



Forest hydrology

New Zealand's freshwater resources are a precious taonga and this resource is increasingly put under pressure due to climate change and land-use intensification.

Understanding where the rainfall (water) enters, moves and leaves a catchment is called forest hydrology.

Hydrology in forests is unique compared to other land uses because the plants and trees, forest litter, and soil all influence where and how water moves and is stored.



Forest canopy

Some **rainfall (1)** is **intercepted (2)** by the forest canopy. The intercepted rainfall then evaporates back into the atmosphere.

The remainder will reach the forest floor via **throughfall (3)** or **stem flow (4)**.

Interception, throughfall and stem flow reduce and slow down rainfall which, protects forest soil from the impact of rain drops and increases **infiltration (6)** into the soil.

This also reduces damage to soil pores and pathways.

Forest litter

Forest litter is one of the many unique features of forests that other land uses do not have. Forest litter protects the soil surface from impact and is porous; it acts as a conduit for water by helping rainfall enter the soil quickly.

Due to the protective nature of the forest litter, forest soils are also insulated from temperature fluctuations, little water **evaporates from forest litter (8)** and soil.

Forest soils

Water moves in the soil both horizontally and vertically through a range of different sized pores and pipes. The large pores (macropores) and pipes in forest soils are formed through processes specific to forests. Larger pores are created by fine and coarse roots of trees and soil animal activity. This water is either **stored (10)** in the soil, **used by plants (11)** or **released to groundwater (12)** and **streams (5 and 9)**.

Water stored by forest catchments is slowly released, even during dry summer months. **Runoff (7)** occurs when water cannot enter the soil because the soil is either saturated or infiltration pathways are damaged. Forest soils rarely experience runoff. Forest litter draws water away from the forest floor and protect infiltration pathways. High soil infiltration occurs because of macropores and soil pipes, even during extreme rainfall events.

Water use

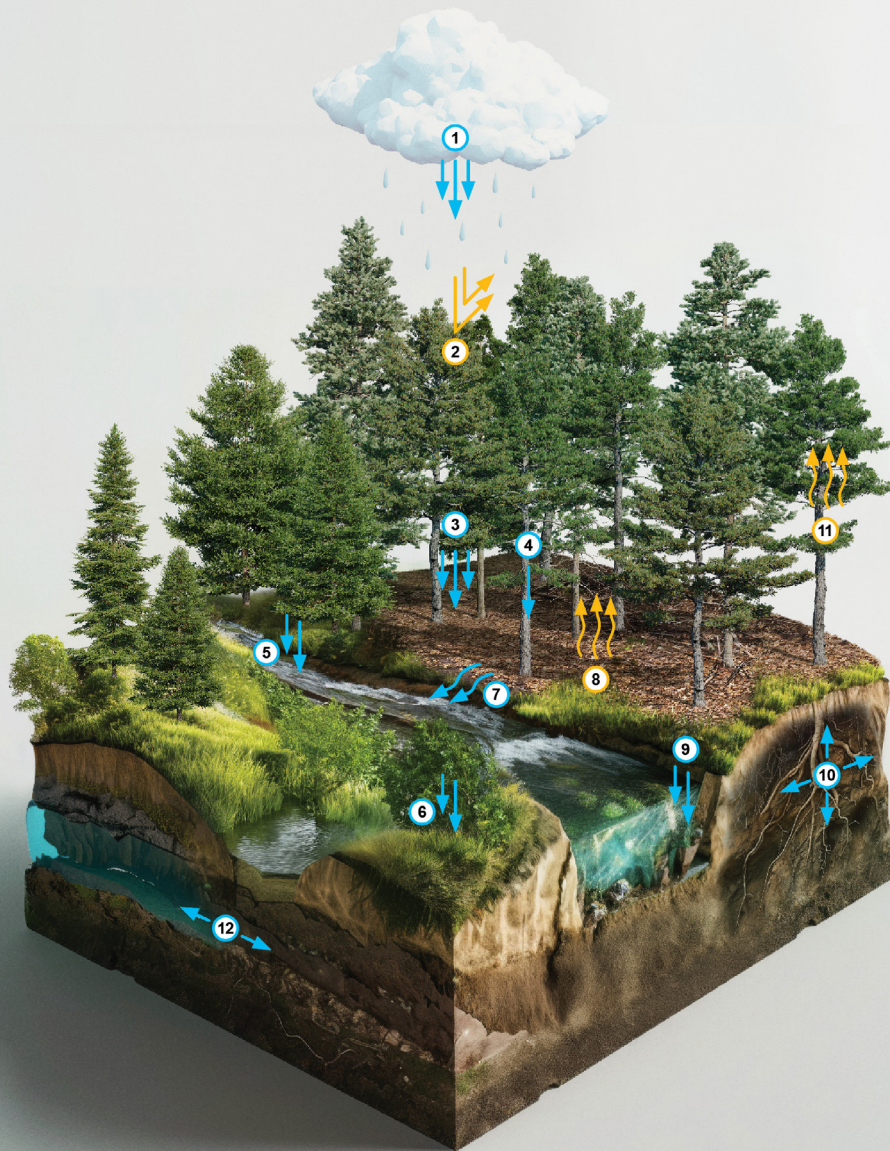
Any available water stored in the **root zone (10)** of forests can be used by trees. Approximately 65 to 75% of the root biomass of mature radiata pine occurs within the top 30 to 50 cm of soil.

Root networks can redistribute water from wetter to drier parts of a soil profile.

Trees use water through **transpiration (11)**, they regulate water flow by opening and closing leaf pores (stomata) and use it for photosynthesis.

Scion's Forest Flows research programme fills a gap in forest hydrology research over the last 40 years. Extensive, integrated sensor networks were set up at five primary forest sites across New Zealand to study hydrology. They cover a range of catchment sizes and are across a rainfall gradient (800 to 3000mm/year). Rainfall, tree growth, soil moisture, water age and more have been measured and analysed. The programme was supported by the MBIE Endeavour fund.





1 Rainfall

Rainfall is the main water input into forests.

2 Interception

Rainfall that does not reach the forest floor (stopped by the forest canopy).

3 Throughfall

Rainfall that moves through the forest canopy and reaches the forest floor.

4 Stem flow

Rainfall that runs down tree stems and reaches the forest floor.

5 Stream flow

Rainfall that falls directly into streams and rivers or from groundwater.

6 Infiltration

Rainfall that reaches and enters forest litter and soil and becomes soil water.

7 Run off

Rainfall that can't infiltrate forest litter and soil runs over the forest floor and into streams.

8 Forest litter water evaporation

Water that evaporates from forest litter back into the atmosphere.

9 Soil water release

Water that leaves soil and enters streams and groundwater.

10 Soil water storage

Soil water that sits in small pores (micropores) or held on particles in the soil.

11 Transpiration

Water in the root zone used by trees during photosynthesis. Surplus water leaves the tree through small pores in the leaves (stomata) and evaporates back into the atmosphere.

12 Groundwater

Water stored below the soil.

Why Forest Flows?

The Forest Flows programme exists at the intersection of both forests and water. The programme is filling a 40-year gap in forest hydrology research.

It will ultimately reveal how resilient New Zealand's planted forests are to floods and drought and how water moving through forests will be impacted by climate change. The programme looks at how water moves through catchments and is stored.

Some key questions the Forest Flows research can address are:

- How much and how long is water stored in planted forested catchments?
- How much water is released?
- Can planted forests improve water quality?
- Are planted forests an important source of water during the summer.

About Forest Flows

Forest Flows established an integrated, wireless sensor network of terrestrial and remote sensing equipment across planted forest catchments. This allows researchers to directly measure tree water use, catchment water storage and release.

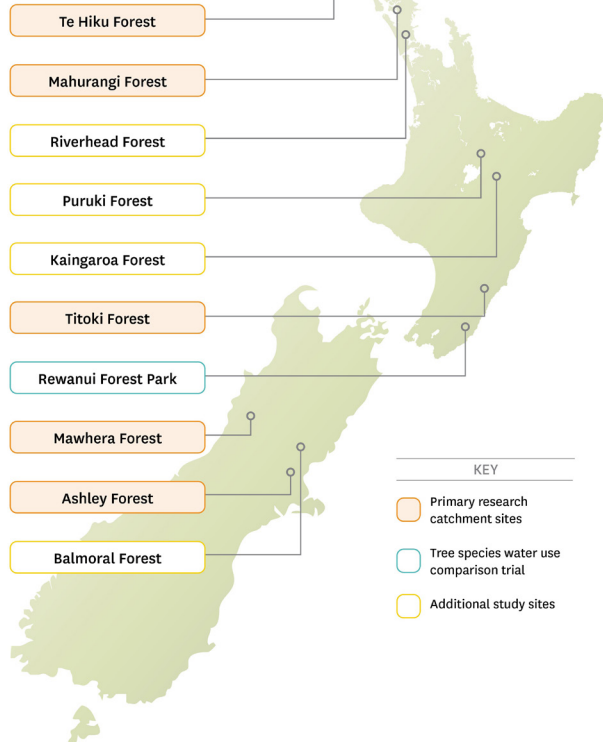
Measurements captured by the various sensors provides 360,000 observations a day, totalling 130 million over a year.

Five primary and five secondary research sites across New Zealand were chosen. The sites were selected from a range of catchment sizes (37-1800ha) and cover a rainfall gradient (800-3000 mm annual rainfall). The five-year programme began in 2019 and has been recording data since 2021.

The Forest Flows programme is led by Scion with 13 local and international collaborators. Initially, \$13.7 million was awarded by the Ministry of Business, Innovation and Employment (MBIE) Endeavour Fund, with further support from the Forest Growers Levy Trust and the forestry industry injected in 2024 to extend monitoring and analysis until the end of 2025.

Forest Flows

STUDY SITES



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About Scion

Scion is the Crown research institute that specialises in research, science and technology development for forestry, wood and wood-derived materials, and other biomaterial sectors.

Scion's purpose is to create economic value across the entire forestry value chain, and contribute to beneficial environmental and social outcomes for New Zealand.