Catchments, Coasts and Coral Reefs (focus on land use intensification and the GBR)

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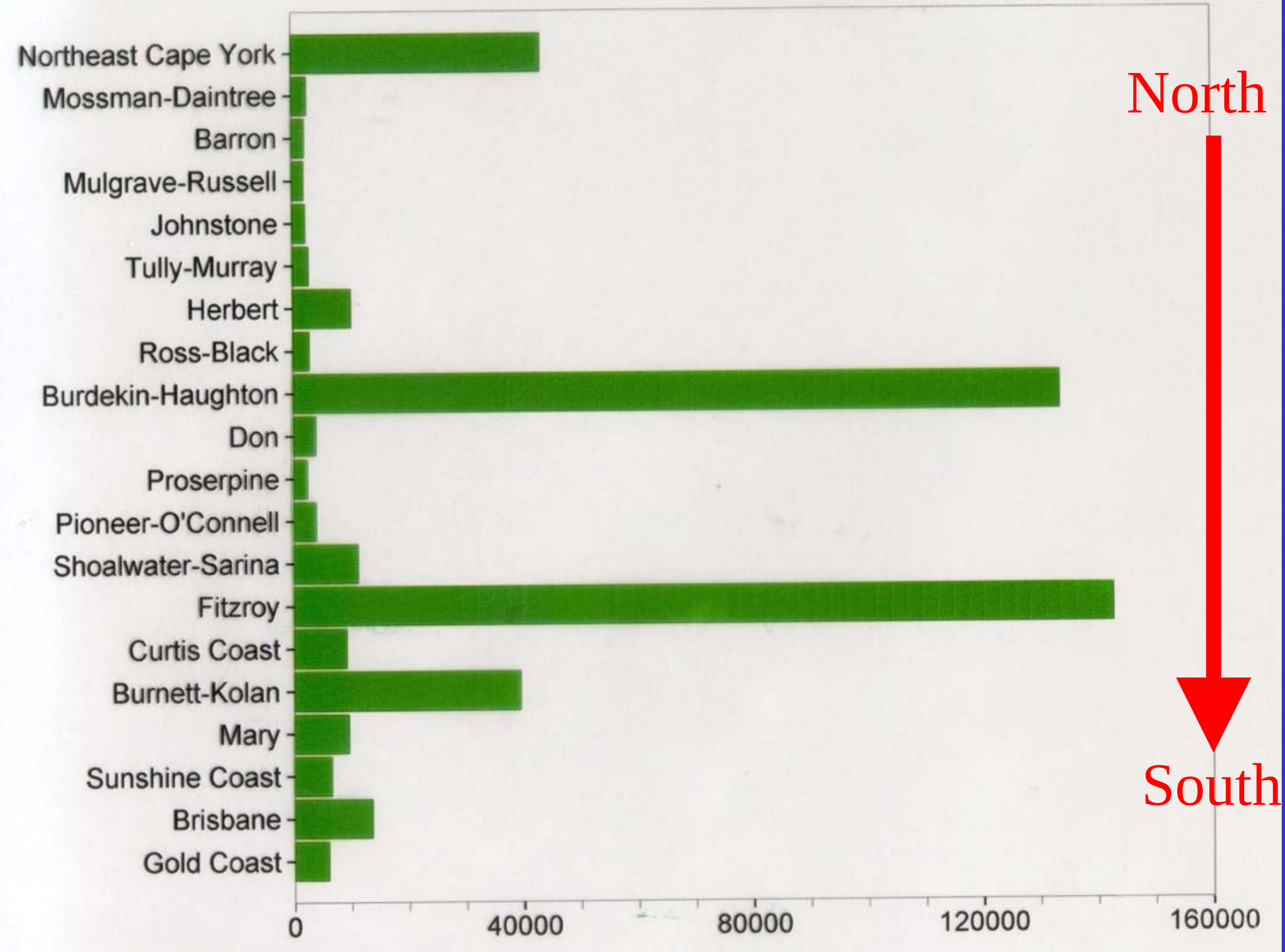
The Issue

"Exposure of reefs to brackish, silt-laden water associated with flood runoff has probably been the single greatest cause of reef destruction historically"

(Johannes, 1975)

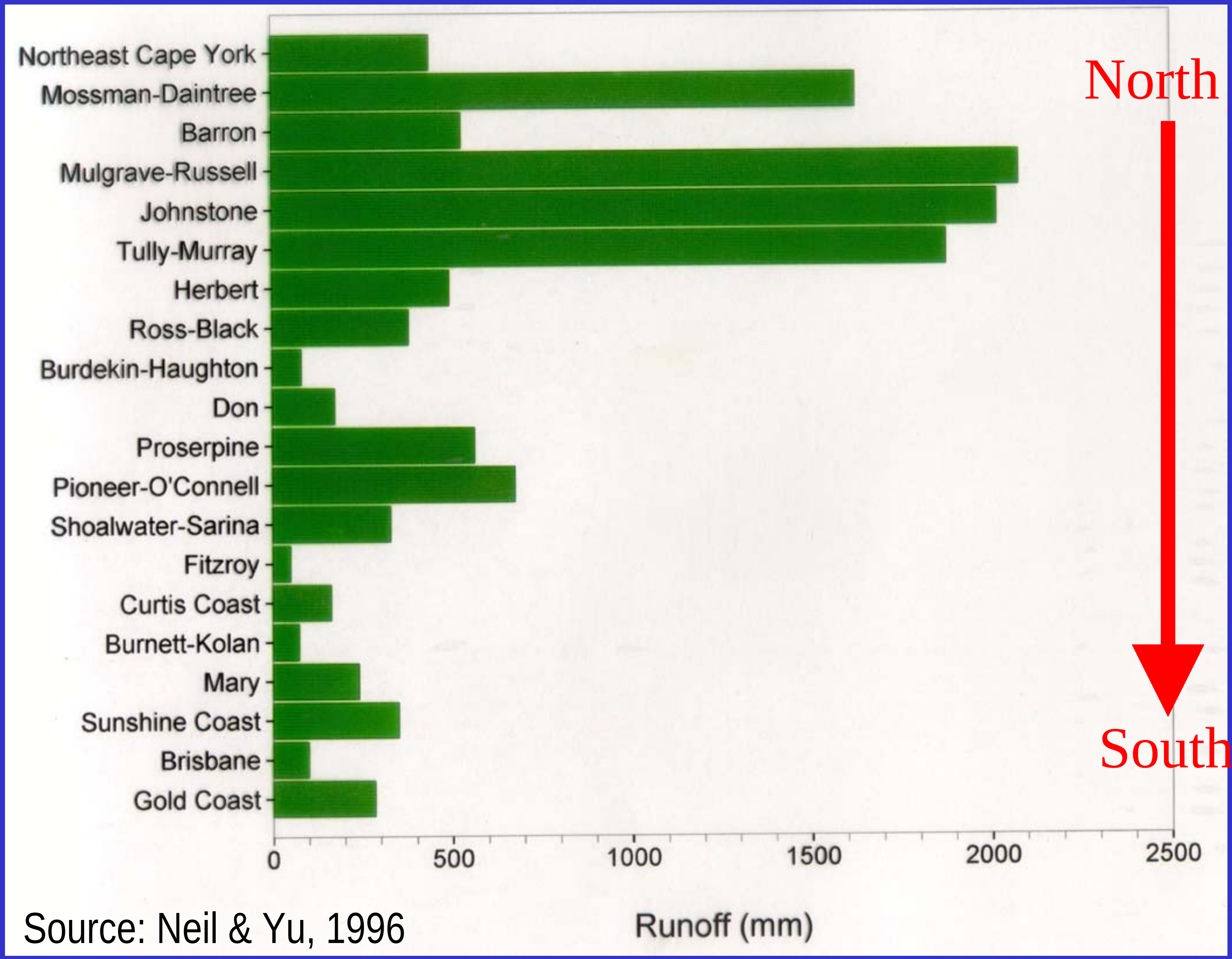
Characteristics of the Catchments



Source: Neil & Yu, 1996

- Catchment area

Characteristics of the Catchments



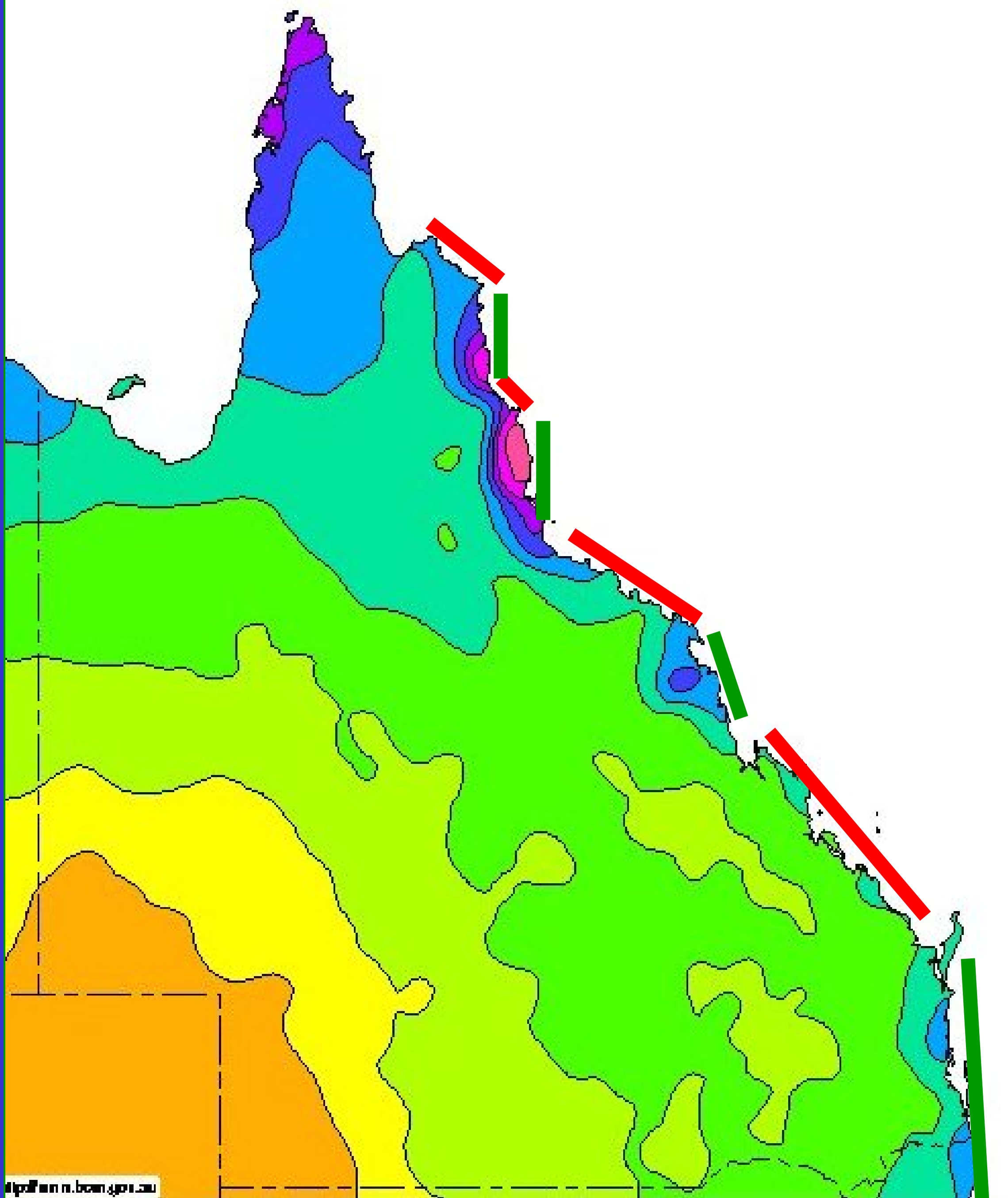
- Catchment runoff –

runoff depth

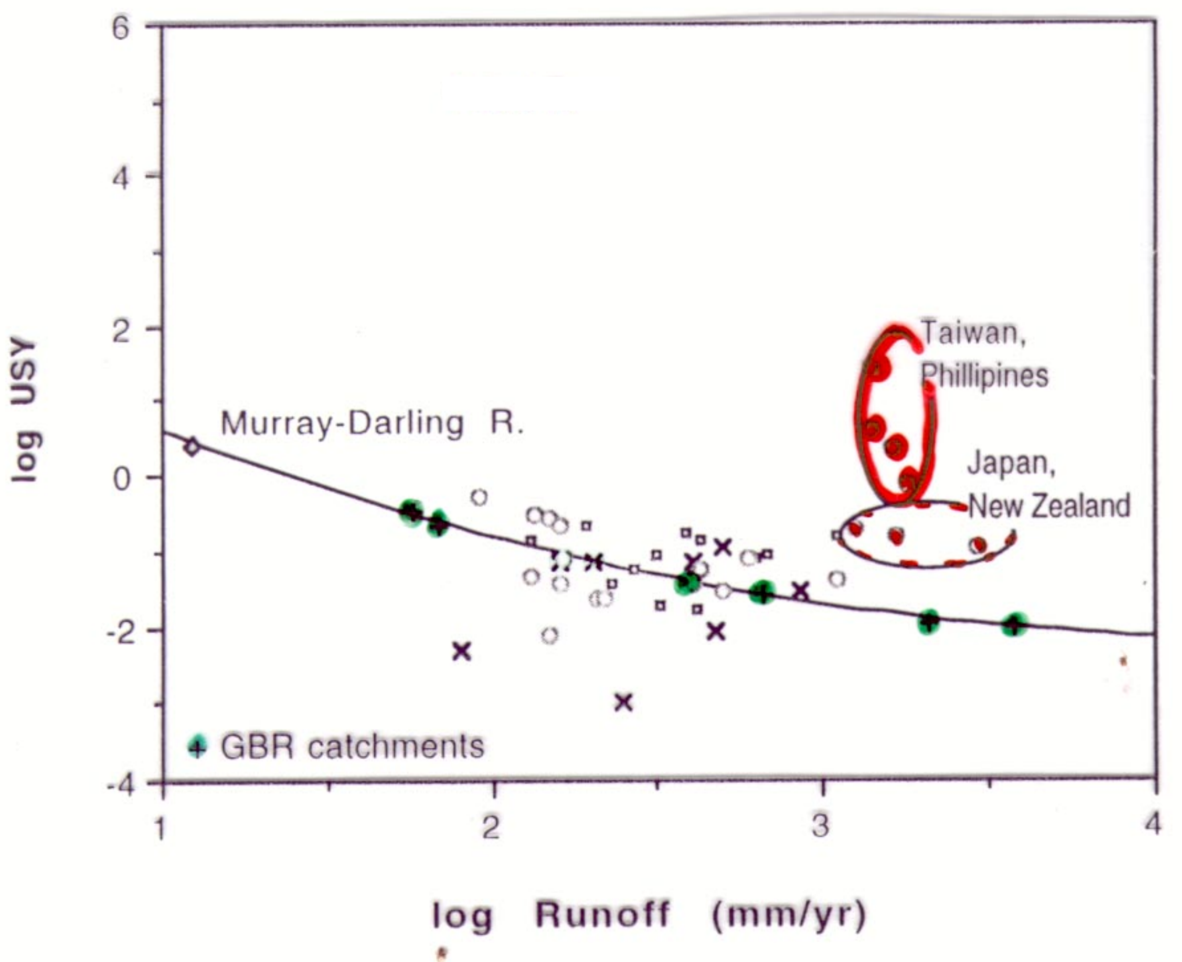
Spatial patterns of rainfall & runoff

Structural control→ orographic effect :

- alignment of coastal ranges
- elevation of coastal ranges
- distance of ranges from the coast



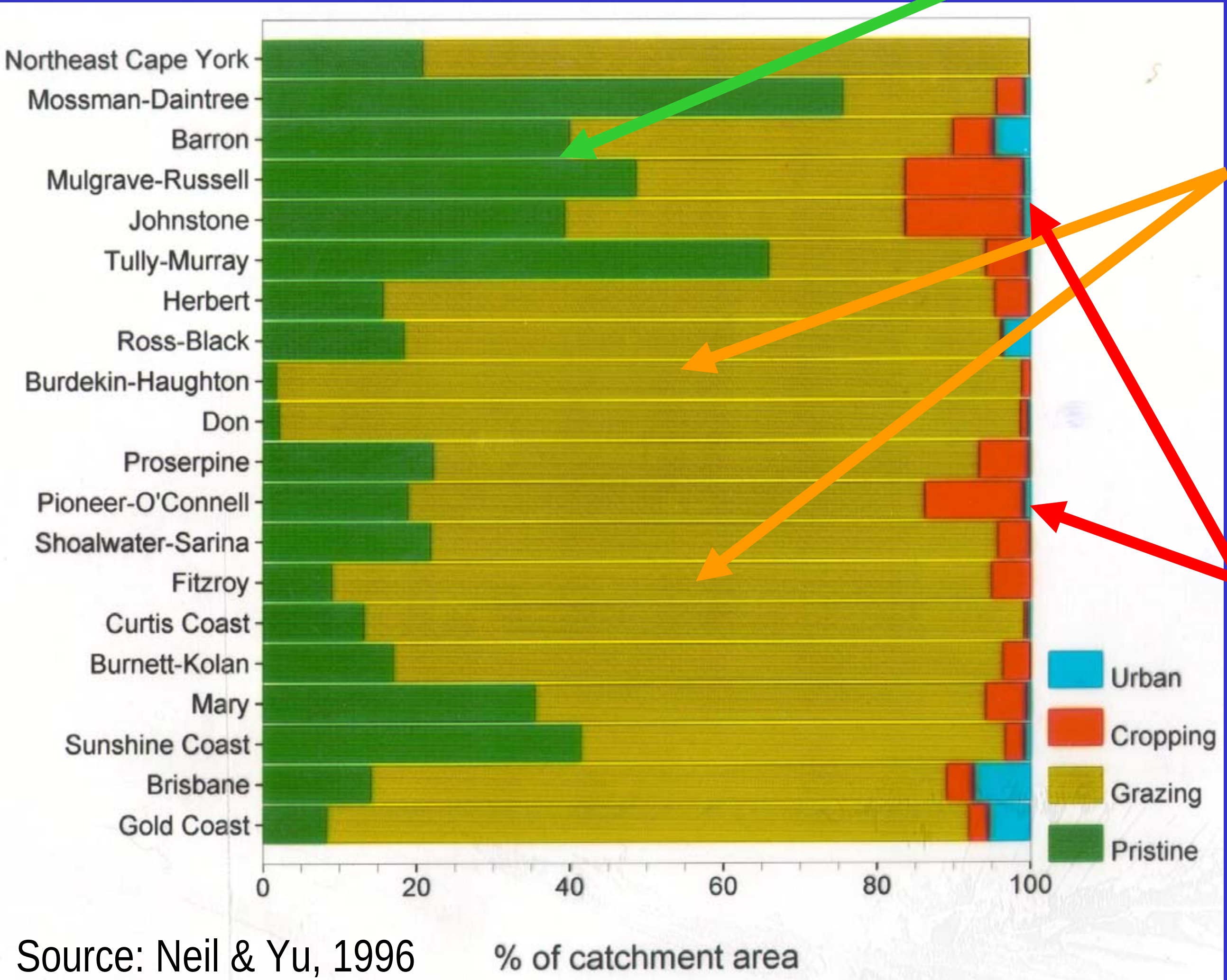
Characteristics of the Catchments



Source: Neil & Yu, unpubl.

- Sediment concentration is correlated with runoff
- GBR sediment concentration is low cf. other tropical areas, eg. Taiwan, Phillipines

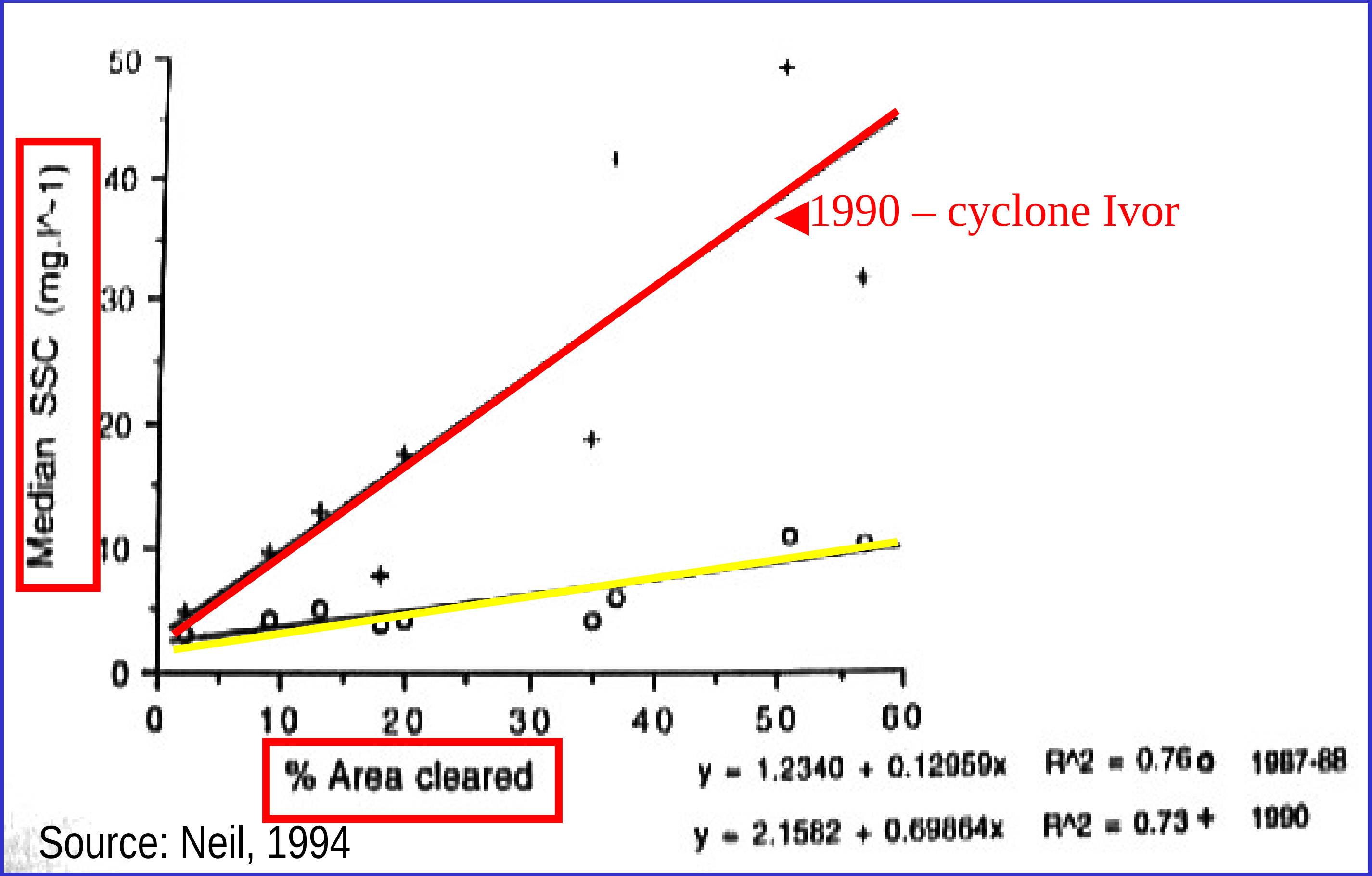
Land use in the Catchments



Source: Neil & Yu, 1996

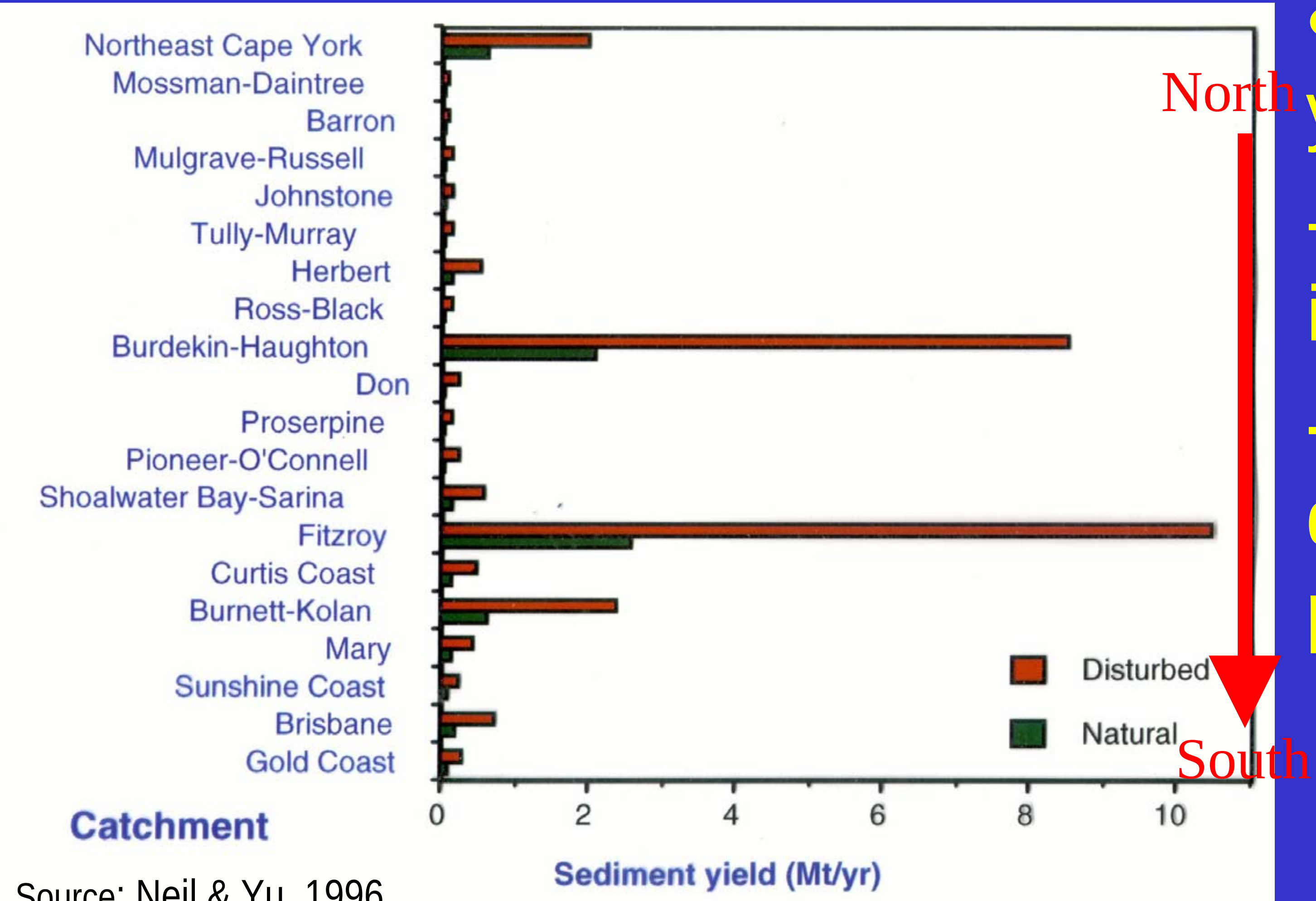
- Significant 'natural' areas - WTWHA
- Grazing most extensive land use – partic. big, dry catchments
- Cropping (sugar, fruit) in wet areas

Consequences of Land Use Intensification – catchment scale



Banyan Creek – 136km^2 subcatchment of Tully River

Consequences of Land Use Intensification – GBR scale

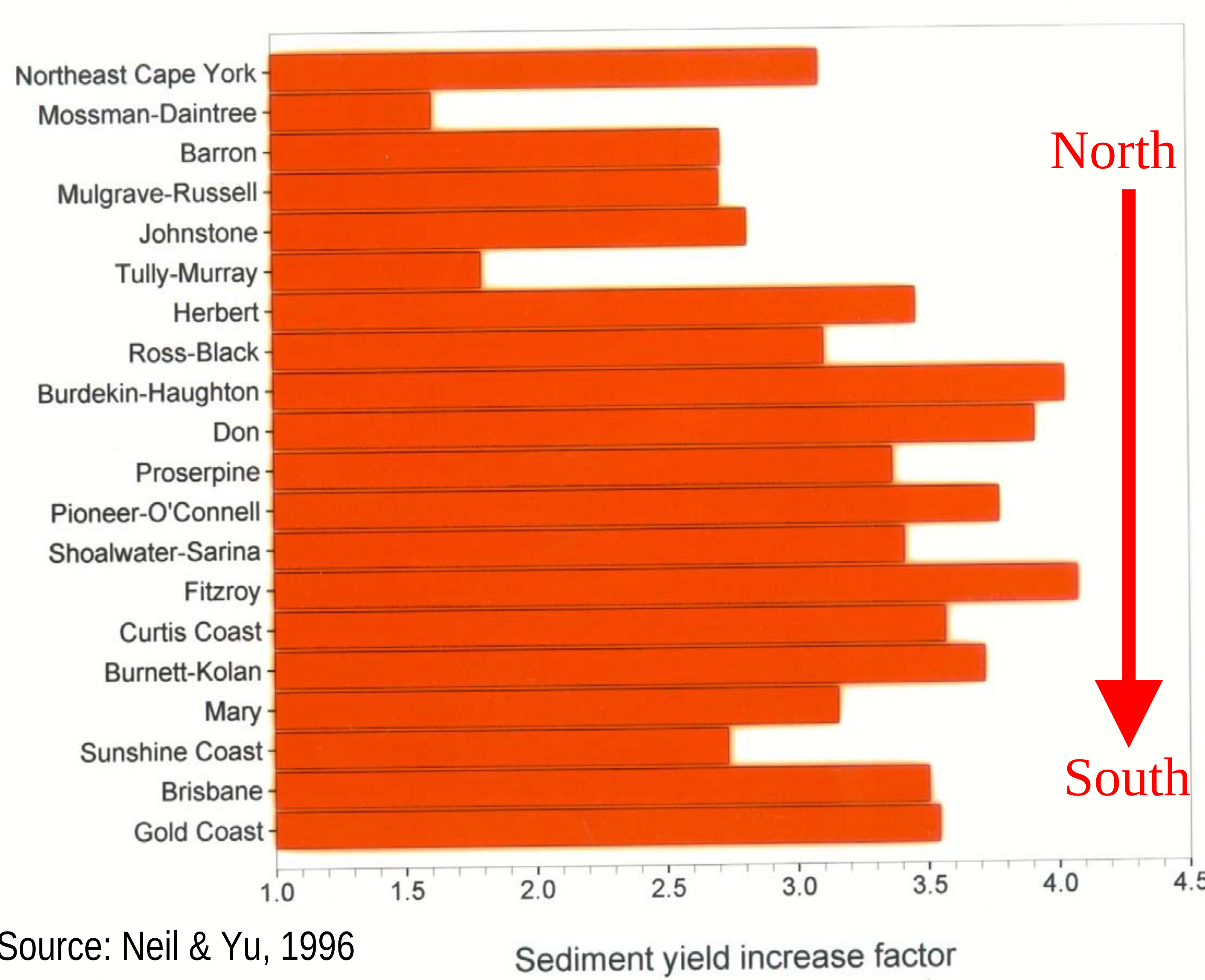


Source: Neil & Yu, 1996

- Sediment yield:
  - how much increase?
  - what distribution pattern?

Consequences of Land Use Intensification

- Sediment yield – how much increase?



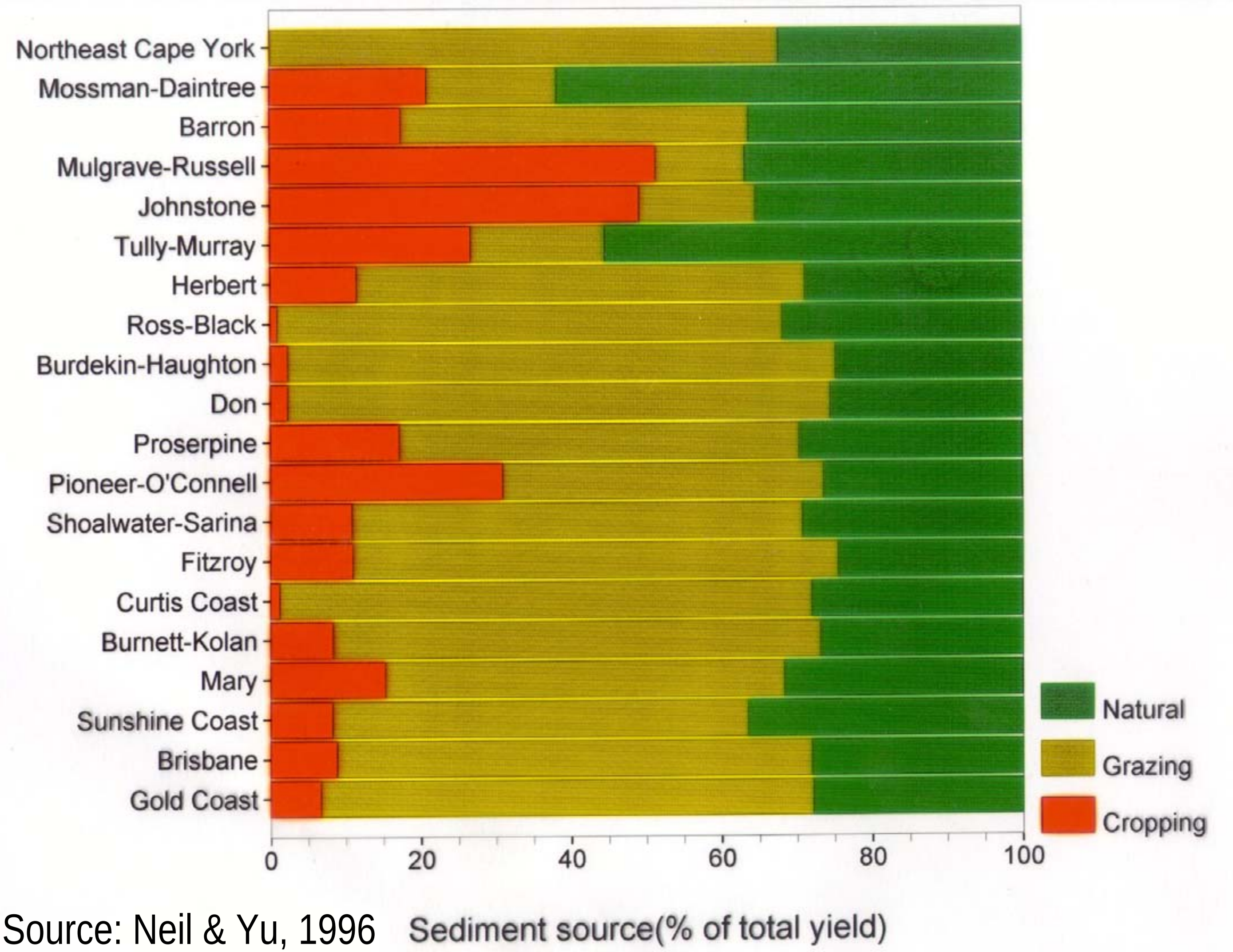
Source: Neil & Yu, 1996

Land use factors

	Lu et al., 01 → GBRMPA, 01 (model output)	Neil&Yu, 95, 96 Rayment & Neil, 97 Neil et al., 02 (model input)
Forest	1.1	1
National Park	1.1	1
Native pasture	1.9	2→4
Improved pasture	5.1	2→4
Cereals (excl. rice)	10.3	10
Rice	5.9	10
Cotton	11.3	10
Sugar cane	56.8	10
Other agriculture	33.6	10

Consequences of Land Use Intensification

- Sediment yield – what sources?

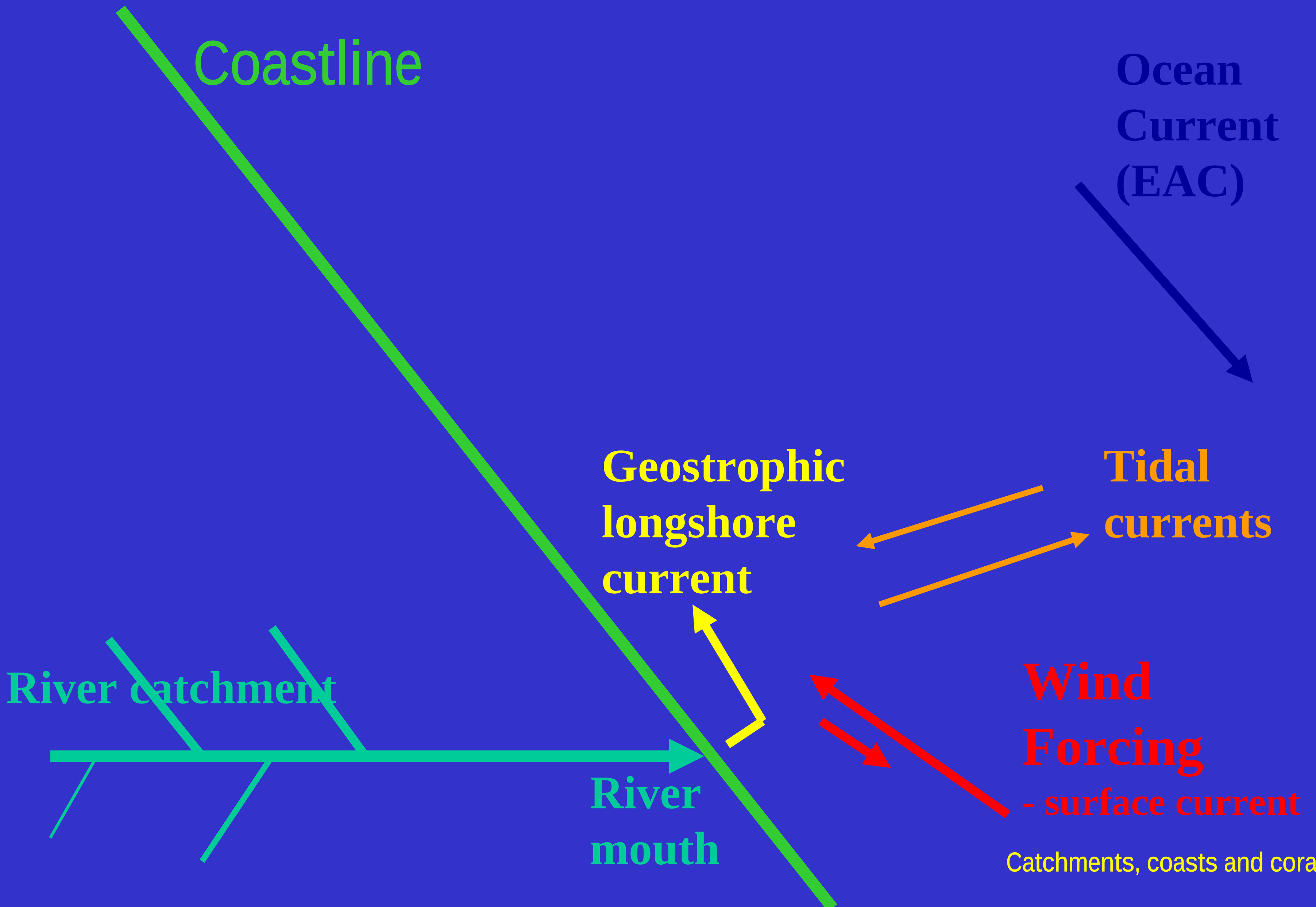


Source: Neil & Yu, 1996

Fate of the Sediments

- River plume / Sediment plume movement
- Freshwater – low density, buoyant – ‘floats’
- Nutrients adsorbed to sediments and in solution
- Sediment settling influenced by:
  - particle size → lithology
  - flocculation
- Plume movement influenced by:
  - Coriolis effect / geostrophic longshore current
  - wind (speed and direction)
  - tidal currents
  - ocean currents

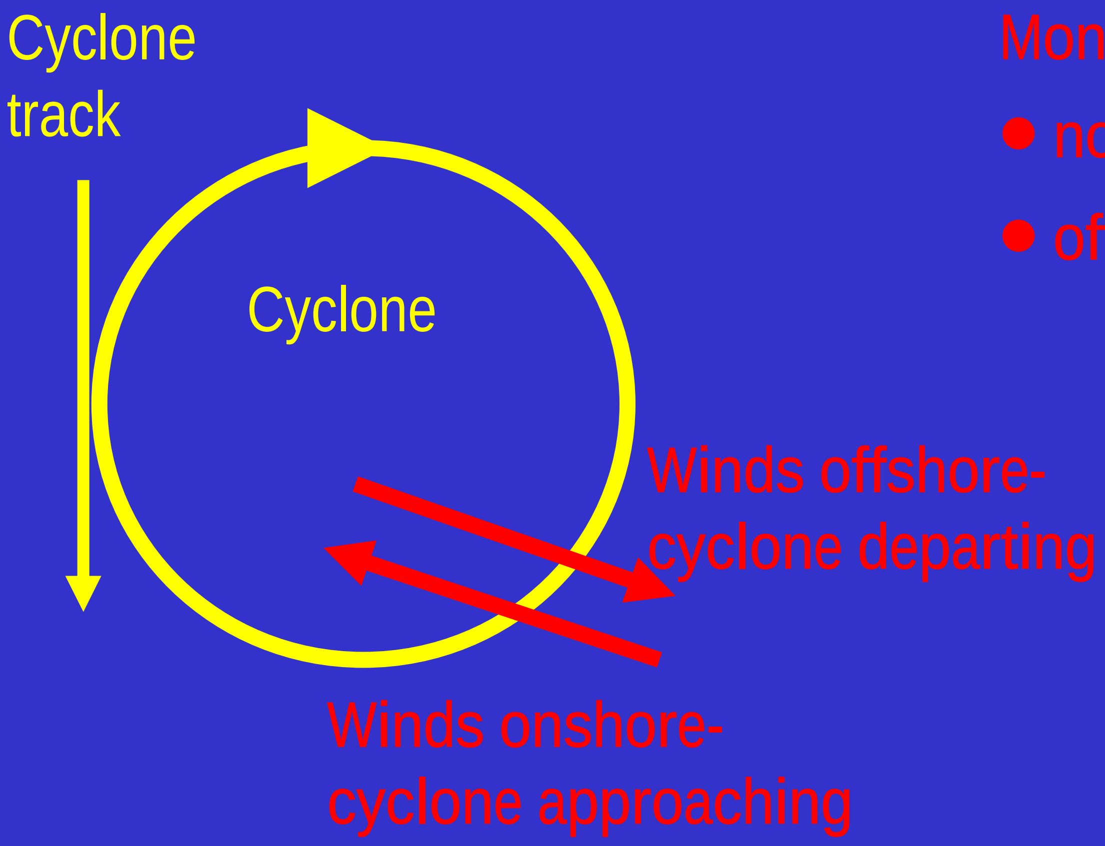
Fate of the Sediments - processes



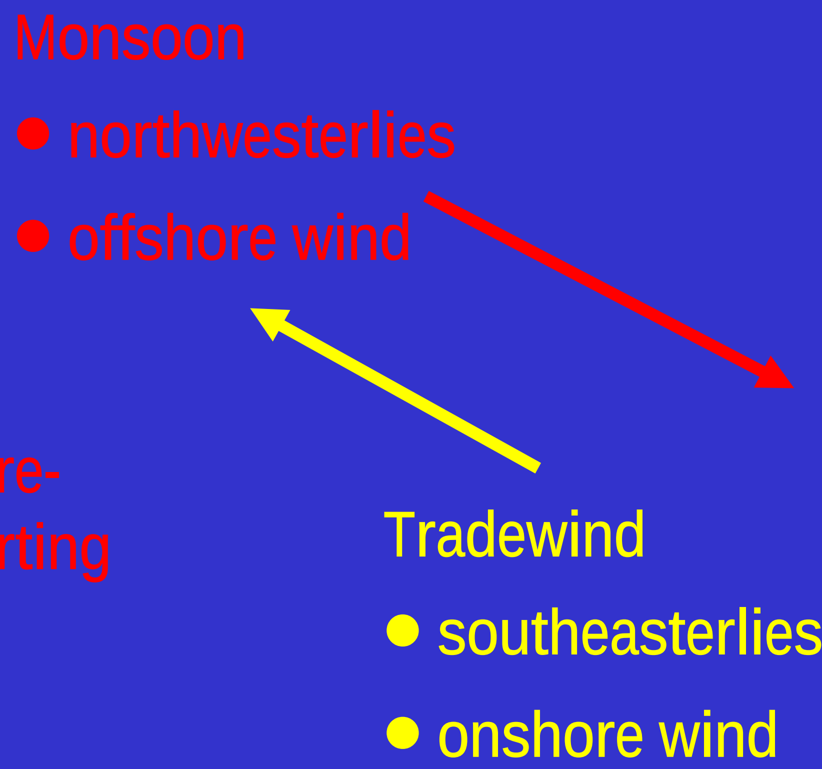
Fate of the Sediments – wind forcing

Wind forcing – variations to ‘prevailing’ (southeasterly) winds:

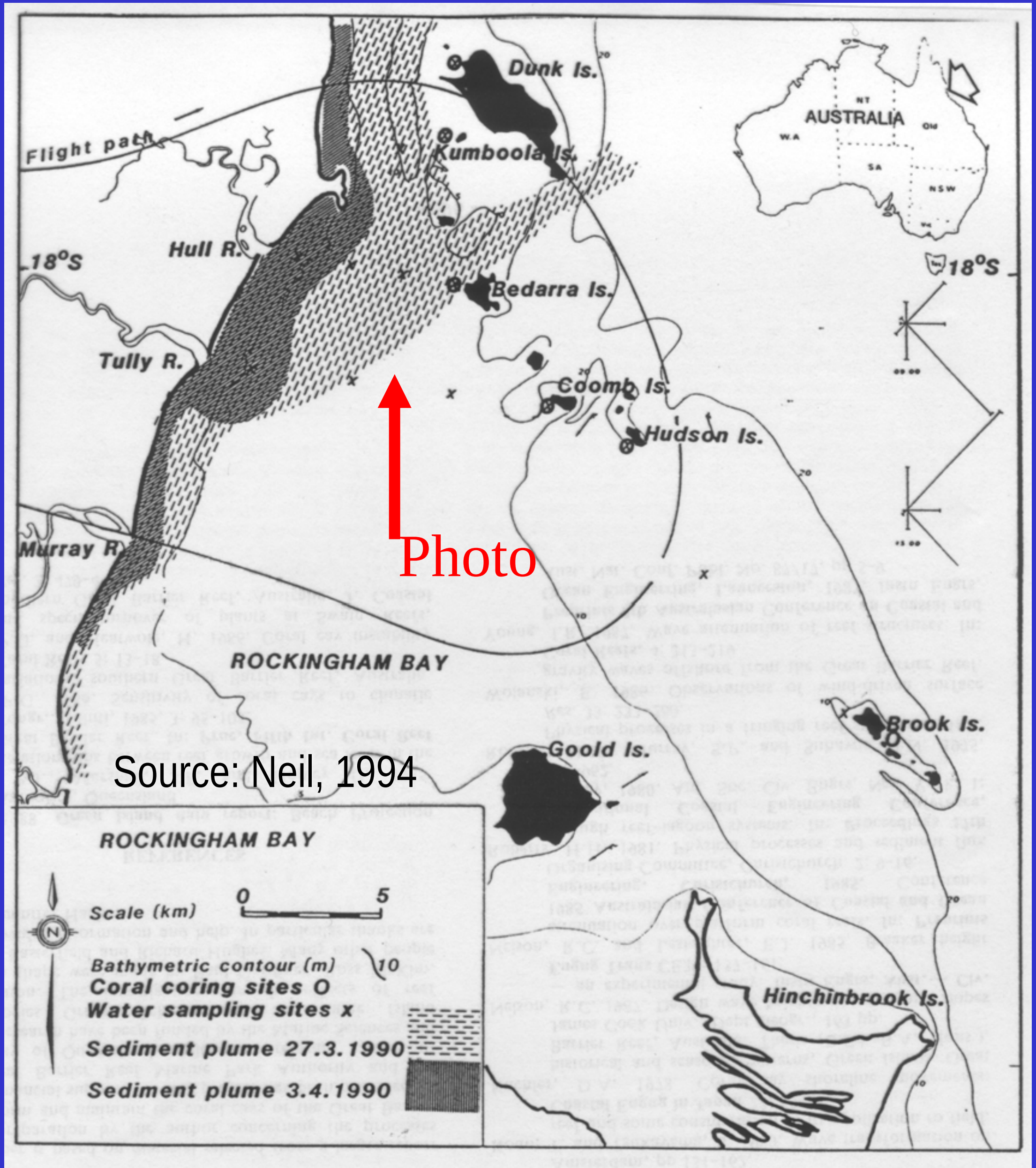
Case 1



Case 2



Fate of the Sediments – Tully R example



- Cyclone Ivor; Tully River; March-April, 1990

- March 27th – about the peak of the flood

Fate of the Sediments – Tully R example

- Cyclone Ivor; Tully River; March-April, 1990
- March 27th

Fate of the Sediments – lithology

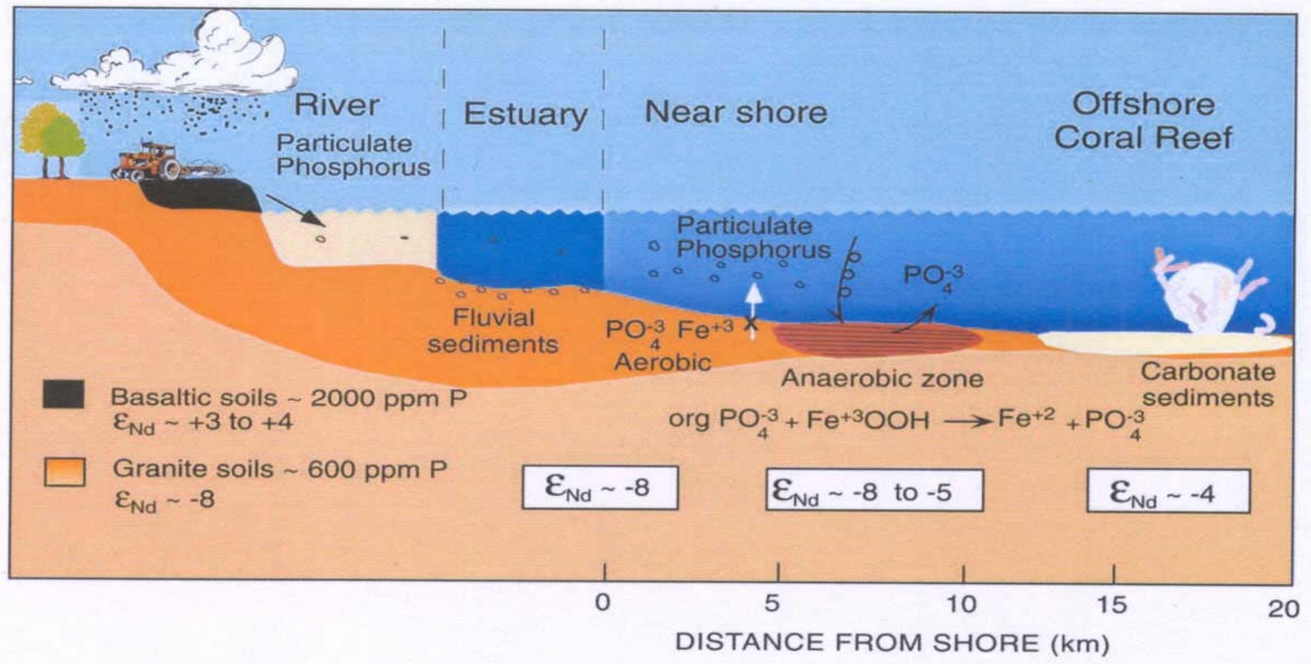


Fig. 5. Schematic diagram showing the transport of suspended sediments and P predominantly as particulate form into the GBR lagoon. The release of P probably occurs as a consequence of iron reduction in anaerobic zones in the sea-floor environment [27–29]. In the carbonate-rich sediments adjacent to the coral reefs, the Nd isotopic constraints indicate that ~40% of the terrigenous sediment is derived from basalt soils. This implies that >80% of terrestrial P entering the GBR is possibly derived from erosion of basaltic soils.

- Granite-derived inshore; basalt-derived offshore
- Basalts have high nutrient concentrations
- c. 80% of P in GBR from erosion of basalt soils (??)

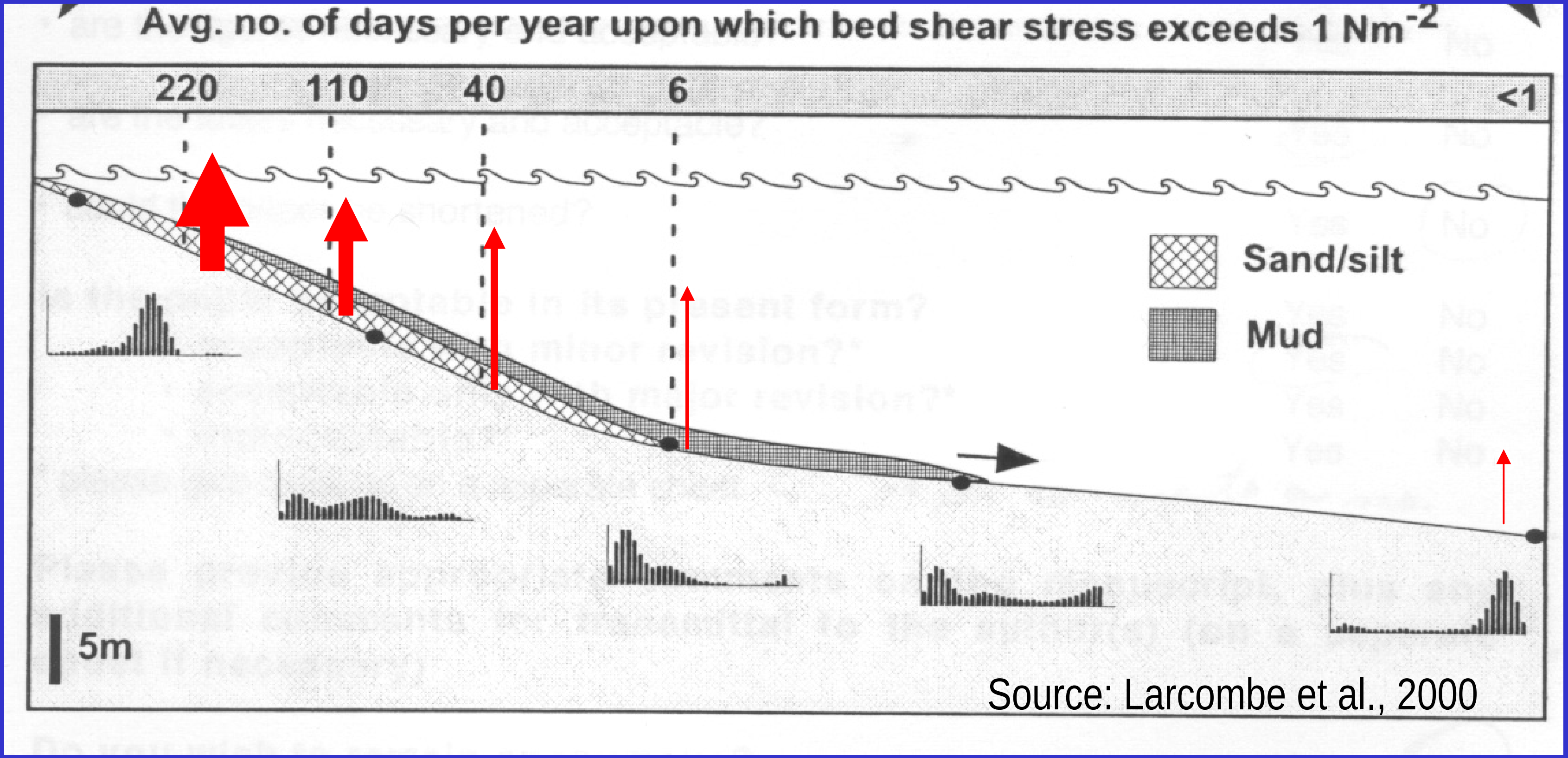
Non-fluvial Sources of Suspended Sediment

- Bottom sediment resuspension by
WAVE ACTION
- sediment concentration increases as wind speed increases
- distance offshore of resuspension increases as wind speed increases
- distance offshore of resuspension increases with lower seabed slope, ie shallow water further offshore

Non-fluvial Sources of Suspended Sediment

- Bottom sediment resuspension by

WAVE ACTION



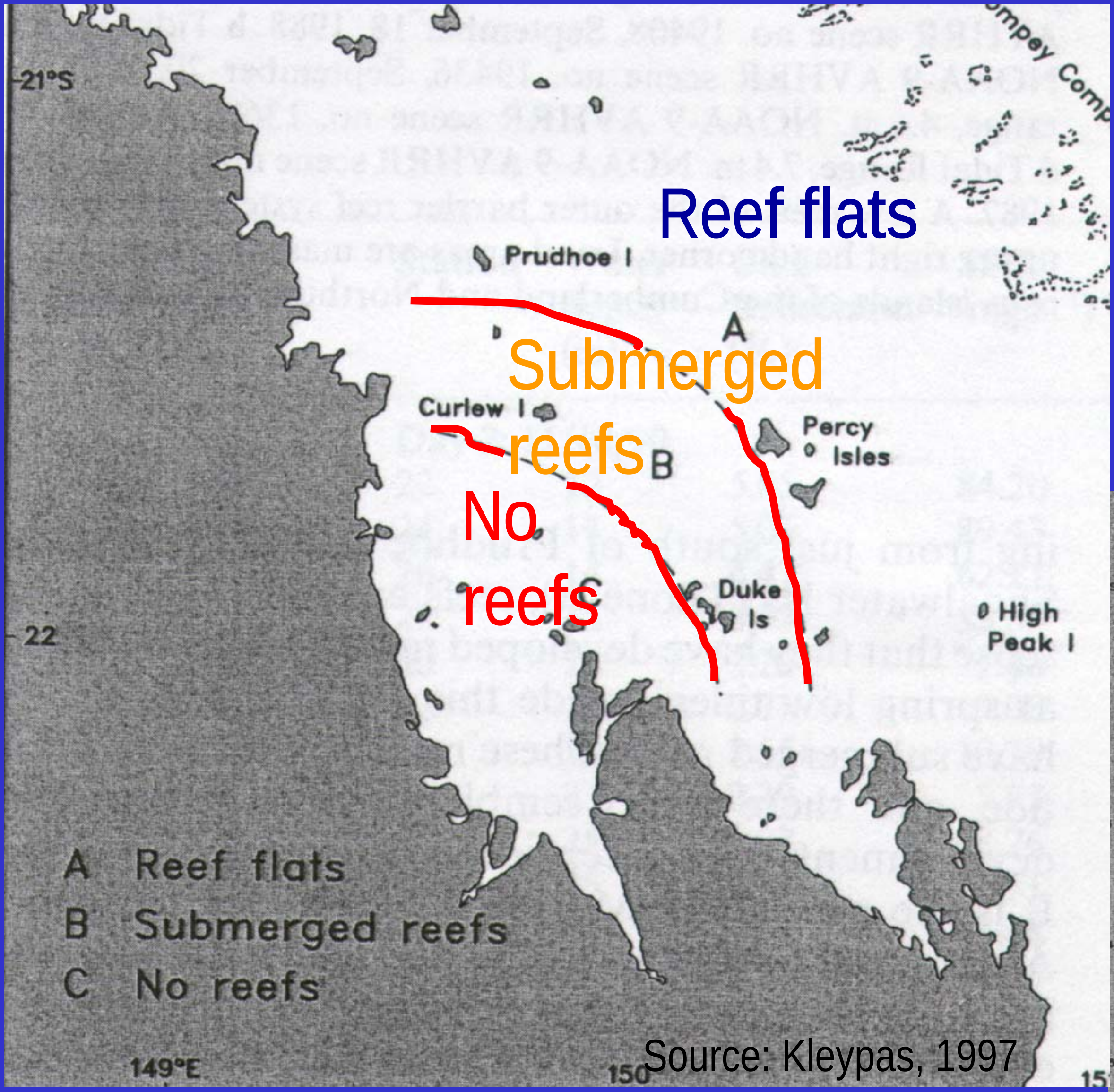
Non-fluvial Sources of Suspended Sediment

- Bottom sediment resuspension by

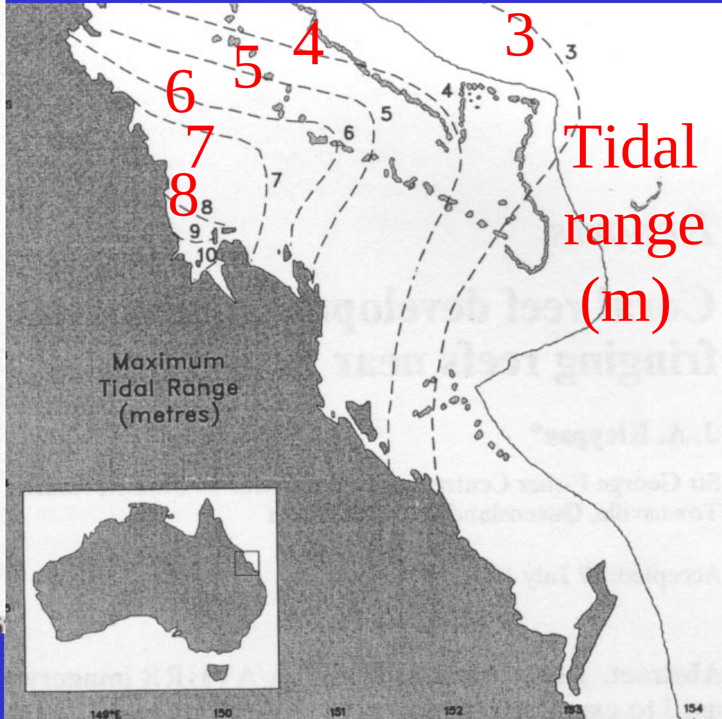
TIDAL CURRENTS

- In areas of high tidal range where tidal current velocities are high
- Restricted to area around Broad Sound
- Gradient in tidal range / current velocity →
  gradient in water turbidity →
  Gradient in coral community composition & structure

Non-fluvial Sources of Suspended Sediment



- Bottom sediment resuspension by TIDAL CURRENTS
- Reef distribution near Broad sound



Measuring sediment input

Nearshore sedimentation rates – land use effect apparently undetectable

Record in coral skeletons – coral drilling

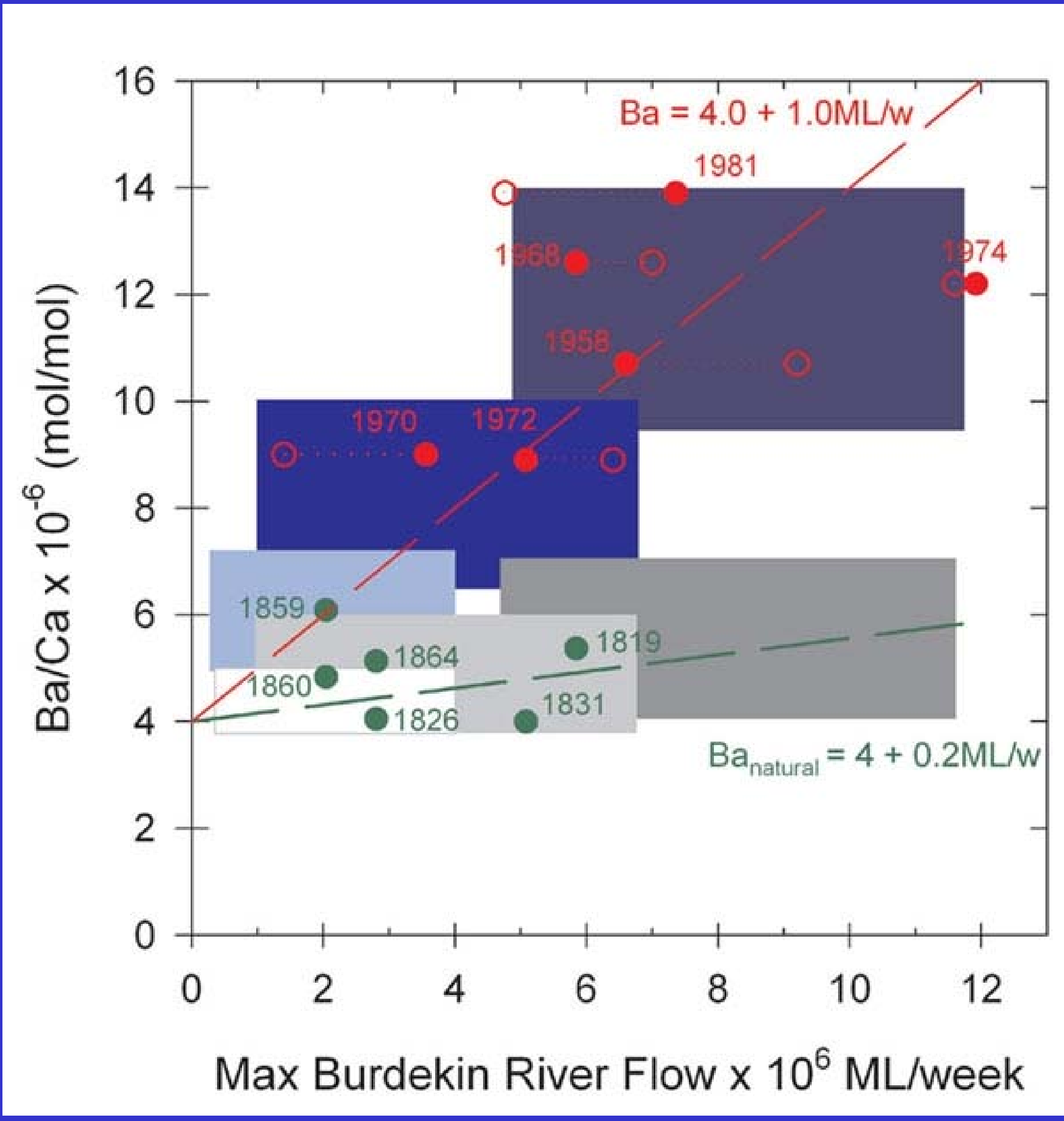
Photos: D.Neil.

Measuring sediment input

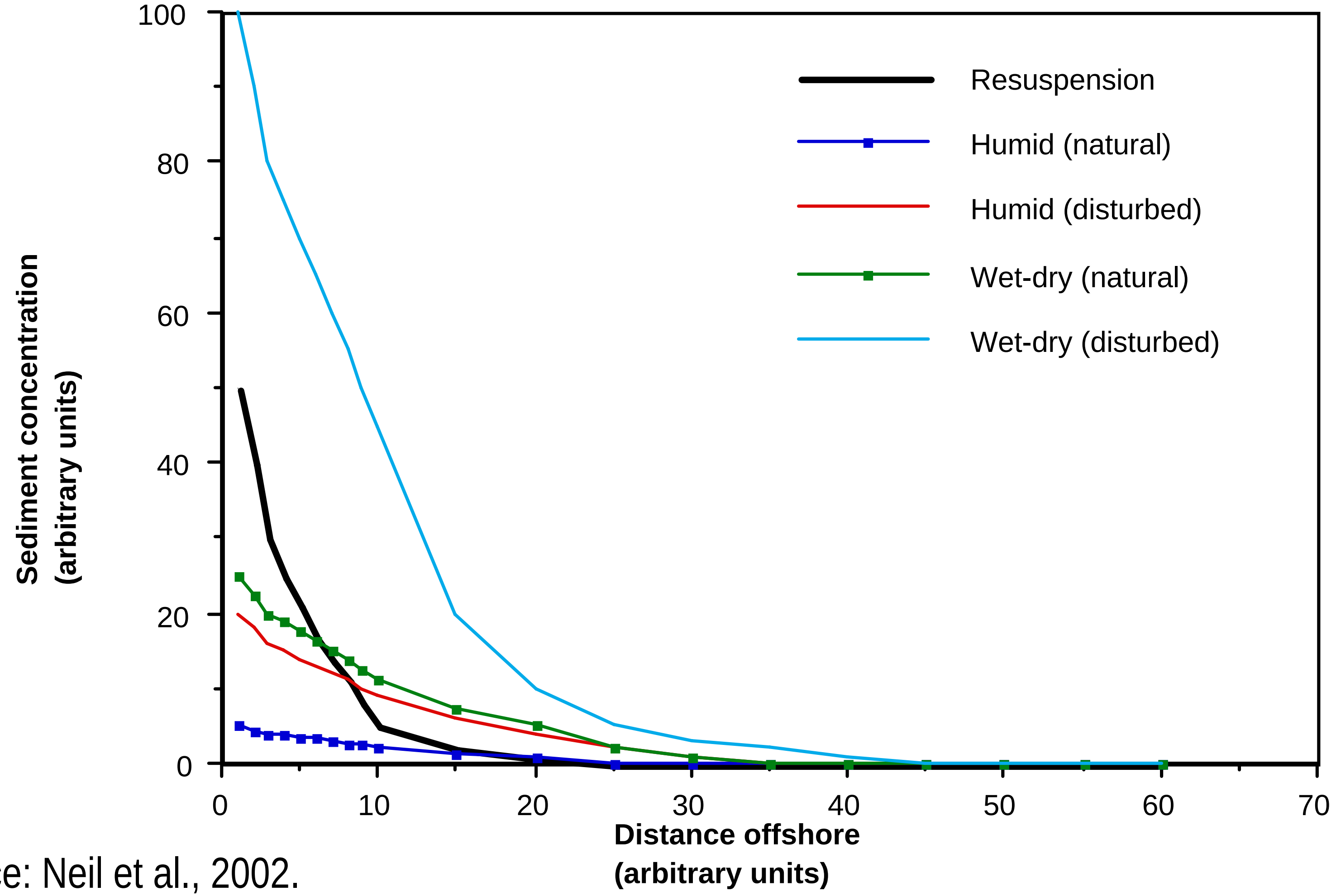
- Ba:Ca ratio in coral skeleton as:

  i. tracer of sediment input to GBR lagoon;

  ii. Indicator of effect of land use change



The Implications - 1

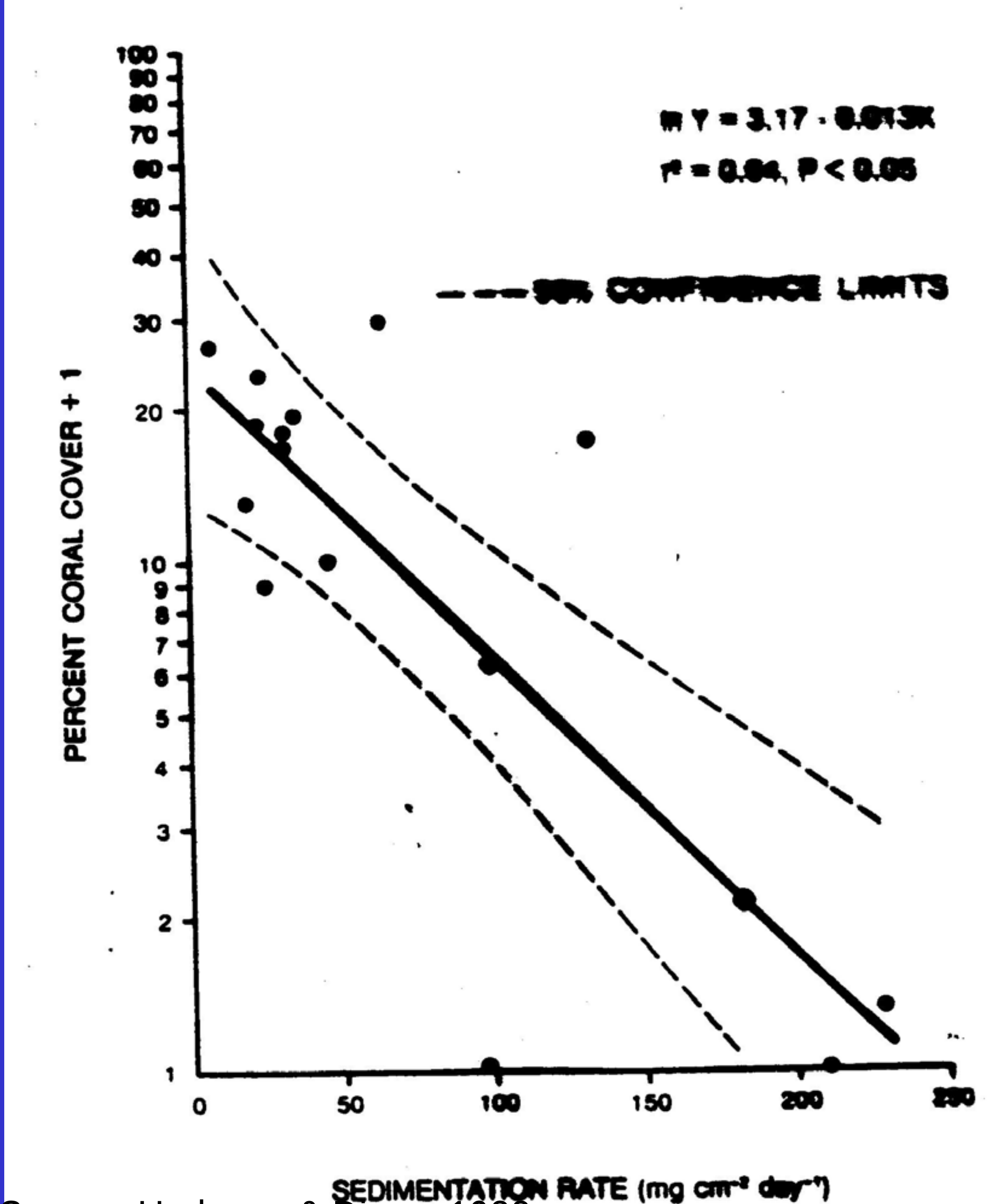


Source: Neil et al., 2002.

The Implications - 2

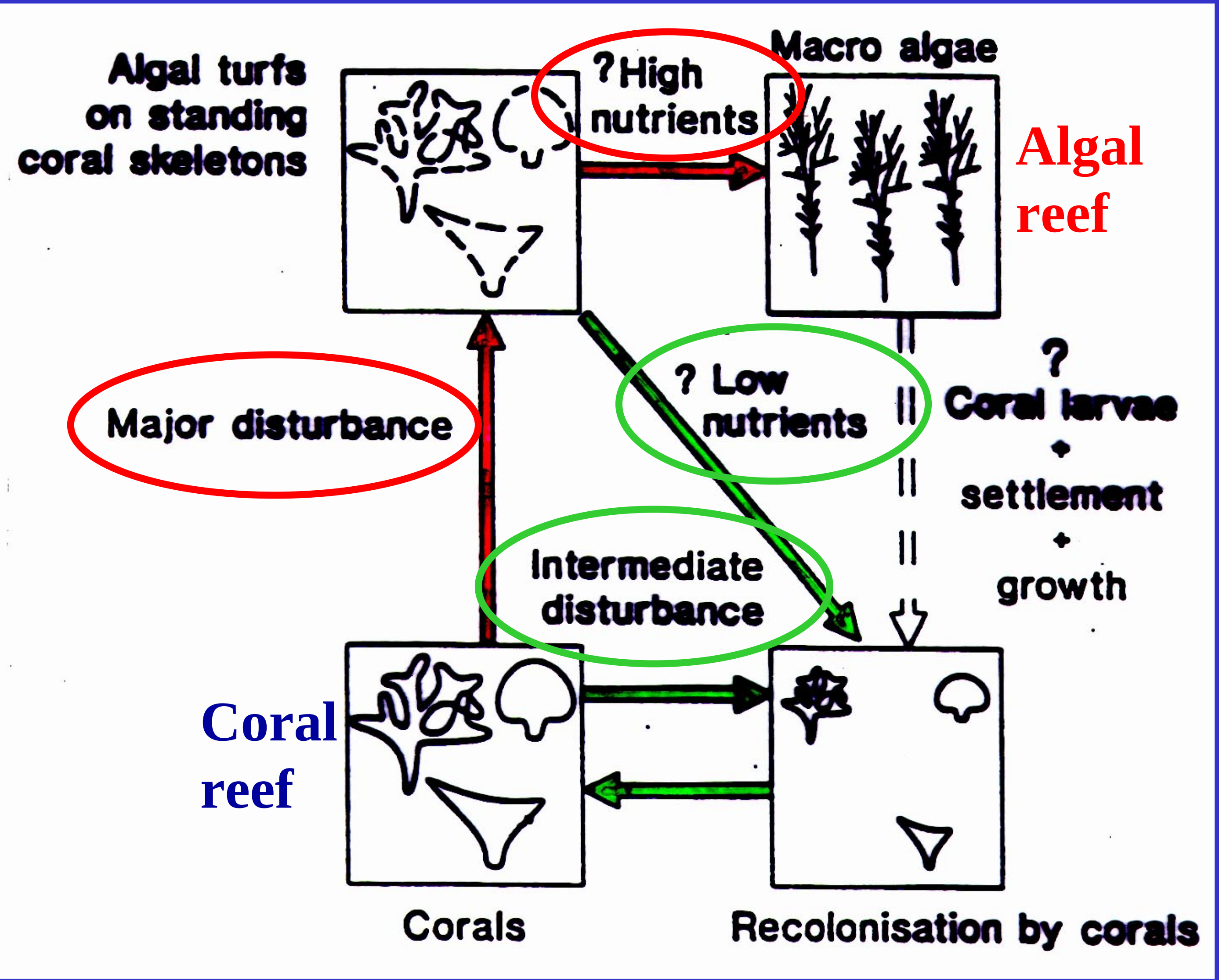
- Increased sedimentation rates reduce coral cover

  - if background (wave resuspension) concentrations are exceeded



Source: Hodgson & Dixon, 1988

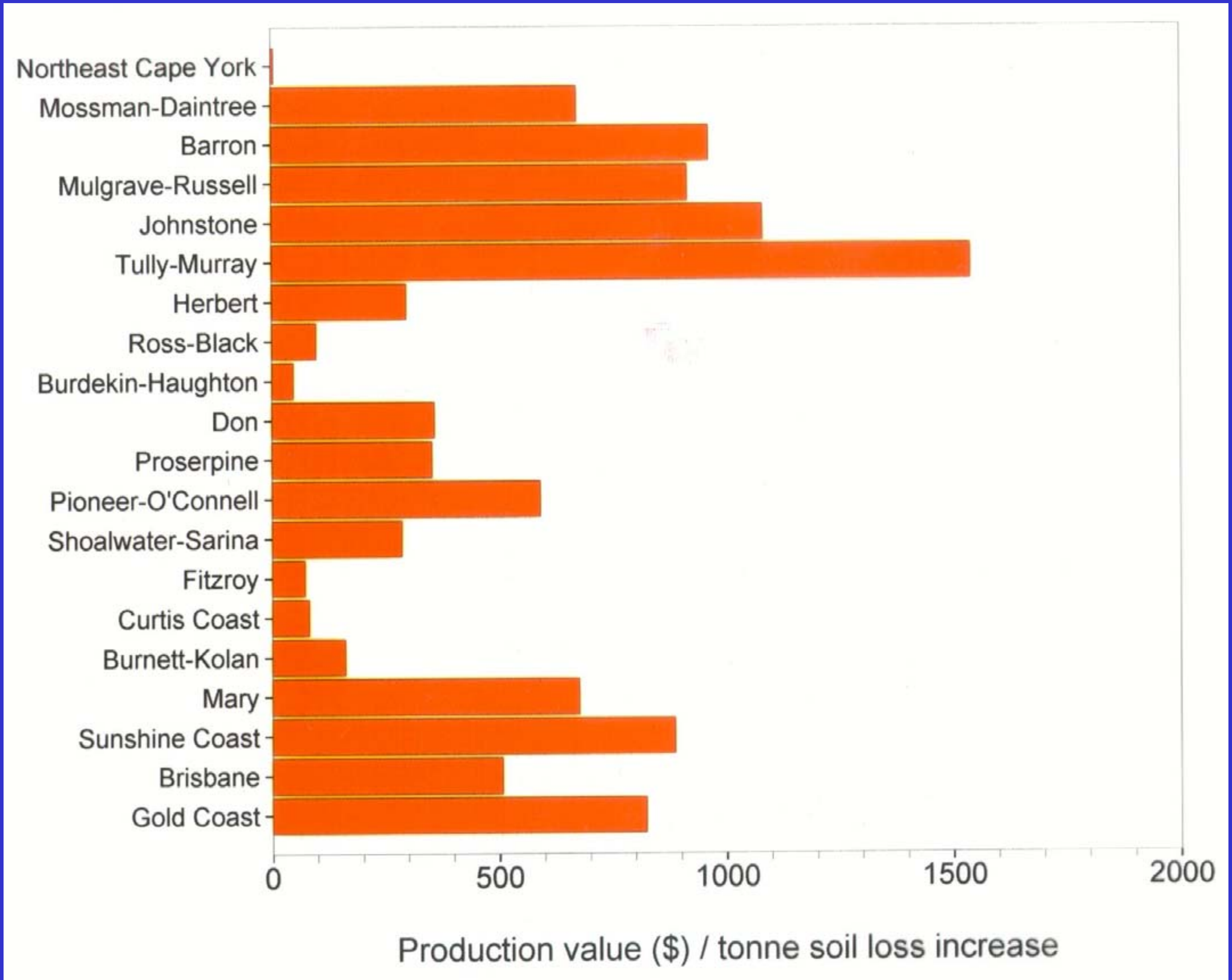
The Implications - 3



- Done's phase shift model for nutrient impacts

Source: Done, ?

The Implications - 4



Source: Neil & Yu, 1996

- Agricultural production value ($) per tonne of increased soil loss –
- c. 1991 data

The Implications - 5

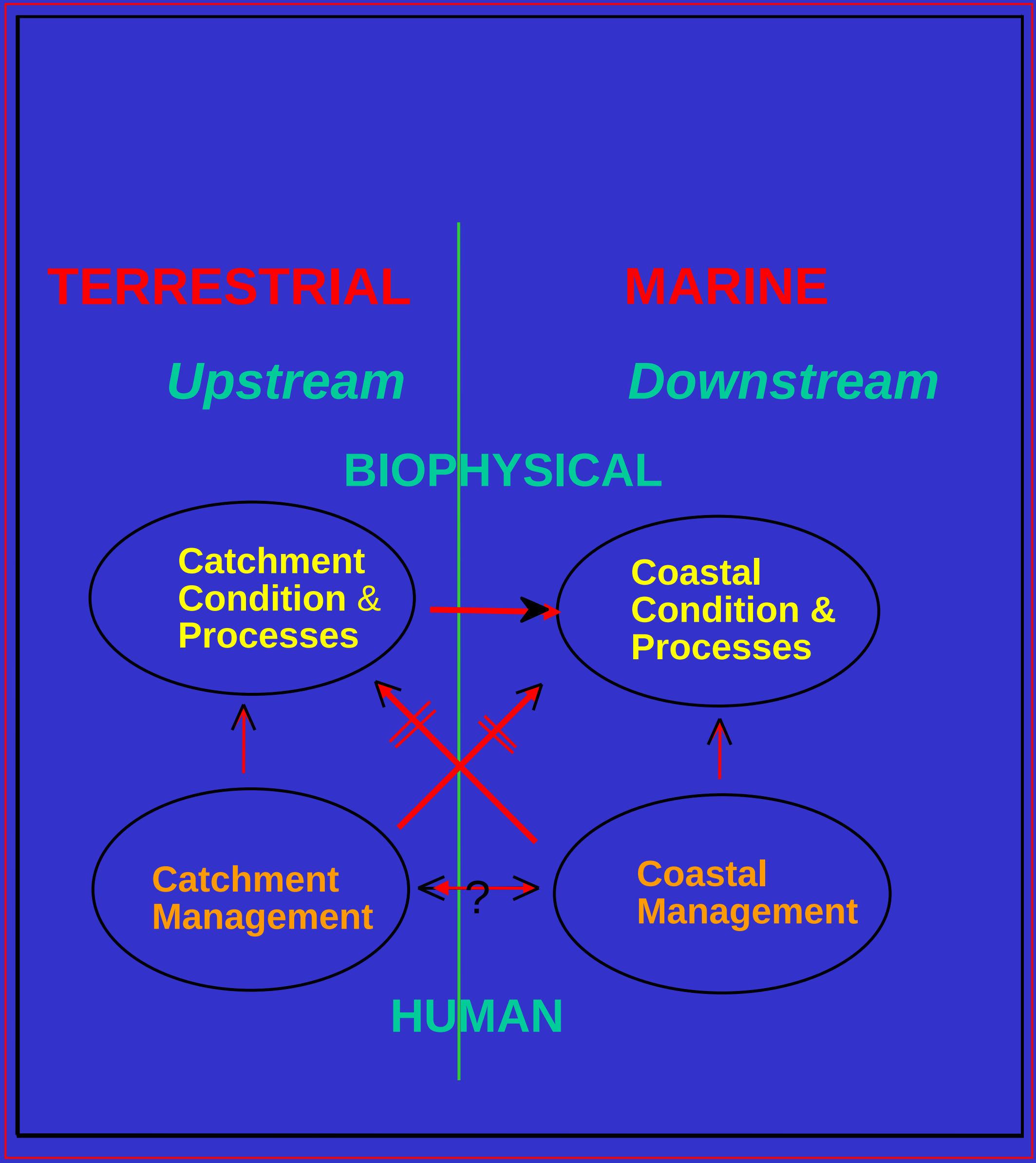
Logging, fisheries, tourism in Palawan

- Model output

	(with logging) $M	(NO logging) $M	
Tourism	8.2	47.4	
Fisheries	12.8	28.1	
Logging	12.9	0	
Total	33.9	75.5	(+41.6)

Source: Hodgson & Dixon, 1988

The Implications - 6



- Assymetry in management
- "Upstream-downstream" environmental management dilemma
- Still poorly recognised in CZM implementation

The End