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# Runoff Characteristics of Different Stands in Dongjiang Lake Reservoir Area

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**Abstract** Different forest stands in the Dongjiang Lake Reservoir area of Zixing were selected as the research objects to study the characteristics of runoff generation in different forest stands. The results showed that there was no significant difference in annual runoff among M3, M1, and M5, and no significant difference between each forest stand and the control. The order was M3 (22.75 mm) > M1 (21.77 mm) > M5 (20.14 mm). Forest vegetation generates less runoff through vegetation restoration compared to the control, indicating that forest vegetation reconstruction and restoration are beneficial for soil and water conservation.

**Key words** Dongjiang Lake Reservoir area; Stand; Surface runoff; Forest management

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Forest vegetation plays an important regulatory role in slope runoff production[1–2]. Rainfall is a prerequisite for slope runoff. During the process of rainfall, the surface soil of the forest has good water permeability, which makes it easy to form interflow[3]. On the basis of the backflow of interflow, surface runoff is generated[4]. The runoff of forest land depends on the intensity and amount of rainfall, and the coverage of forest vegetation also has a decisive impact on it[5], preventing soil erosion[6]. Different regions and types of forest vegetation have different canopy structures and soil environments, which alter the distribution of precipitation in the canopy layer, litter layer, and soil layer, thereby affecting the formation of surface runoff[7–8]. The impact of forest vegetation changes on forest hydrological processes will alter various aspects of water balance, affecting the water status and runoff of forests.

In this paper, the 2019 observation data of runoff plots in different forest stands in the Dongjiang Lake Reservoir area of Zixing, Hunan Province were selected to study the runoff under different forest stands. It could provide theoretical and technical support for selecting suitable afforestation tree species, carrying out appropriate reconstruction and restoration work, and reducing soil erosion in degraded areas of the Dongjiang Lake Reservoir area.

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## 1 Overview of the research area

**1.1 Overview of the research area** The Dongjiang Lake Reservoir area in Zixing City belongs to a subtropical monsoon humid climate, with distinct four seasons. Drought is frequent in summer and autumn, and it is rich in rainfall. The average annual temperature is 17.7 ℃, the average annual rainfall is 1 487.6 mm, and the average annual sunshine is 1 700 h.

**1.2 Forest stand characteristics** M1 (mixed forest of coniferous and precious broad-leaved tree species), M2 (coniferous forest of *Pinus massoniana*), M3 (mixed forest of bamboo and trees), M4 (bamboo forest), M5 (mixed forest of coniferous and general broad-leaved tree species), and M6 (cypress) were selected as research objects in the Dongjiang Lake Reservoir area of Zixing City. The vegetation characteristics were shown as Table 1, and the soil characteristics were shown as Table 2.

## 2 Materials and methods

**2.1 Rainfall observation** Data were continuously collected at rainfall observation sites.

**2.2 Surface runoff observation** The surface runoff adopted the plot positioning monitoring research method of slope runoff. Slope runoff plots were set up for forest stand type in each project area and each non project forest stand for location monitoring, with 3 repetitions.

**2.3 Determination and calculation method of soil moisture content** Soil profiles were excavated in the sample plot, and soil hierarchy and soil layer thickness were recorded. Samples were taken in layers using a ring knife, and they were brought back to the laboratory to measure soil bulk density, capillary porosity, non capillary porosity, moisture content, and soil water holding capacity. At the same time, the volume content of gravel was measured.

**2.4 Data processing** In this paper, Excel 2010 was used to merge and analyze the observed statistical data, and output charts.

**Table 1 Vegetation characteristics of each forest stand**

| No. | Model | Forest type | Density plants/$hm^2$ | Average tree height//m | Mean breast diameter//cm |
|---|---|---|---|---|---|
| M1 | Coniferous trees + precious broad-leaved tree species | *P. massoniana* + *Camphora officinarum* + *Liquidambar formosana* | 1 350 | 13 | 11 |
| M2 | Coniferous forest | *P. massoniana* | 1 200 | 12 | 12 |
| M3 | Mixed forest of bamboo and trees | *Phyllostachys edulis* + *Elaeocarpus decipiens* | 2 700 | 14 | 11 |
| M4 | Bamboo forest | Bamboo forest | 2 250 | 15 | 12 |
| M5 | Coniferous trees + general broad-leaved tree species | Cypress + *Ziziphus jujuba* + *Michelia figo* | 1 350 | 14 | 11 |
| M6 | Coniferous forest | Cypress | 1 200 | 13 | 12 |

**Table 2 Basic physical and chemical properties of soil**

| No. | Slope direction | Slope of the plot//° | Soil bulk density//$g/cm^3$ | pH | Organic carbon//g/kg | TN//g/kg | TP//g/kg |
|---|---|---|---|---|---|---|---|
| M1 | Southwest | 10.76 | 1.33 | 5.08 | 5.29 | 1.37 | 0.286 |
| M2 | Southwest | 10.78 | 1.32 | 5.04 | 5.51 | 1.39 | 0.280 |
| M3 | Southwest | 25.43 | 1.35 | 5.81 | 8.55 | 1.33 | 0.277 |
| M4 | Southwest | 25.44 | 1.34 | 5.74 | 8.20 | 1.43 | 0.278 |
| M5 | North | 20.57 | 1.40 | 5.92 | 5.40 | 1.36 | 0.245 |
| M6 | North | 20.53 | 1.39 | 5.93 | 5.45 | 1.42 | 0.250 |

## 3 Results and analysis

**3.1 Rainfall characteristics** The total rainfall of Zixing City in 2019 was 1 424.5 mm, and statistics were conducted based on six rainfall intervals: daily rainfall < 10 mm, 10 – 20 mm, 20 – 30 mm, 30 – 40 mm, 40 – 50 mm, and ≥50 mm. The results showed that rainfall in 2024 in each interval was 155.24, 154.29, 357.44, 215.13, 161.24 and 381.20 mm respectively, and total rainfall in 2024 was 1 424.5 mm. There were significant differences in rainfall between different intervals. The maximum rainfall was in the interval≥ 50 mm and was 381.5 mm, approximately accounting for 26.76% of the annual rainfall. The minimum rainfall was the interval of 10 – 20 mm, which was 154.29 mm, accounting for approximately 10.83% of the annual rainfall. Rainfall in the maximum interval was about 2.47 times of that in the minimum interval.

**3.2 Soil water storage**

**3.2.1** Maximum water storage capacity of soil. There was a significant difference in soil water storage capacity between M5 and M1, M3 in the cultivation mode of forest stands, while there was little difference between M1 and M3 (Table 3). There was not much difference between each forest stand and its respective control, and its sequencing was: M5 > M6 > M3 > M4 > M1 > M2.

**Table 3 The maximum water storage capacity of soil**

| Sample plot | Soil thickness//cm | Total porosity//% | Capillary porosity//% | Non capillary porosity//% | Maximum water storage capacity//$t/hm^2$ |
|---|---|---|---|---|---|
| M1 | 56 | 38.49 | 35.29 | 3.2 | 229.4 |
| M2 | 55 | 39.23 | 34.13 | 5.1 | 225.4 |
| M3 | 56 | 38.25 | 33.85 | 4.4 | 246.4 |
| M4 | 57 | 38.46 | 33.16 | 5.3 | 245.1 |
| M5 | 49 | 44.11 | 38.21 | 5.9 | 285.2 |
| M6 | 46 | 42.65 | 38.15 | 4.5 | 253.5 |

Due to the different composition of tree species in different forest stands, the soil structure formed varies significantly, resulting in different soil water storage capacities, most of which have high functions of regulating and conserving water sources.

**3.3.2** Soil water storage amount. There was not much difference in the annual soil water storage amount between M5 and M1, M3 in each forest stand, and there was also no significant difference between each forest stand and its respective control (Table 4). Its sequencing was: M5 > M3 > M1 > M6 > M4 > M2.

**3.3 Annual surface runoff** There was no significant difference in annual runoff among M3, M1, and M5, nor was there a significant difference between each forest stand and the control. The sequencing was: M3 > M1 > M5. The forest surface runoff is greatly affected by rainfall, especially after heavy rain and rainstorm, the forest runoff shows a significant increase trend. Each forest stand has a complete canopy layer, shrub grass layer, and litter layer, which changes the redistribution of rainfall and reduces the generation of surface runoff. Among the six rainfall intervals, each forest stand did not produce any runoff within the range of 0 – 10 mm (Table 5).

**Table 4 Annual soil water storage amount of each forest stand** t/100 $m^2$

| Rainfall interval//mm | M1 | M2 | M3 | M4 | M5 | M6 |
|---|---|---|---|---|---|---|
| <10 | 2.13 | 1.22 | 0.91 | 0.61 | 0 | 0 |
| 10 – 20 | 8.10 | 7.14 | 7.95 | 7.54 | 7.59 | 7.65 |
| 20 – 30 | 15.61 | 14.59 | 17.19 | 16.22 | 16.69 | 17.02 |
| 30 – 40 | 16.25 | 15.02 | 16.72 | 16.63 | 19.22 | 16.80 |
| 40 – 50 | 7.21 | 6.67 | 7.42 | 7.38 | 8.53 | 7.45 |
| ≥50 | 9.76 | 9.02 | 10.04 | 9.99 | 11.54 | 10.09 |
| Total | 59.05 | 53.66 | 60.23 | 58.37 | 63.57 | 59.00 |

**Table 5 Annual runoff interval distribution of each forest stand** mm

| Rainfall interval//mm | M1 | M2 | M3 | M4 | M5 | M6 |
|---|---|---|---|---|---|---|
| <10 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 – 20 | 2.84 | 3.05 | 2.55 | 2.75 | 2.95 | 3.08 |
| 20 – 30 | 7.55 | 7.61 | 6.63 | 6.83 | 6.43 | 7.07 |
| 30 – 40 | 2.32 | 2.41 | 2.65 | 2.64 | 2.88 | 2.93 |
| 40 – 50 | 2.54 | 2.62 | 2.98 | 3.07 | 2.12 | 2.24 |
| ≥50 | 6.52 | 6.86 | 7.94 | 8.18 | 5.76 | 5.93 |
| Total | 21.77 | 22.55 | 22.75 | 23.47 | 20.14 | 21.25 |

# 4 Conclusions and discussion

Research suggests that in terms of soil structure, soil structure is determined by the degree of compaction, compactness, and porosity of the soil[9]. The larger the porosity of the soil, the looser the soil structure, and the stronger the soil permeability. The surface runoff is related to soil permeability. The stronger the soil permeability, the more surface water infiltration, and the smaller the runoff. Conversely, the weaker the soil permeability, the larger the runoff[10].

Research has shown that runoff is influenced by multiple factors such as canopy interception, forest litter status, and soil structure[11]. Crown interception can slow down surface runoff within the forest, and different forest types have varying abilities to intercept rainfall. The interception effect of the canopy layer on rainfall will affect the magnitude of surface runoff[12]. Research has shown that the litter layer has a significant impact on runoff in forest areas. It not only has strong water absorption and retention capacity, but also can intercept rainwater, reduce its erosive effect, enhance soil permeability, and slow down the surface runoff.

Therefore, through the reconstruction and restoration of forest resources, coniferous forests can be transformed into mixed coniferous and broad-leaved forests, and vegetation communities with multiple layers, different ages, and multiple tree species could be constructed, increasing forest vegetation coverage, enhancing the canopy interception capacity of forest land, and improving the storage of forest litter. It could reduce the direct impact of rainwater on the surface, improve soil permeability, slow down the surface runoff in forest land, prolong runoff time, increase underground runoff, and effectively ease soil erosion.

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