Sediment and its sources: From land to river to the Bay of Islands,
Okaihau Golf Course, Bay of Islands, 30 April 2015

Sediments & sources: Land to river to sea. What do marine sediment cores tell us?

Bay of Islands, NZ

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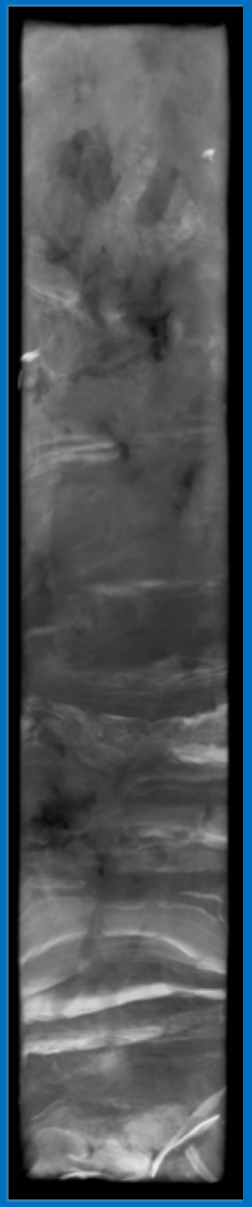
BoI sedimentation



Sediments deposited in receiving environments (e.g., estuaries) preserve long-term records of environmental change.

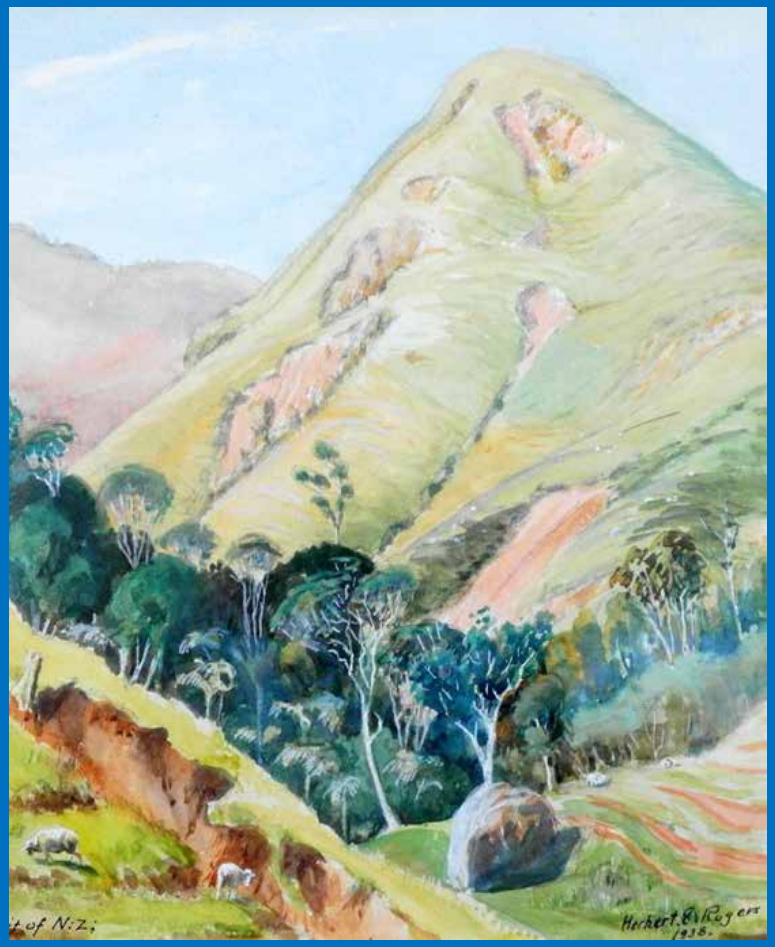
Bay of Islands Oceans 20/20 Study (2010), NRC (2012)
Stable isotope analysis of dated-sediment cores used to reconstruct the effects of catchment disturbance on sedimentation.

Focus:

- Sources of eroded soils
- Persistence of sediment sources over time
  time scales: centuries to thousands of years
- Fate
  in receiving marine environment

Soil erosion - NZ

Impacts on receiving estuaries



- **Eroded soils:** major contaminant in aquatic receiving environments
- Sediment-bound contaminants
  (e.g., phosphorus, microbes, heavy metals)
- **Sedimentation** in NZ estuaries:
  10 x increase following deforestation
  (i.e., accelerated estuary infilling & habitat changes)
- Shift from **sand-to-mud** habitats
- **loss** of sensitive species: smothering & high SSC
  (e.g., filter-feeding shellfish)
- Reduced water clarity & light levels
  (e.g., loss of seagrass, fish & bird feeding)

Deforestation

1000 AD 1840AD Present

Native-forest area reduced from ~90 to 25%
between 1300 AD and present

Study area

Bay of Islands, NZ

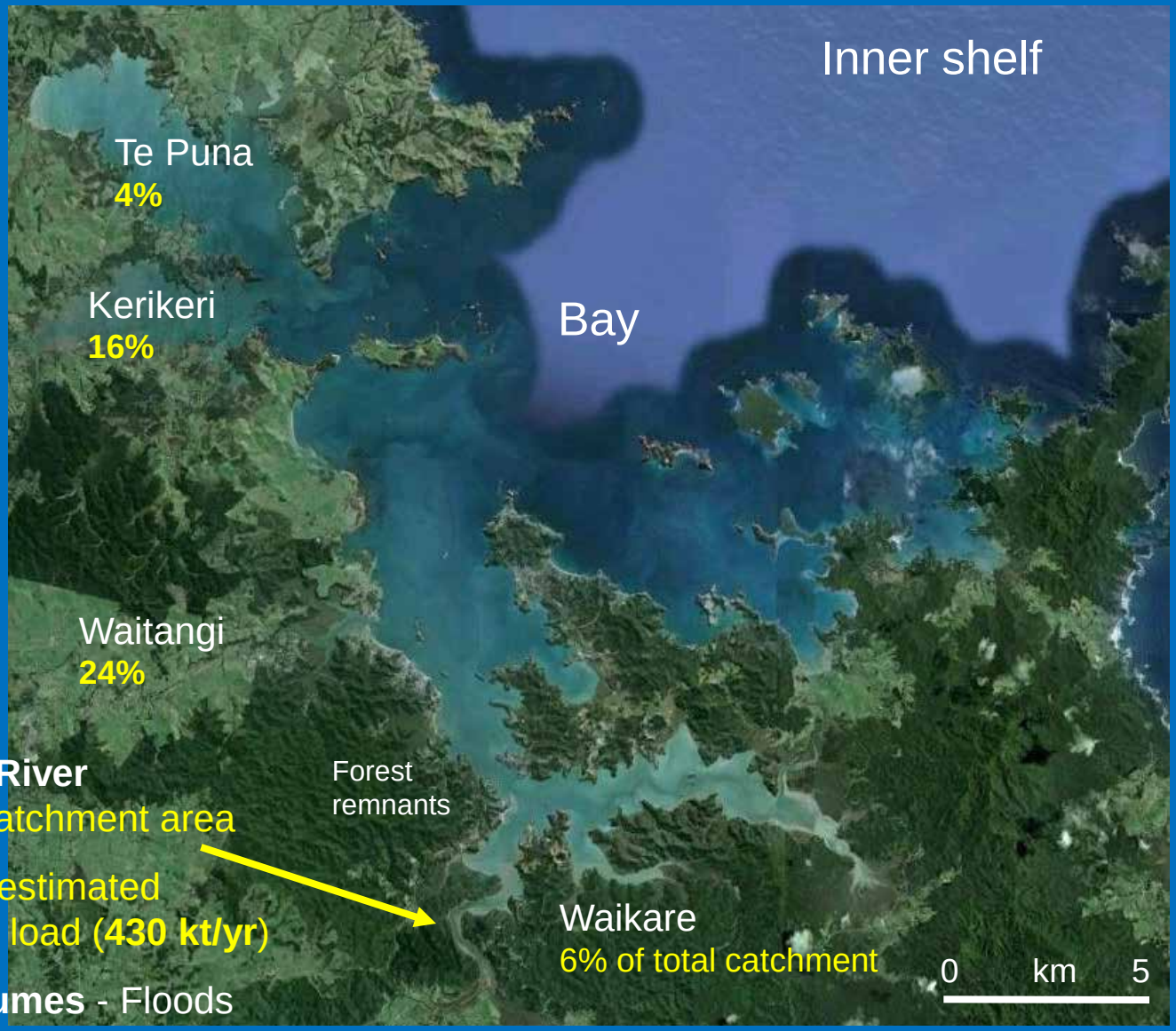
BoI system: 290 km^2 embayment + fringing estuaries
Catchment: 1,300 km^2
Land use: **46%** pasture, **30%** native forest, **11%** pine, **3%** orchards

Marine habitats:
estuaries, subtidal, intertidal, mud, sand, rocky reefs

Ecological impacts of eroded soils:

- Loss of sensitive benthic communities
- Mangrove-habitat expansion (estuaries)

Study area



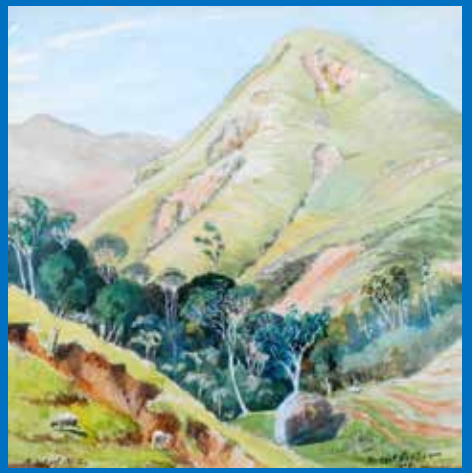
Citrus

Kawakawa River

- 40% of catchment area
- **~80%** of estimated sediment load (**430 kt/yr**)
- **River Plumes** - Floods

Environmental history





Polynesian arrival (Māori): ~1300 AD

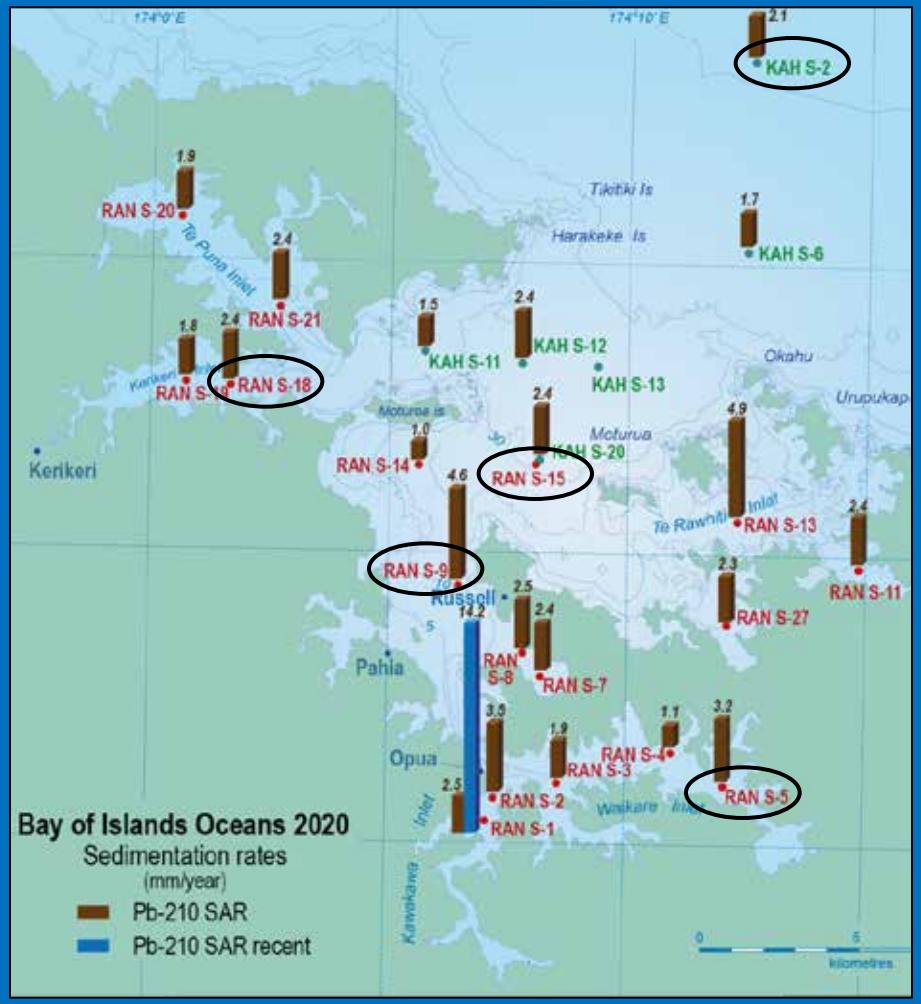
- Deforestation: mid-1300s (sediment record – swamps)
  several centuries before European settlement
- Large Māori population
  volcanic soils, warm climate, extensive gardens (e.g., sweet potato)

European period

- Captain Cook: 1769
- Whalers & sealers: **late-1700s** (potato, Māori staple)
- Settlers arrive: **1819**, forest-remnants cleared, sheep & cattle farming
- Citrus orchards: early **1930s** (Kerkeri)

Sedimentation

Bay of Islands



Sediment accumulation rates (SAR)

23 core sites:

- water depths 1-100 m
- cores ≤ 2 m
- ^{210}Pb, ^{137}Cs, ^{14}C dating
- time period: last ~9,000 yr

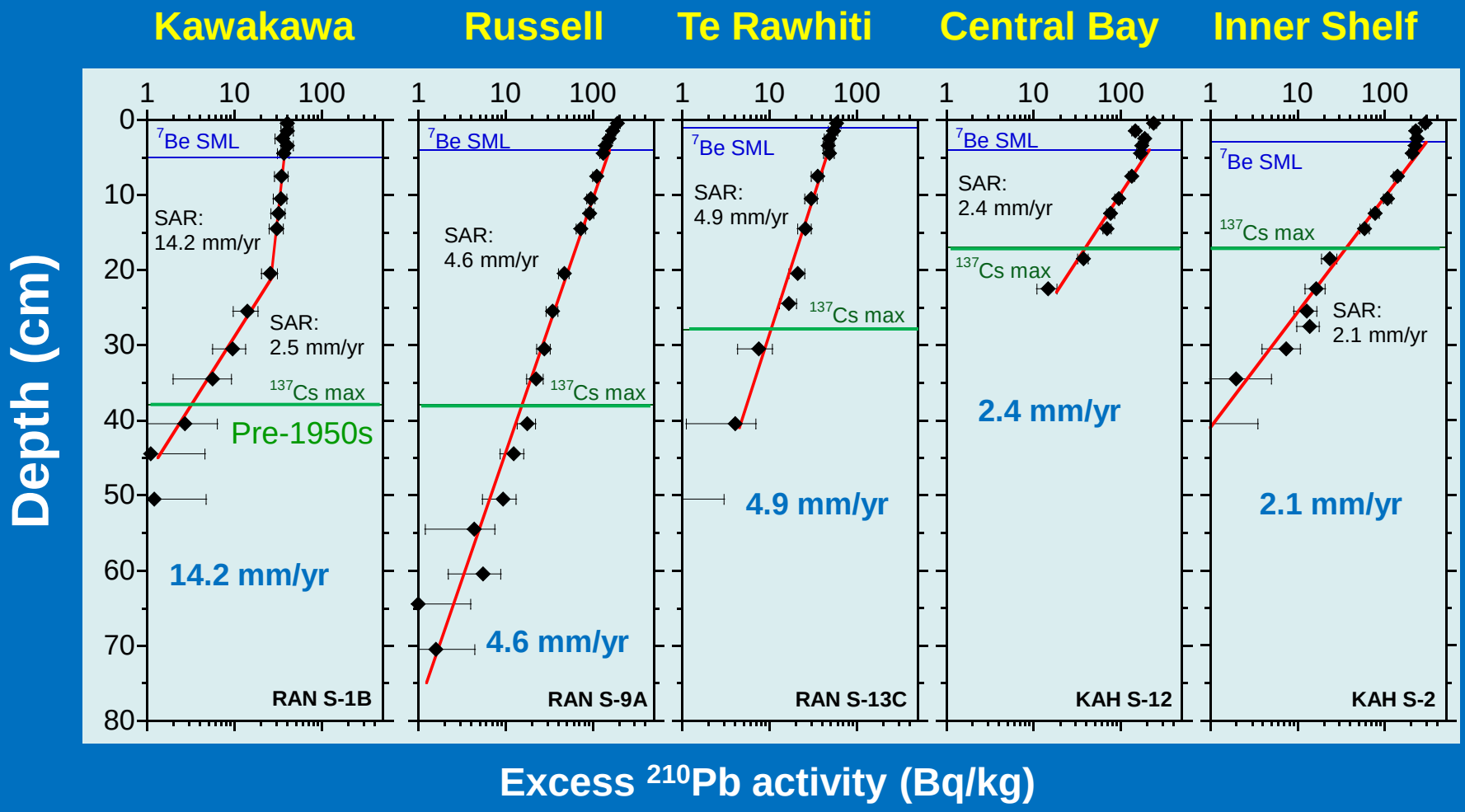
Sediment deposition **20x higher** than pre-deforestation

- ~500,000 t/yr (last 150 yr, eroded soils)
- ~23,000 t/yr (last 10,000 yr)

5 sites selected for soil-source ID

Sedimentation gradient

Estuaries → SAR decline with distance from land → **Inner Shelf**



METHODS

Soil sources

I**dentify sources of soils** deposited in Bay of Islands system **over time:**

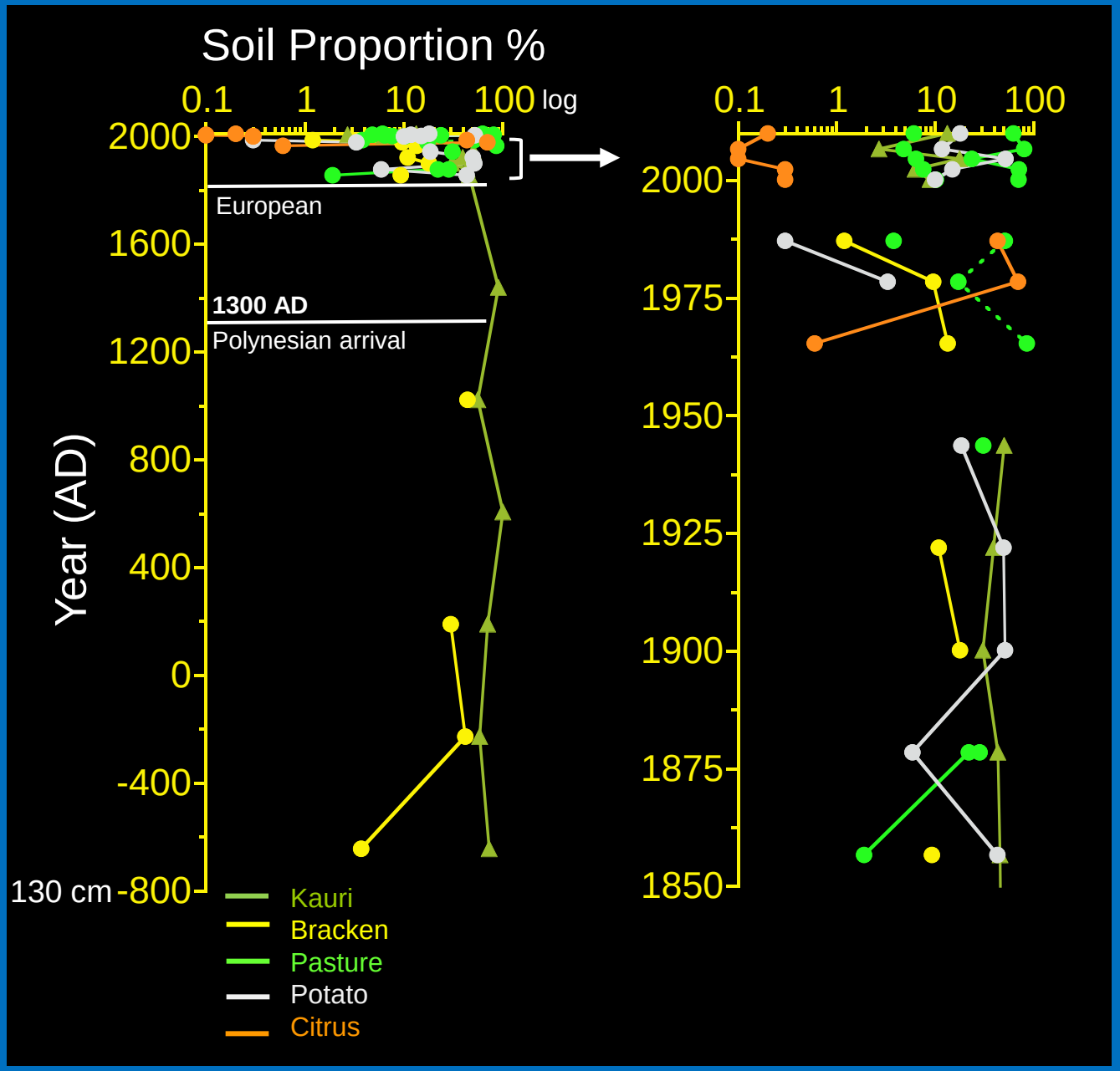
- straight-chain **fatty acids (FA)** secreted by plants useful sediment tracers*
  e.g., palmitic (C16:0), stearic (C18:0), arachidic (C18:0)
- isotopic reference library of potential soil sources
  (composite samples by land use: native forest, pasture etc.)
- measure $d^{13}C$ signatures of FA profiles in dated marine sediment cores
- correct $d^{13}C$ core signatures for **Suess effect**
  (depletion of $d^{13}C$ due to fossil-fuel burning, -2‰ post-1700)

*Gibbs, M. (2008) *Estuaries & Coasts* 31: 344-359

Russell

Water depth: 10 m

^{210}Pb SAR **4.6 mm/yr**
1858-2010 AD (70 cm)

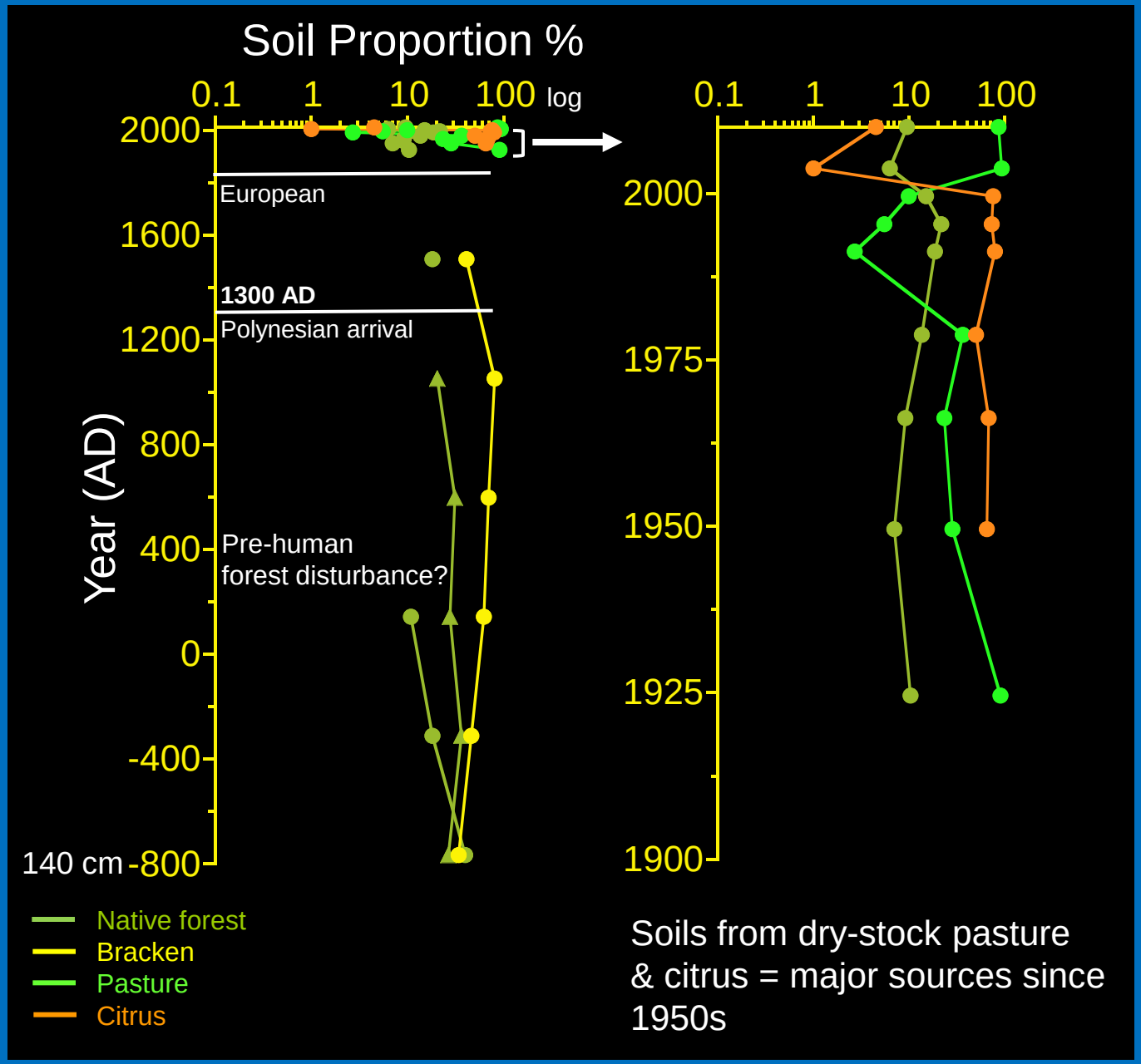


Kerikeri

Water depth: 4 m

^{210}Pb SAR **2.4 mm/yr**
1920-2010 AD (22 cm)

Pre-human: **0.4 mm/yr**

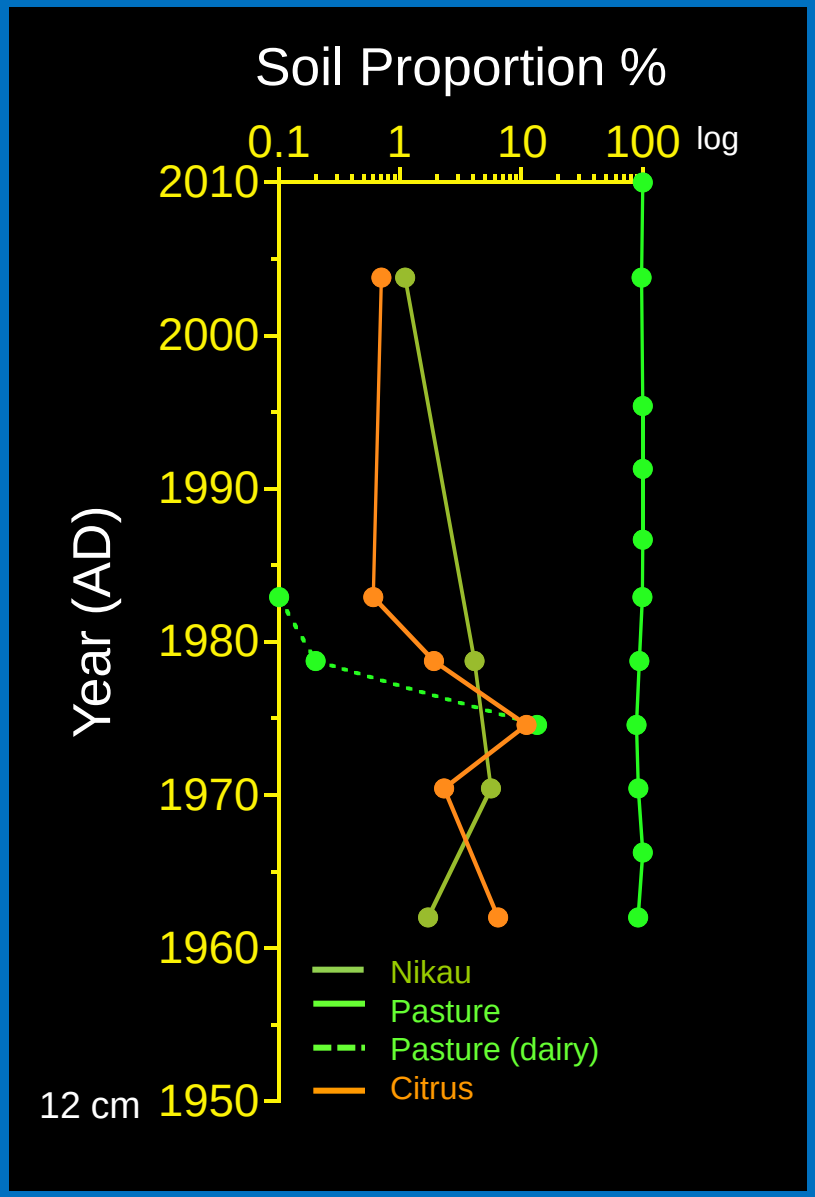


Inner Bay

Water depth: 30 m

^{210}Pb SAR **2.4 mm/yr**
1843-2010 AD (40 cm)

Soils from dry-stock pasture = major source since 1960



Conclusions

Method

- Sources and fate of eroded soils can be determined using stable isotopes & radioisotope records preserved in cores
  (historical record: constrain sources, reduce uncertainty)

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Sources & persistence (time)

- **Bracken**-labelled soils deposited in estuaries indicate catchment disturbance was a natural feature of the landscape for 2,000 yr + before human arrival
- Soils derived from **pastoral agriculture** & **horticulture** dominate sedimentation in the Bay of Islands over last ~150 years

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Fate

- Wide-spread dispersal of eroded soils in the receiving environment (from estuaries to continental shelf)
- Powerful tool for environmental managers

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