Forest water dynamics

Water can be available from planted forest catchments even in the driest parts of New Zealand. Forests have the potential to release water during dry periods and regulate stream flow during storms and floods.

Forested catchments provide downstream benefits, with the potential to supply water during the spring and summer and regulate stream flow during storm events. It is possible to manage water supply from forested catchments through species and genotype selection, and good forestry practices.

Water is an essential resource providing a wide range of economic, ecological, cultural, social and recreational benefits to all New Zealanders. The demand for water is increasing with the intensification of New Zealand's primary sector and the country's growing population and urbanisation.

With Government tree planting initiatives and the forestry industry's desire to intensify production, planted forests are increasingly seen as a competitor for water resources by downstream users.

Planted forests intercept some but not all rainfall. Water use research shows that even in the driest parts of New Zealand, there is still available water in catchments planted in radiata pine.

The forest water cycle

Factors that affect water in a forested catchment include climate, rainfall intensity and duration, topography, aspect, stand stocking and silviculture, soil physical properties, above ground biomass and canopy density.

Precipitation. Some of the rain is intercepted by the forest canopy and will evaporate into the atmosphere. The remainder will fall through the canopy to the forest floor.

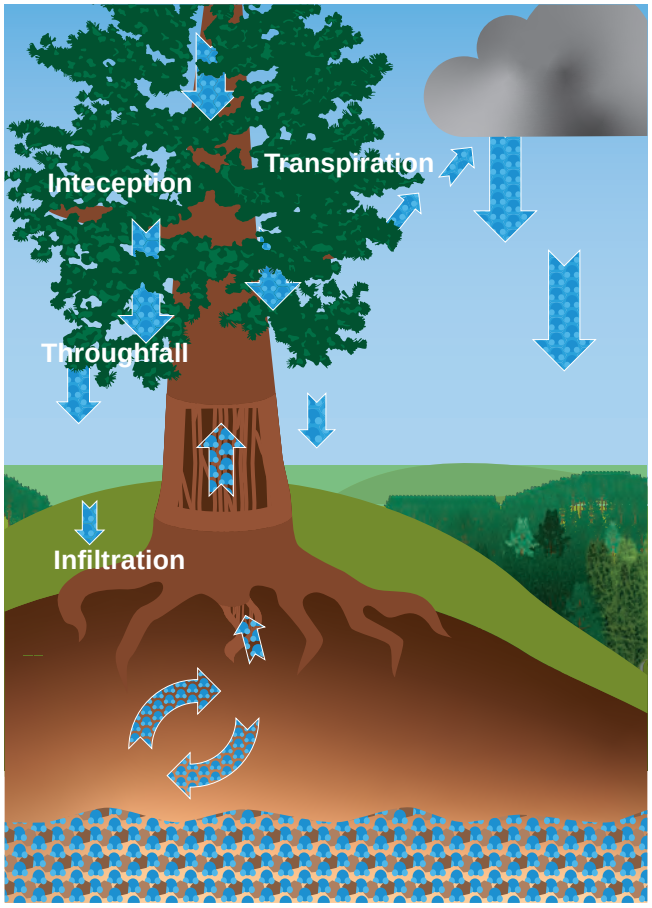
Interception. Interception rates vary across forests and canopy types. Radiata pine is estimated to intercept between 19 and 30% and indigenous scrub between 31% and 42% of precipitation.

Infiltration. Throughfall, water that reaches and infiltrates the forest soil, can remain in the soil and be available to trees and other plants, or move to ground water storage and stream flow.

Runoff. Water that does not infiltrate the soil is called runoff. It can occur in forests in heavy rain. However, the porosity of forests soils and the cover created by the forest canopy reduces the amount of water available for runoff, especially when compared to pasture.

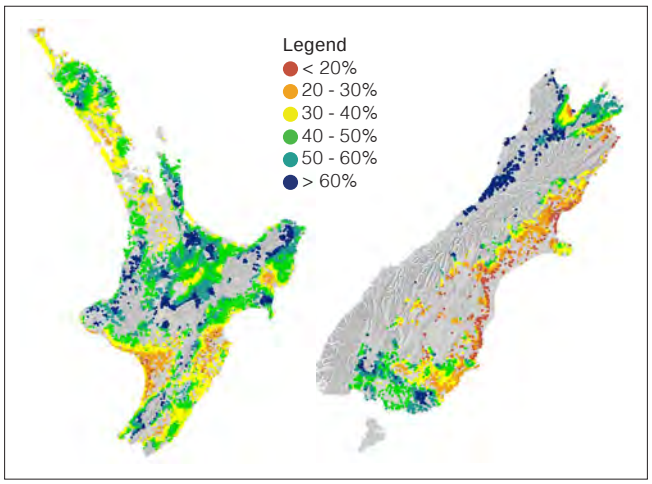
The root zone. Any available water that is in the root zone of forests can be used by trees. Approximately 65 to 75% of the root biomass of mature radiata pine occurs within the top 30 to 50 cm of soil. Root networks can redistribute water from wetter to drier parts of a soil profile.

Transpiration. Transpiration is a consequence of photosynthesis and growth. Water in the root zone is transported through the tree and used in photosynthesis. Surplus water is transpired through small pores in the leaves (stomata) and evaporated into the atmosphere.



Water use by planted forests across New Zealand

Pinus radiata is the dominant planted tree species and its water use has been heavily studied. Rain that has not been used by planted forests is available water. Modelled water use across the country shows most sites use between 30 and 50% of water. Generally, there is more available water in higher rainfall areas. This modelling indicates that even in the driest parts of the country, there is still available water in catchments planted in radiata pine. Research into water use and its impacts on water yield is ongoing in a range of catchments.



Percentage rainfall surplus to radiata pine tree water use.

Effects of new forests on water supply

There are concerns about the effects on downstream water supply due to land use change when new forests are planted as generally there is a reduction in water yield with an increase of tall vegetation.

What do we know? Paired catchment studies. Paired catchment studies have been widely used globally to compare changes in water yield with changing vegetation types. New Zealand studies have compared conversions for a range of land uses.

A 1982 study of 94 catchments around the world indicated that with a 10% increase in forest cover, annual flow was reduced by 40 mm in pine and *Eucalyptus* plantations and 10-25 mm for deciduous hardwood or scrub.

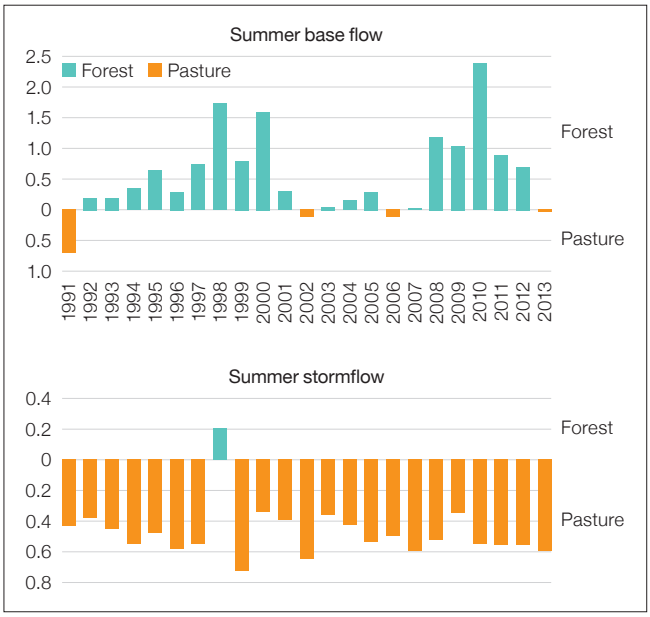
Reductions of annual water yields of 37, 13 and 33%, respectively, have been seen after converting native scrub, indigenous forests and tussock grassland to radiata pine. A catchment partly covered in gorse then converted to radiata pine showed no difference in flow once the trees were established.

However, annualised water yield cannot provide information on water storage and release from forested catchments. For example, the annual reduction in water yield with afforestation includes the important mitigation in stormflow during high rainfall events and reduces storm impacts downstream.

The Maimai paired catchment study conducted in Tawhai Forest, in the South Island investigated water yield from a catchment covered in indigenous beech-podocarp-hardwood compared with an adjacent catchment where the land was harvested and treated before being converted to a radiata pine plantation.

This 1971 study showed water yields returned to pre-treatment levels three to six years after converting native beech or podocarp stands to radiata pine. Canopy closure and interception loss were the main causes of reduction in water yield. However, afforestation also reduced average flood peaks by between 55 and 65%.

Annualised water yields also mask complex water flows within forested catchments on smaller timescales such as changing seasons. The Purukohukohu basin paired catchment study, located in Bay of Plenty in the North Island of New Zealand followed water yield over 22 years and two forest rotations, finding that the radiata pine catchment had higher summer stream base flows than the neighbouring pasture catchment for all but four years.



Relative difference in water yield between radiata forest and pasture catchments during summer (Purukohukohu Experimental Basin)

Forests regulating water supply. Climate change is expected to bring more extreme weather to New Zealand with some areas likely to experience more severe droughts, more storms and more flooding, affecting forest water flows.

Drought. There is a common perception in New Zealand that radiata pine will either intercept or use all water that reaches the root zone in forested catchments during summer months.

The Purukohukohu basin paired catchment study results suggest that forested catchments have the potential to supply water to downstream users during dry spring and summer months.

A recent study of a mature radiata pine forest catchment in the Central North Island found that during the drier spring and summer months, rainfall did pass through the canopy and infiltrate to a soil depth of at least half-a-metre on a regular basis over a two year period.

The study concluded that, although it is possible that the radiata pine roots were accessing soil water at deeper depths, it is unlikely that all infiltrated water past 40 cm was being used.

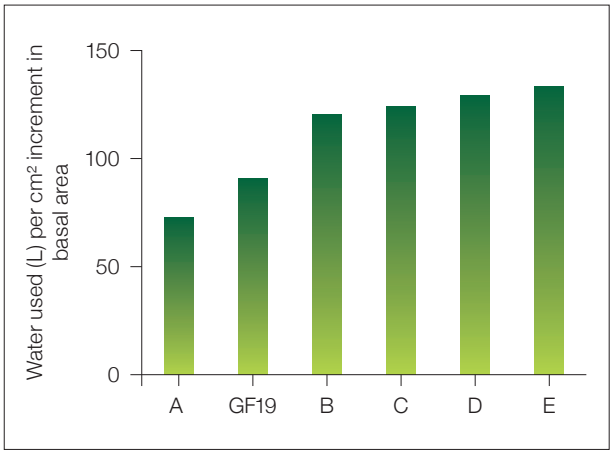
Flooding. Forested catchments regulate storm flow in wet winter months when compared with pasture, as shown by the Purukohukohu basin paired catchment study results. Generally, planted forests can reduce the peak flows in small floods by as much as 50%.

Enhancing water supply from forested catchments

Forest owners can manage water supply from forest catchments through careful tree genotype selection, species selection and silviculture regimes.

Genotypes. Recent research has shown that some radiata pine genotypes use different amounts of water. In the future, selecting plants that use water efficiently may be possible. This also may help foresters manage productivity and ensure survival during times of drought.

Different radiata pine genetic varieties also use different mechanisms to cope with drought. These water stress indicators trigger plants to increase growth in root biomass to capture more soil moisture while limiting transpiration, above growth of above ground biomass. Once the trees receive water again, the most tolerant recover from drought stress.



Water use by different radiata pine genotypes.

Species selection. Water use and tolerance to high and low rainfall events can also be managed by matching site climatic conditions to the most appropriate species. In low rainfall regions in Australia, Eucalyptus plantations can see a 90 to 100% reduction in stream flow compared with radiata pines (40 to 60%). Douglas-fir also uses 74 to 84% of annual precipitation compared to radiata pine (60%) in similar situations.

Silviculture regimes. There is a strong relationship between site water availability and above ground biomass in radiata pine and other species suggesting water availability plays an important role in site productivity of radiata pine plantations.

Thinning operations reduce canopy closure and leaf area. Activities such as selective harvesting and thinning can help manage scarce water supplies in drought-prone areas and help regulate catchment water dynamics in high rainfall areas.

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