New Zealand Perspectives of Forest Hydrology

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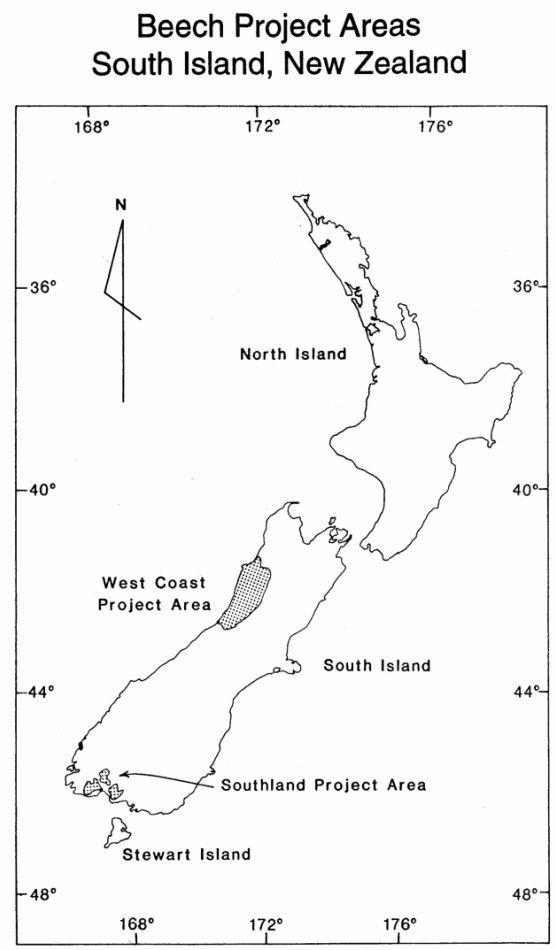
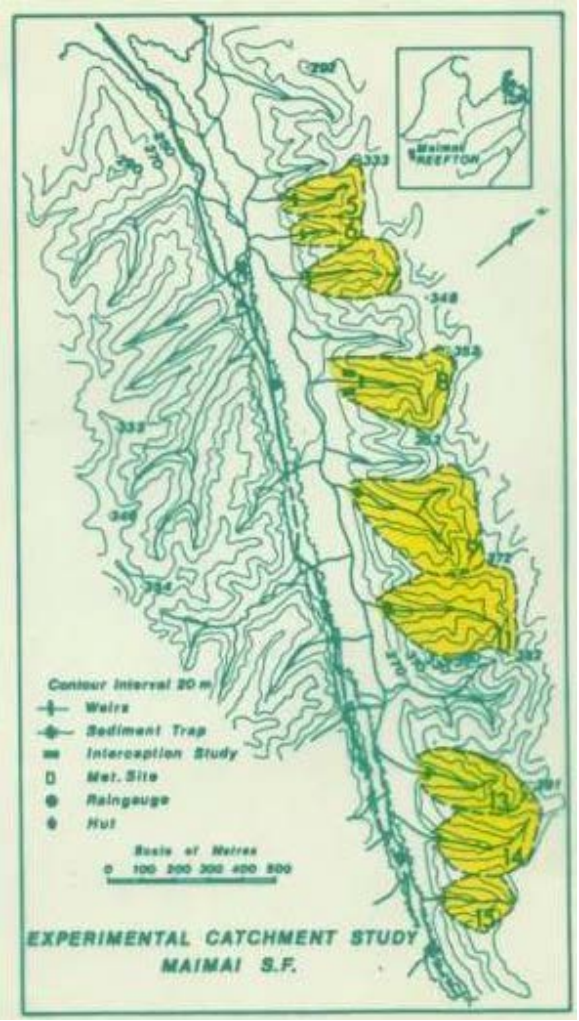
Applied forest hydrology research at Maimai

- What are the long-term effects of beech conversion on water yield?

- What are the short-term effects of forest harvesting on water yields and storm flows?

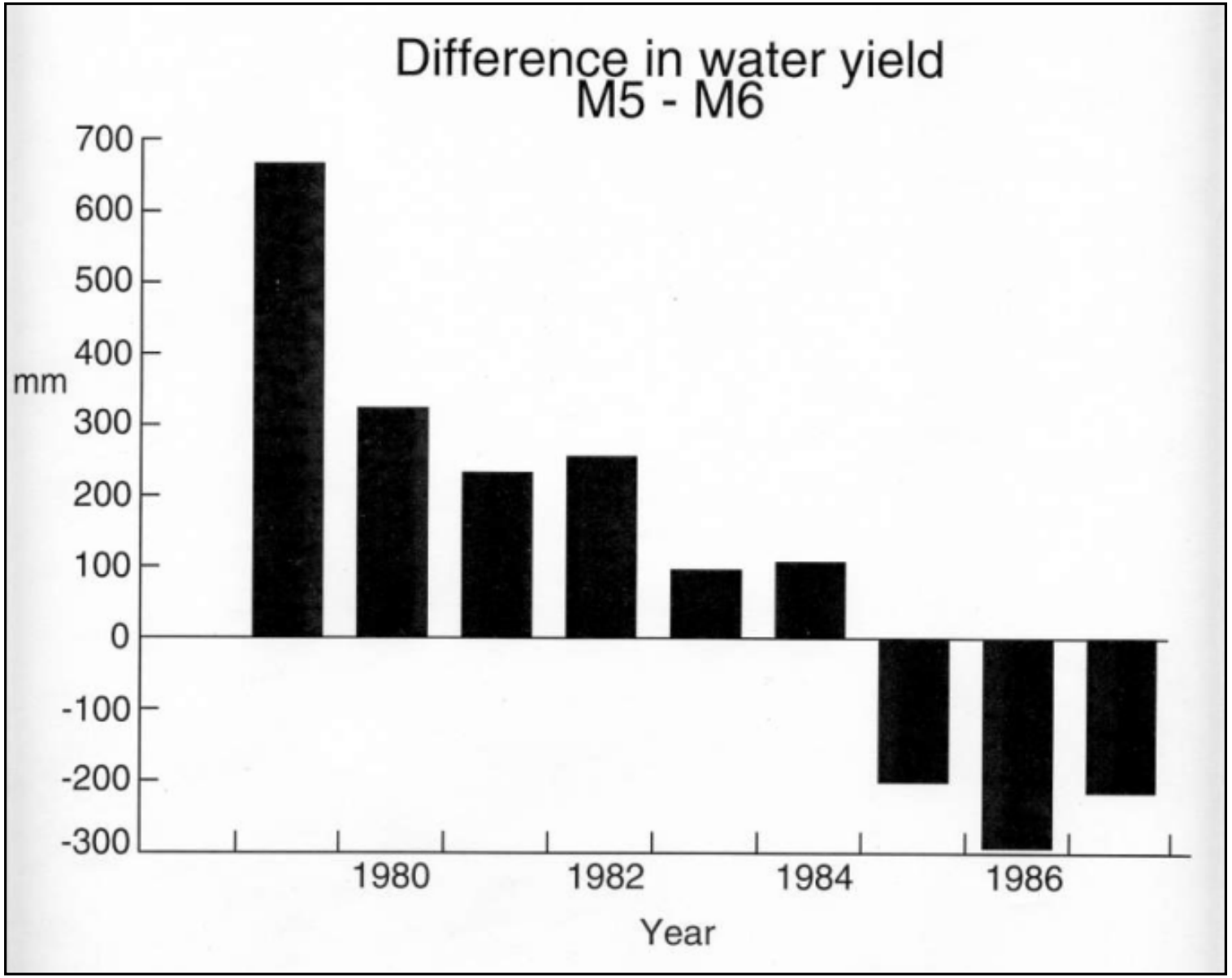
Rowe et al. (1994); Rowe and Pearce (1994)





Maimai catchments after harvesting

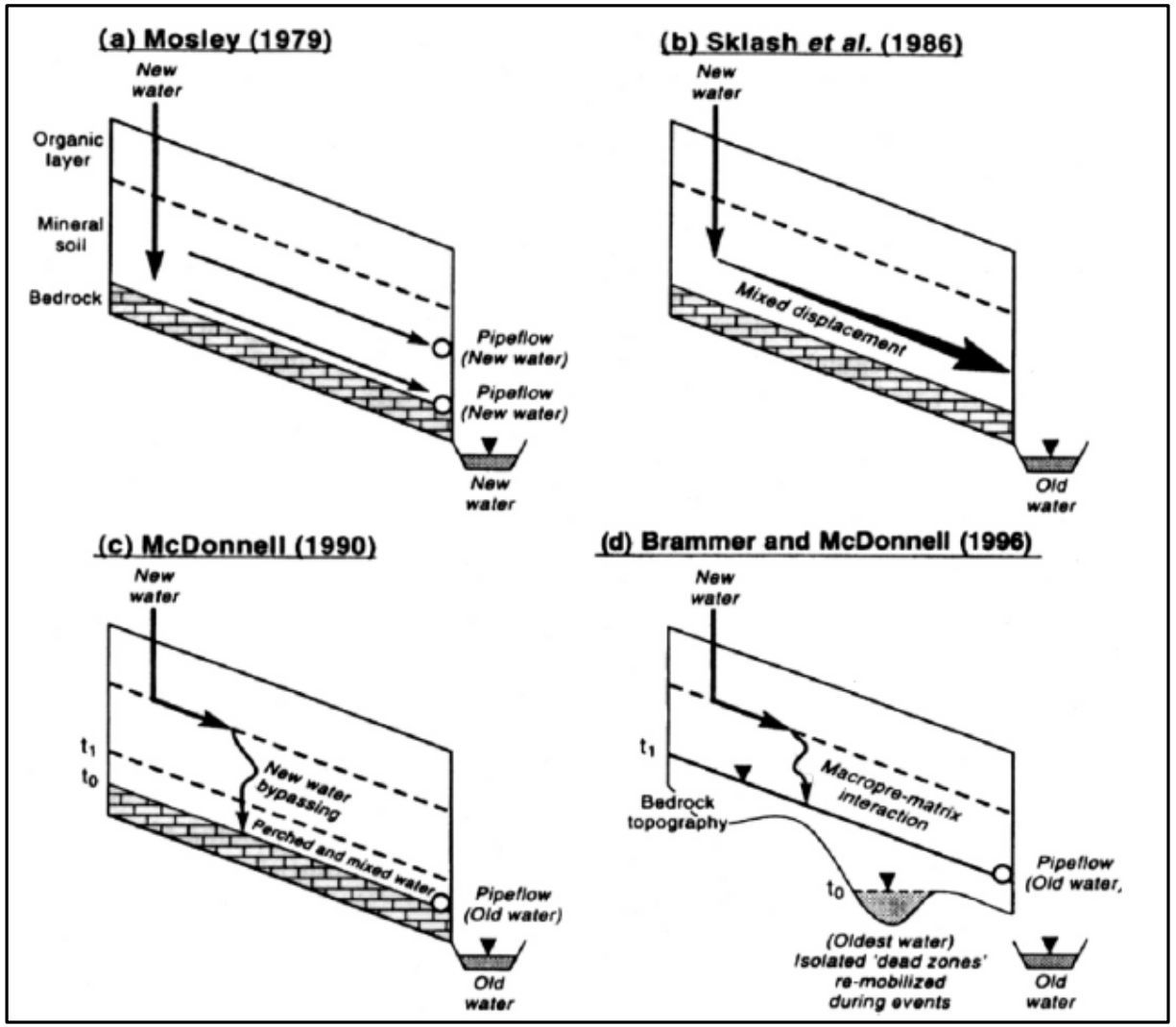
Photo provided by Barry Fahey


Difference in water yield
M5 - M6
700
600
500
400
mm
300
200
100
0
-100
-200
-300
1980
1982
1984
1986
Year

Hillslope hydrology studies at the Maimai research catchment

- Initial question: How does forest management impact water resource quantity, quality, and aquatic habitat?

- Perceptual model development of subsurface flow (McGlynn et al., 2002)



Effects of plantation forestry on water yield

Fahey (1994)

- How does land cover conversion to plantation forestry impact water yield, storm flows, low flows and groundwater recharge?
  - Impacts are compared with pasture, scrub, tussock grasslands, and native forests

- Can forest management techniques help to reduce forest demands on water (e.g. thinning, understory suppression)?

- How do the findings from small catchments scale to large catchments?

Further research needs for applied forest hydrology

- 1.6 million ha, or 90% of planted forest area in NZ, is Radiata pine (NZFOA, 2014).

- Fahey (1994) identified water demand from plantation forest types other than Radiata pine (e.g. Douglas Fir, Eucalyptus) as a research need, especially for drier areas (e.g. Canterbury).

- Other research needs identified by Fahey (1994)
  - Afforestation and low flows
  - What is the relative importance of canopy removal and soil disturbance (i.e. compaction) for post-harvest peak flows and quick flows?

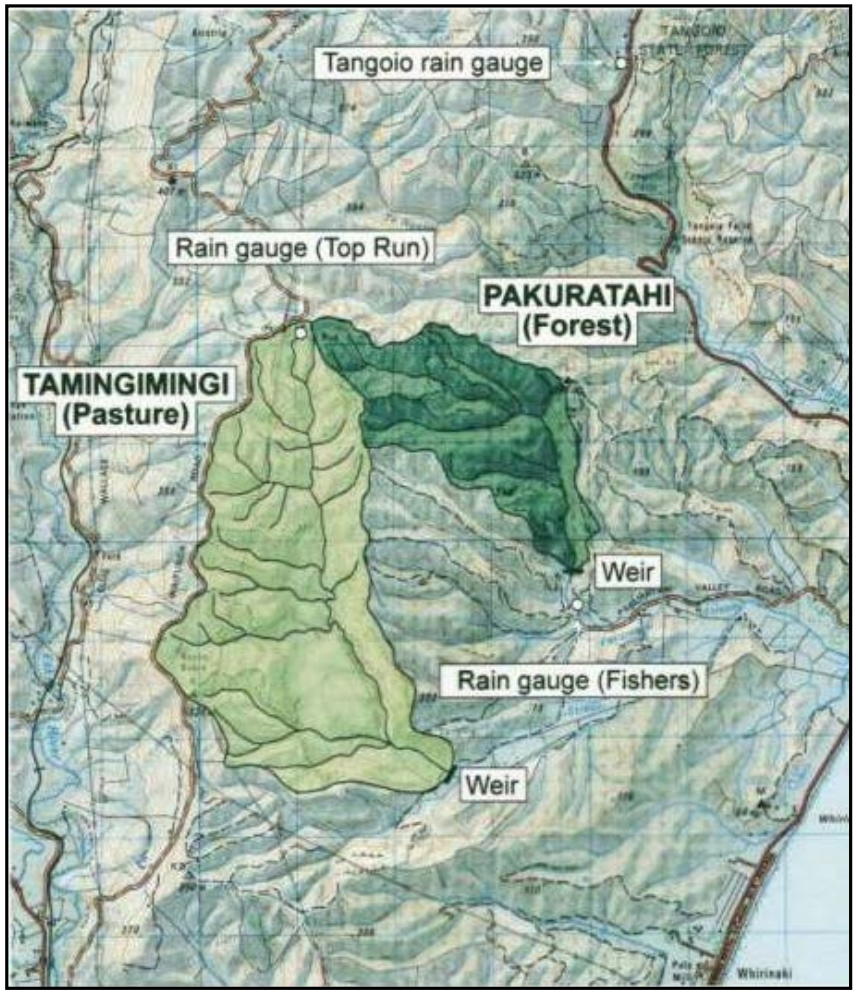
The Pakuratahi-Tamingimingi Land Use Study (Hawke's Bay, east coast North Island)

- Is forest harvesting likely to cause a major episode of erosion similar to that after deforestation in the 1900s?
- Over the long-term, which land use produces more sediment, pasture or forestry?
- Tamingimingi (795 ha) in pasture since 1900s
- Pakuratahi (345 ha)

  -planted in *P. radiata* in 1971

  -harvested between 1998 and 1999

  -oversown and replanted in 2000



The Pakuratahi Land Use Study, G. Eyles and B. Fahey Eds. 2006)

Changes in catchment specific discharge

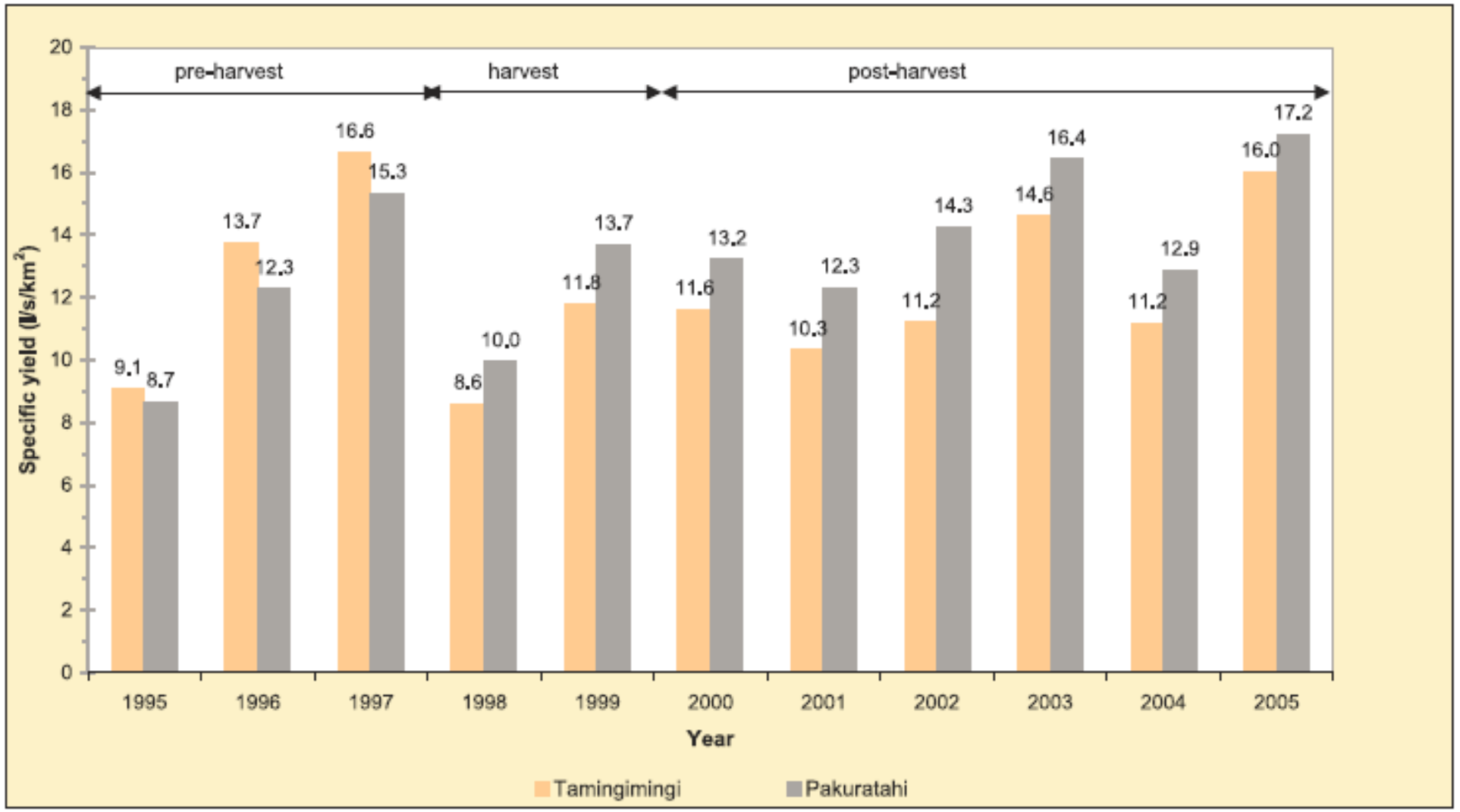


Figure 8. Specific yields for the Tamingimingi and Pakuratahi catchments, 1995-2005.

Changes in suspended sediment yield

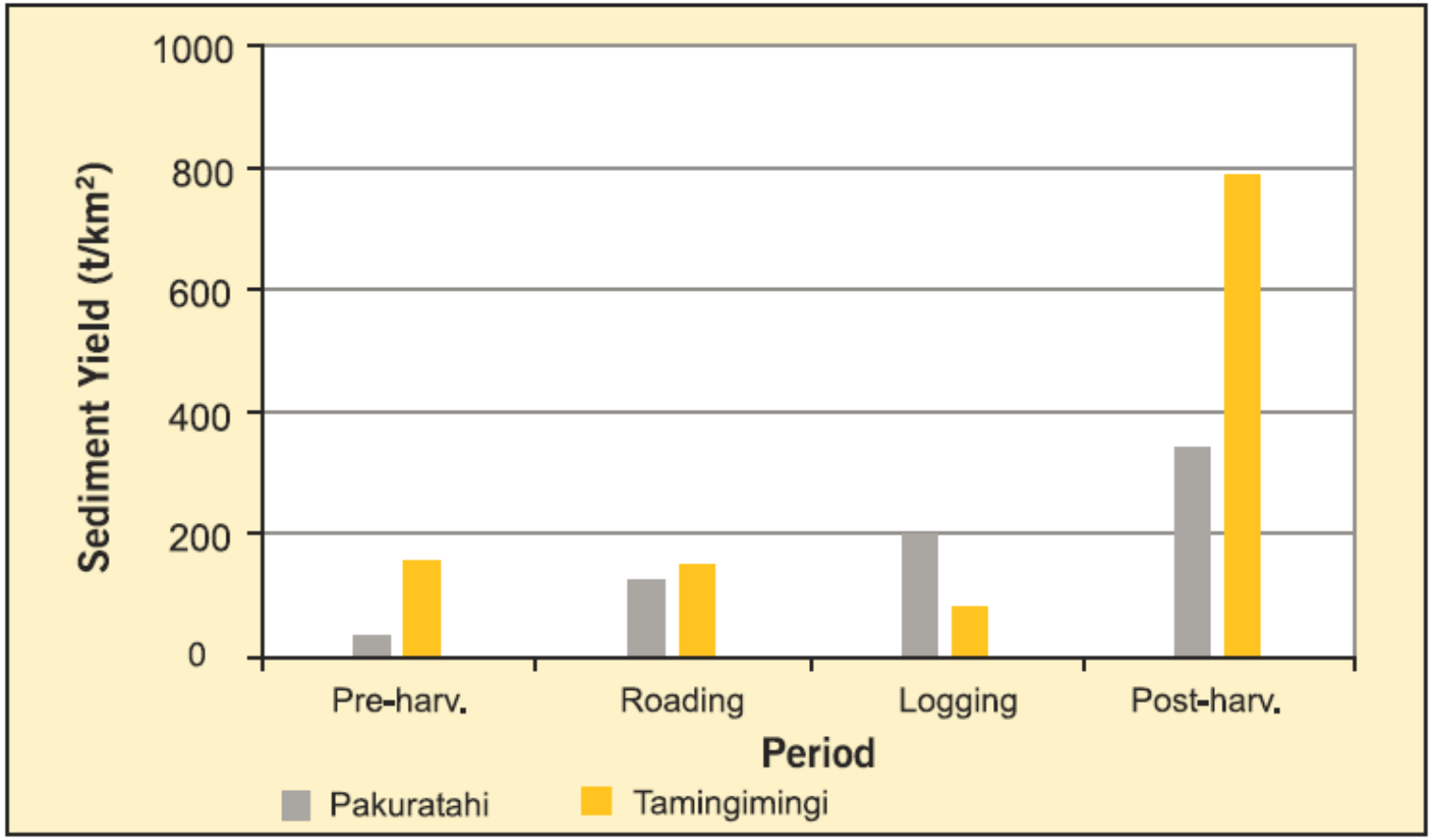


Figure 4. Suspended sediment yields for the pre-harvest period (Jan 1995 to Jun 1997), the road construction phase (Jul to Dec 1997), the logging phase (Jan 1997 to Dec 1999), and the post-harvesting period (Jan 2000 to Dec 2005).

Outlook for forest harvesting in New Zealand

- Timber harvest volume increased from 19 Mm^3 in 2004 to 30 Mm^3 in 2014.

- By 2025, annual harvest volume is expected to reach 42 Mm^3 (40% increase)

Outlook for forest roading in New Zealand

- Approximately 1600 km of new roads will be constructed annually for the next 5-10 years

- “New” forestland to be harvested is characterized by steep slopes, erodible soils, and remote locations

Road impacts on surface erosion

- **Surface erosion from NZ forest roads**: trace amounts to 150 t/ha/yr (Fransen et al., 2001)
- **Potential erosion from the running surface at stream crossings**: trace amounts to 9 t/ha/yr (Brown and Visser, 2015 *In Review*)
- **Sediment delivery from re-graded legacy forest roads at stream crossings in the Virginia Piedmont, USA**: 34-287 t/ha/yr; Graveled roads: 10-16 t/ha/yr (Brown et al., 2013)

Road impacts on mass movements

- Landslides can generate **40 to 8000 t/km** at the road-network scale (Fransen et al., 2001).

- **This is 1 to 3 orders of magnitude greater than combined surface road erosion processes.**

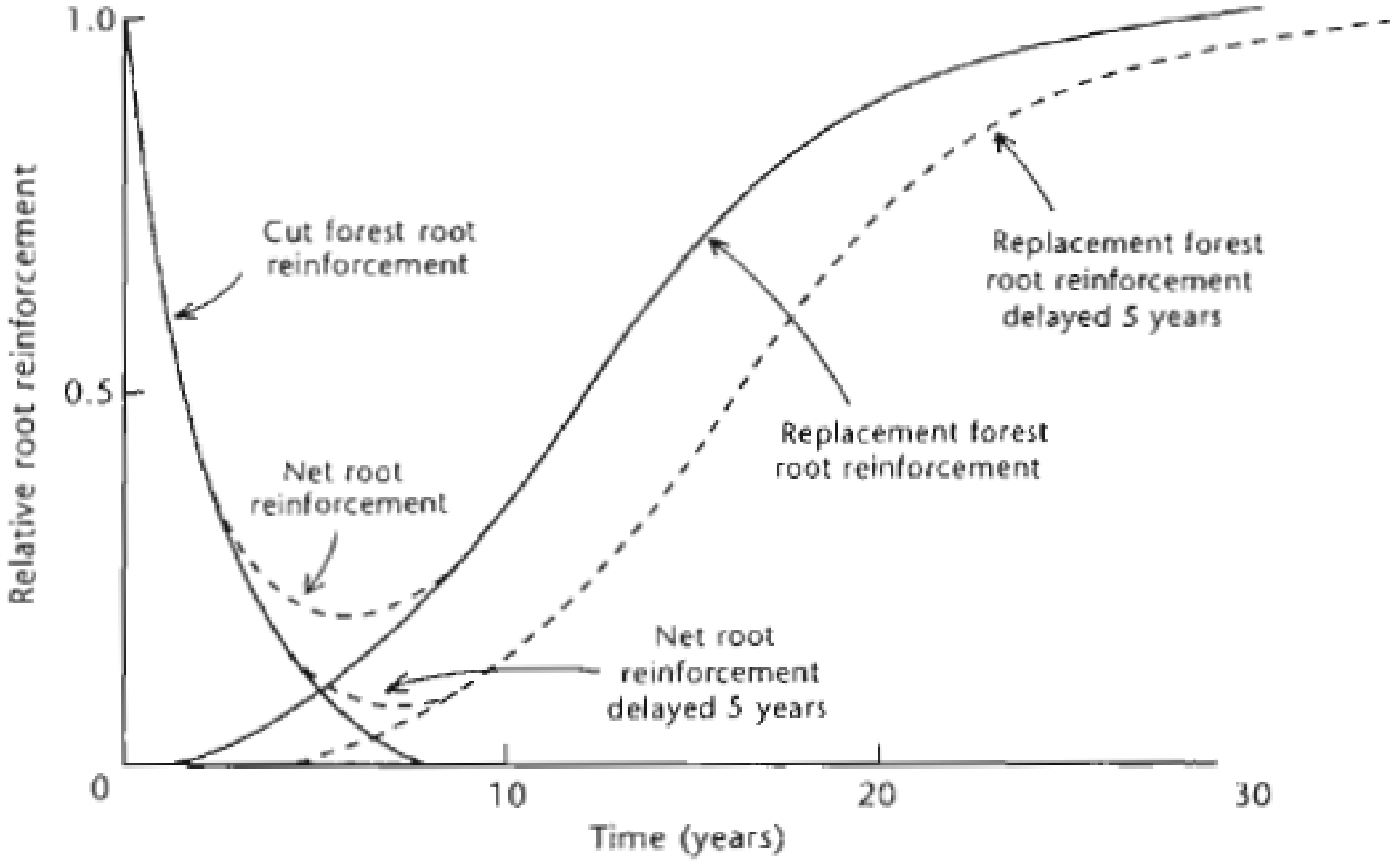
Forest road impacts on slope stability

Hillslope road construction decreases site stability:

1) Adding weight to the fillslope
2) Cut and fill slopes are steeper than existing topography
3) Removing support of the cut slope
4) Rerouting and concentrating road runoff

(Sidle et al. 1985)

Fig. 2: Relative root reinforcement changes after clearfelling.



O'Loughlin (2005)

Relevance for hillslope hydrology

- If you cut a road into the hillside, what is the likelihood of exposing a subsurface flow path that could undermine the stability of the fill slope?

- Can we predict where this situation is most likely to occur?

Summary

- Our understanding of hillslope subsurface flow has evolved with recurring research at Maimai.

- Applied forest hydrology research dominates in New Zealand with a focus on the effects of vegetation conversion and forest harvesting on streamflow and sediment.

- About 1/3 of forests to be harvested over the next decade are located in steep terrain with erodible soils.

Key questions

The problem of scaling up research findings exists for both hillslope studies of subsurface flow and applied catchment studies of forest management effects on streamflow.

How would perceptual models like those developed at Maimai change over larger catchment areas or for different soil types or geologies?

What are the cumulative effects of surface cover change and forest operations (i.e. harvesting and road construction) on streamflow?