Comparative Study of Main Meteorological Factors Inside and Outside the Forest of Xianweng Mountain National Forest Park

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Abstract. Investigations of meteorological conditions can reveal the dynamics of microclimates in specific forests. Meteorological factors are necessary factors for quantitative observation and research of forest ecosystems. A systematic analysis of the forest boundary and the main meteorological factors outside the forest in Xianweng Mountain National Forest Park can accurately reveal the interaction between the forest and meteorological factors in Xianweng Mountain National Forest Park. Based on the meteorological observation data of the forest of Xianweng Mountain National Forest Park for three consecutive years, and using experimental methods to locate meteorological factors inside and outside the forest, compare meteorological factors such as atmospheric temperature, relative humidity, precipitation and wind speed, and wind direction, and analyze their different characteristics. The results show that the main reason for the difference in temperature and humidity inside and outside the forest is that the canopy absorbs solar radiation and emits long-wave radiation from the ground. The dense canopy also impedes air exchange inside and outside the forest, reducing wind speeds in the woods. Meteorological factors play an important role in guiding the distribution of forests, and have an important impact on the growth of trees in the forest, the development of trees, and the accumulation of tree biomass. A systematic comparative analysis of the main meteorological factors inside and outside the forest of Xianweng Mountain National Forest Park revealed the interaction between the forest and meteorological factors of Xianweng Mountain National Forest Park. According to the meteorological observation data of Xianweng Mountain National Forest Park, in order to make reasonable use of meteorological resources in the future, to develop forests, to protect the balance of natural ecosystems and their healthy development are of great significance.

1. Materials and methods

1.1. Survey area
Xianweng Mountain National Forest Park is located in the northeast of Heilongjiang Province, at the southeast foot of the Xiaoxing'an Mountains, at the intersection of the Tangwang River and the Yongcui River, about 10km from Nansha District. The geographical coordinates are 129°09′39″ - 129°25′45″ east longitude, 46°36′09″ - 47°20′20″ north latitude[1]. Xianweng Mountain National Forest Park is a low-mountain hilly landform, most of which are crystals. It is composed of granite and...
gneiss, with an altitude of 170-498m. The geological and geological relics of Xianweng Mountain are of complete types, with typical development and complex genesis. Xianweng Mountain National Forest Park belongs to the cold temperate continental climate zone[2]. It is warm and rainy in summer, long and cold in winter, and dry in the climate. The average annual rainfall is 550-750 mm, the annual temperature is ≥10.0℃, and the accumulated temperature is about 2200-2300℃. The annual precipitation is 350-500 mm, concentrated in July-August[3]. The precipitation in this period reaches 85% - 90% of the annual precipitation, the relative humidity of the air is 70% - 75%, and the annual evaporation is 900-1000 mm. The temperature rises rapidly in spring, with a maximum temperature of 12℃ and a minimum temperature of -16℃. The wind speed is high, dry, and less rainy. The snow period in winter is as long as five months, and the average annual sunshine time is 2680h. Soil types are mainly brown coniferous forest soil, dark brown soil, gray forest soil, meadow soil, marsh soil, and impact soil. There are 87 species of vascular plants in Xianweng Mountain National Forest Park of Heilongjiang, belonging to 76 genera of 40 families[4]. Among them, there are more than ten kinds of virgin forest species including Korean pine, larch, spruce, fir, pine, ash, yellow pineapple, walnut cypress, birch, lime tree, colour tree, linden tree, poplar and so on[5]. Wild plants include edible plants such as wild plants; aromatic plants such as pine needles; medicinal plants such as Schisandra and nasturtium; beverage plants such as northeast kiwi, Sorbus and mountain grapes; and five broad categories of forage plants such as camphor and wild peas[6].

1.2. Research Methods

1.2.1. Test method. According to the Ground Meteorological Observation Code, meteorological stations were set up inside and outside the forest of the plot. In 2016, 2014, and 2019, control observations were made on the plots inside and outside the forest of Xianweng Mountain National Forest Park from May to October every year. Three observations are made daily at 8:00, 14:00, and 20:00.

1.2.2. Statistical analysis methods. A comparative analysis method of meteorological factors inside and outside the forest is used for research. The difference between meteorological factors outside the forest and meteorological factors inside the forest during the same period (meteorological factor difference = meteorological factors outside the forest-meteorological factors inside the forest). Differences in meteorological characteristics inside and outside the forest[7].

1.2.3. Species diversity measurement method.

(1) Species diversity index : \( H' = -\sum_{i=1}^{s} P_i \ln P_i \)

(2) Species uniformity index: \( E = H' / \ln S \)

(3) Species dominance index : \( C = \sum_{i=1}^{s} N_i (N_i - 1) / N(N - 1) \)

(4) Species richness index : \( DMG = L(S - 1)/\ln N \)

Note: \( H' \) is the Shannon-wiener index; \( E \) is the Pielou index; \( C \) is the Simpson index; DMG is the Margalef index; \( S \) is the number of species in the sample; \( P_i \) is the ratio of the number of individuals in the \( i \)-th species in the community, \( P_i = Ni/N; \) \( N \) is the total number of individual samples; \( Ni \) is the number of individuals of the \( i \)-th species.

2. Results and analysis

2.1. Atmospheric temperature
Temperature is closely related to the growth of forest trees and maintains the life activities of trees. It is an important meteorological factor that affects the composition and distribution of forest vegetation. Based on the meteorological observations of the forest inside and outside the forest of Xianweng Mountain National Forest Park for three successive years from 2016 to 2019, three consecutive temperature observations from May to October in the woods and near the ground can be obtained for three successive years, which are the average temperature and the highest average. Air temperature, average minimum temperature (in Table 1), and then subtract the measured value outside the forest and the measured value inside the forest to get the corresponding difference between the outside and inside the forest.

| Table 1. Comparison of the temperature inside and outside of Xianweng Mountain National Forest Park |
|---------------------------------------------------|----------|----------|----------|----------|----------|----------|
| air temperature                                   | May      | June     | July     | August   | September| October   |
| Outside forest average temperature                | 16.9     | 18.8     | 20.4     | 17.8     | 10.2     | 0.17     |
| Mean temperature                                 | 13.8     | 14.0     | 15.9     | 15.5     | 9.9      | 0.15     |
| Highest temperature outside the forest            | 18.9     | 29.1     | 32.4     | 28.8     | 28.0     | 15.5     |
| Highest temperature in the forest                 | 16.6     | 23.5     | 28.3     | 25.9     | 26.9     | 15.3     |
| Lowest temperature outside the forest             | -0.9     | 11.5     | 14.9     | 12.7     | -8.5     | -14.5    |
| Lowest temperature in the forest                  | -1.1     | 14.5     | 17.8     | 15.8     | -7.8     | -14.1    |

2.2. Influence of daylight radiation factors
During the growth of trees, solar radiation acts as an energy source for photochemical reactions and regulates the development of trees. When the solar radiation is too intense, it will cause tree damage. The growth of trees and whether they bloom or bear fruit will depend on the hours of sunlight. Adequate sunlight hours will promote the growth of trees; otherwise, the lack of light will cause the trees to grow slowly and even show some sub-health status. The temperature inside and outside the forest is closely related to the hours of sunshine and the total solar radiation. From Table 2, it can be seen that the average outside temperature and the average maximum temperature outside the forest in Xianweng Mountain National Forest Park from May to October are higher than inside the forest. Only the average minimum temperature in May is outside the forest. In the forest, from June to October, the average minimum temperature in the woods is higher than the average minimum temperature outside the forest. The highest temperature occurred in July, and the lowest temperature was in October. Xianweng Mountain National Forest Park is located in the northernmost part of China. Due to its unique geographical location, winter is long, and summer is short, while the sunshine time is concise. The summer is only about two months. However, from June to August each year, the sunshine time is long, up to 17 hours.

| Table 2. The temperature difference between the inside and outside forest Xianweng Mountain National Forest Park |
|---------------------------------------------------|----------|----------|----------|----------|----------|----------|
| Temperature / ℃                                   | May      | June     | July     | August   | September| October   |
| Monthly average temperature                        | 2.4      | 4.9      | 4.7      | 2.8      | 0.4      | 0.0      |
| Monthly maximum temperature                        | 2.5      | 4.8      | 5.8      | 3.8      | 0.6      | 0.2      |
| Monthly minimum temperature                        | 0.3      | -2.0     | -2.5     | -2.5     | -0.1     | -0.2     |

2.3. Atmospheric humidity
Atmospheric humidity is the water vapor in the air. The turbulence, convection, and molecular diffusion of the air determine the distribution of water vapor in the air, mainly from the evaporation of the underlying surface. The distribution of near-earth meteorological elements in addition to radiation...
differences is largely dependent on air movement, especially the turbulence exchange effect. Therefore, atmospheric humidity changes with changes in temperature. Forest vegetation has become a source of water vapor transport due to its strong evapotranspiration. From May to October, the humidity inside and outside the forests of Xianweng Mountain National Forest Park is very high, all above 60%. A comparative analysis of the relative humidity values inside and outside the forest of Xianweng Mountain National Forest Park (see Figure 1) shows that the relative humidity values inside the forest are higher than those outside the forest, and below the canopy are higher than the forest gap. The hours of sunshine under the canopy are different. The roots of the trees in the forest are developed and huge. They can draw a lot of water from the soil for the transpiration of the leaves. The roots of the trees extend in all directions and can be penetrated the deep soil. When the temperature in the forest is high, the transpiration of trees is faster, and more water vapor is evaporated on the surface of the forest.

![Fig.1 Comparison of relative humidity inside and outside forest](image)

2.4. Precipitation
According to the comparison and analysis of the observations of precipitation in and outside the forest from 2016 to 2019, the snow in and out of the wood was similar in the four months, which were May, June, September, and October, and the observations of the precipitation in July and August. It is larger than the forest, and the snow outside the forest is more significant in July and August. This is mainly due to the increase in rainfall in these two months. The leaves of the leaves in the woods come into contact with precipitation, get wet first, and are partially absorbed by the leaves.

They are absorbed through the layers of the canopy leaves and branches, and finally, the precipitation in the forest decreases. When there is a large amount of precipitation, some of the water is absorbed by the canopy, and then more water passes through the canopy to reach the surface of the forest. Forests have unique types of composite structures from top to bottom, including forest canopy, underwood, and ground cover. This structure can re-separate and re-adjust precipitation, and the method of redistribution is closely related to rainfall magnitude and rainfall intensity. The snow is redistributed after it is first intercepted and intercepted by the forest canopy. The precipitation reaches the understory and ground cover layers of the forest for redistribution. Redistribution affects the water movement in the woods, but does not affect the total amount of water entering the forest.
2.5. Wind speed and direction
According to the observation data from May to October, the average wind speed in May is the highest, the average wind speed in August is the smallest, June and September are similar, and July and October are identical. The maximum wind speed reached 11.4 m/s. The maximum wind speed reached 20.6 m/s. From the wind direction, the frequency of the northeast and northwest winds in this area was the highest.

3. Conclusion
From May to October in Xianweng Mountain National Forest Park, the average outside air temperature is higher than the temperature inside the wood, the relative humidity outside the woods is less than the relative humidity inside the forest, and the relative humidity in the forest gap is less than under the canopy. The results show that the main reason for the difference in temperature and humidity inside and outside the forest is due to the absorption of solar radiation by the canopy and the emission of long-wave radiation from the ground. Due to the unique geographical location, most of the trees in Xianweng Mountain National Forest Park began to fall leaves in September, and the interception of the canopy on precipitation in the forest decreased, resulting in a gradual decrease in precipitation difference between the wood and outside the forest.

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