Growing confidence in forestry's future Research Programme

SCION FORESTS | PRODUCTS | INNOVATION

Planted Forests and Their Impact on Water Quantity and Quality in New Zealand's Hydrological Landscape

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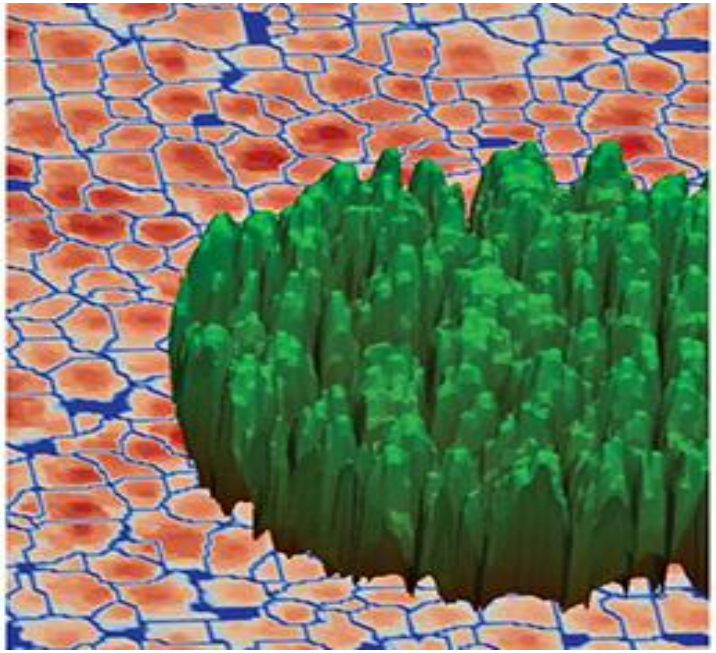

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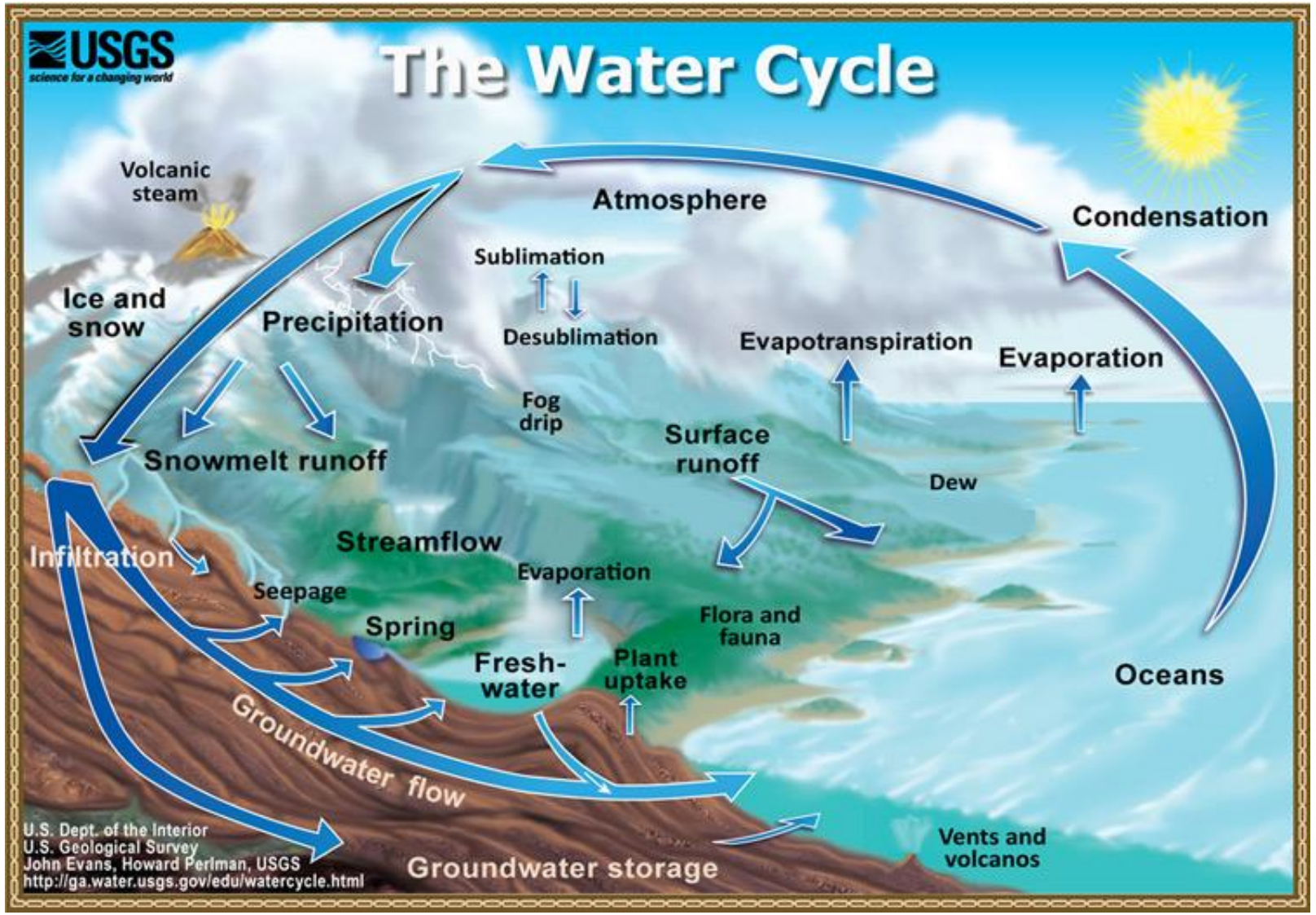
FOREST GROWERS RESEARCH

Overview

- Perception of trees, water use and water yield
- Brief history of NZ forested catchment studies
- Modelling radiata pine water use in NZ
- Hard data on radiata pine transpiration
- Water use verses water yield
- Puruki catchment case study
- Summary and future directions

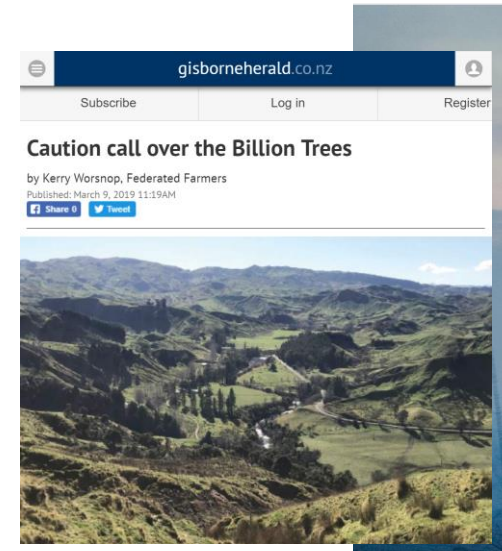


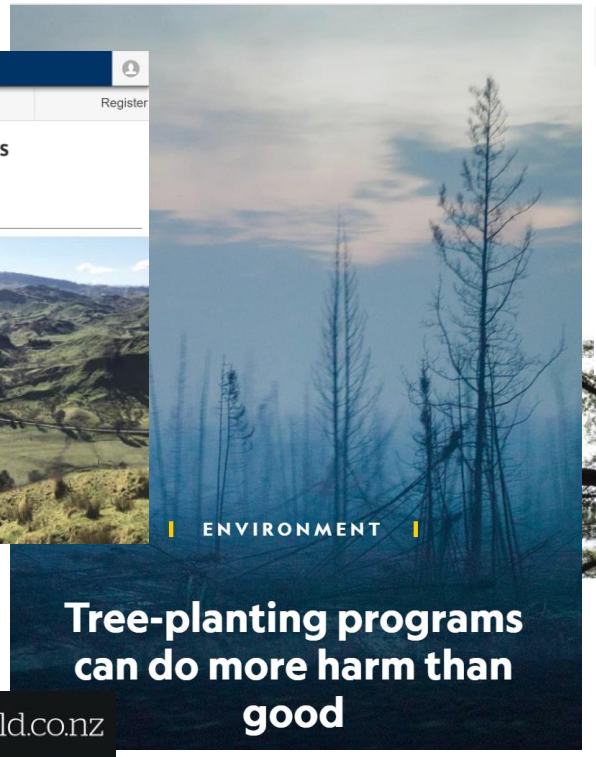
https://water.usgs.gov

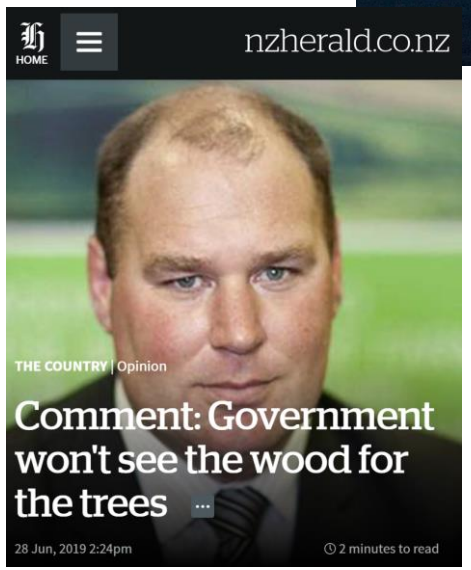
Trees, water use, and forest water yield

Common assumptions

- Native trees use far less water than exotics
- Radiata forests use 42% of annual rainfall
- No surplus water from radiata pine forests during the summer
- Exotic trees pollute the soil and waterways
- Large scale afforestation with the 1BT programme will reduce water supply for downstream users



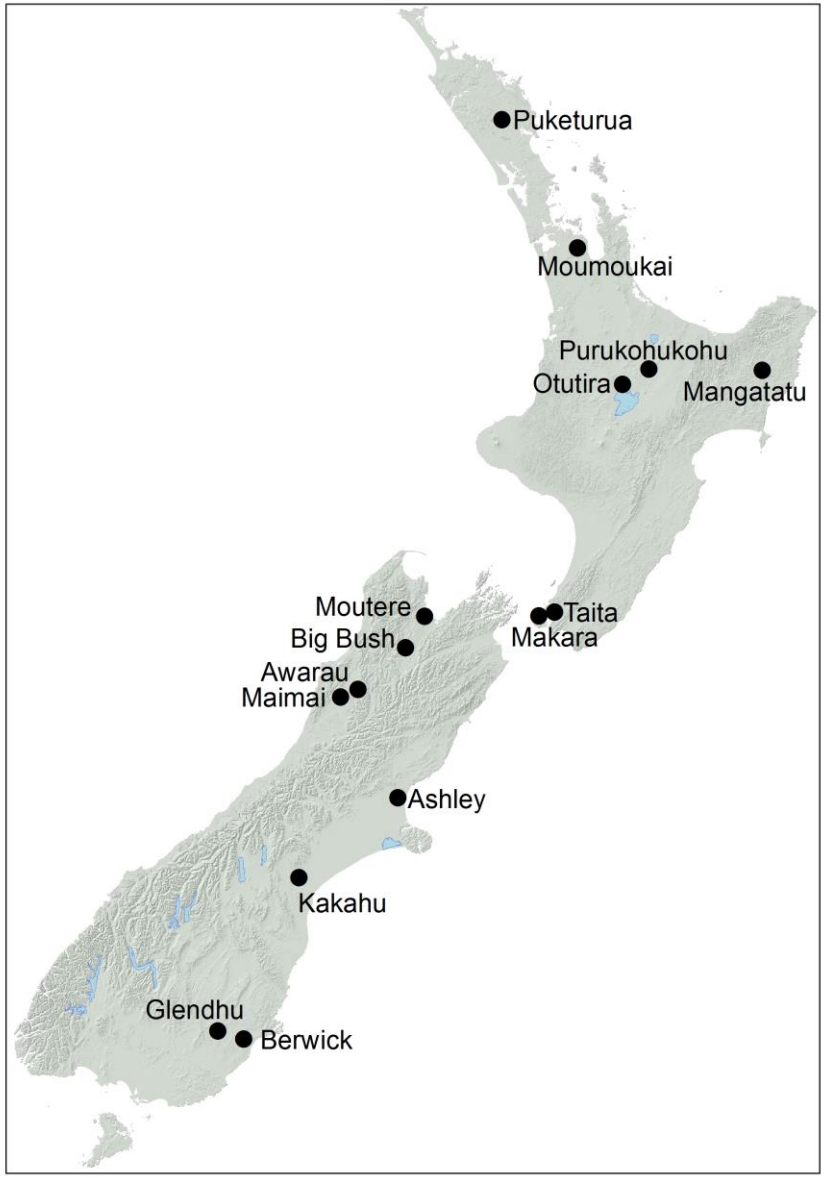




Brief history

- Hydrology seen as a “mature” science
  - Lots of research in 20th Century
- Experimental catchments tested land use change & management on water resources
  - first used in the 1950’s
- Last studies created in late 1970’s: Ministry of Works Land-use Basin program
  - pair catchment approach
- Produced lots of valuable data

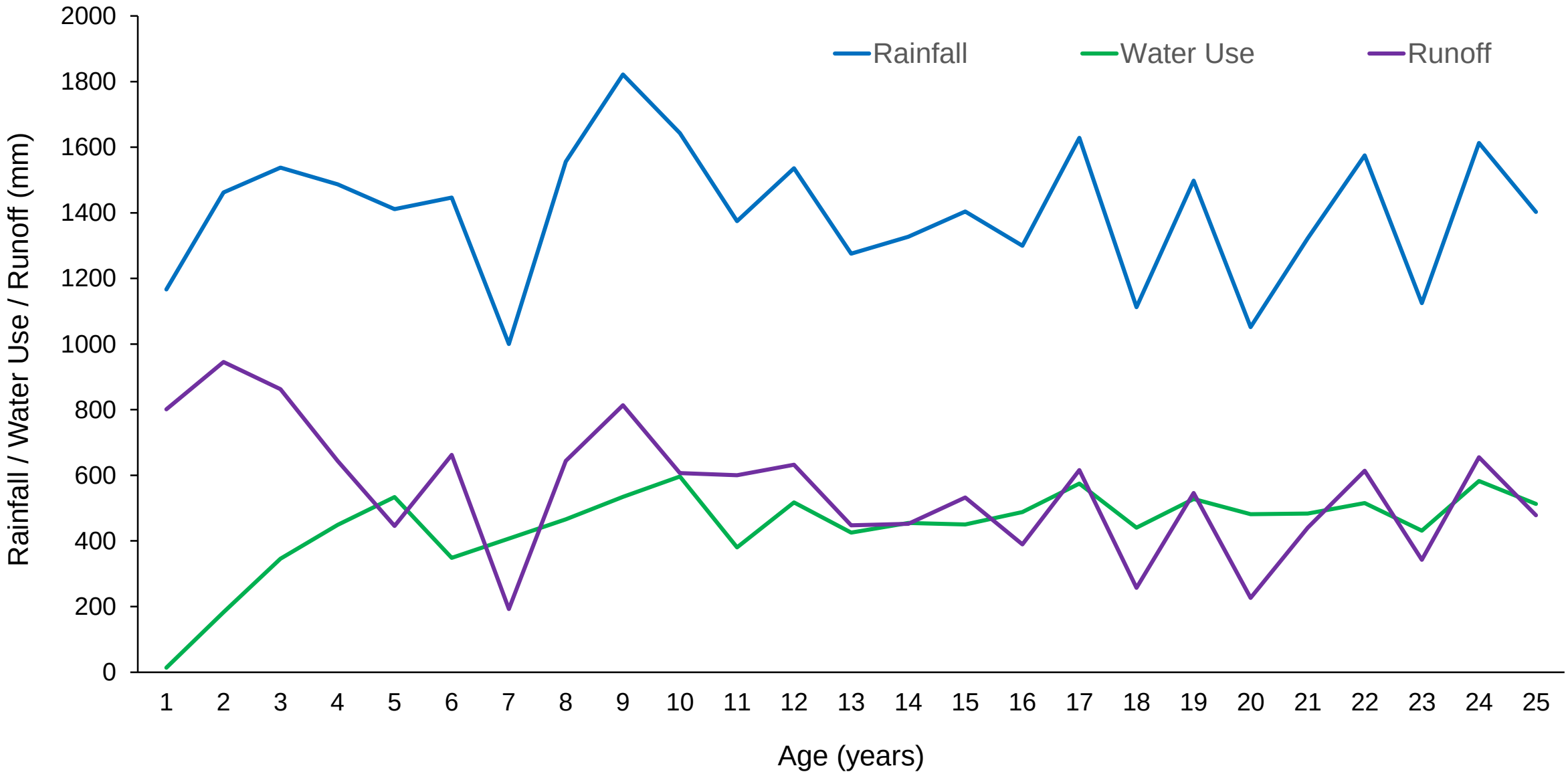
Location of Experimental Catchment Studies



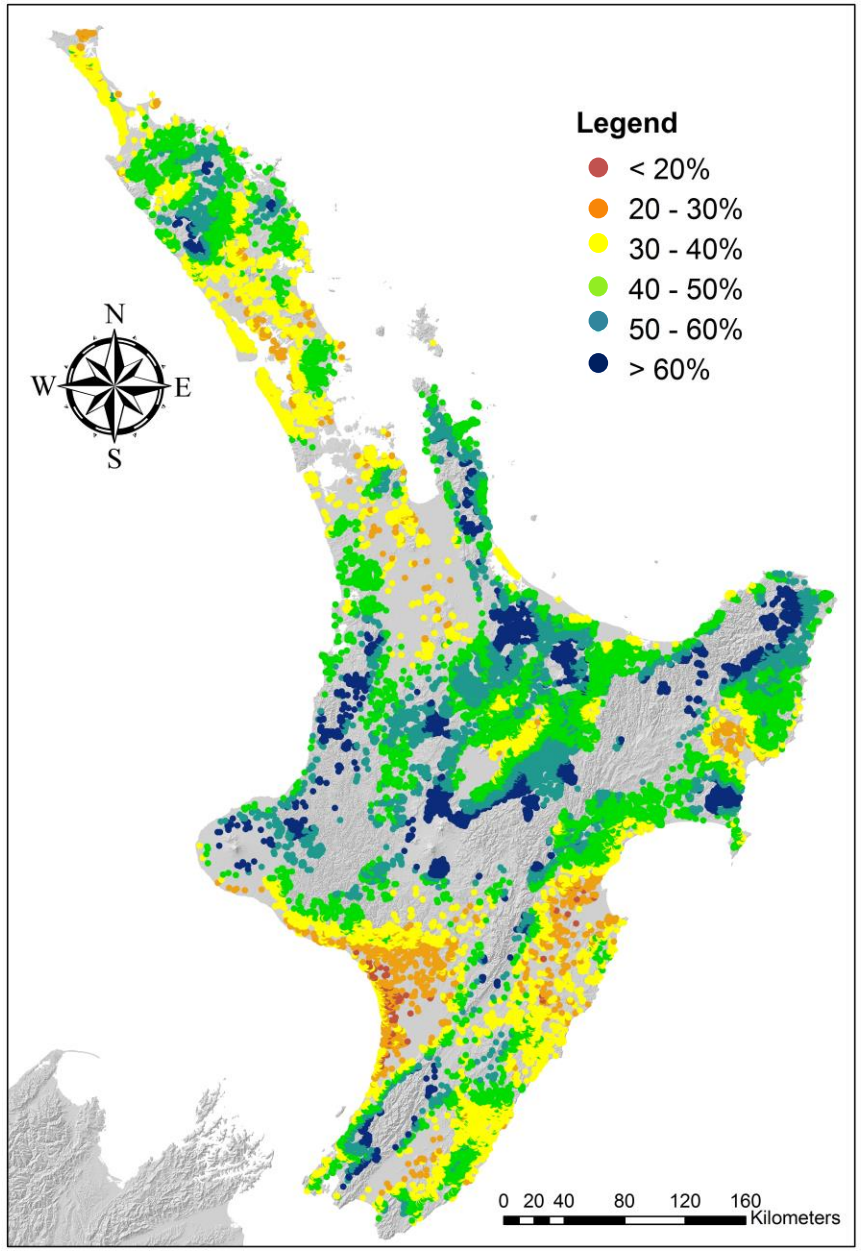
Experimental catchments – mission accomplished?

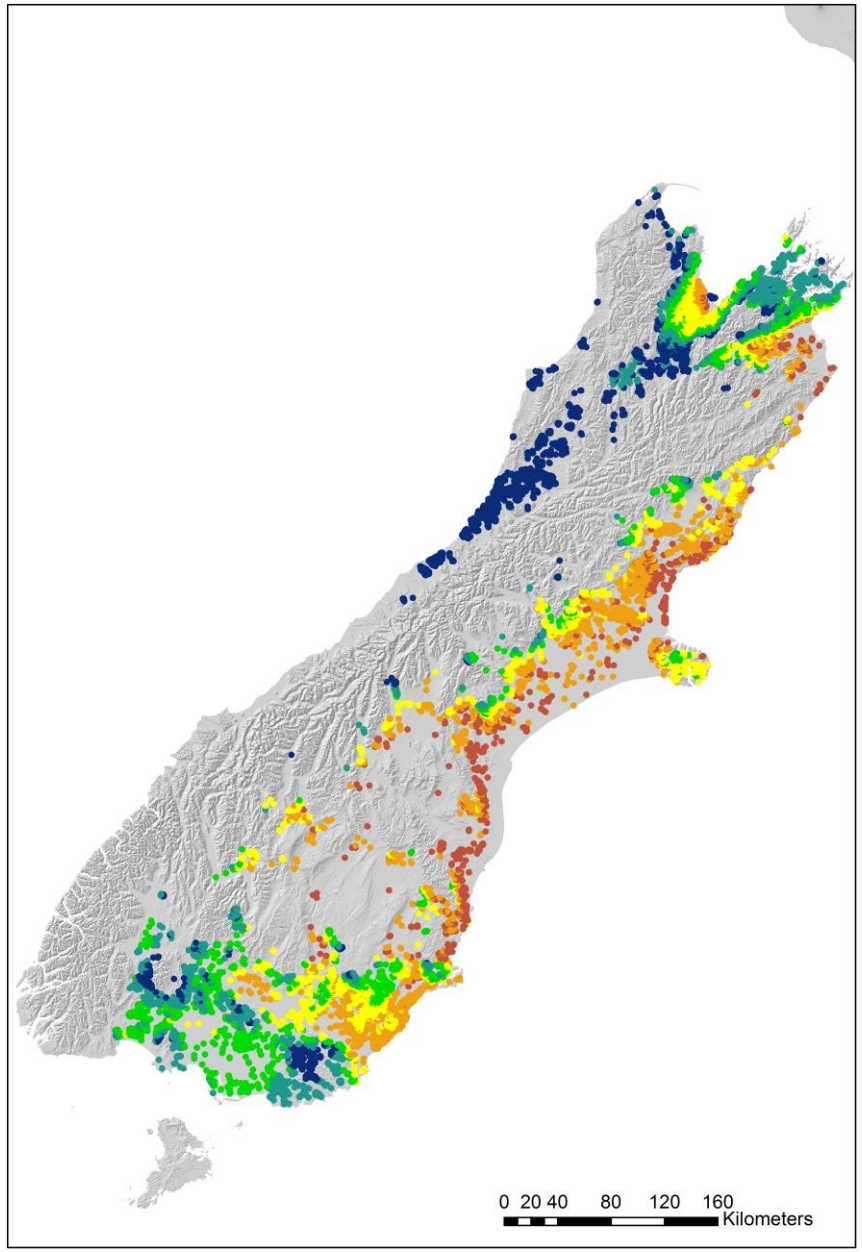
- Lots of data but are site specific
  - Resulting fitted models are also site specific
- Wide range of reduction in annual water yield with afforestation: 30 to 80% (Davie and Fahey, 2005)
  - Generalised values further generalised
- Good data on forest impacts on stream flow during storm events
- Poor understanding on forested catchments on low flows (Davie and Fahey, 2005)
- Hydrological models from agricultural systems perform poorly in complex forested catchments
- Annualised water yield mask the complex hydrological dynamics within a forested catchment

Modelled radiata pine stand water use over 25 years

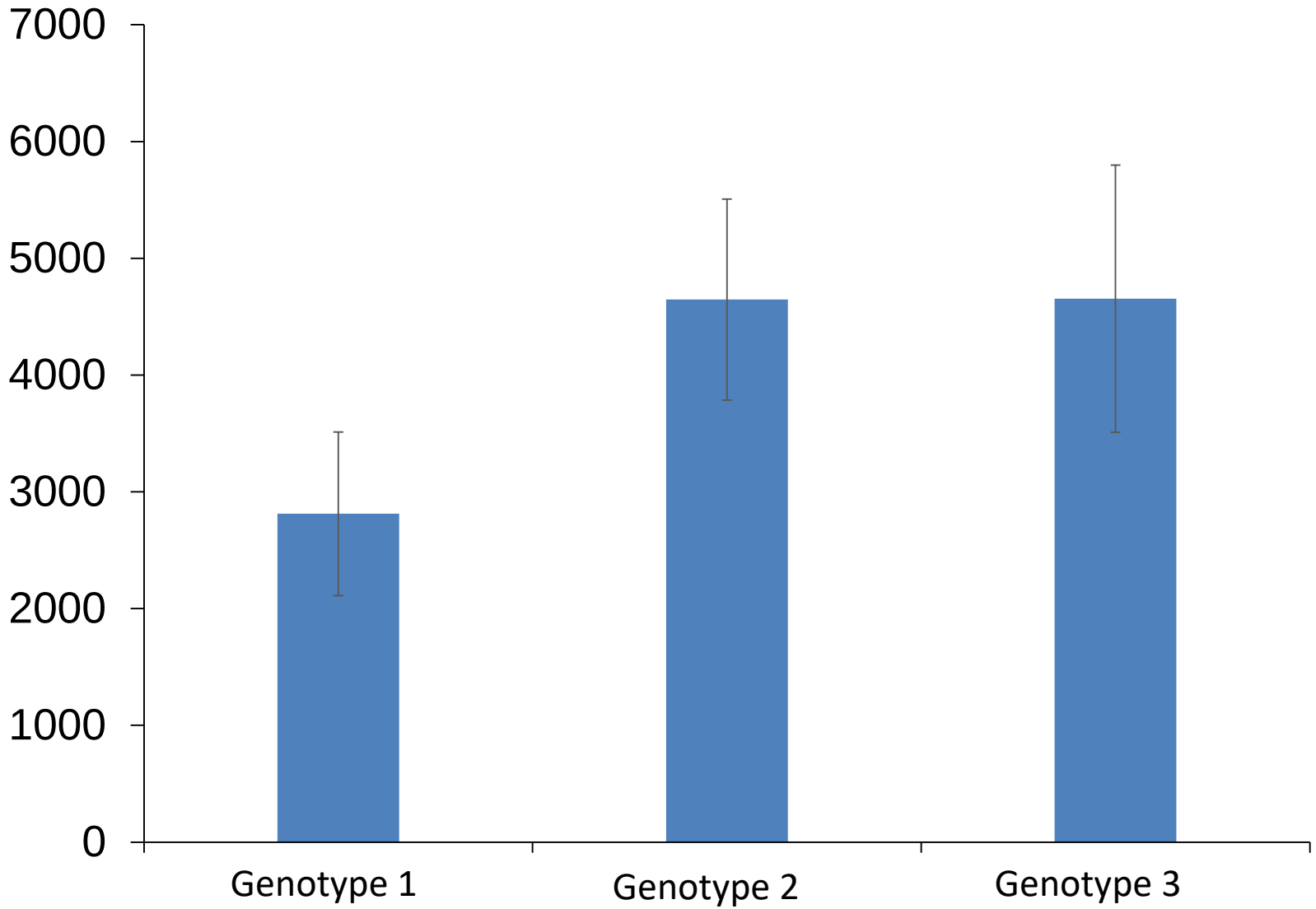


Modelled radiata pine water use – percentage surplus rainfall over 30 years





Some radiata pine genotypes use less water than others



Litres transpired by three radiata pine genotypes to grow 1 cm diameter of stem at DBH over 9 months at age 13

Water use verses water yield

- Two dimensional, “tipping bucket” model - difference between rainfall, forest water use, and changes in soil water storage
- Unable to represent the 3-dimensional catchment level processes
- Unable to represent the forest hydrology dynamics that change daily, weekly, monthly, & seasonally
- Unable to quantify water storage and release

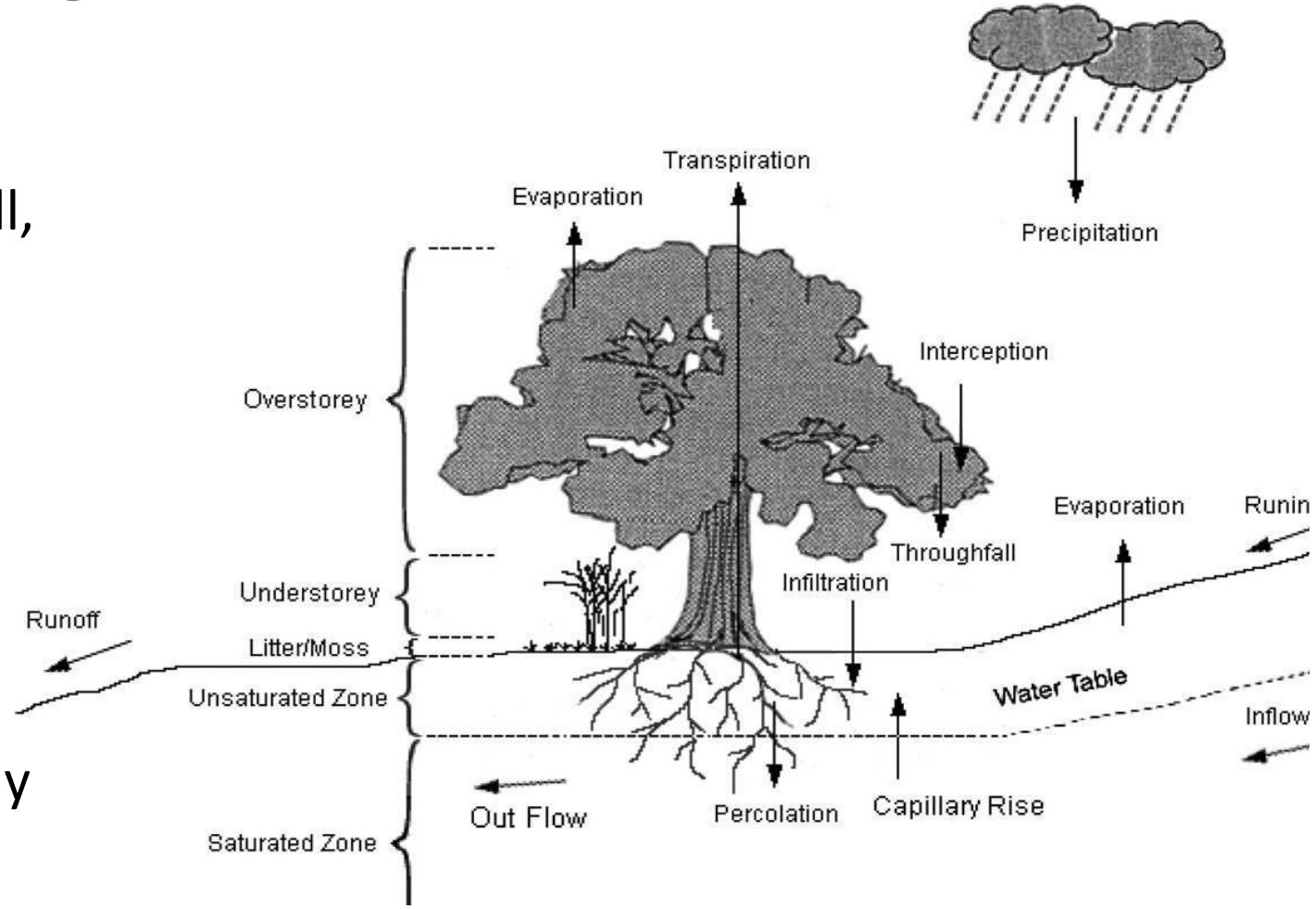
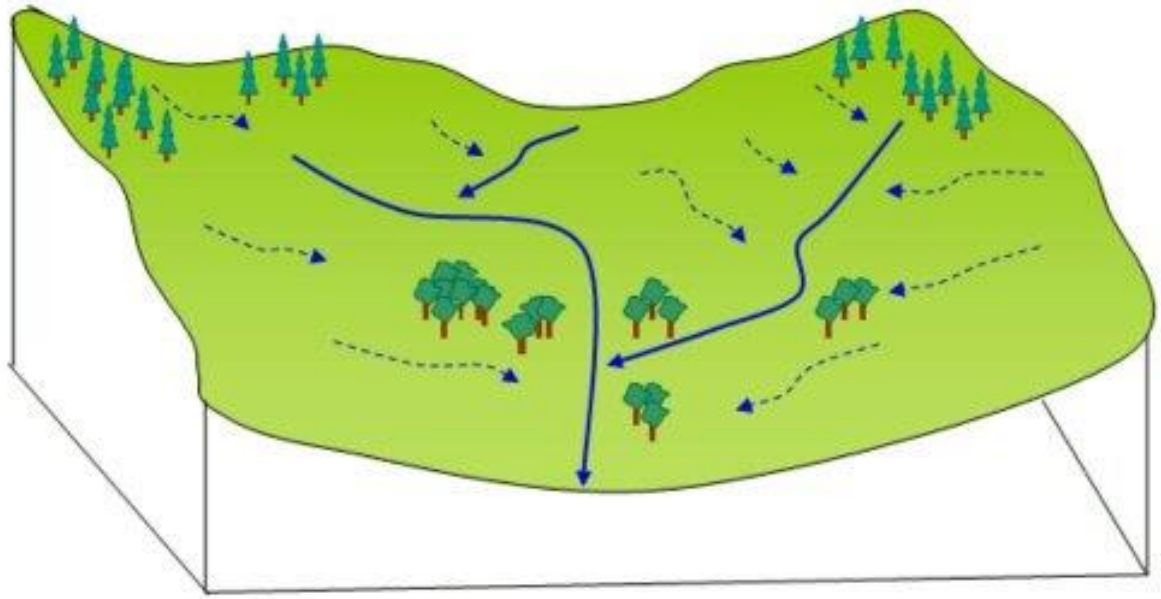


Figure 1 Hydrological processes at the forest scale (Chen et al., 2005)

Water use verses water yield

Forest catchment water yield is also controlled by:

- Rainfall event intensity, duration, amount
- Tree species, stand tree density (stocking), and age classes
- Topography & aspect
- Highly variable soil physical properties
- Unique forest soil processes including infiltration, subsurface flow, & soil water storage
- Intermittent & permanent stream network

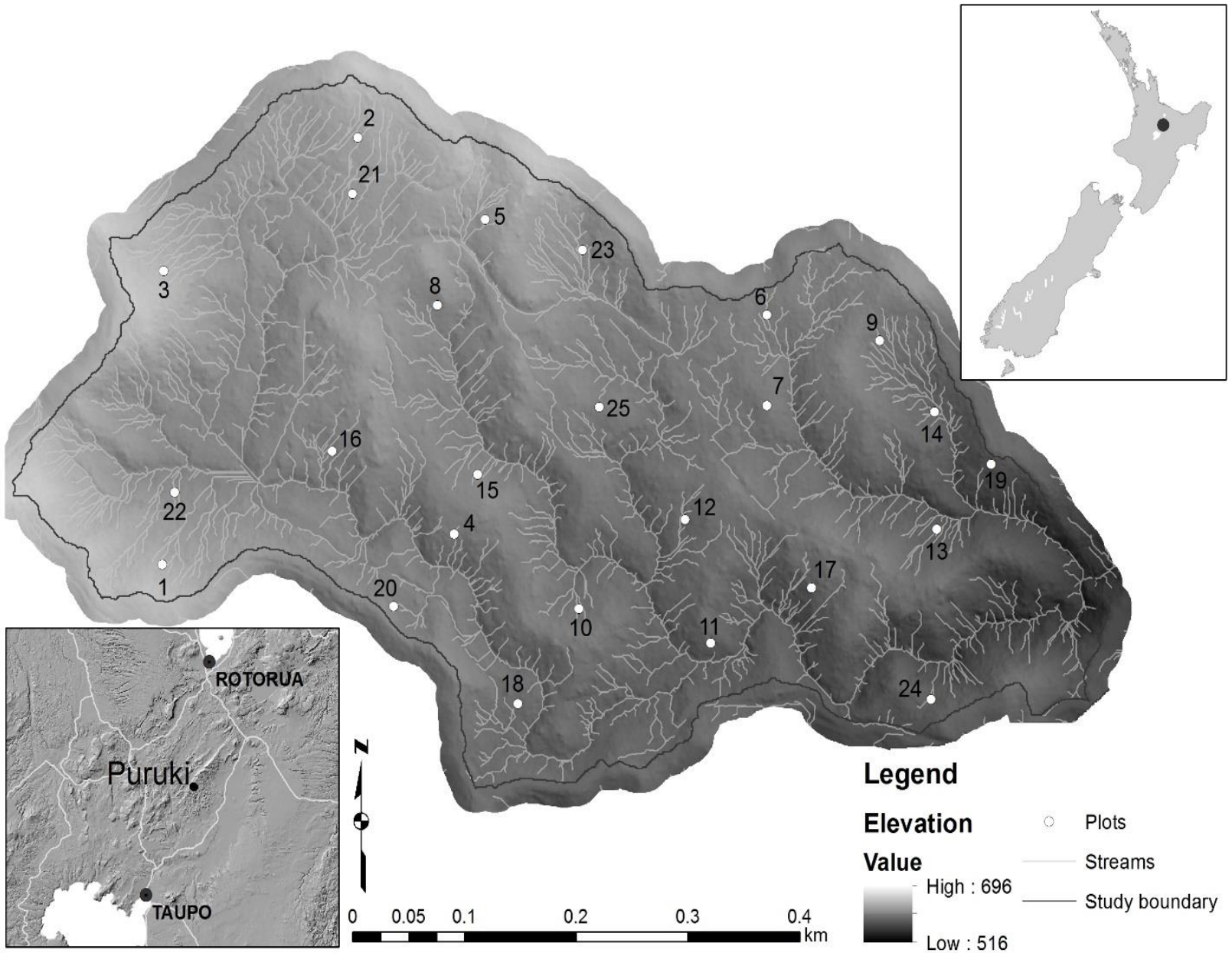


A catchment area.

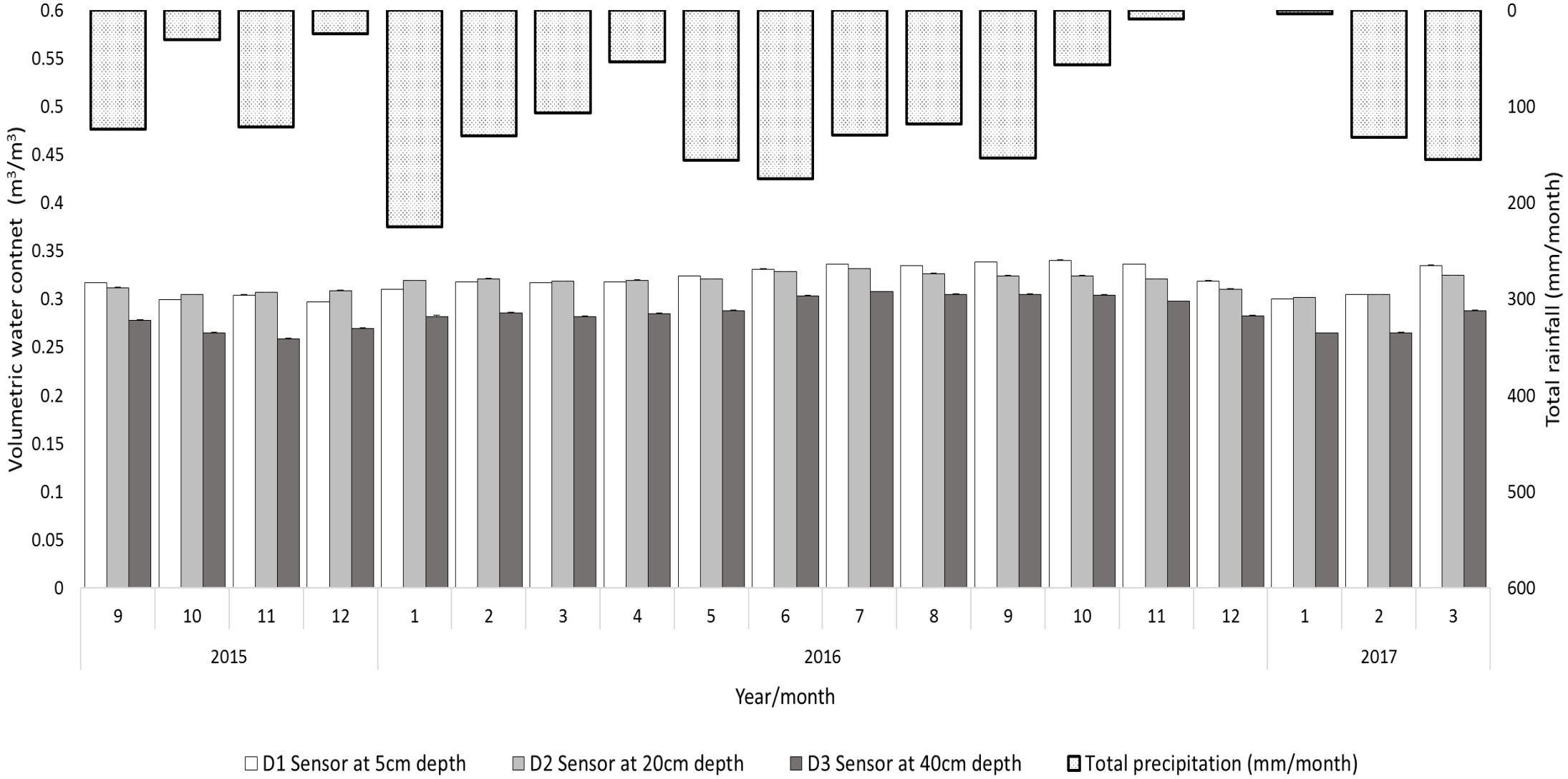
https://qph.ec.quoracdn.net/main-qimg-304b34b4131e6a4250f92d8c482e61a2

Paired experiment catchment example: Purukohukohu, Waikato

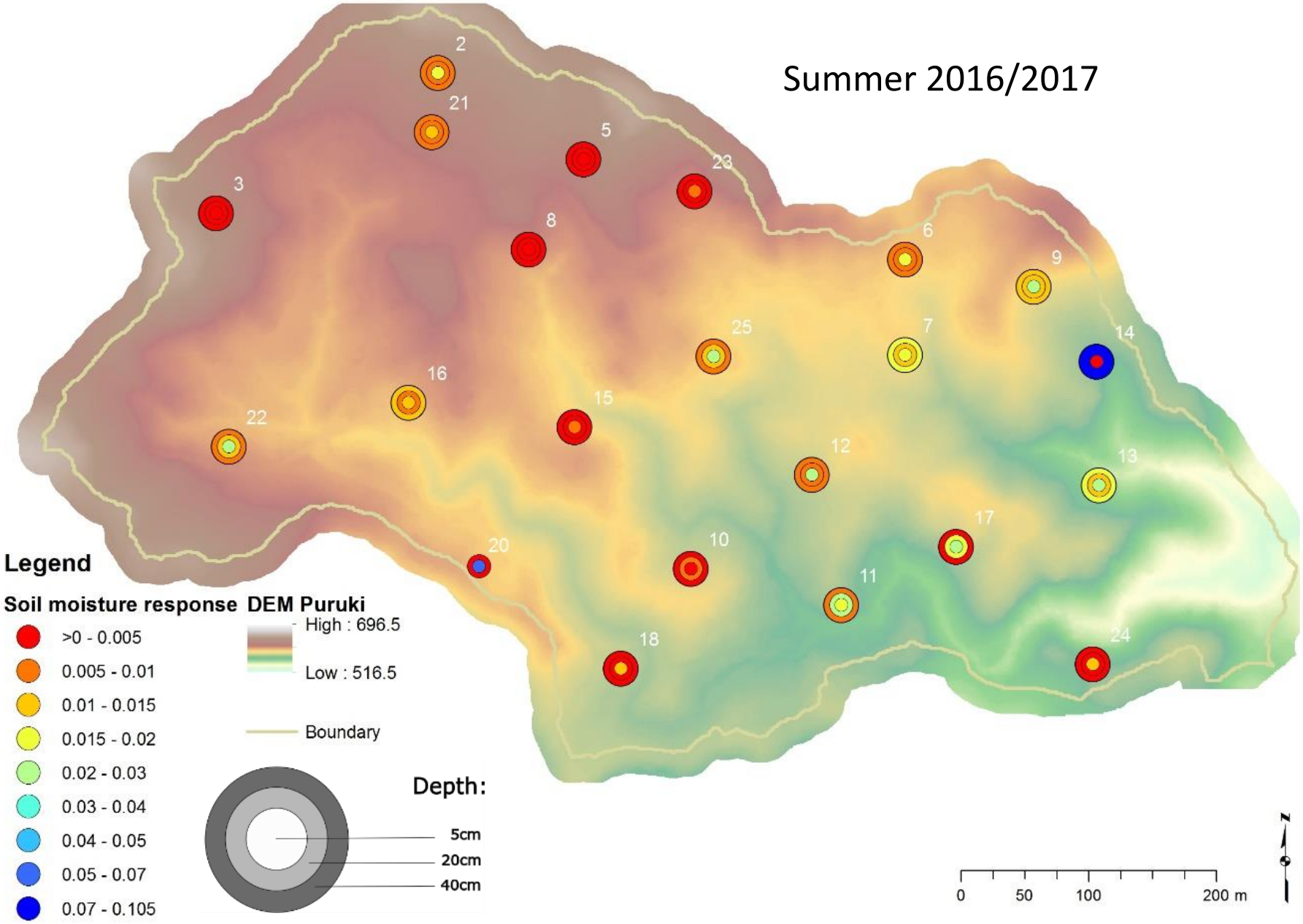
Puruki forest hydrological dynamics and water yield



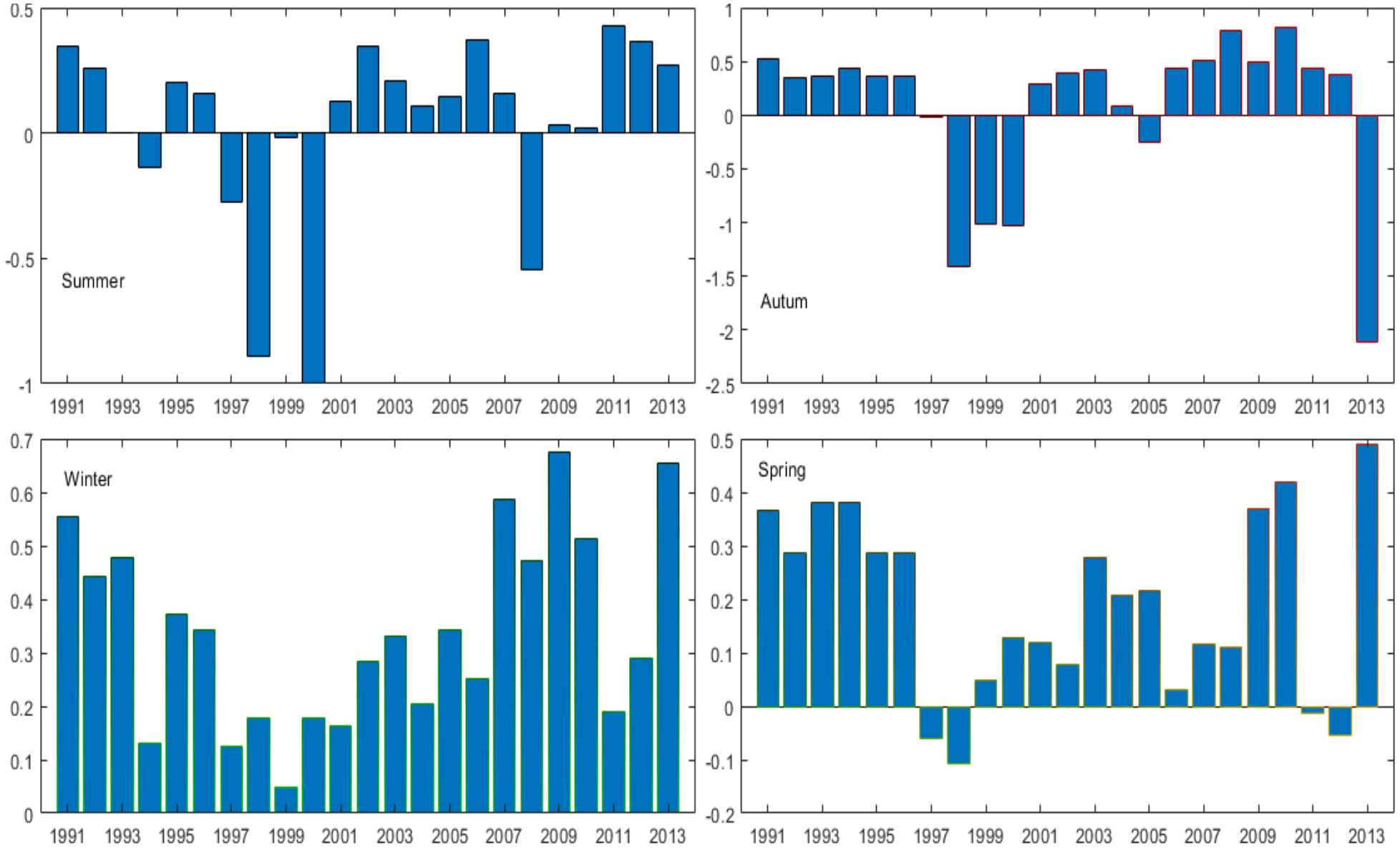
Puruki mean volumetric soil water content and rainfall by month



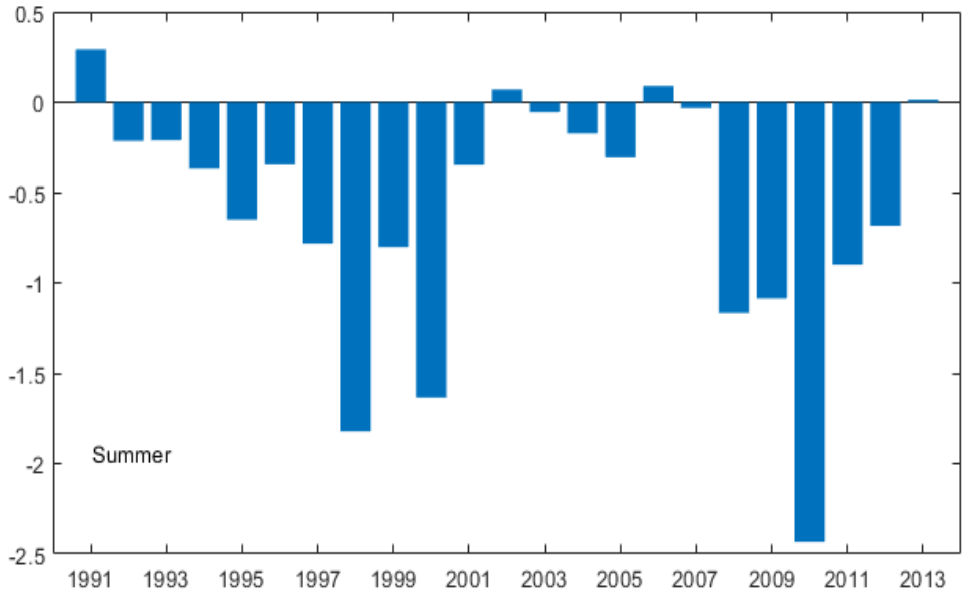
Puruki rainfall infiltration dynamics

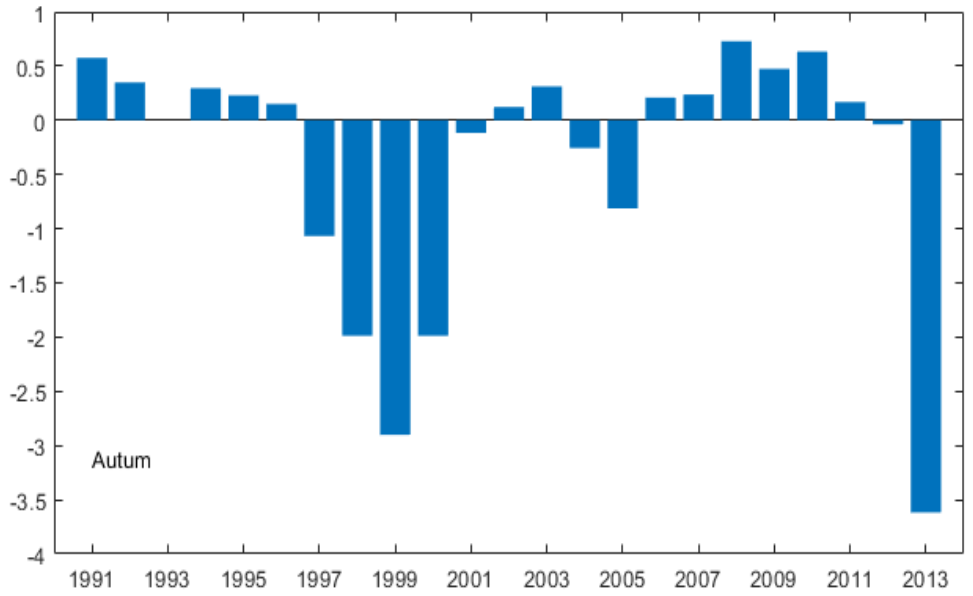


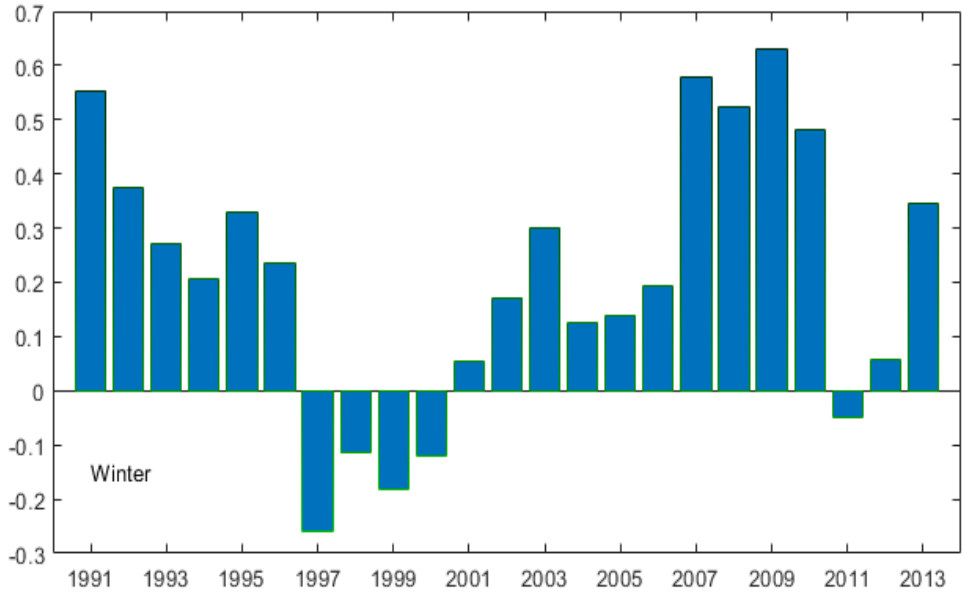
Relative difference in total stream flow between forest and pasture

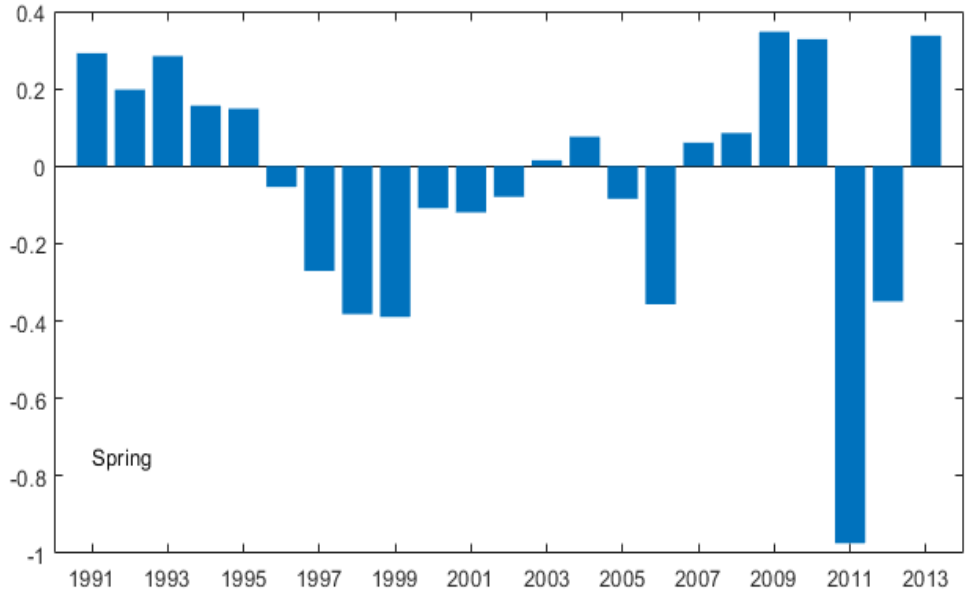


Relative difference in base flow between forest and pasture









Leaching and stream concentrations of nitrate from Puruki

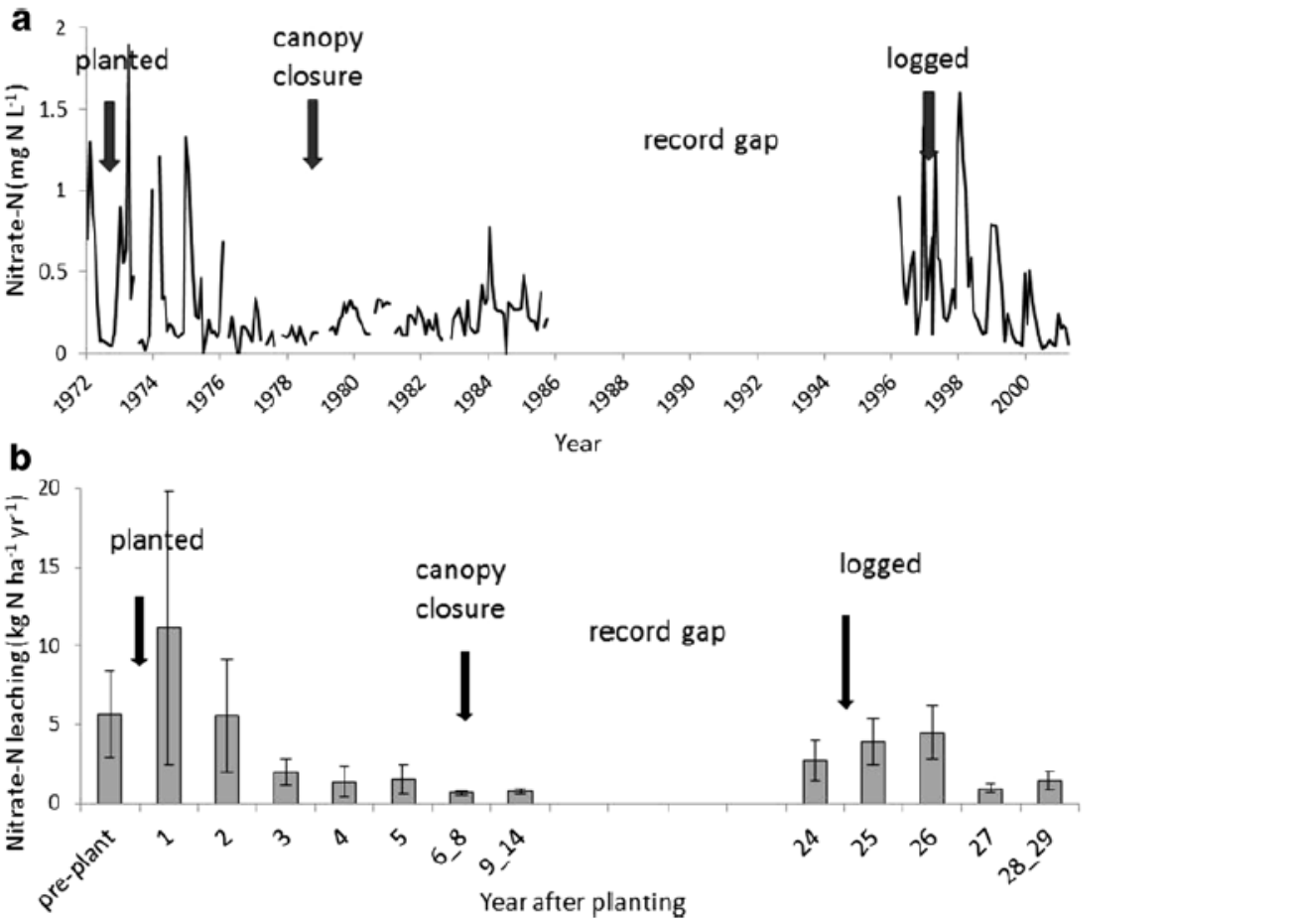
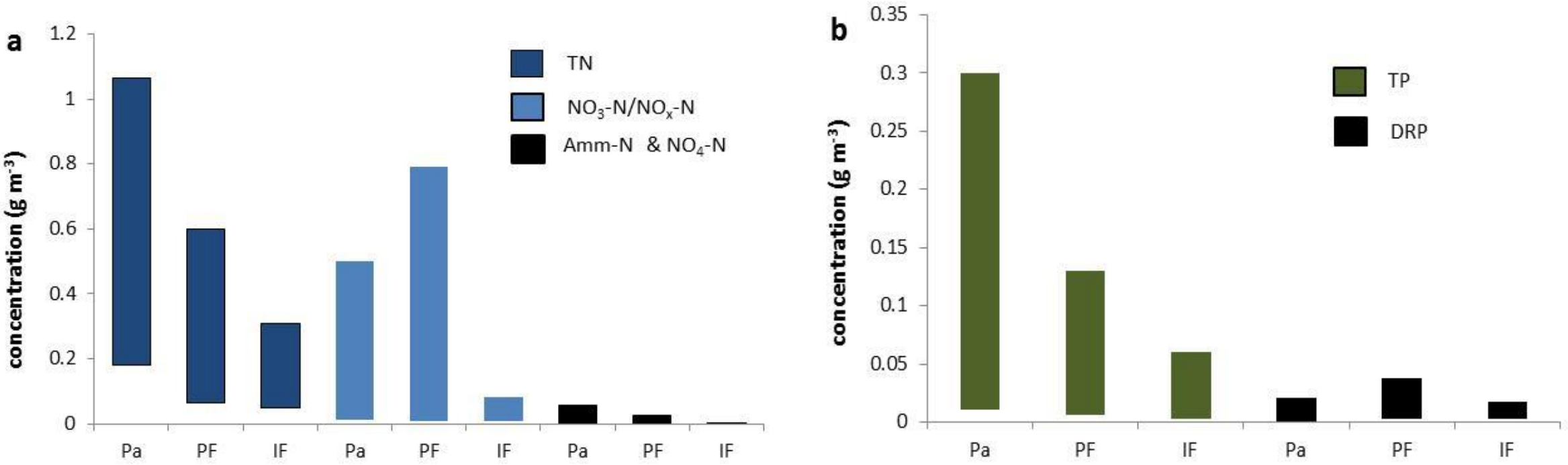


Figure 1 Long-term variation in nitrate concentrations (a) and leaching losses (b) in stream flow from Puruki catchment of pasture before radiata pine planting, through tree planting, growth and logging to regrowth of the second rotation crop. Data was obtained monthly. Bars show standard errors. After Quinn and Ritter (2003).

Figure 1 source: Davis, M. (2014). Nitrogen leaching losses from forests in New Zealand. *New Zealand Journal of Forestry Science*, *44*(1), 2.

Water quality under different land uses

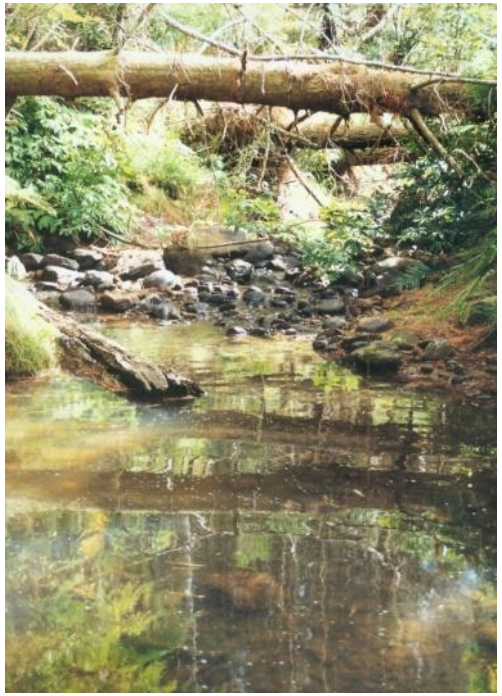


Water quality in mature planted forests is similar to indigenous forests or intermediate between indigenous & pasture

Water quality in planted forests across a rotation

Key findings:

- Rapid improvements in water quality when afforesting from pasture to pine (within 5-6 years)
- Mid-rotation to mature forest (approx. 7-28 years), water quality is generally high across New Zealand
- Greatest impact on water quality is during harvesting (similar to pasture streams) and recovery time is variable
- Harvesting impacts mediated with riparian buffers

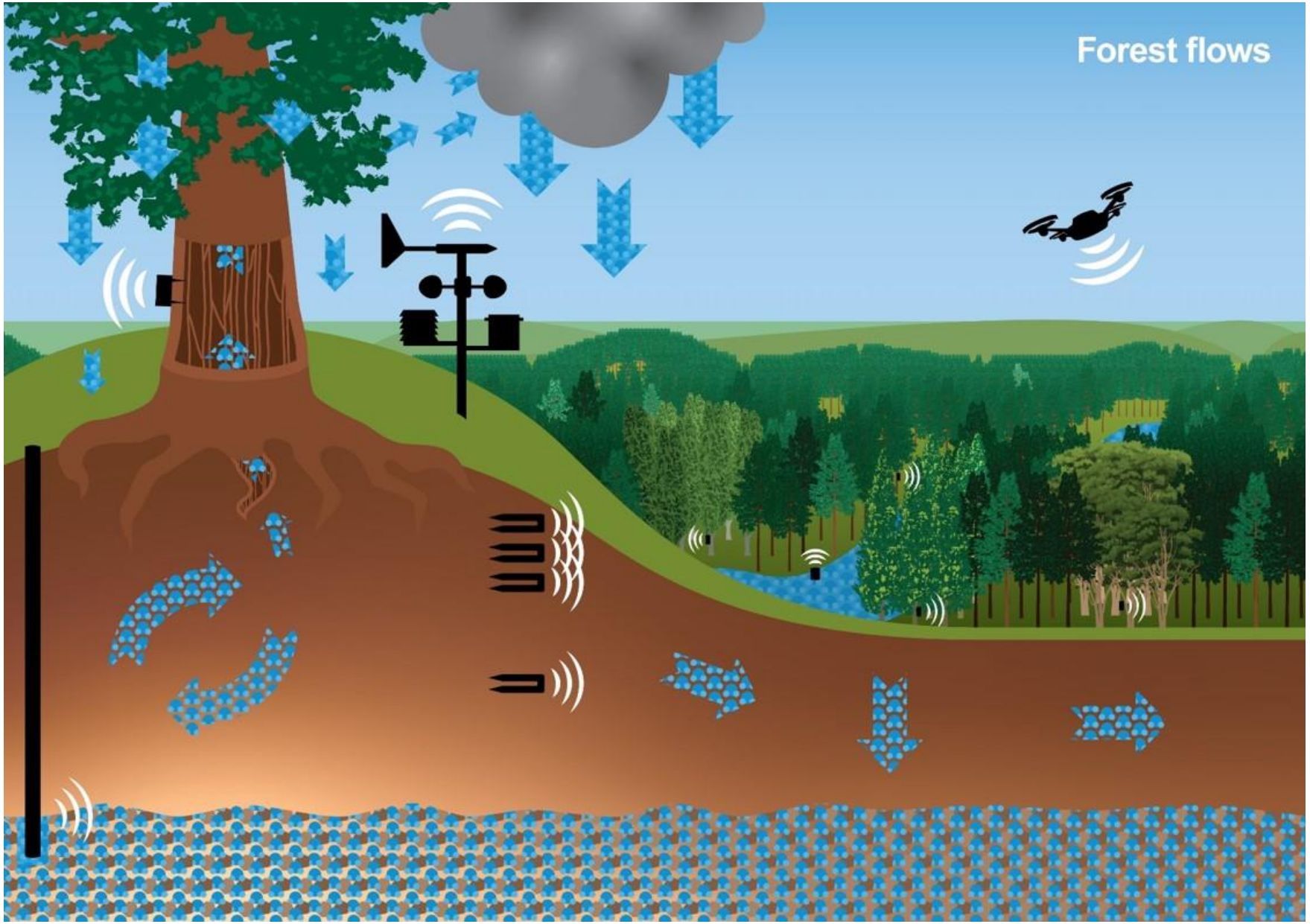


Baillie B.R.; Neary, D.G. 2015. Water quality in New Zealand's planted forests: a review. New Zealand Journal of Forestry Science, 45 (7), 18p. DOI 10.1186/s40490-015-0040-0.

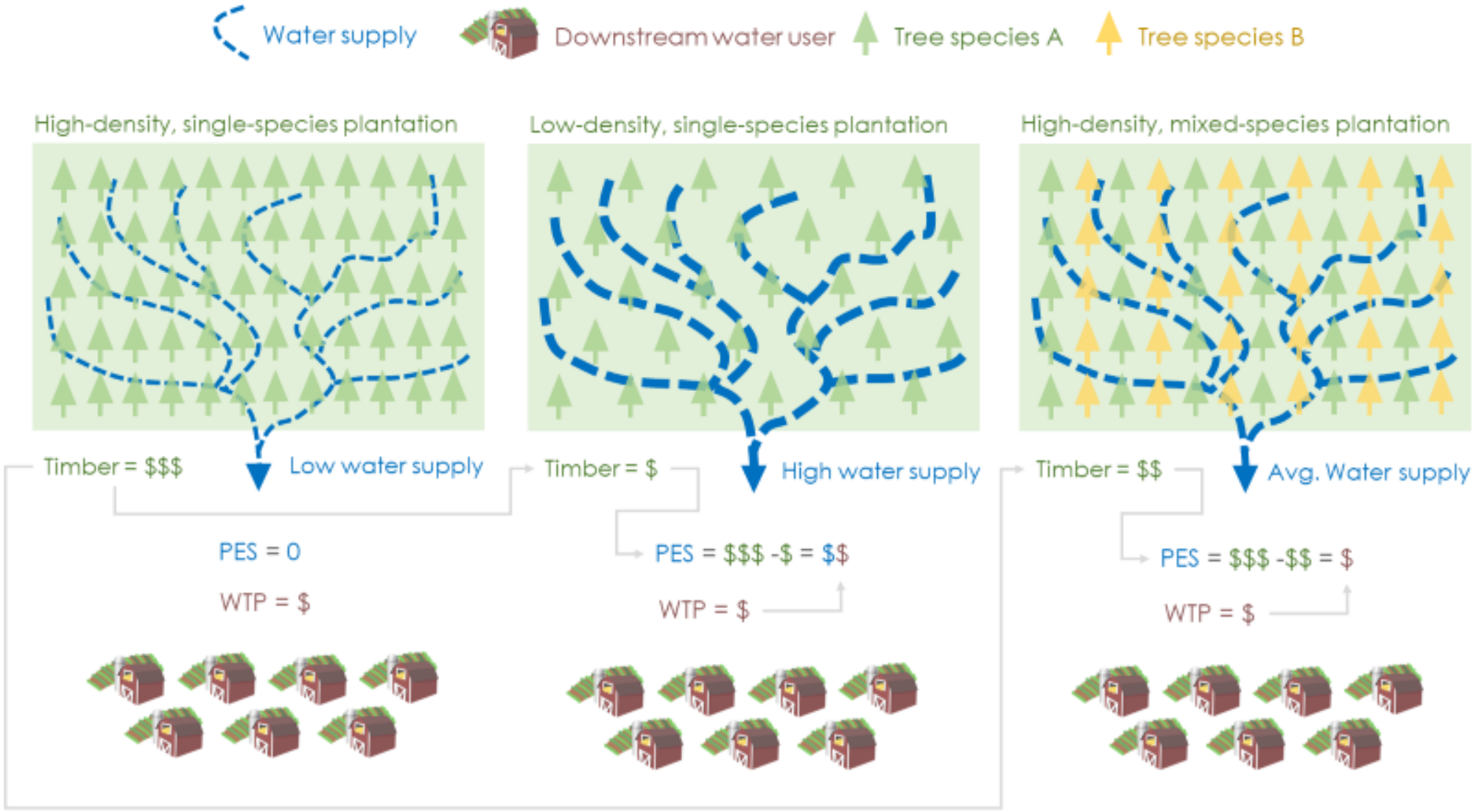
Summary & Future Directions

- Modelled radiata pine water use varied throughout NZ
- Generally more water surplus in higher rainfall areas
- Modelled radiata water use dynamic and depends on a number of factors – not one static factor
- Some radiata pine genotypes are more water efficient than others
- Forested catchments have the potential to supply water to downstream users during the spring and summer
  - Potential important ecosystem service for downstream rural and urban users
- More research required to develop accurate radiata forest water yield model that can be readily applied to large & small catchments throughout NZ

Summary & Future Directions



Summary & Future Directions

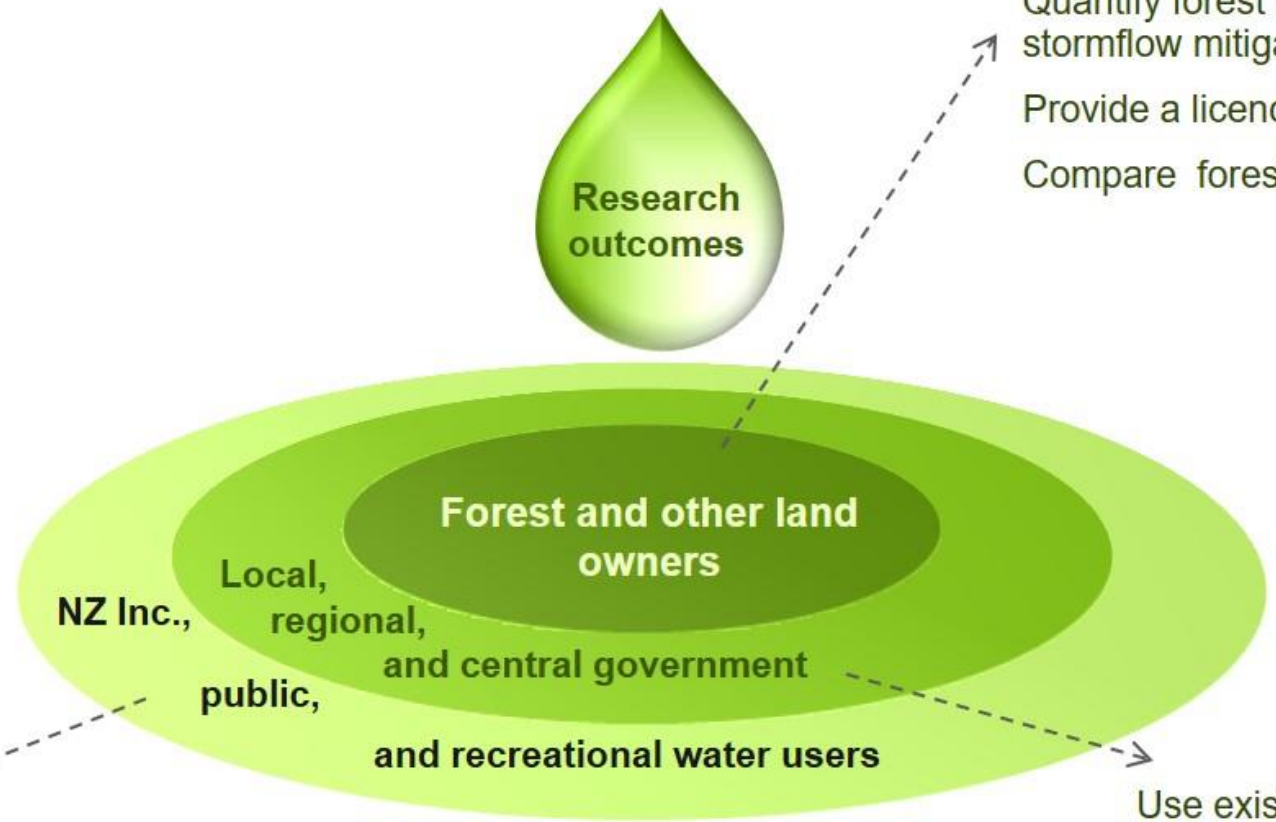


PES = Payment for environmental services from water

WTP = Willingness to pay of downstream water users

Summary & Future Directions

Beneficiaries



Optimise land management for water quantity/quality/storage.

Quantify forest water ecosystem services for stormflow mitigation and low-flow water supply.

Provide a licence to operate.

Compare forest water use with other land uses.

Provide a paradigm shift in hydrological research for forests and other land uses.

Generate world-leading, new methodology so New Zealand is at the forefront of this research.

Quantify the potential water ecosystem-services benefits of forests for downstream stakeholders.

Use existing and new forests for water security to urban and other rural users.

Identify areas that would benefit from specific types of afforestation now and in the future.

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