1
Dioscoreaceae	1	1
Liliaceae	1	1
Orchidaceae	1	1
Iridaceae	1	2
Amaryllidaceae	1	2
Asparagaceae	4	5
Commelinaceae	1	1
Campanulaceae	2	4
Araliaceae	1	1
Berberidaceae	2	2
Sapindaceae	1	2
Polemoniaceae	1	1
Asteraceae	10	16
Cyperaceae	1	4
Papaveraceae	1	1
Menispermaceae	1	1
Ranunculaceae	4	4
Rosaceae	9	12
Rhamnaceae	1	4
Ulmaceae	1	1
Ericaceae	2	2
Fagaceae	1	1
Betulaceae	2	2
Cucurbitaceae	1	1
Celastraceae	1	1
Violaceae	1	6
Paeoniaceae	1	1
Crassulaceae	3	3
Vitaceae	1	1

Amaranthaceae	1	2
Caprifoliaceae	2	4
Apiaceae	4	4
Salicaceae	1	1
Euphorbiaceae	1	1
Geraniaceae	1	1
Onagraceae	2	2
Malvaceae	1	1
Brassicaceae	1	1
Caryophyllaceae	4	5
Oleaceae	1	1
Plantaginaceae	1	1
Lamiaceae	4	4
Phrymaceae	1	1
Orobanchaceae	1	1
Polygalaceae	1	1
Fabaceae	6	11
Rubiaceae	2	3
Apocynaceae	1	1
Solanaceae	1	1
Urticaceae	2	2

Table 3.
Life type spectrum (%) of 142 species of plants in Pinus densiflora var. ussuriensis forests.

Woody plant	Tree					Dioecious	Vine			
	Ever-green	Deci-duous				Deciduous	Deciduous			
22.54	0.70	6.34				14.79	0.70			
Terrestrial herb	Perennial herb					Pteridophytes				
	Rootstock	Upright miscellaneous	Trailing and climbing		Lotus seat	Succu-lent	Parasitic			
77.46	15.49	42.25	11.97		4.93	1.41		1.41		

Table 4.

Characterization of the number of tree layers in the *Pinus densiflora* var. *ussuriensis*+*Quercus mongolica* - *Lespedeza bicolor* - *Carex caespitosa* Association.

Serial number	Latin name of species	Frequency	Density (plants/ 600 m ²)	Diameter at breast height (cm)	Tree height (m)	Breast height section area (cm ² /600 m ²)	Significant value (%)
1	<i>Pinus densiflora</i> var. <i>ussuriensis</i>	6	70.3	18.2	14.7	34935.1	63.5
2	<i>Quercus mongolica</i>	4	8.8	18.1	16.0	2570.7	11.9
4	<i>Tilia amurensis</i>	1	1.5	18.1	17.5	440.2	7.7
5	<i>Acer tegmentosum</i>	1	2.0	18.8	14.0	733.1	6.8
6	<i>Populus davidiana</i>	2	1.3	10.9	15.6	121.8	6.6
7	<i>Acer pictum</i>	1	0.5	8.8	8.5	35.8	3.5

Table 5.
Characterization of the number of shrub layers in the *Pinus densiflora* var. *ussuriensis*+*Quercus mongolica* - *Lespedeza bicolor* - *Carex caespitosa* Association.

Serial number	Latin name of species	Frequency	Density (plants/ 100 m ²)	Coverage (%)	Basal diameter (cm)	Height (cm)	Significant value (%)
1	<i>Quercus mongolica</i>	2	46.5	7.0	1.5	89.0	13.6
3	<i>Lespedeza bicolor</i>	4	23.5	10.4	0.6	76.8	10.6
4	<i>Prunus padus</i>	1	1.0	1.0	2.0	185.0	8.4
5	<i>Acer tegmentosum</i>	1	3.5	5.0	1.3	290.0	7.8
2	<i>Rhamnus arguta</i>	1	0.5	10.0	2.7	178.0	7.7
7	<i>Eleutherococcus sessiliflorus</i>	3	8.0	8.0	1.1	92.7	6.8
6	<i>Pinus densiflora</i> var. <i>ussuriensis</i>	1	12.0	5.6	1.9	107.5	6.7
8	<i>Euonymus verrucosus</i>	2	17.5	2.8	0.7	102.3	6.4
9	<i>Acer pictum</i>	2	17.0	1.7	0.9	116.0	6.0
10	<i>Lonicera praeflorens</i>	1	13.5	5.0	0.2	41.0	5.6
11	<i>Lespedeza juncea</i>	1	13.0	5.0	0.1	44.0	5.5
12	<i>Tilia amurensis</i>	1	0.5	0.5	2.7	210.0	3.8
13	<i>Lonicera chrysantha</i>	1	1.0	2.0	1.3	140.0	3.5
14	<i>Prunus tomentosa</i>	1	7.5	2.0	0.4	55.0	3.3
15	<i>Rhamnus schneideri</i> var. <i>manshurica</i>	2	1.0	2.5	1.0	99.0	3.0
16	<i>Rhamnus ussuriensis</i>	1	3.0	2.0	0.4	71.0	2.7
17	<i>Berberis amurensis</i>	2	2.0	1.0	0.2	61.0	1.9
18	<i>Sophora flavescens</i>	1	3.0	1.0	0.1	35.0	1.6

Table 6.

Characterization of the number of herbaceous layers in the *Pinus densiflora* var. *ussuriensis*+*Quercus mongolica* - *Lespedeza bicolor* - *Carex caespitosa* Association.

Serial numbe	Latin name of species	Frequency	Density (plants/ m ²)	Coverage (%)	Height (cm)	Significant value (%)
1	<i>Carex caespitosa</i>	4	9.8	10.0	35.0	8.0
2	<i>Deyeuxia purpurea</i>	1	0.8	40.0	45.0	6.4
3	<i>Polygonatum odoratum</i>	1	2.0	30.0	35.0	5.7
4	<i>Phryma leptostachya</i> subsp. <i>asiatica</i>	1	2.1	25.0	19.0	4.8
5	<i>Carex lanceolata</i>	2	3.1	17.6	29.6	4.7
6	<i>Rubia cordifolia</i>	1	0.3	3.0	170.0	4.6
7	<i>Carex appendiculata</i>	1	0.6	25.0	30.0	4.1
8	<i>Stellaria radians</i>	3	4.8	5.4	15.2	3.9
9	<i>Spodiopogon sibiricus</i>	3	4.4	3.8	30.4	3.8
10	<i>Rorippa globosa</i>	1	1.3	10.0	50.0	3.2
11	<i>Moehringia lateriflora</i>	2	2.6	5.5	21.0	2.8
12	<i>Viola collina</i>	4	3.3	4.6	7.2	2.7
13	<i>Deyeuxia pyramidalis</i>	1	0.8	10.0	35.0	2.5
14	<i>Isodon excisus</i>	1	0.9	10.0	30.0	2.5
15	<i>Potentilla chinensis</i>	1	0.1	10.0	40.0	2.3
16	<i>Vicia amoena</i>	2	0.3	7.3	43.5	2.1
17	<i>Potentilla fragarioides</i>	2	1.8	4.7	15.0	2.0
18	<i>Artemisia mongolica</i>	1	1.8	1.0	30.0	1.9
19	<i>Artemisia lavandulifolia</i>	1	0.1	3.0	60.0	1.9
20	<i>Peucedanum baicalense</i>	1	0.1	5.0	45.0	1.8

Table 7.

Characterization of the number of tree layers in the *Pinus densiflora* var. *ussuriensis* - *Rhododendron dauricum* - *Carex callitrichos* Association.

Serial numbe	Latin name of species	Frequency	Density (plants/ 600 m ²)	Diameter at breast height (cm)	Tree height (m)	Breast height section area (cm ² /600 m ²)	Significant value (%)
1	<i>Pinus densiflora</i> var. <i>ussuriensis</i>	11	54.8	17.7	10.4	18108.6	75.1
2	<i>Quercus mongolica</i>	9	9.8	8.9	6.5	748.5	15.7
3	<i>Ulmus pumila</i>	1	0.1	19.0	6.3	38.6	9.2

Table 8.

Characterization of the number of shrub layers in the *Pinus densiflora* var. *ussuriensis* - *Rhododendron dauricum* - *Carex callitrichos* Association.

Serial number	Latin name of species	Frequency	Density (plants/100 m ²)	Coverage (%)	Basal diameter (cm)	Height (cm)	Significant value (%)
1	<i>Rhododendron dauricum</i>	4	29.5	42.5	0.3	77.3	33.0
2	<i>Quercus mongolica</i>	2	7.6	37.5	269.5	245.0	31.0
3	<i>Lespedeza bicolor</i>	10	13.1	11.4	0.4	74.7	26.4
4	<i>Maackia amurensis</i>	1	3.3	15.0	0.1	46.0	9.0
5	<i>Lespedeza juncea</i>	2	6.5	6.5	0.1	25.0	7.1
6	<i>Corylus heterophylla</i>	1	0.4	10.0	0.2	25.0	4.6

Table 9.

Characterization of the number of herbaceous layers in the *Pinus densiflora* var. *ussuriensis* - *Rhododendron dauricum* - *Carex callitrichos* Association.

Serial numbe	Latin name of species	Frequency	Density (plants/ m ²)	Coverage (%)	Height (cm)	Significant value (%)
1	<i>Carex callitrichos</i>	11	34.9	14.3	26.2	27.0
2	<i>Carex cespitosa</i>	1	1.4	40.0	32.0	11.5
3	<i>Iris uniflora</i>	7	4.4	6.9	31.3	5.7
4	<i>Spodiopogon sibiricus</i>	6	3.3	6.3	41.8	5.3
5	<i>Artemisia vestita</i>	3	0.5	7.2	57.4	4.3
6	<i>Deyeuxia pyramidalis</i>	2	0.5	3.5	74.5	4.2
7	<i>Gypsophila pacifica</i>	3	0.5	4.7	62.7	4.0
8	<i>Patrinia rupestris</i>	1	0.2	3.0	70.0	3.6
9	<i>Atractylodes lancea</i>	2	0.2	11.0	22.5	3.6
10	<i>Potentilla fragarioides</i>	2	0.2	11.5	19.0	3.6
11	<i>Galium maximoviczii</i>	3	2.1	4.4	26.8	3.5
12	<i>Artemisia lavandulifolia</i>	1	0.1	3.0	62.0	3.3
13	<i>Artemisia argyi</i>	4	2.1	3.6	21.2	3.0
14	<i>Adenophora pereskiifolia</i>	1	0.1	2.0	57.0	2.8
15	<i>Viola dactyloides</i>	1	0.3	8.0	19.0	2.8
16	<i>Artemisia stolonifera</i>	1	0.1	1.0	50.0	2.3
17	<i>Iris ruthenica</i>	1	0.2	3.0	34.0	2.2
18	<i>Neottianthe cucullata</i>	1	0.1	2.0	37.0	2.0
19	<i>Allium flavum</i>	1	0.1	2.0	37.0	2.0
20	<i>Polygala tenuifolia</i>	1	0.1	2.0	26.0	1.6
21	<i>Pyrola asarifolia</i> subsp. <i>incarnata</i>	1	0.1	2.0	6.0	0.8
22	<i>Saposhnikovia divaricata</i>	1	0.1	1.0	7.0	0.6
23	<i>Orostachys spinosa</i>	1	0.1	1.0	6.0	0.5

Supplementary material

Suppl. material 1: *Pinus densiflora* var. *ussuriensis* species list

Authors: Yutong Zhang

Data type: species list

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