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Comparison of the soil evaporation and trees transpiration for Fraxinus mandshurica- Populus davidiana forest, Tilia mandshurica forest and Quercus monglica forest

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Abstract By using of field observation and room analysis, the characteristics of evapotranspiration of three forest types beside Songhua River were studied through measure forest land evaporation and forest transpiration. The results showed that: (1) Forest land evaporation of Fraxinus mandshurica- Populus davidiana forest, Tilia mandshurica forest and Quercus monglica forest is 79.88 mm, 62.46 mm and 42.72 mm, respectively; (2) Transpiration of Fraxinus mandshurica- Populus davidiana forest, Tilia mandshurica forest and Quercus monglica forest is 148.67 mm, 128.24 mm and 124.64 mm ,respectively; (3) Evapotranspiration of Fraxinus mandshurica- Populus davidiana forest, Tilia mandshurica forest and Quercus monglica forest is 228.55 mm, 190.7 mm and 167.30 mm, respectively.

Introduction

Water balance of the forest ecosystem follows the certain principle. For the reason that evapotranspiration is an important composition part of the water balance, it is necessary to study evapotranspiration of the forest. Many studies have been done about evapotranspiration with different methods. It deals with many regions such as Northeast[1,2], Huabei[3,4,5] and Northwest[6,7], many forest ecosystems such as Larch forest[8], Pine forest[3,4,5], Oak forest[3], Acacia forest[4] and tropical monsoon forest[8] , and many methods such as EBBR method[1,2], meteorological method[7,8], tracer meter method[3] and heat pulse method[4,5]. In this paper, we choose *Fraxinus mandshurica-Populus davidiana* forest, *Tilia mandshurica* Forest and *Quercus monglica* forest as material, study evapotranspiration effects of forest ecosystems, aim to provide a theoretical basis for the calculation of the ecological water requirement amount, the protection of the ecological environment, and the ecological function recovery of the these forests.

Materials and methods

Study area and plot. The study site is located in Shahezi forest farm, Fanzheng forest bureau, Heilongjiang province, China (129 ° 21 ' E, 45 ° 60 ' N). Average temperature of the year is 2.2 ℃, the accumulate temperature above 10 ℃ is 2300 ~ 2500 ℃, frost-free period is 115 ~ 120 days, the average precipitation of the year is 560 ~ 700 mm. The main forest types are the needle mixed and broad-leaved mixed forest. The main tree species are Tilia mandshurica, Juglans mandshurica, Quercus monglica, Fraxinus mandshurica, Poplus davidiana, Betula platyphylla, Ulmus davidiana,

Pinus koraiensis, Larix olgansis and Picea koraiensis. Main forest soil type is brown forest soil. The study forest is as Table 1.

Table 1 Characteristics of three forest types

Forest type	Slope direction	Slope angle (°)	Forest age（a）	Average diameter (cm)	Average height (m)	Canopy coverage (%)	Density (/hm^2)	Species composition
Fraxinus mandshurica- Populus davidiana forest	South	5	16	12.3	9.8	85	2160	5 *Populus davidiana* 3 *Fraxinus mandshurica* 2 *Betula platyphylla*
Tilia mandshurica forest	East	15	15	10.8	10.2	90	3300	9 *Tilia mandshurica* 1*Umus davidiana*
Quercus monglica forest	East	15	37	12.2	18.6	92	1060	9 *Quercus monglica* 1 *Ulmus davidiana*

Atmospheric rain fall observation The automatic meteorological station(HOBO), common ordinary rain cylinder and the header tank (200 cm × 20 cm × 15 cm) were adopt to observe precipitation, rain fall level and rain fall frequency.

Determination of forest land evaporation Forest land evaporation was measured by using of the soil evaporating dish made of steel, weighing the soil inside evaporation dish every 24 hours, soil evaporation equals to the weight difference between two times weighing.

Determination of forest transpiration Quick weighing method was adopted to determine canopy transpiration. Transpiration = Total leaf area per tree ×Transpiration intensity ×Average transpiration hours per day ×transpiration days. Leaf area was measured by using of Li - 3000 scanner made in U.S. By building the relationship between leaf area and leaf weight, total leaf area per tree could be calculation from total leaf weight per tree. Transpiration intensity =Transpiration water loss/ Fresh leaf area/Measure time. Sample branches was cut from central canopy of standard tree, fast weighing , and then the branches was hung back to its original position for 3 minutes, weighing again, the weight difference of two times weighing was transpiration water loss. Measure time is 8:00, 10:00, 12:00, 14:00, 16:00 and 18:00.

Determination of forest evapotranspiration Total evapotranspiration = Canopy transpiration + Forest land evaporation

Results

Atmospheric rain fall characteristics Atmospheric rainfall concentrated in June, July and August. Heavy rains appeared in June, July and August, especially in August. Total rain fall amount during June to August accounted for 91.9％ of the whole rainy season. Little rain fall and the rainfall was not more than 10 mm in May. Small rain and moderate rain were relatively concentrated and only a heavy rain in June. Rainfall day decreased and primarily small rainfall in September (Table 2)

Table 2 Precipitation and rain grade distribution in Shahezi forest farm

Time	May	June	July	August	September	Total
Precipitation(mm)	14.20	142.62	134.02	157.03	24.00	471.87
≤10mm	4	10	8	6	4	33
10.1~25mm	0	6	6	1	1	14
25.1~50mm	0	1	0	2	0	3
>50mm	0	0	0	1	0	1

Forest land evaporation Due to tall height of the tree, dense canopy, thick lower vegetation layer and thick litter layer, evaporation of forest land was small during the whole rainy season.

Forest land evaporation of *Quercus monglica* forest only account for 9.15% of the precipitation; forest evaporation of *Fraxinus mandshurica- Populus davidiana* forest only accounted for 17.12% of the precipitation. Forest land evaporation is small in June. During June, Soil just melts, vegetation began to enter vigorous growth period, transpiration consumes most water of the soil, soil water content is low, and soil evaporation was suppressed. Forest land evaporation in July was similar to that in August due to the reason that the difference of precipitation and soil water contents between July and August was small, and trees transpiration intensity in July was similar to that in August. In September, with a dropping of rainfall and temperature, soil evaporation became small. Trees began to fall leaves, transpiration began to decrease, and soil water contents was not too low, forest land evaporation was not weakened to a great extent. While forest land evaporation of *Quercus monglica* forest was only 42.72 mm, forest land evaporation of *Fraxinus mandshurica- Populus davidiana* forest was 79.88 mm. That was mainly because of dense canopy, little understory light and low understory temperature of *Quercus monglica* forest. The bigger the canopy density, the smaller the forest land water evaporation.

Table 3 Forest land evaporation in growth season (mm)

Forest type	June	July	August	September	Total
Fraxinus mandshurica- Populus davidiana forest	17.79	21.87	24.12	16.1	79.88
Tilia mandshurica forest	17.38	19.57	18.85	17.66	73.46
Quercus monglica forest	8.37	12.22	14.81	7.32	42.72

Forest transpiration During growth season, the month order of forest transpiration from big to small was: August, July, June to September. During July and August, the nutrition growth of the trees was strong. Big precipitation, high temperature and suitable solar radiation intensity were conducive to the metabolism of vegetation, so the transpiration was bigger than that of other month. Rainfall was scarce, temperature was low and transpiration became very weak, even stop in September. So little water loss of transpiration took place in September. Among three forest types, transpiration of *Fraxinus mandshurica- Populus davidiana* forest was the largest, 148.67 mm. The difference of transpiration between *Tilia mandshurica* forest and Quercus monglica forest was small, only 7.40 mm. Because of its high transpiration intensity, big through rainfall and good soil water condition, transpiration of the *Fraxinus mandshurica- Populus davidiana* forest was biggest among three forest types. Although the leaf quantity per unit area was bigger than that of other forest types, because transpiration intensity was small, canopy was dense, soil water content was low, and transpiration of *Quercus monglica* forest was smallest among three forest types.

Table 4 Forest transpiration in growth season (mm)

Forest type	June	July	August	September	Total
Fraxinus mandshurica- Populus davidiana forest	35.74	39.96	45.88	27.09	148.67
Tilia mandshurica forest	26.55	30.53	36.87	23.29	117.24
Quercus monglica forest	29.87	34.76	36.65	23.36	124.64

Forest evapotranspiration Among three forest types, forest land evaporation was the largest in *Fraxinus mandshurica- Populus davidiana* forest, 228.55 mm, was smallest in *Quercus monglica* forest, 167.36 mm, which was only 73.23% of that in *Fraxinus mandshurica- Populus davidiana* forest. The difference of the transpiration and evaporation among different forest types cause the difference of the evapotranspiration among different forest types. Transpirations were 60% bigger

more than evapotranspirations among all three forest types; transpiration was the main factor to determine evapotranspiration.

Table 5 Evaporation, transpiration and evapotranspiration of the forest during growth season (mm)

Forest type	June			July			August			September		
	T	E	ET	T	E	ET	T	E	ET	T	E	ET
Fraxinus mandshurica- Populus davidiana forest	35.74	17.79	58.53	45.88	21.87	67.75	39.96	24.12	64.08	27.09	16.1	43.19
Tilia mandshurica forest	26.55	17.38	43.96	30.53	19.57	50.10	36.87	18.85	55.72	23.29	17.66	40.95
***Quercus monglica* forest**	29.87	8.37	38.24	34.76	12.22	46.98	36.65	14.81	51.46	23.36	7.32	30.68

T - Transpiration, E - Evaporation, ET - Evapotranspiration

Conclusions

Among three forest types, forest land evaporation of *Tilia mandshurica* forest was the smallest, nearly half that of *Fraxinus mandshurica- Populus davidiana* forest. Forest land evaporation was negative to the forest canopy density.

Among three forest types, transpiration of *Fraxinus mandshurica- Populus davidiana* forest was the biggest, 148.67 mm. The difference of transpiratin between *Tilia mandshurica* forest and *Quercus monglica* forest was small, only 7.4 mm

Among three forest types, evapotranspiration of *Fraxinus mandshurica- Populus davidiana* forest was the biggest, 233.55 mm, that of Quercus monglica forest was the smallest, only account of 73.23% that in *Fraxinus mandshurica- Populus davidiana* forest during whole growth season, throughout the growing season, the order of evapotranspiration and transpiration of all forest type was the same.

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