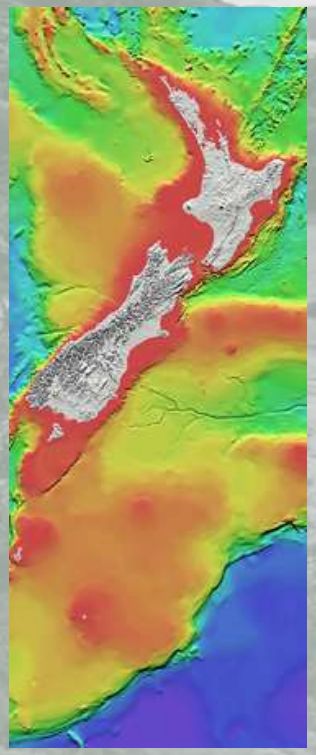

Physical & biological sediment processes in the Hauraki Gulf

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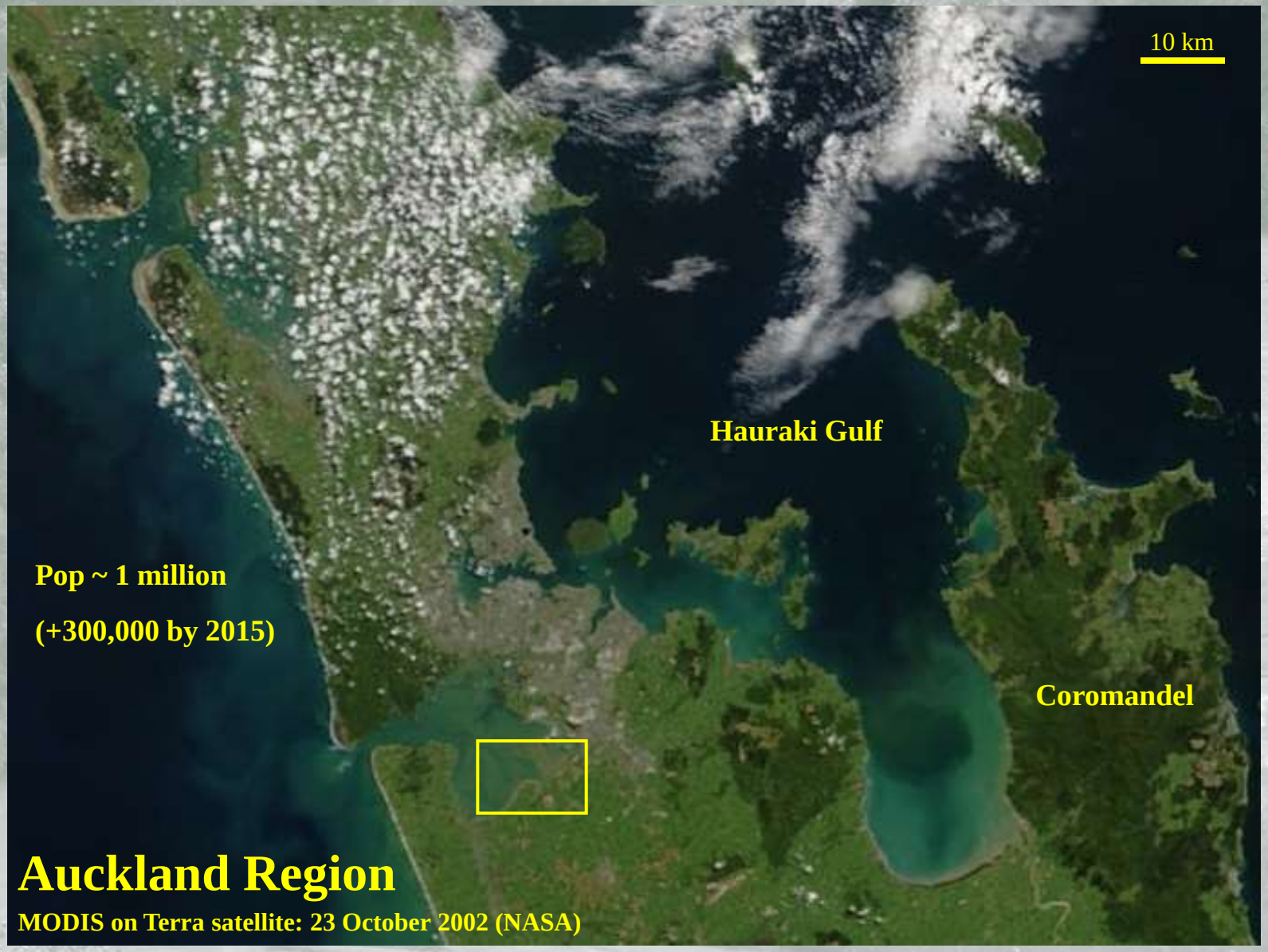
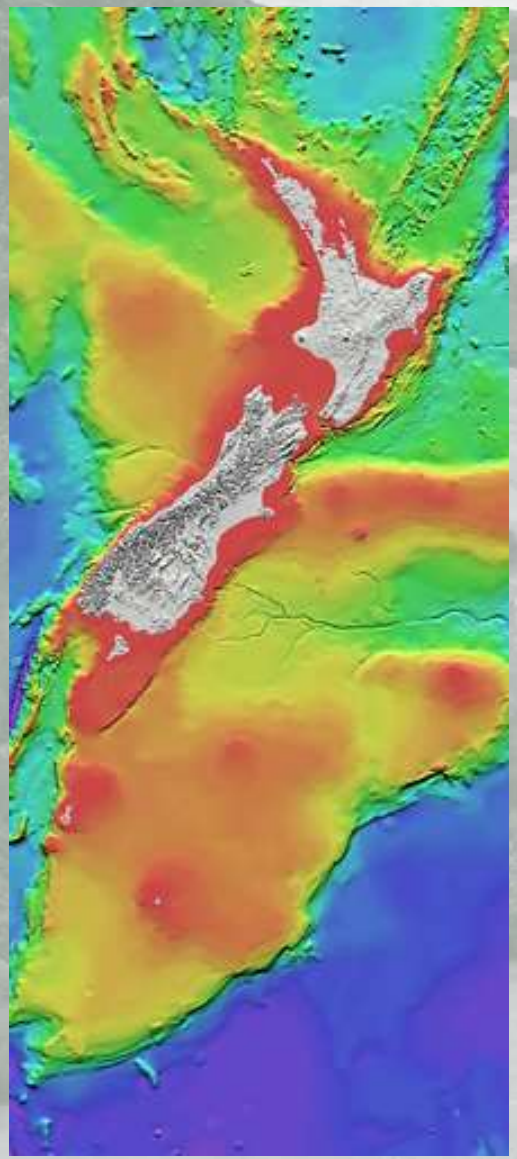
National Institute of Water & Atmospheric Research Ltd
[a.swales@niwa.co.nz]
[Mark Morrison presenting on behalf of]

Talk Outline

Physical and Biological Sediment Processes

- **Part 1:** **Recent Sedimentation**
  Human Impacts – a regional snapshot (Auckland).
- **Part 2:** **Suspended Sediments**
  Implications for biological impacts
- **Part 2:** **Mangrove forests**
  Firth of Thames example


10 km
Hauraki Gulf
Pop ~ 1 million
(+300,000 by 2015)
Coromandel
Auckland Region
MODIS on Terra satellite: 23 October 2002 (NASA)



NZ: A Brief (Recent) History

Aotearoa – land of the long white cloud – last major landmass to be colonised.

- **Maori**: - East Polynesia (1250-1450 AD)

- **Europeans**

- **Abel Tasman** (1642)
  brief & bad contact with Maori (18 days)

- **James Cook** (1769 – 1774)
  4 visits – (328 days)

- **Colonisation** (1790 –)
  sealers, whalers & missionaries (1790–)
  settlers (1830–)

Effects: What Did We Know ?

Deforestation

- **Pre-Maori**: **90%** landcover = coniferous & broadleaf forests
- **1800 AD**: **50%** landcover = forest (loss of megafauna – Moa)
- **1820-1900 AD** (European) logging & pastoral agriculture
- **Today**: **25%** landcover = forest

Estuaries (last 150 yrs)

- **10x** increase in **SAR** (from < 0.5 mm)
- Large-scale changes in **morphology** (subtidal to intertidal)
- Changes in **sediments**
- Increasing **contaminant** conc.
- **most knowledge from tidal creeks**

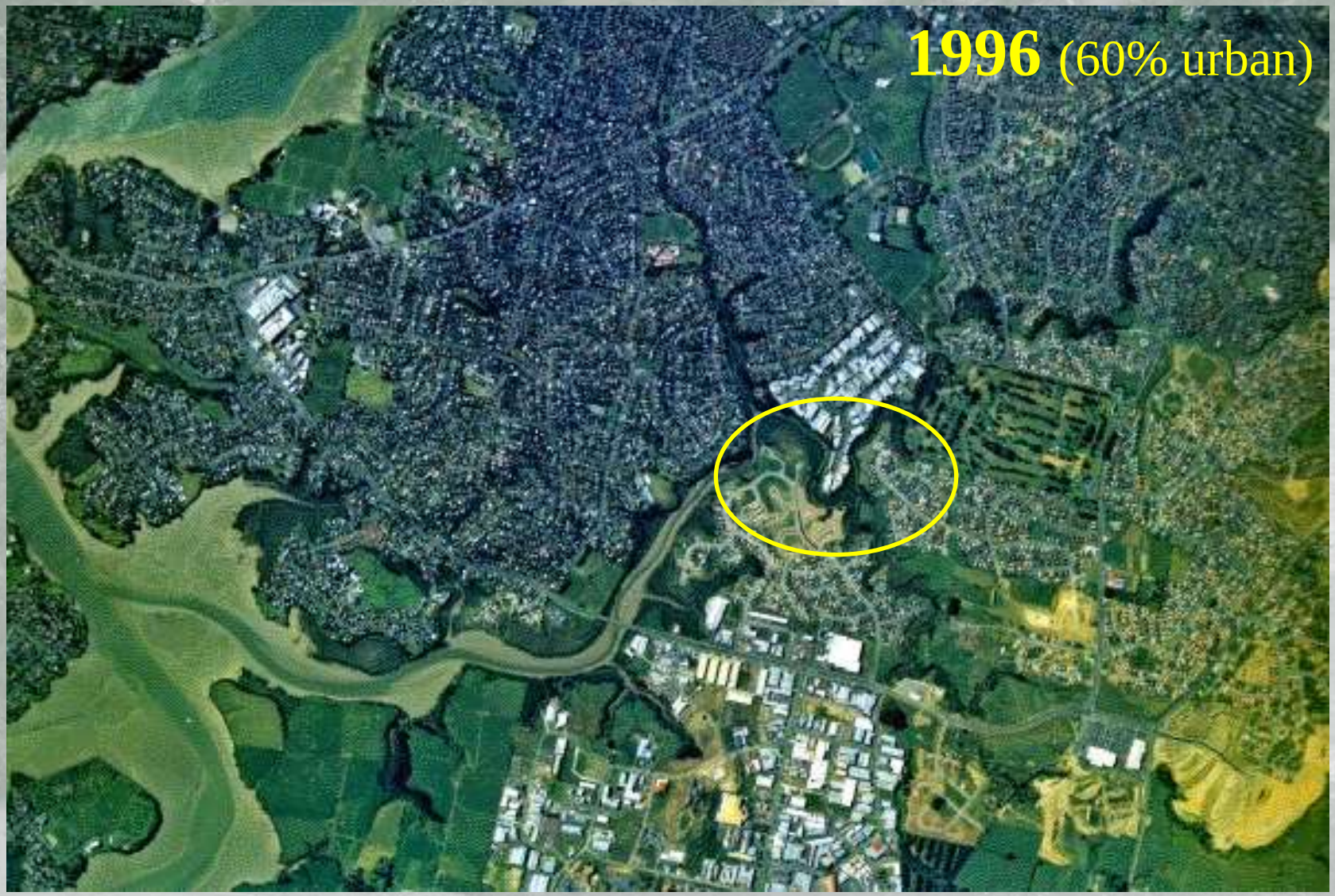
Catchment Changes – last 150 yr

Auckland's History

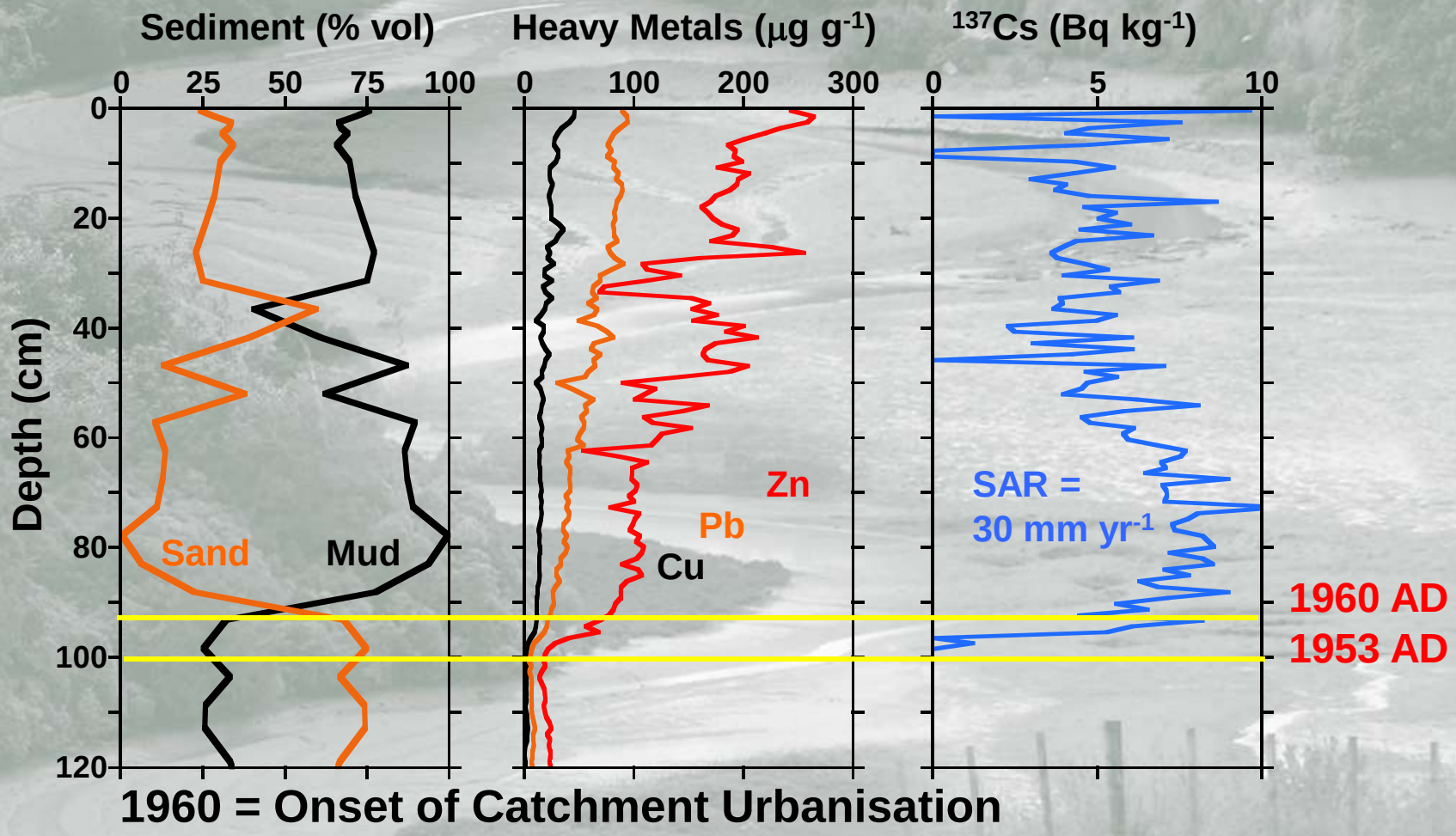
- Deforestation (mid-1800's)
- Agriculture
- Forestry (1930's, 1970's)
- Urbanisation (post WW II)

Urbanisation (Pakuranga)


1969 (19% urban)


1996 (60% urban)

Pakuranga Creek



Study Objectives

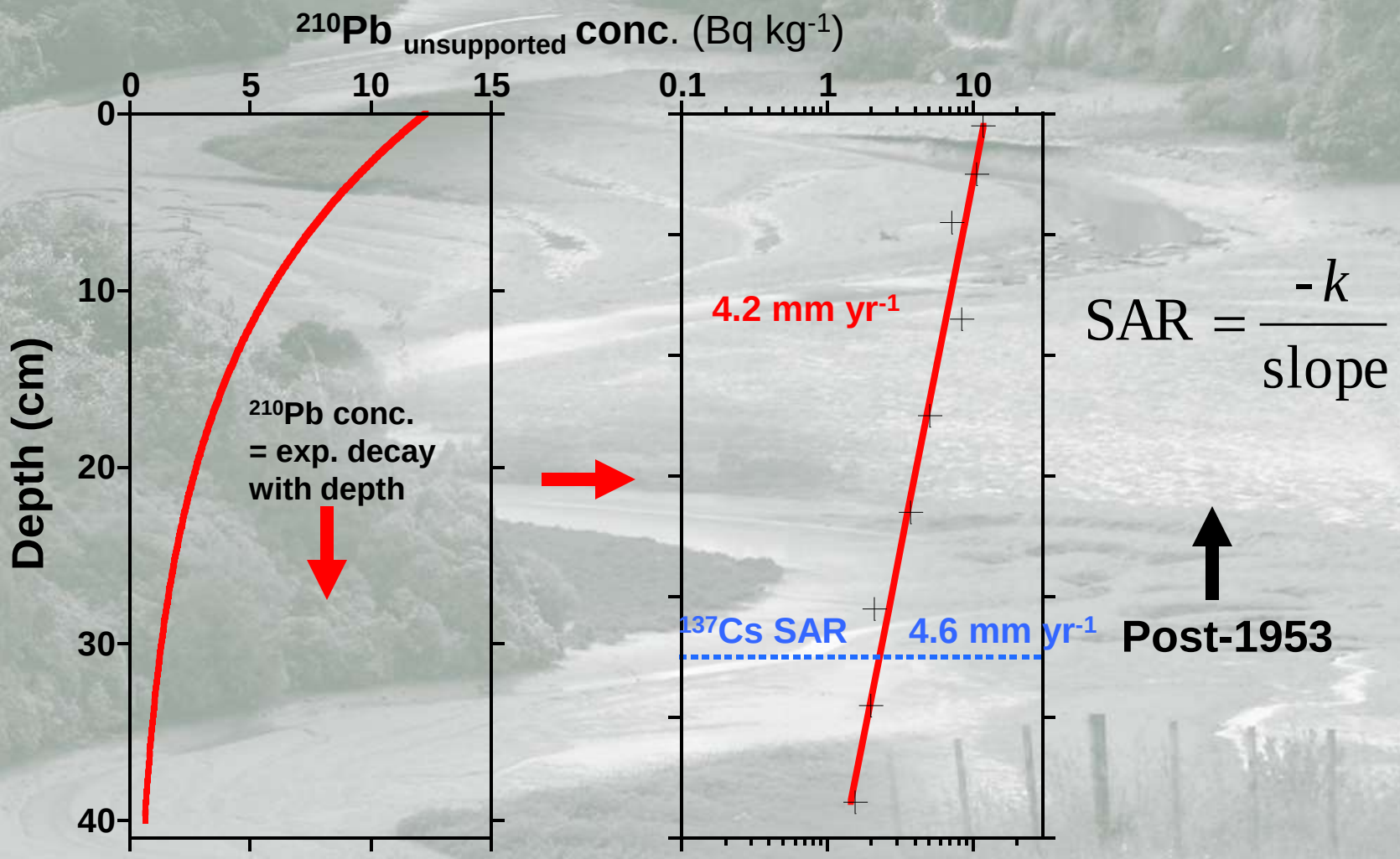
- regional “snap-shot” of recent sedimentation
- intertidal vs subtidal flats
- spatial variability (flat scale)
- info. for model validation
- likely effects of future catchment soil loss

Study Estuaries

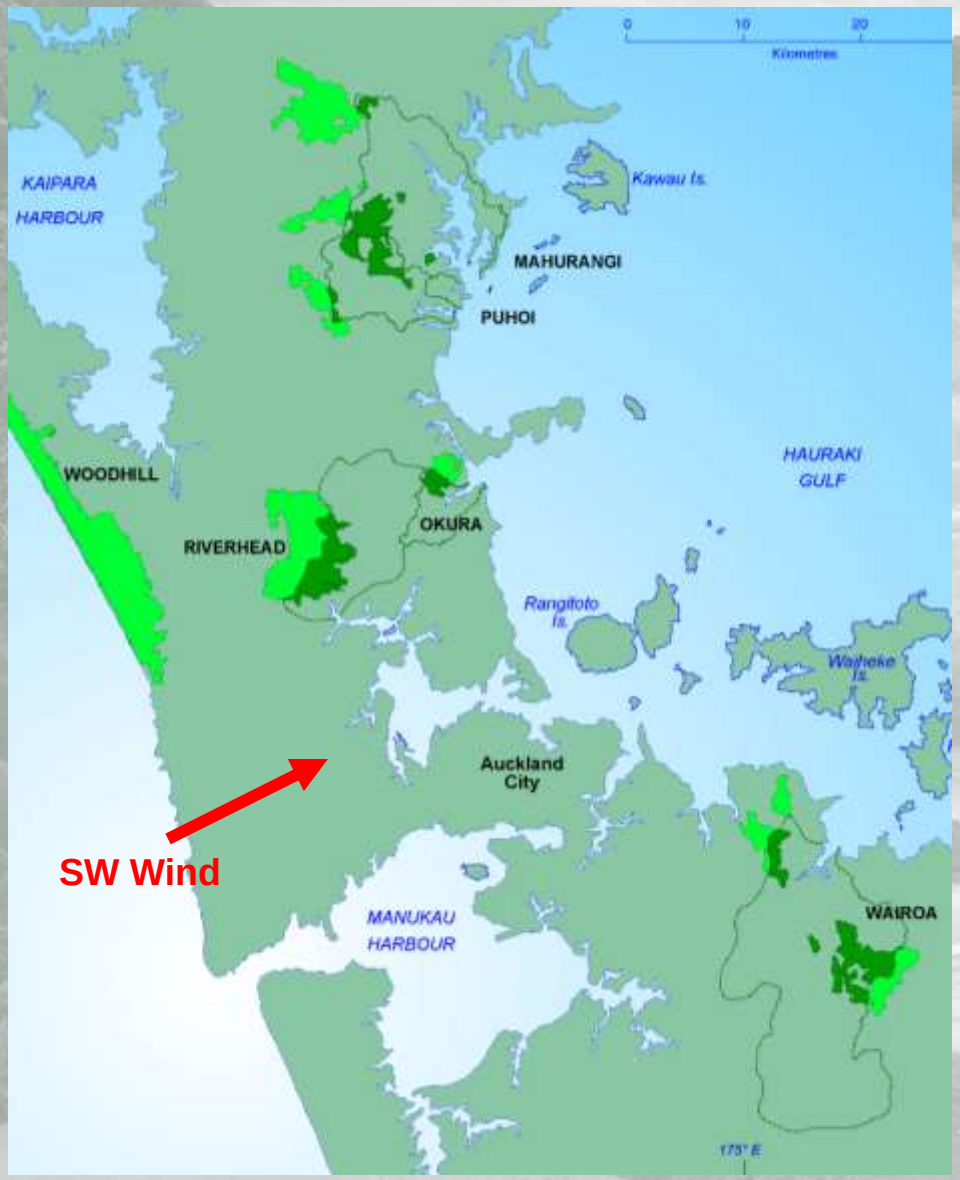
Methods

- **cores:** 18 intertidal sites
  12 subtidal sites
- **dating** ^{137}Cs (post-1953)
  ^{210}Pb (last 150 yr)
  pollen (vege. changes)
- **zinc** “urban” sediment indicator
- **particle size**

Unsupported ^{210}Pb: Average SAR



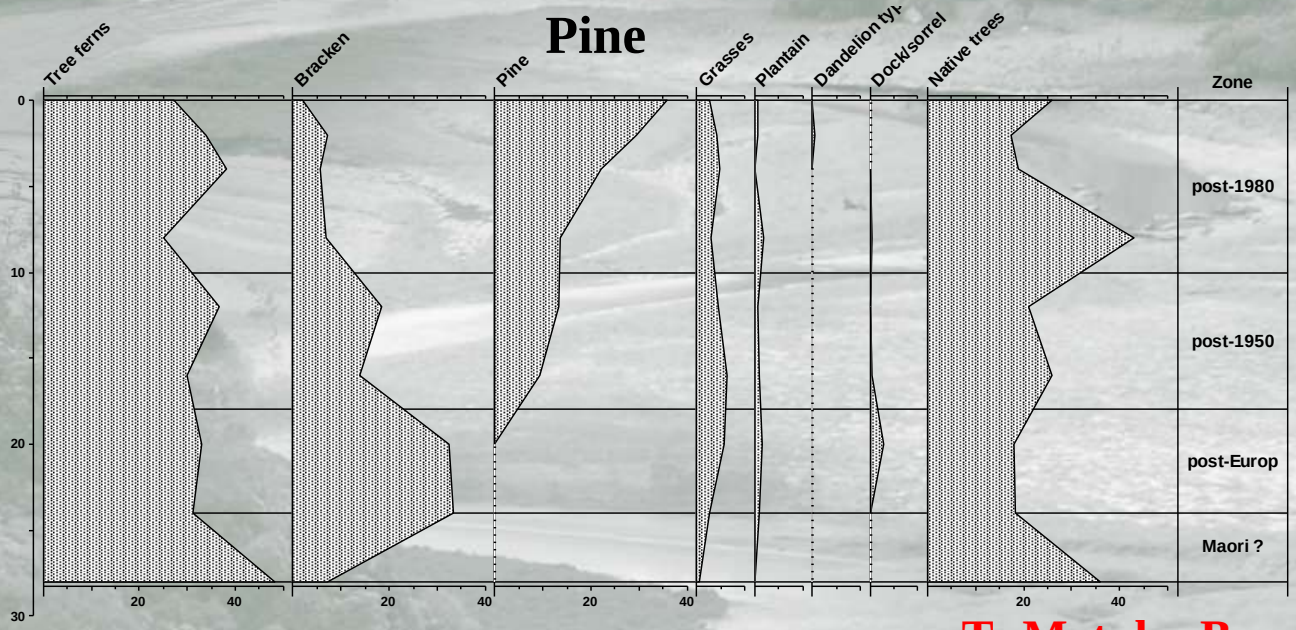
Pine



- most abundant & widely dispersed pollen
- Auckland forests

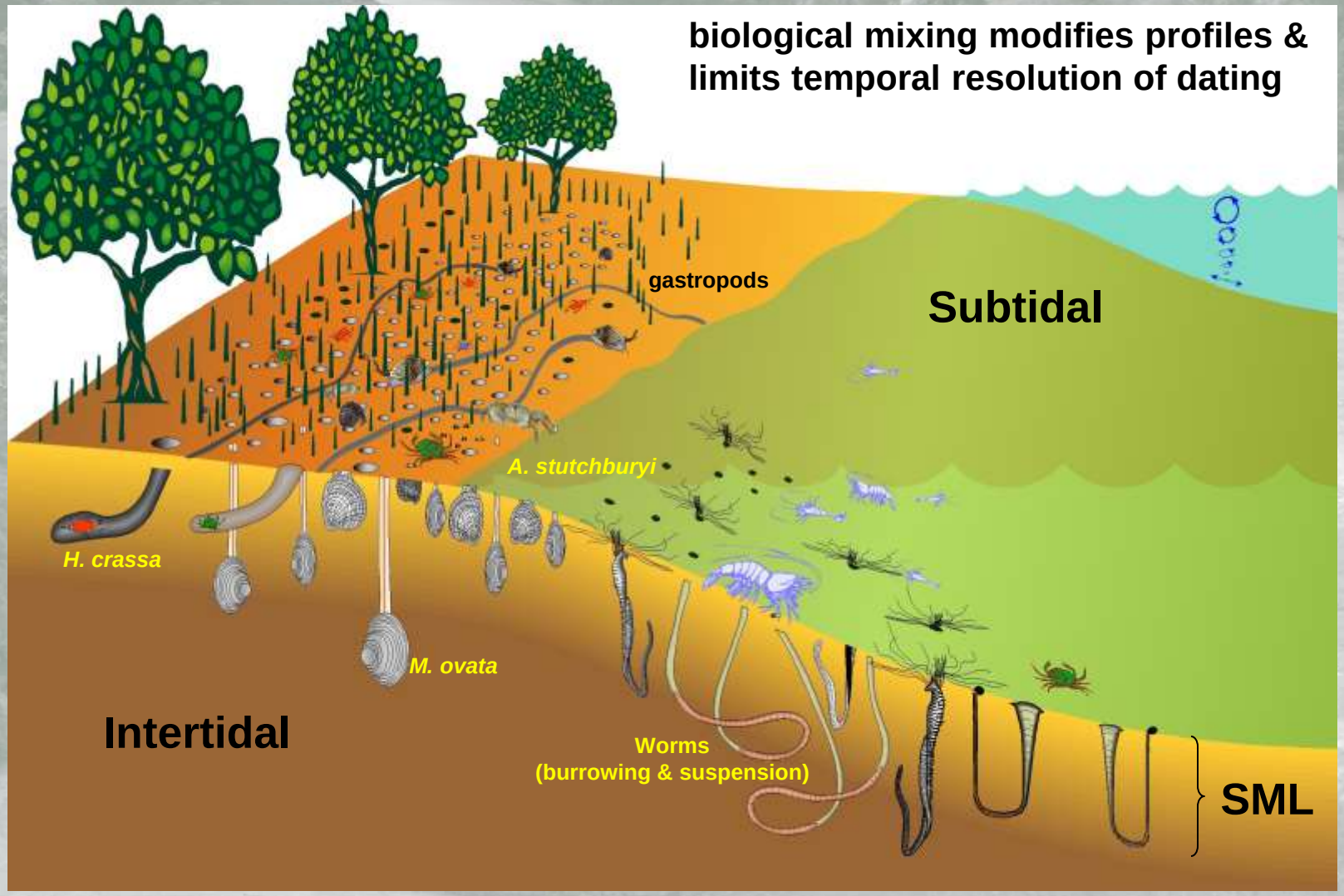
  mid-1930's: Woodhill/Riverhead
  mid-1970's: east coast
- Pollen rain: 5+ yr after planting
- enter record ~1940's

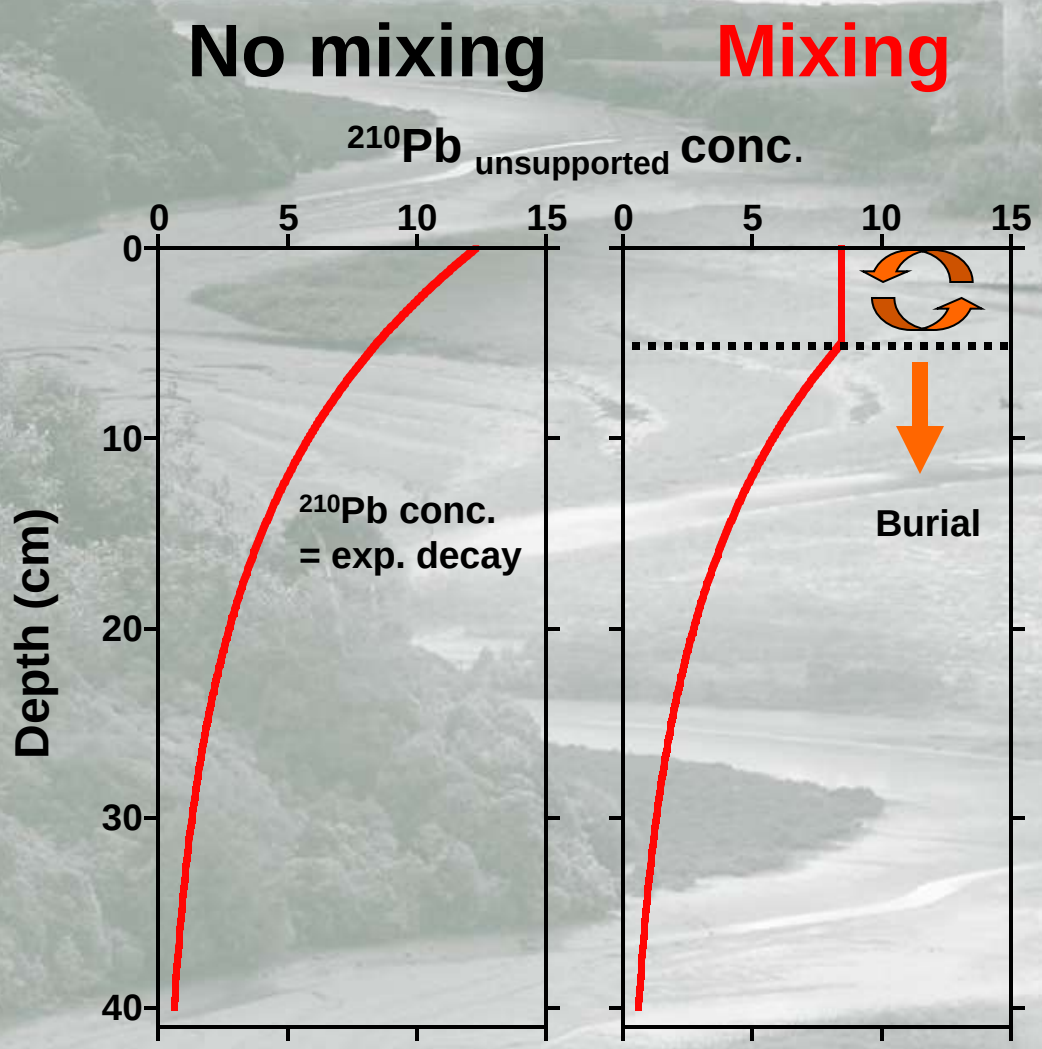
Pollen Profiles



Te Matuku Bay

Bioturbation





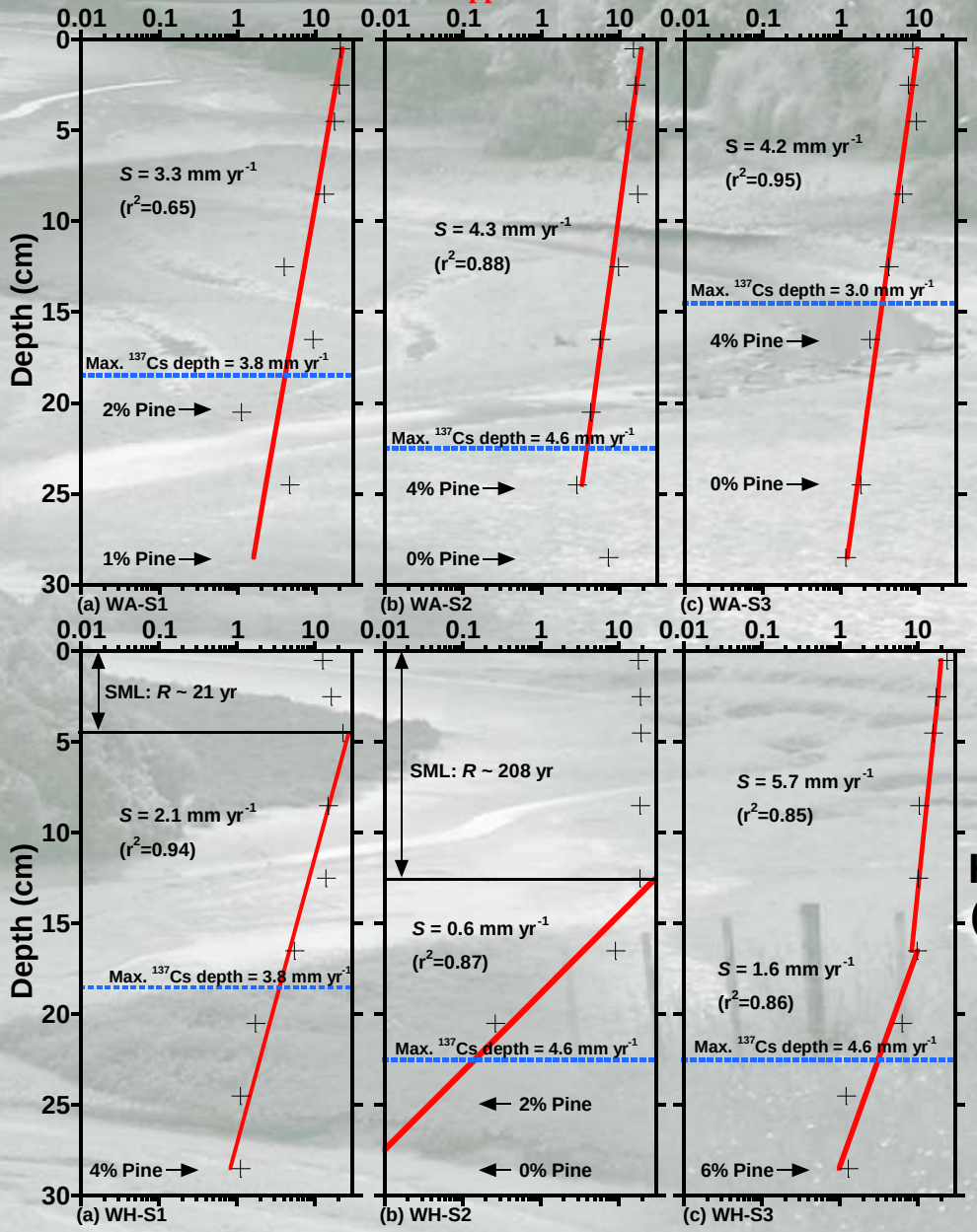
SML (biological activity)

^{210}Pb conc. = constant

$$R = \frac{\mathrm{SML}}{\mathrm{SAR}}$$

Study
mean SML = 4 cm
mean *R* = 18 yr

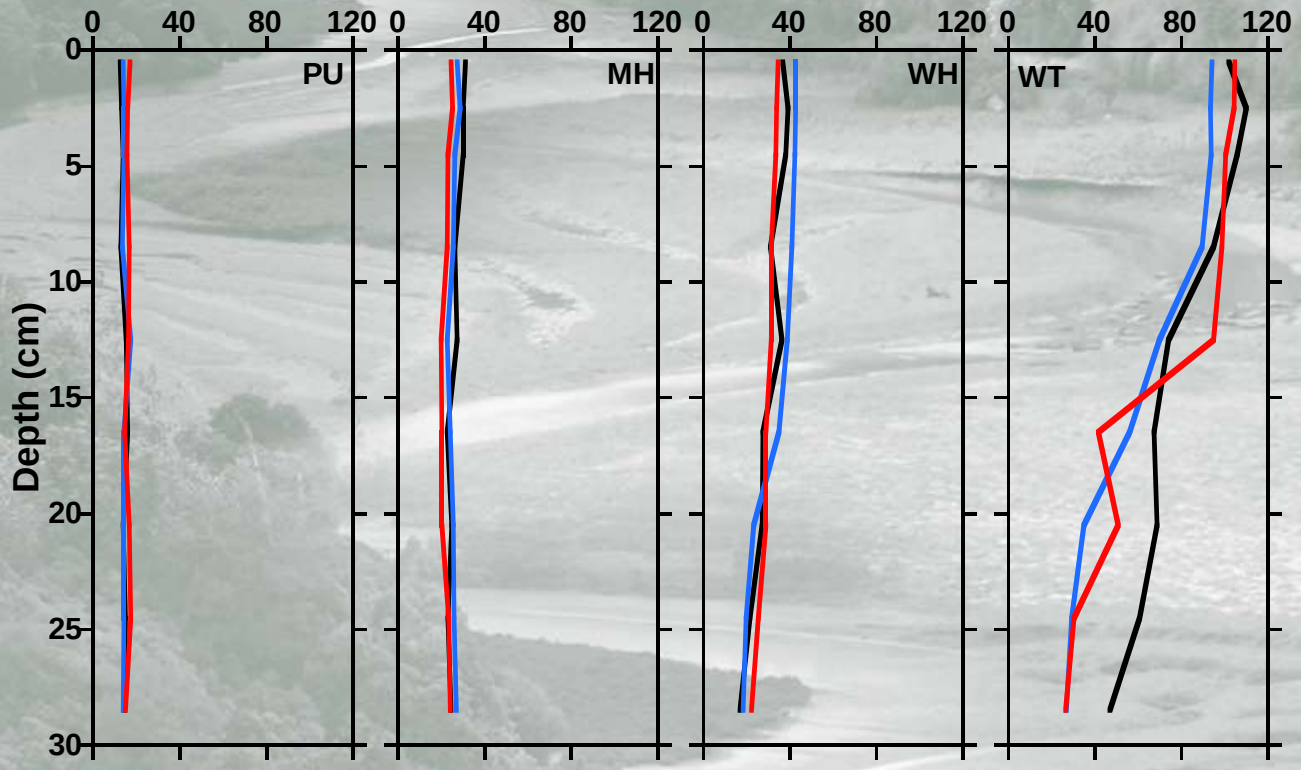
Spatial Variability (Flat Scale)



Homogenous
- ^{210}Pb slopes
- ^{137}Cs depth

Heterogeneous (local processes)

Zinc Concentration (μg g^{-1})



Rural → increasing contamination → **Urban**

Zn < Effects Range Low = 150 μg g^{-1}

(adverse biological effects may occur, Long et al. 1995)

^{210}Pb Modelling

- **used to reconstruct SAR time-series**

- **2 models:** dating ^{210}Pb profiles (variable SAR)

  CIC **(^{210}Pb source = soil)**

  CRS **(^{210}Pb source = atmosphere)**

- **Tests**

  Compare mean ^{210}Pb supply rate (*P*) with:

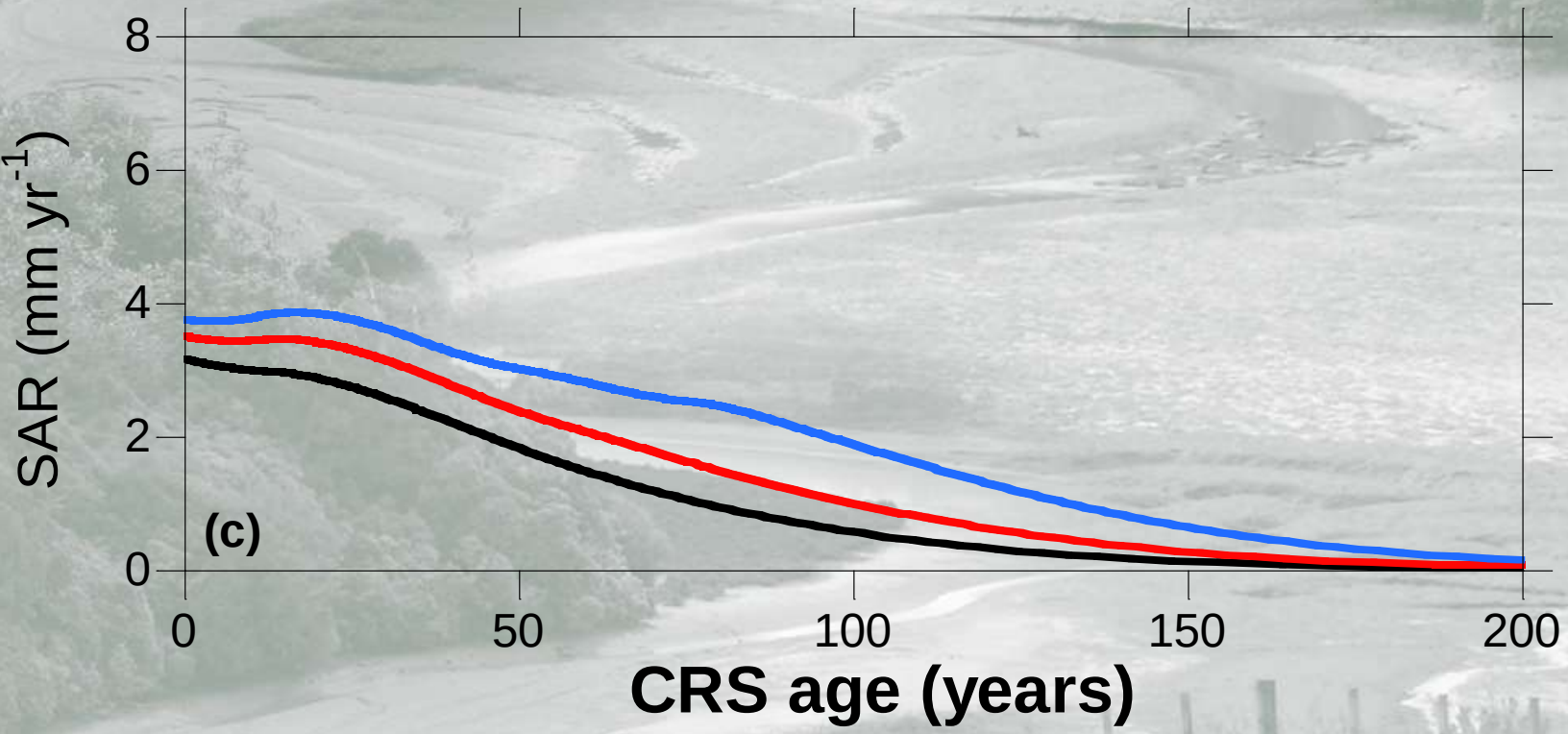
  (1) *P* from other nearby cores

  (2) atmospheric flux (0.006 Bq cm^{-2} yr^{-1}) +/- 30%

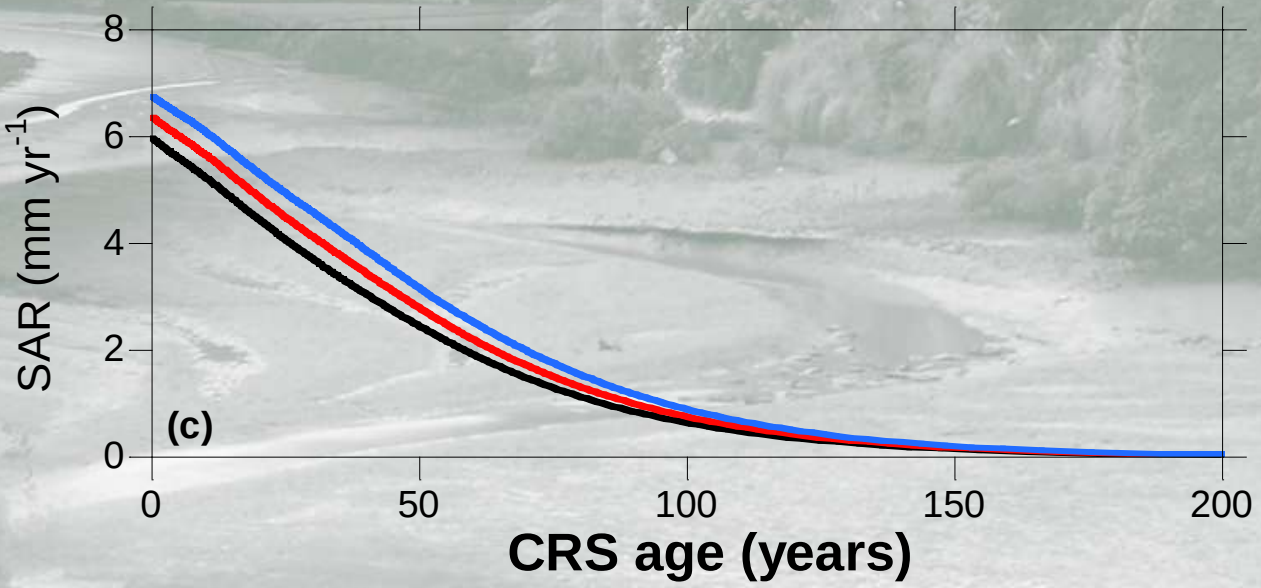
  (3) constrained ^{210}Pb profile by max ^{137}Cs depth

What's the fate of catchment sediment delivered to infilled estuaries ?

Wairoa Estuary (Subtidal)



Te Matuku Bay

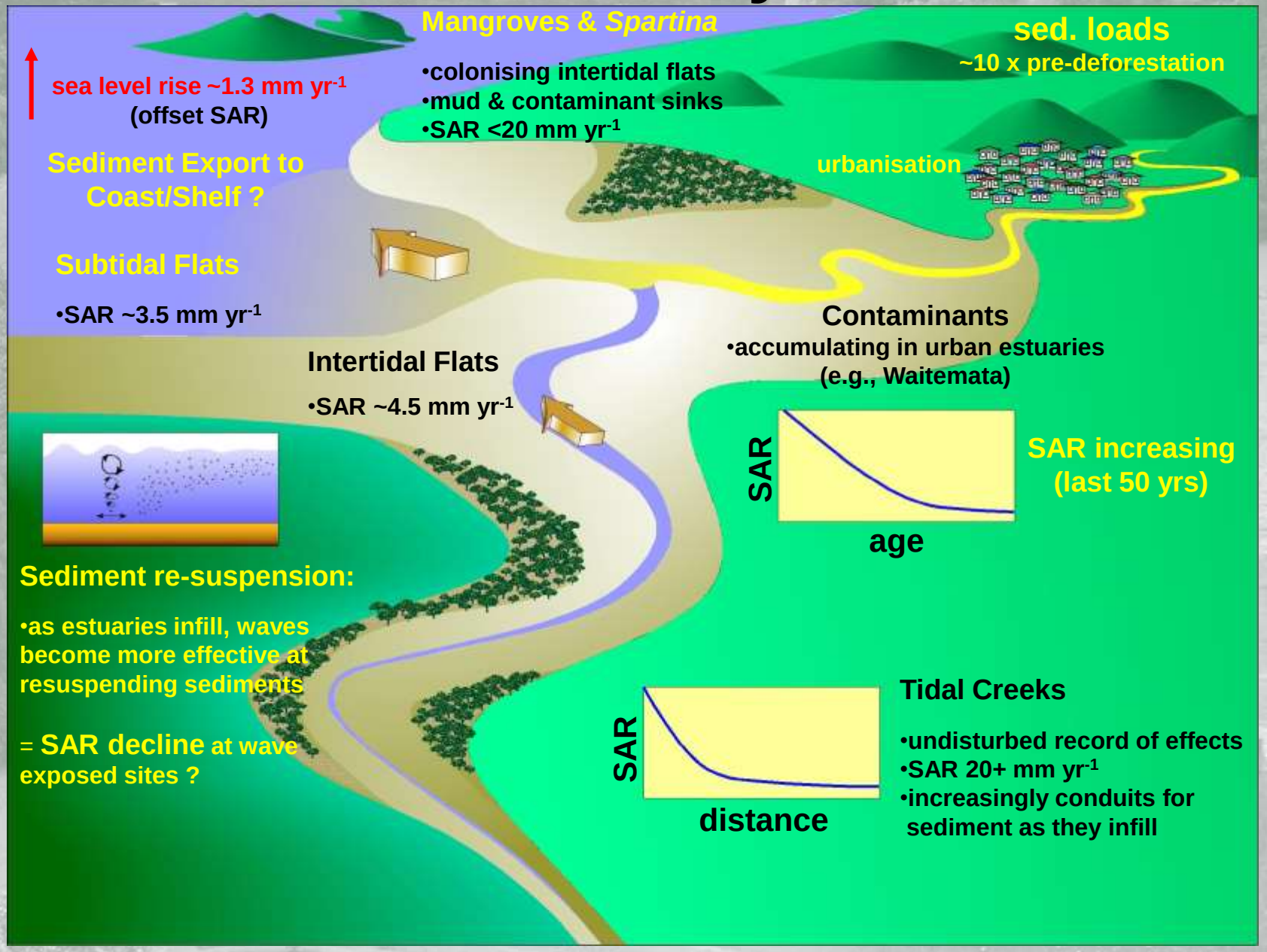


SAR increasing over last 100 yr despite:

- **relatively small catchment (12 km^2)**
- **50% of area regenerating bush**

likely sediment source = **Wairoa**

Summary


Mangroves & *Spartina*
•colonising intertidal flats
•mud & contaminant sinks
•SAR <20 mm yr-1
sed. loads
~10 x pre-deforestation
sea level rise ~1.3 mm yr-1
(offset SAR)
urbanisation
Sediment Export to Coast/Shelf ?
Subtidal Flats
•SAR ~3.5 mm yr-1
Contaminants
•accumulating in urban estuaries (e.g., Waitemata)
Intertidal Flats
•SAR ~4.5 mm yr-1
SAR
age
SAR increasing (last 50 yrs)
Sediment re-suspension:
•as estuaries infill, waves become more effective at resuspending sediments
= SAR decline at wave exposed sites ?
SAR
distance
Tidal Creeks
•undisturbed record of effects
•SAR 20+ mm yr-1
•increasingly conduits for sediment as they infill

Multiple effects of Fine Suspended Sediment

NIWA
Taihoro Nukurangi

Effects of Fine Sediment – *When deposited*

- Shoaling or infilling
- Clogging of sediment beds
- Smothering of biota

These (depositional) effects ***do*** seem to relate to sediment mass (given bulk density…)

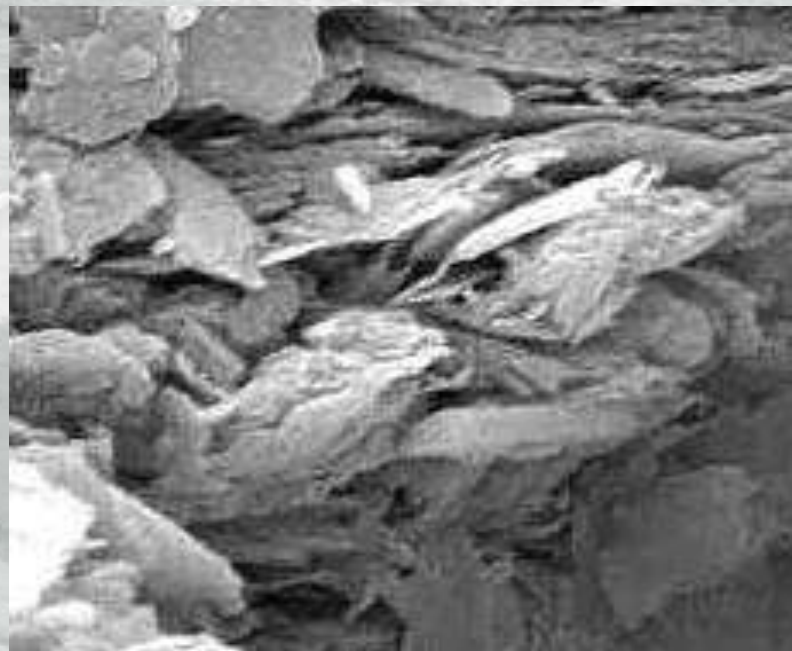
But what about FS while still suspended?

Effects of Fine Sediment – *while still suspended*

- Damage to biological structures
- Reduced food quality for filter feeders
- Transport of (other) pollutants (e.g. toxics)
- Light attenuation –
  - Reduced *visibility*
  - Reduced *light penetration*
  - Changed *water colour*

These (suspended) effects of FS depend on –

- Composition
- Particle size & shape - *photo*
- Surface chemistry



Light attenuation by FS

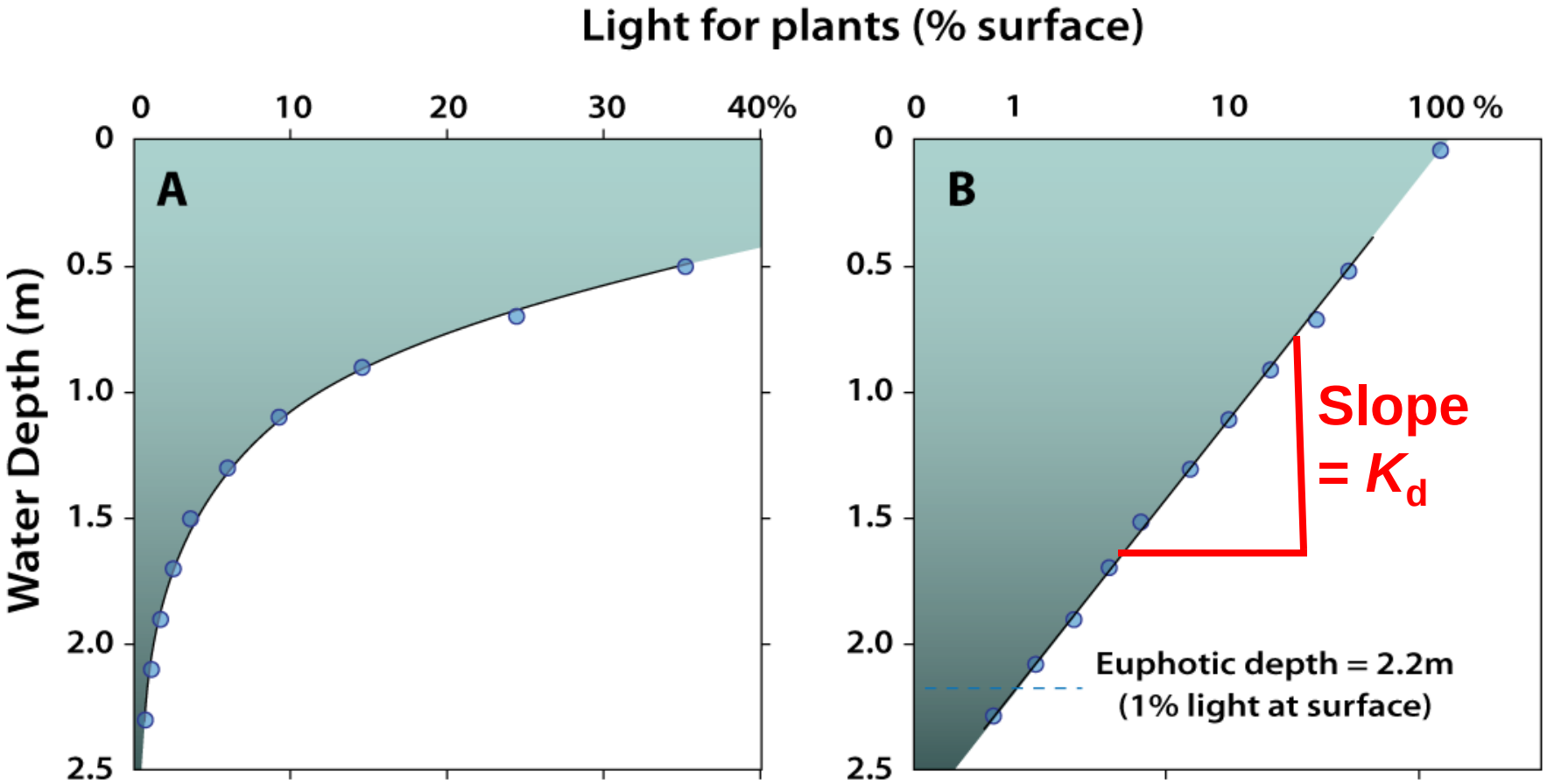
- Cloudiness (‘turbidity’) due to FS light scattering
- ‘Muddy’ colours – due to light absorption by humics
- Rivers, Estuaries

Key quantity:
Light beam attenuation
$c = a + b$

Inversely proportional to visibility

$y_{BD} = 4.8/c$

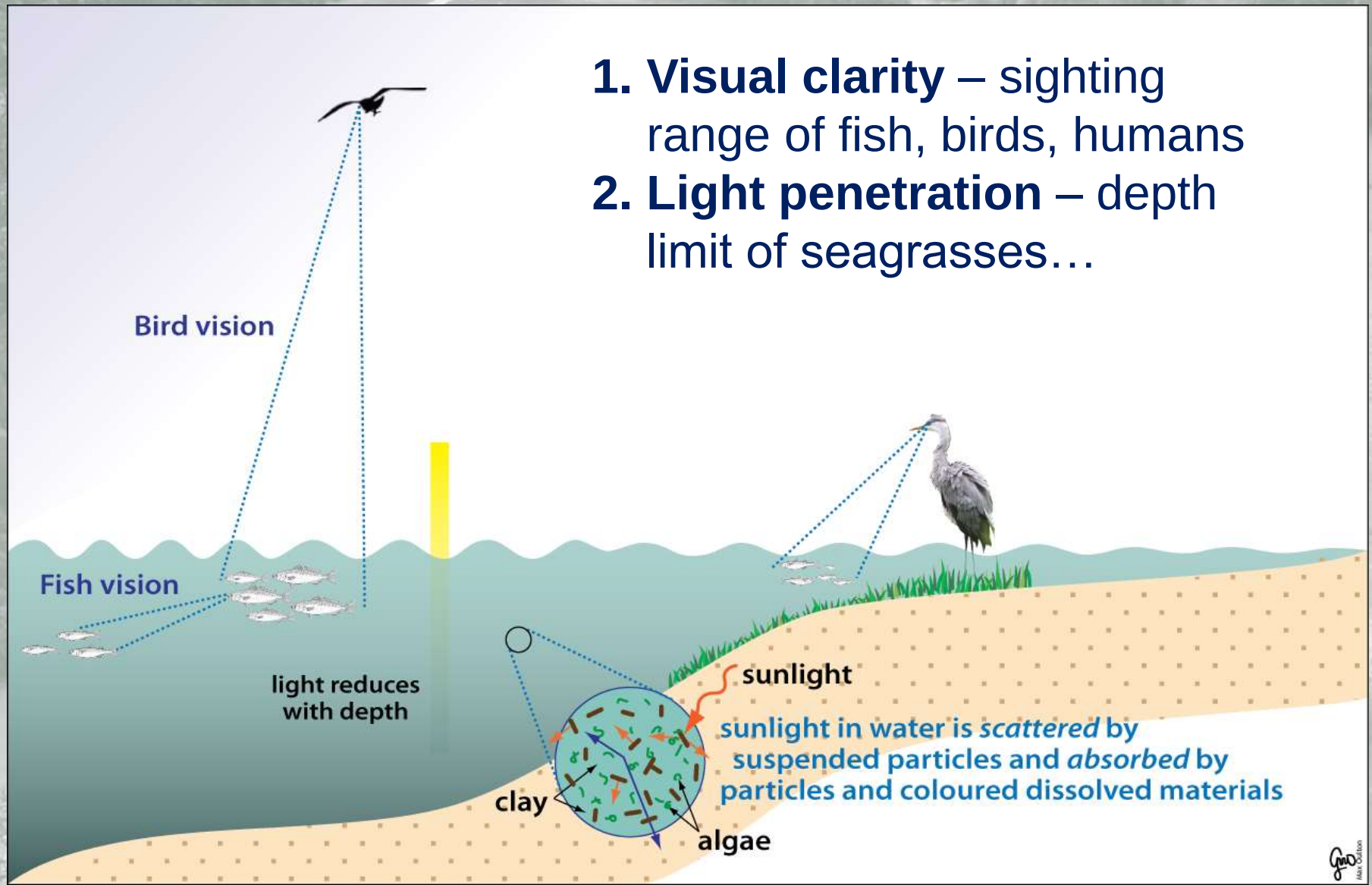
Light penetration reduced by FS



In rivers: $K_d = f\ (y_{BD}$, CDOM)
Similarly in estuaries?

Light attenuation effects of FS

1. **Visual clarity** – sighting range of fish, birds, humans
2. **Light penetration** – depth limit of seagrasses…



Other pollutants associated with FS

- Pollutants sorb to particle surfaces
- Surface area concentration: m^2 per m^3 water volume… dimensions are m^{-1} (same as *c*)
- So light attenuation may provide a useful index of pollutant-sorbing surfaces of FS?

H: That light attenuation may be a better index of the 'amount' of FS than its mass concentration.

Testing the H:

that light attenuation may be a better index of 'amount' of sediment than mass conc.

"Sediment, and water quality" project in "Effects" programme

***Test-beds** for research include –*

1. National scale – NRWQN
2. Horizons Region rivers
3. **Kaipara system** – *Photo*

(+ some other estuaries)

Summary and ongoing work

- FS has multiple environmental effects
- Light attenuation by FS has comparable environmental significance to its mass concentration
- Light attenuation is a *better* measure than TSS
- SO, light attenuation deserves to be more widely measured (+ P,N,C, faecal bacteria, toxics?)

Such wider datasets will enhance modelling and management of FS and sediment-associated pollutants.

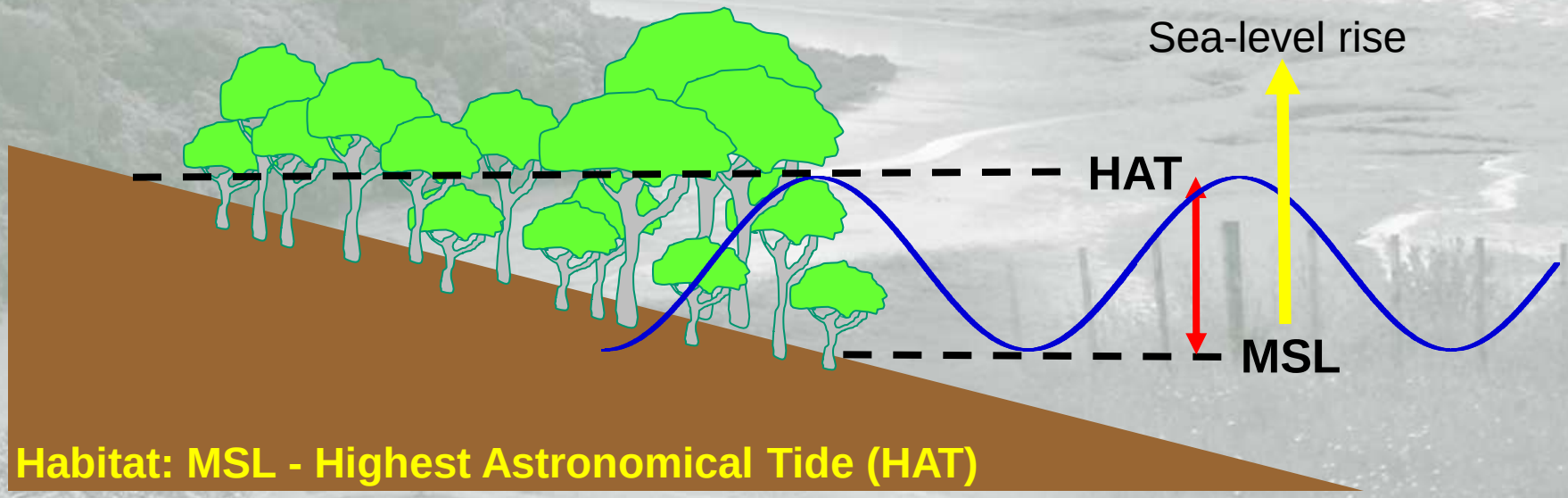
The role of mangrove forests in the modern geomorphic evolution of estuaries – Firth of Thames

NIWA
Taihoro Nukurangi

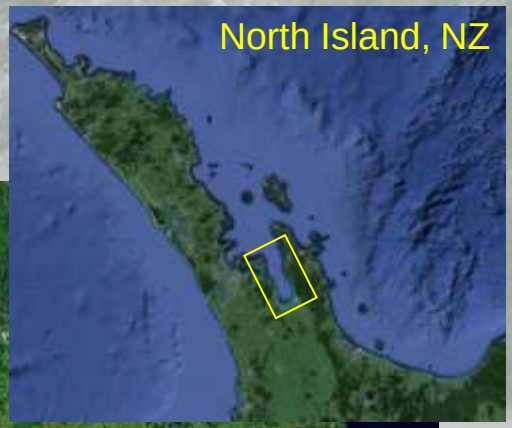
The University of Queensland

NZ Mangroves

- Mangrove forests (*Avicennia marina)* occur in upper North Island estuaries
- **Modern forests** developed over last ~150 yr =
  increased catchment erosion & accelerated estuary infilling
- M**angrove-habitat expansion** averaging **4% yr^{-1}** (last ~70 yr)
  = **displaced** other habitats
- **Intertidal zone** above mean sea level (**MSL**) = physiological tolerance to immersion
- **Must maintain position relative to MSL** as sea-level rises (surface elevation gain)



Firth of Thames



N

Auckland City

35 m

10 m

2 m

Coromandel Ranges

Tide gauge

mangrove forest

Waihou
150 Kt/yr

Piako
35 Kt/yr

Hauraki Plains

0 10
Km

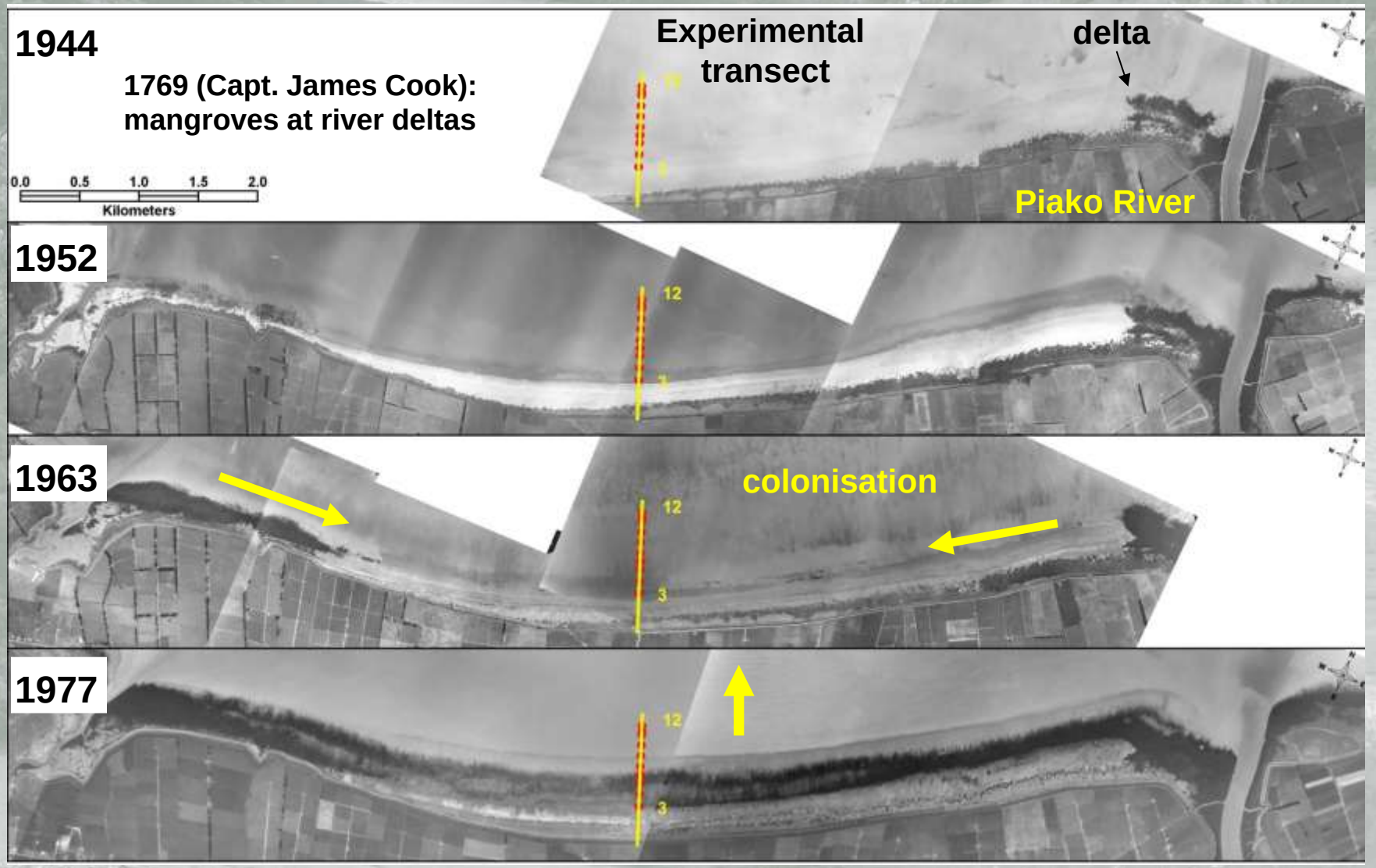
- 800 km^2 mesotidal estuary
- 3,600 km^2 catchment:
- deforestation: 1850-1920

Sediment input
- **190** Kt/yr today
- **10x** higher deforestation

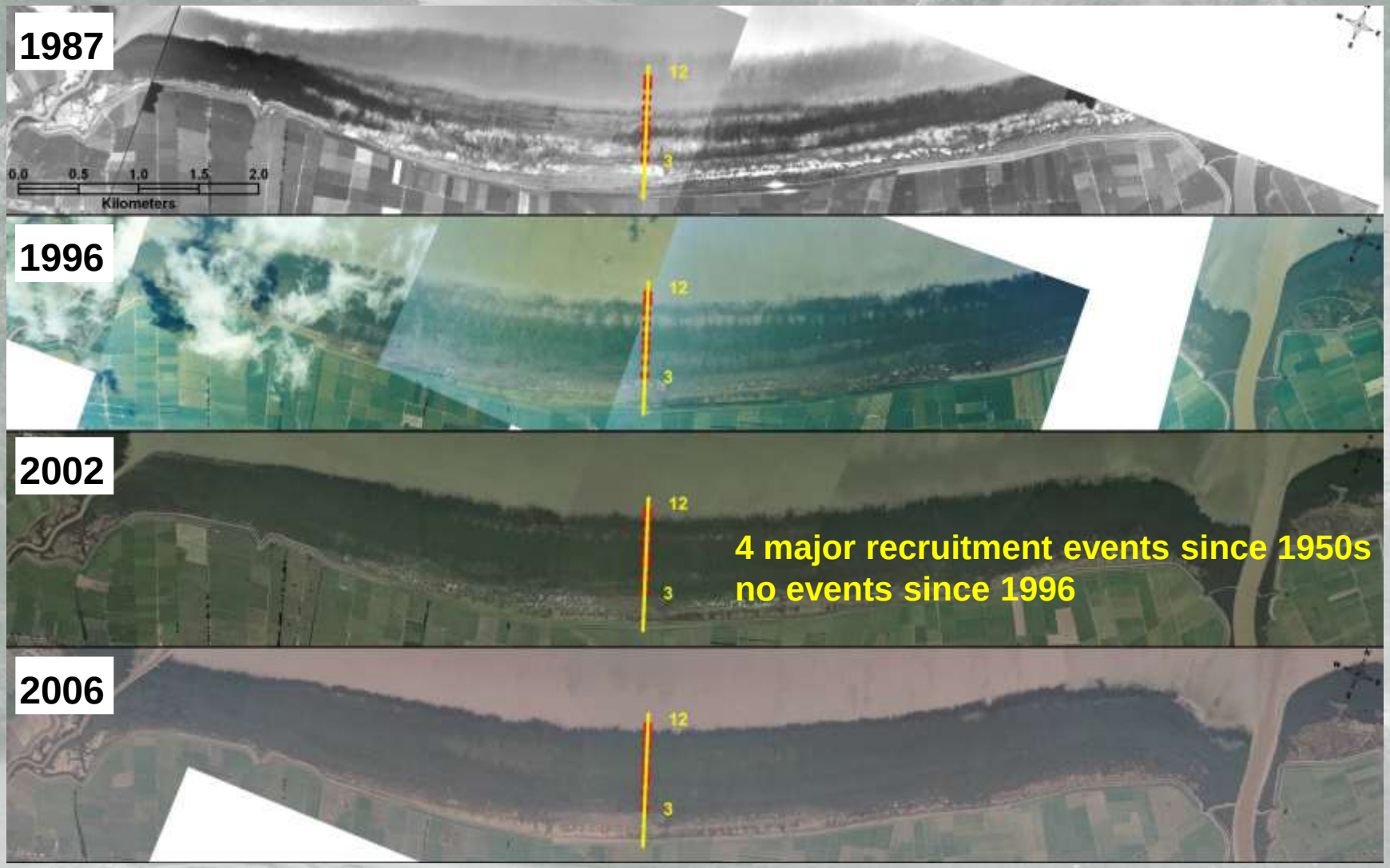
Intertidal: 70 km^2
mangrove forest: 11 km^2
= last 50 yr

- winds: NE – SW
- waves = **resuspension**

Mangrove-habitat expansion: 1944 - 1977

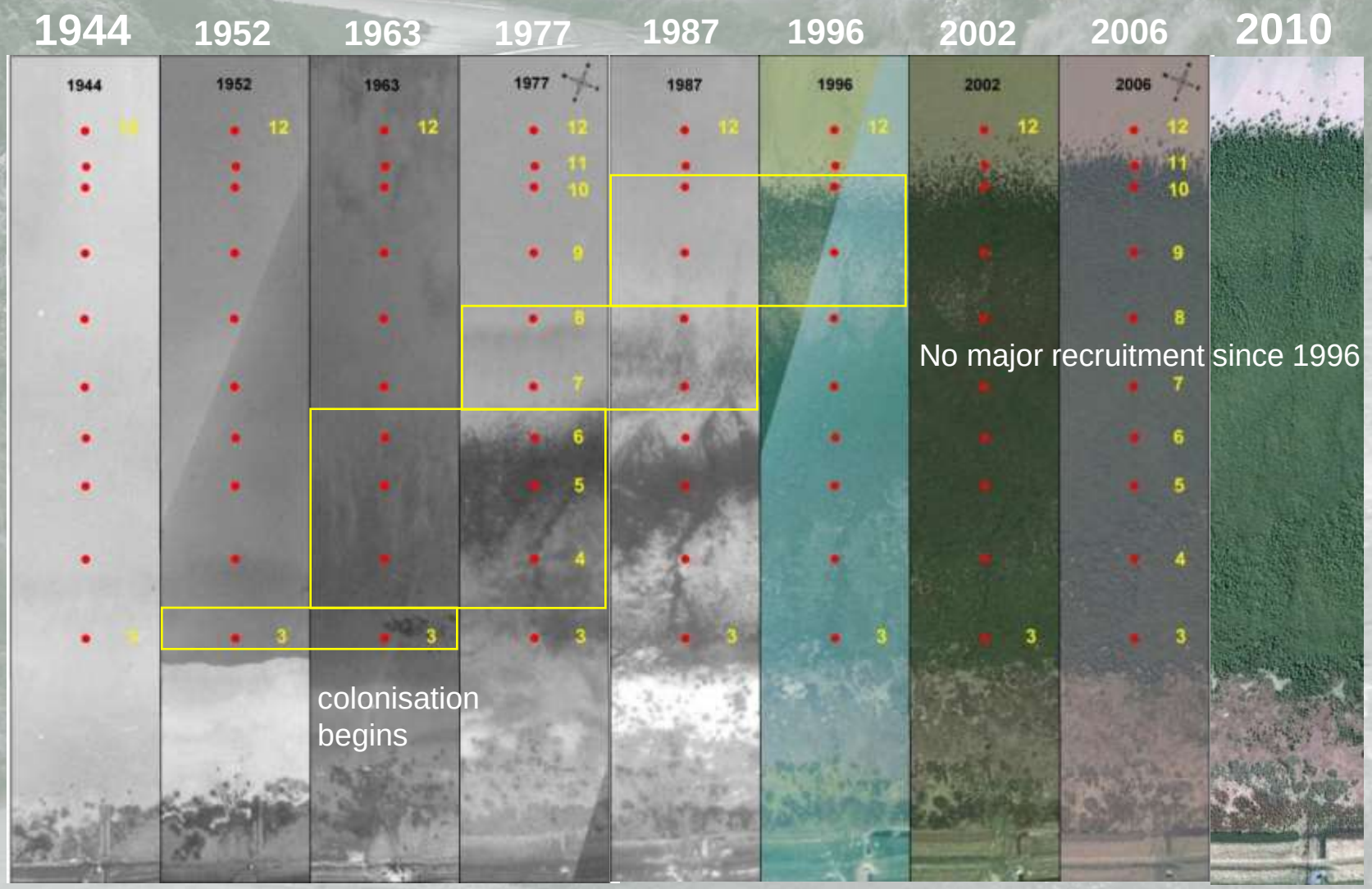


Mangrove-habitat expansion: 1987 - 2006



Life on the fringe

Recruitment events



Conclusions

Firth of Thames study

- Important to work across time scales in dynamic natural systems
  (to identify key processes and to integrate their effects)

- **Subsidence**: could influence mangrove-forest fate in some estuaries
  (e.g., Firth RSLR ~10 mm/yr = at upper-range of SLR predicted by the 2090s)

- **Sediment supply**: key factor influencing future fate of intertidal habitats in NZ estuaries (inc. mangroves)

- **Mangroves are opportunistic & do not strongly influence the geomorphic evolution of NZ estuaries**