

# Daily Dynamic Change of Soil Moisture in the Forestlands with Typical Vegetation Forms before and after Rainfall in the Mountainous Area of West Hunan

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**Abstract.** Taking *Pinus massoniana* forest, maple-camphor mixed forest, *Eucommia ulmoides* forest and slope cropland as the research objects, research has been carried out on the dynamic change of soil moistures at the soil depths of 7.5cm, 12cm and 20cm before and after typical rainfalls. The result indicates: (1) at the 3 soil depths, the soil moistures under typical vegetation forms rank as follows: *Eucommia ulmoides* forest > maple-camphor mixed forest > *Pinus massoniana* forest > slope cropland; (2) before and after rainfall, soil moisture content has negative pertinence with wind speed and temperature, while soil moisture content has positive pertinence with humidity.

**Keywords.** daily dynamic change of soil moisture; before and after rainfall; typical vegetation form; mountainous area of West Hunan.

## 1. Introduction

As a space-time continuous variant and an important state parameter of soil [1], soil moisture has obvious spatial heterogeneity for it is complexly influenced by multiple factors including artificial and natural factors. Soil moisture exerts an important influence on water-soil process and matter migration in the soil-atmosphere-vegetation transmission [2], thereby affects forest and trees' multiple service functions including growth. The previous soil moisture research mainly focused on the response of soil moisture to rainfall and the pertinence between soil moisture and vegetation, e.g. Ru Hao and his colleagues [10] made a study on the response of soil moisture to rainfall in rain-fed orchard in the loess area of West Shanxi, their research result indicates that rainfall has a significant effect on surface soil moisture content. However, with the increase of soil depth, soil moisture content's response to rainfall recedes layer by layer; Wang Shuai and his colleagues [11], by investigating the vegetation restoration watershed in the loess plateau, analyzed the pertinence between soil moisture and rainfall response, and studied the effects of different vegetation coverage on rainfall infiltration. The previous studies [12-14] focused on the comparative analysis of soil moisture conditions in different artificial forestlands, and the research on the response of forestland soil moisture to rainfall was carried out only



by choosing single woodland as the research object. However, it was rare in the comparative study of soil moisture in artificial pure woodland and in artificial mixed forest land and natural secondary pure woodland.

Taking *Pinus massoniana* forest, maple-camphor mixed forest, *Eucommia ulmoides* forest and slope cropland as the research objects, for the purpose of finding out the daily dynamic change of soil moistures in different vegetation form forestlands, we have carried out observation and analysis on the dynamic change of soil moistures at the soil depths of 7.5cm, 12cm and 20cm before and after typical rainfalls, so as to provide the research area with technical support in forest and water comprehensive management, watershed scientific treatment and forest multi-function efficient operation.

## 2. Materials and methods

### 2.1. Profile of the research area

Located at Nverzhai small watershed (E111°12'42.836", N29°25'27.582") in Wuling Mountainous Region of West Hunan, the research area lies in Liangxi Village, Lingyang Town, Cili County, Changde City, Hunan Province, 7km away from the northwest part of Cili County Seat. As a grade-II small tributary of the Lishui River, Nverzhai small watershed flows from south to north. Covering an area of 3.15km<sup>2</sup>, the small watershed has minimum altitude 210m (at the exit of the main ravine), maximum altitude 917.4m, length of main ravine 1.2km, vertical gradient of main ravine 28.4‰ and forest coverage 80% above. Its vegetation is mainly of returning-grain-plots-to-forestry forest and secondary forest. It is linked pieces of conserved lands for returning-grain-plots-to-forestry. Its soil mother rocks are mainly sandy shales, and its soils are mainly yellow-red earth.

The main vegetation forms in this watershed are *Eucommia ulmoides* artificial forest, *Pinus massoniana* forest, *Citrus reticulata* forest and some serayah-shrub forest.

### 2.2. Methods and data analysis

American SPECTRUM TDR300 soil moisture content analyzers were used to monitor the dynamic change of soil moistures at the sample plots of different vegetation forms before and after typical rainfalls [15]. 20m×30m standard sample plots were set up, three monitoring points with relative homogeneities were selected in each sample plot, PVC tubes were used to demarcate the monitoring points. Based on the different probe lengths (7.5cm, 12cm, 20cm) of the monitoring instrument, we monitored the water-holding capacities at different soil depths on the first day before individual-based rainfall, and on the first, second and third days after rainfall. The monitoring period was from June 29 to July 3 in 2015, during which there was one rainfall on June 30, with a rainfall capacity of 11.176mm, no monitoring was implemented that day. On each monitoring day, monitoring was implemented four times, separately at 6:00, 10:00, 14:00 and 18:00.

## 3. Result and analysis

### 3.1. Analysis of difference of soil moistures at different soil depths

Table 1 shows the difference of soil moistures at different soil depths in the monitoring period. At the shallow soil layer and medium soil layer (7.5cm, 12.0cm), the water contents of the four sample plots presented significant difference as follows: *Eucommia ulmoides* forest > maple-camphor mixed forest > slope cropland [16-18].

At 7.5cm-12.0cm soil layer, the soil moistures under different vegetation forms reduced along the vertical section, the vertical change feature was that soil moistures under different vegetation forms reduced with the increase of soil depth. At the deep soil layer (20.0cm), the difference between *Eucommia ulmoides* forest and maple-camphor mixed forest was not obvious, while the difference between *Pinus massoniana* forest and slope cropland was obvious. At the three soil depths, the soil moistures under different vegetation forms ranked as follows: *Eucommia ulmoides* forest > maple-camphor mixed forest > *Pinus massoniana* forest > slope cropland. It shows that forest has relatively

good capacity in water and soil conservation and water resource conservation, for the aboveground vegetation and litter layer has lowered soil breath and transpiration and reduced water loss. Among the vegetation forms, *Eucommia ulmoides* forest has the highest effect.

**Table 1.** Analysis of difference of soil moistures at different soil depths (%)

Soil depth	<i>Pinus massoniana</i> forest	Maple-camphor mixed forest	<i>Pinus massoniana</i> forest	Slope cropland
7.5cm	21.483±0.269A	29.731±0.094B	31.076±0.006C	15.018±0.124D
12.0 cm	20.309±0.352A	28.971±0.185B	30.271±0.045C	14.304±0.047D
20.0 cm	18.581±0.146A	29.653±0.241B	30.484±0.161B	16.733±0.104C

Note: the capitalized letters indicate obvious difference of different vegetation forms at the same soil depth. (P=0.05)

### 3.2. Pertinence between soil moisture content and environmental factors in the forestland

**Table 2.** Pertinence between soil moisture content and environmental factors in the forestland

After rainfall: pertinence				
Item	Wind speed	Temperature	Humidity	Water content
Wind speed	1			
Temperature	.609*	1		
Humidity	-.602*	-.979**	1	
Water content	-0.244	-.579*	.677**	1
Before rainfall: pertinence				
Item	Wind speed	Temperature	Humidity	Water content
Wind speed	1			
Temperature	.622*	1		
Humidity	-.736**	-.980**	1	
Water content	-.158	-.653**	.544*	1
* Obvious pertinence appears at 0.05 level (two-sided).				
** Obvious pertinence appears at 0.01 level (two-sided).				

Note: \*\* the pertinence is obvious at 0.01 level, \* the pertinence is obvious at 0.05 level.

The monitoring period was from late June to early July, in this period plants grew rapidly and experienced higher transpiration, then rainfall goes into a fastigium. A portion of rainfall was consumed for plant transpiration and soil evaporation, and a portion of rainfall was reserved for soil moisture supply, in the end soil water content reached peak value. Before rainfall, soil moisture content had negative pertinence with wind speed and temperature, reflecting obvious pertinence with temperature at 0.01 level; soil moisture content had positive pertinence with humidity, reflecting obvious pertinence with humidity at 0.05 level. After rainfall, soil moisture content also had negative pertinence with wind speed and temperature, reflecting obvious pertinence with temperature at 0.05 level; soil moisture content also had positive pertinence with humidity, reflecting obvious pertinence with humidity at 0.01 level.

## 4. Conclusion and discussion

Regarding water conservation capacity among the 4-vegetation forest stands, *Eucommia ulmoides* forest ranks the first, maple-camphor mixed forest ranks the second, *Pinus massoniana* forest ranks

the third. As coniferous forest, *Pinus massoniana* forest has relatively hard needles, which cannot be easily resolved by microorganisms, as a result the dry branches and fallen leaves remain on the surface layer and cannot easily enter into soil to improve soil structure. In addition, a thick layer of fallen needles covering the land surface obstruct the sunshine for other vegetation growth, therefore there is little vegetation under *Pinus massoniana* forest. Comparing with the other three vegetation forms, *Pinus massoniana* forest has compacted soil, which shall cause slow rainwater seepage, a large proportion of rainwater becoming surface runoff and disadvantageous water resource conservation. Slope cropland has the lowest water resource conservation capacity, since frequent human activities result in relatively serious loss of soil moisture and nutrient. When farming on the slope cropland, farmers must plant crops with high coverage degree and adopt no-tillage or deep-tillage, to improve the water conservation capacity of slope cropland.

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