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Modelling: does it have a role in nutrient management?

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Outline

- **Some modelling philosophy**
  - What is a model
  - Some examples of models in nutrient management
  - The ‘cost’ of complexity
  - What is sensible to model

- **Model applications in nutrient management**
  - Exploring N fertiliser management strategies
  - Exploring crop-inputs from organic N sources
  - Evaluating water quality under different management regimes
  - Assessing management impacts on N_2O emissions

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Some modelling philosophy...

- **...a model is anything used in any way to represent anything else. ...models...are represented by concepts...which are formed after a conceptualization process in the mind...**
  - *Wikipedia, the free encyclopaedia*
- **Models about the world v. models of the world**
  - *Brian Keating (1996)*
- **Models are simplifications of the world. If they were complex as the world they would take 'real time' to run and so cease to be useful.**
  - *Calvin Rose (1986)*
- **"...(all) models are wrong, but some are useful..."**
  - *George E P Box (1971)*

Some models in nutrient management...

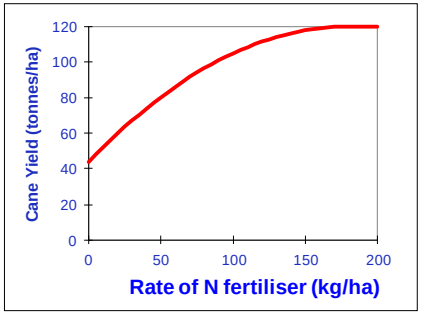
Simple models

- **To maximise yield, always...**
  - Apply 160 kg N/ha
  - Apply 160 kg N/ha to Soil 1
    140 kg N/ha to Soil 2
  - Apply 160 kg N/ha to Soil 1
    140 kg N/ha to Soil 2
    Except after a legume,
    then reduce by...

A rugby analogy:
The Springboks always win
The Wallabies always lose

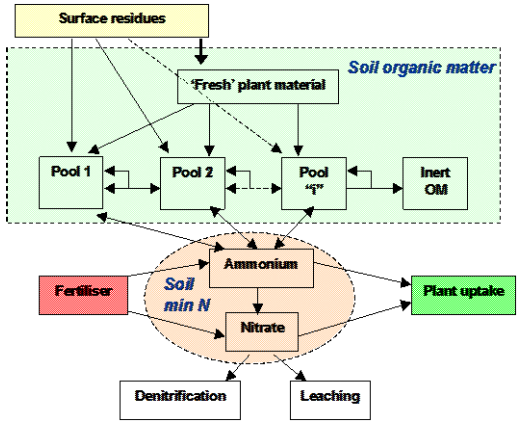
More complex models

Response curves:
Polynomial, Mitscherlisch, hyperbolic, etc.
Issue: Many dependencies



after Keating et al (1994)

Mechanistic daily time step C & N:
e.g. APSIM-SoilN, DayCent etc.

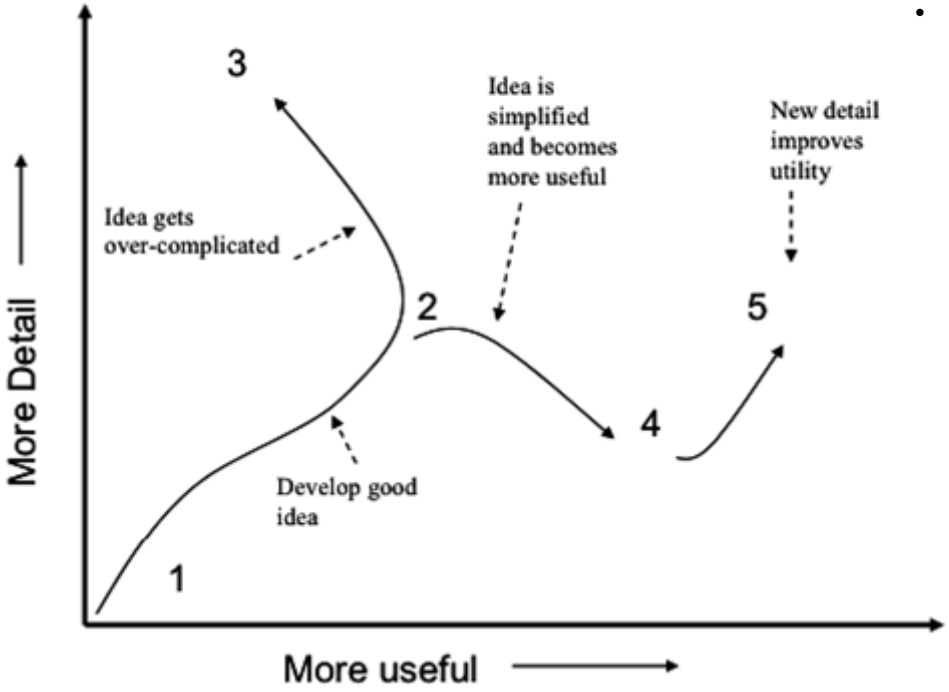


Thorburn et al (2005)

Model complexity – ‘power’ at a cost

- **Simple models**
  - Generally static
    - No consideration of time dimension
  - Constant conditions
    - Production potential
    - Underlying process

- **More complex models**
  - Generally dynamical systems models, capturing
  - Climate variability
    - Seasons are different
    - Climate deviates from average, etc
  - Soil processes
    - Structure declines, improves
    - Organic matter runs down, builds up
    - Some process are mediates by temperature and moisture



Stirzaker et al. (2010, Fig 5)

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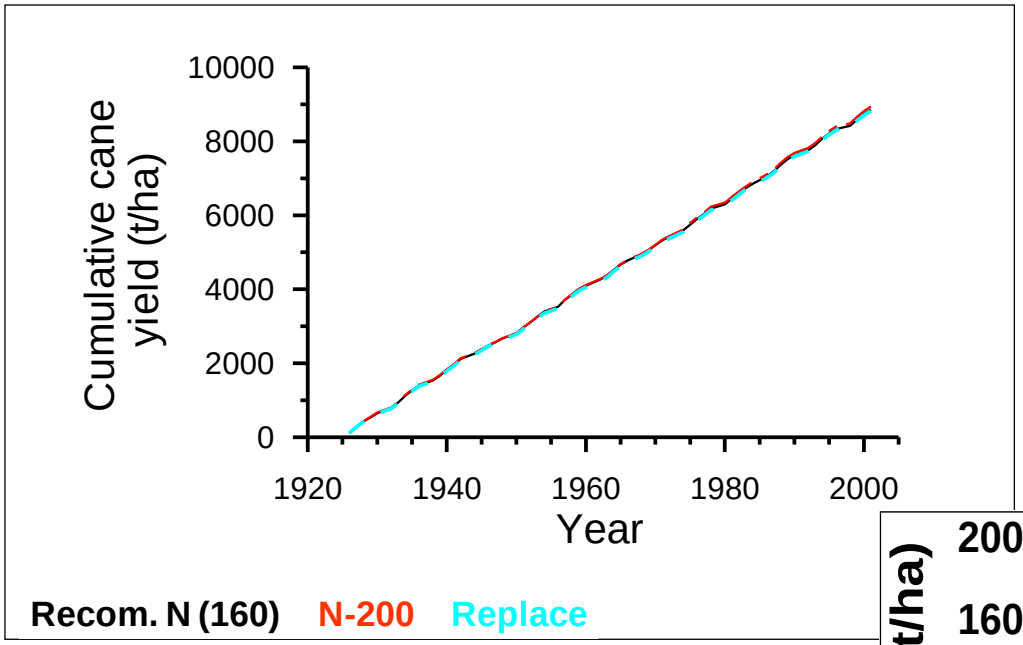
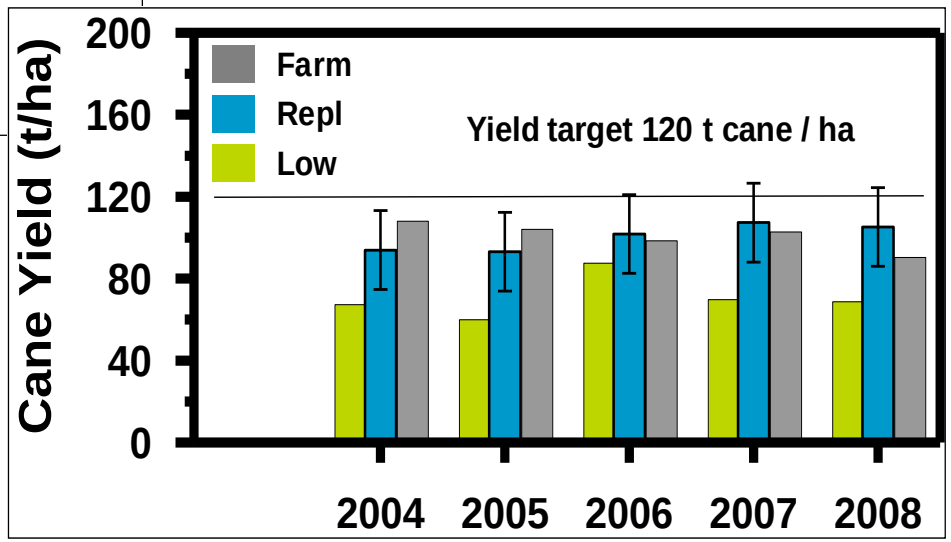
Exploring/developing concepts in N fertiliser management recommendations

Predicted performance of 'N Replacement' system
(Thorburn et al., 2003, 2004)

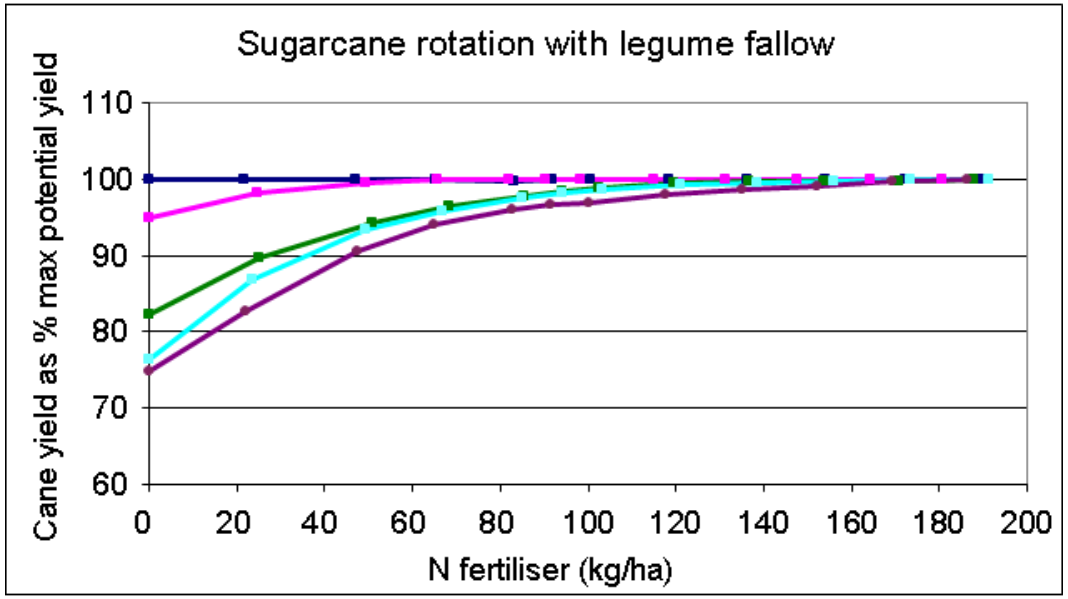


Actual performance of 'N Replacement' system *(Thorburn et al., 2011)*

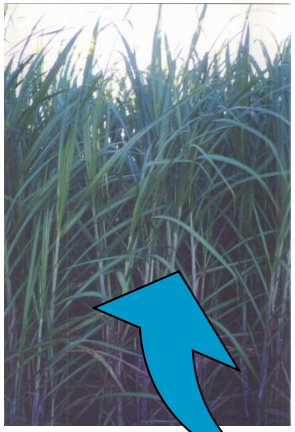


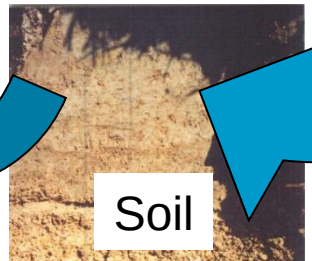
Availability of N following soybean crops:
Can we reduce N fertiliser applications?

Park et al. (2010)



Crop	Predicted reduction in N fert applied for optimum yield (%)
Plant	100
Ratoons	Up to 40



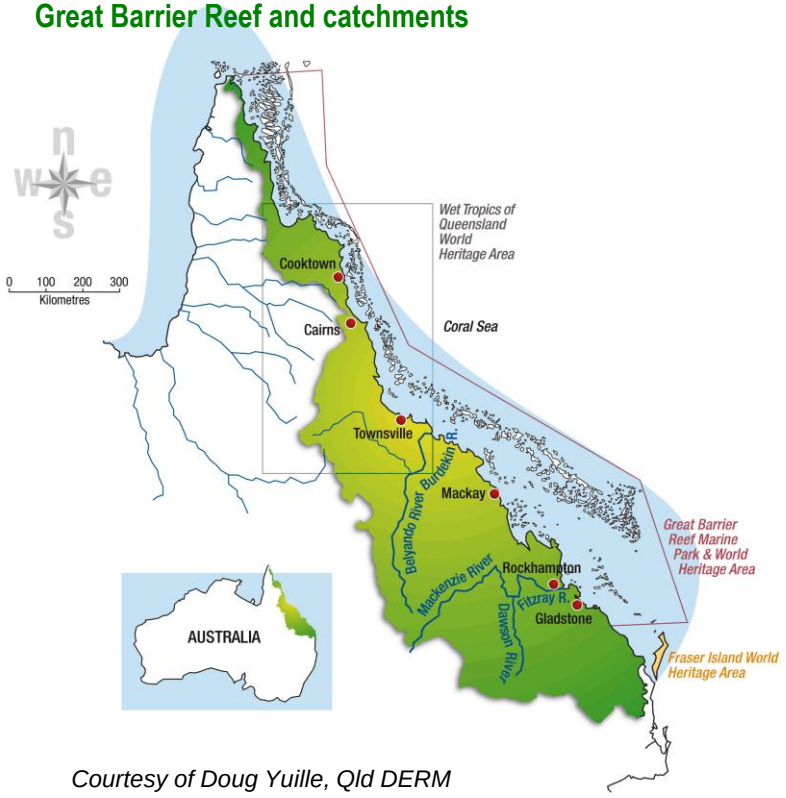


Evaluating effects of different management strategies on water quality and production

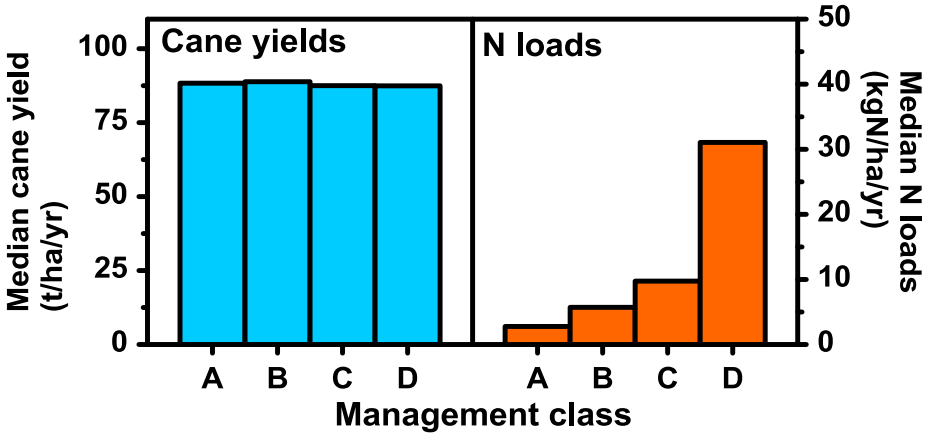
Water quality issues driven over concerns about GBR health

- Federally funded incentives to move from D- and C-Class management
- Sugarcane management now regulated in three main catchments

Great Barrier Reef and catchments



Courtesy of Doug Yuille, Qld DERM



N losses through runoff and leaching under four managements: Mackay loam *(Biggs et al, 2011)*

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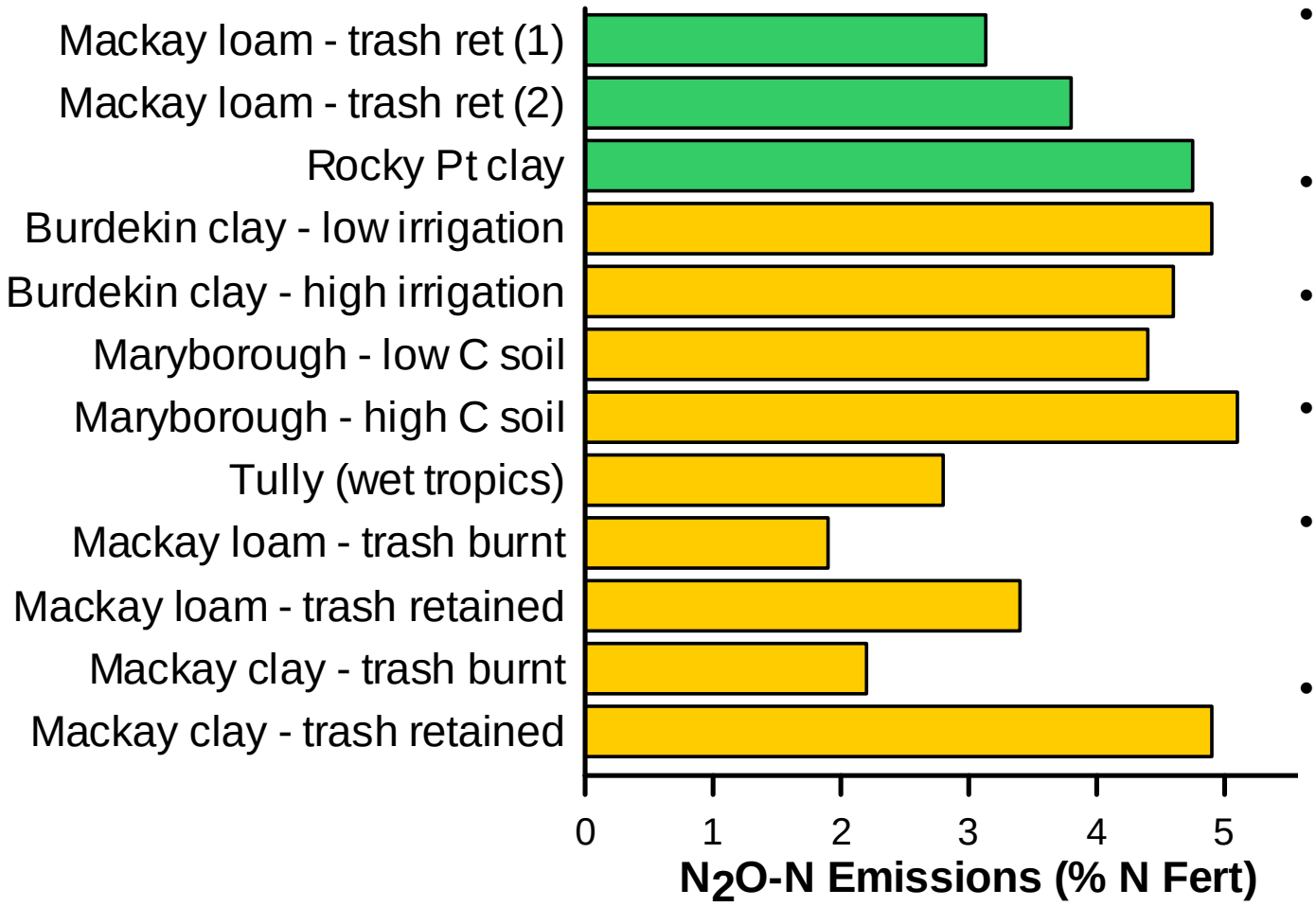
Exploring N_2O emissions in different cane production systems *(Green bars measured data)*



- Simulation *v.* measurement
  - Good (as expected)
- Impact of irrigation
  - Small
- Impact of soil carbon
  - Small
- Impact of trash
  - Big
- Impact of soil type
  - Moderate
  - Only with trash
- Impact of climate x management
  - Substantial

Thorburn et al. (2010 a,b)

Conclusions *(for sugarcane production)*

- **Nutrient management revolves around models**
  - Complexity differentiates models
- **Sensible to model nutrients at process level where...**
  - Processes/availability environmentally controlled
  - Complex, non-linear feedbacks
  - Competing objectives
- **Models for N cycling in soil-plant system well advanced**
- **Aid understanding of complex problems**
  - Organic inputs
  - Environmental loss problems

- **Models under-utilised to explore optimum management**

- ***"...(all) models are wrong, but some are useful..."***

What is sensible to model?

N

- **Important nutrient**
- **Competing economic and environmental goals**
- **Biology dominates availability**
  - Environmentally controlled
- **Non-linear interactions**
- **Dynamic process**

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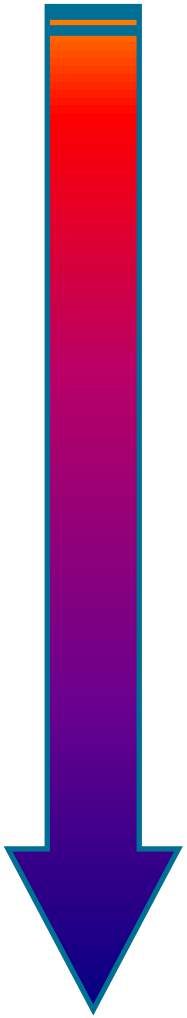
Cations & anions

Micro nutrients

- **Physical processes dominate**
- **Well sorbed**
- **Small environmental impacts**



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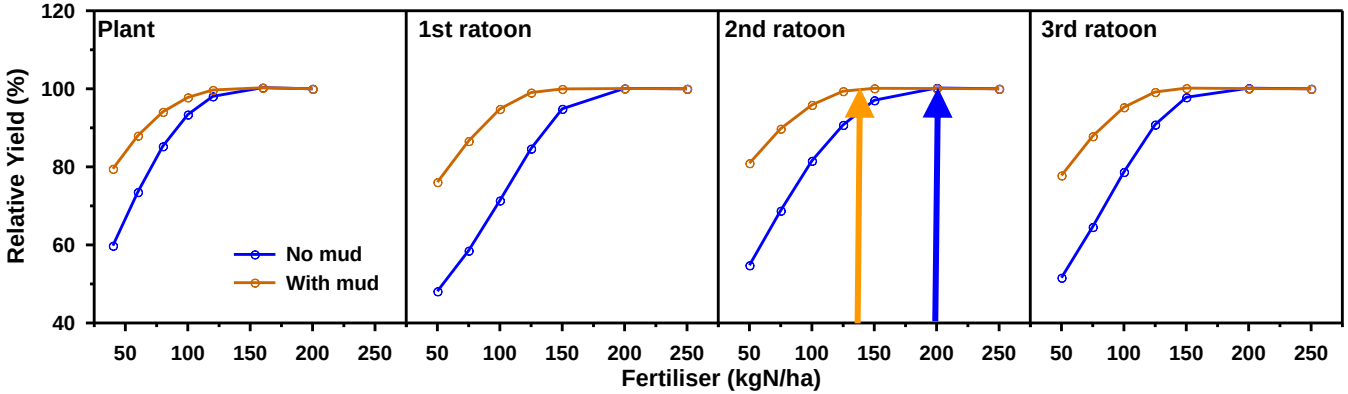
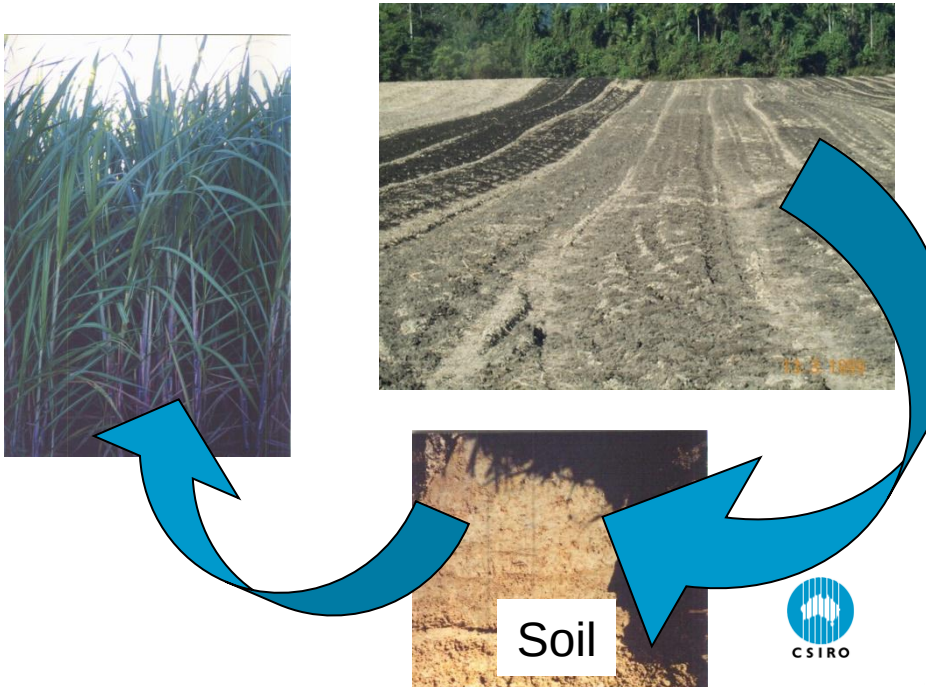
Availability of N following filter mud:
Can we reduce N fertiliser applications?

Thorburn et al (2008, in prep)

Burdekin example

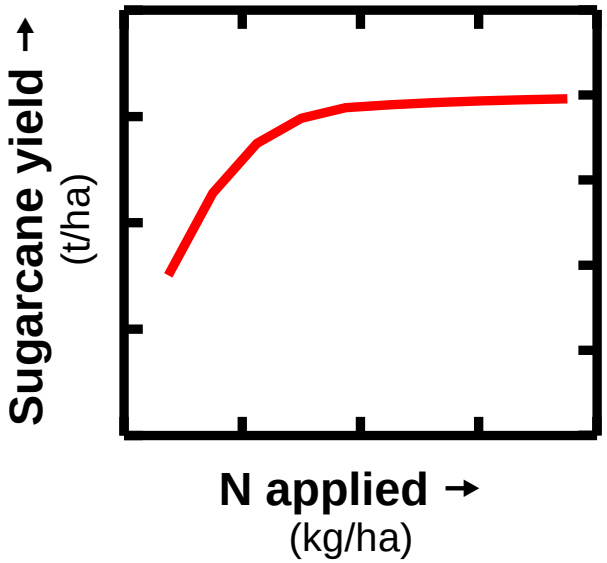


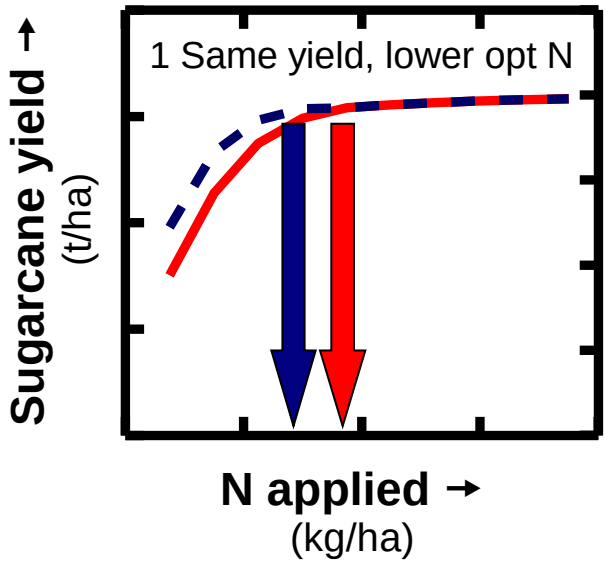
- **Yield optimum predicted to occur at lower N with filter mud**
- **Similar results across wide range of environments**
- **At predicted optima, only approx half N in filter mud 'recovered' by crops**

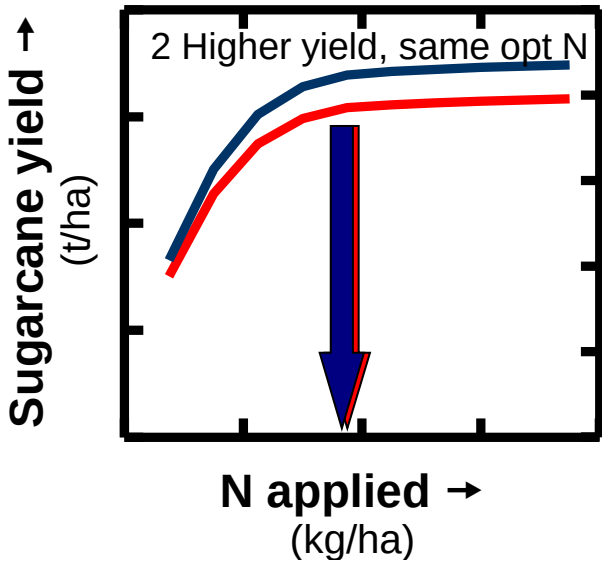


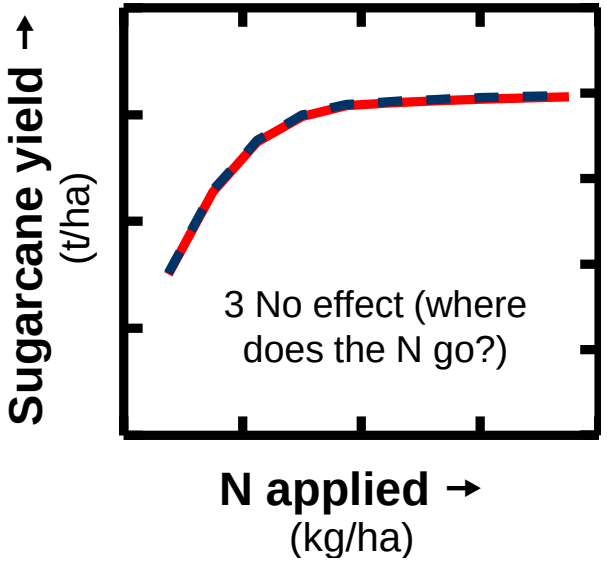
How could trash retention affect N responses? *Three possibilities...*

Legend:
Residue
Burnt
Retained

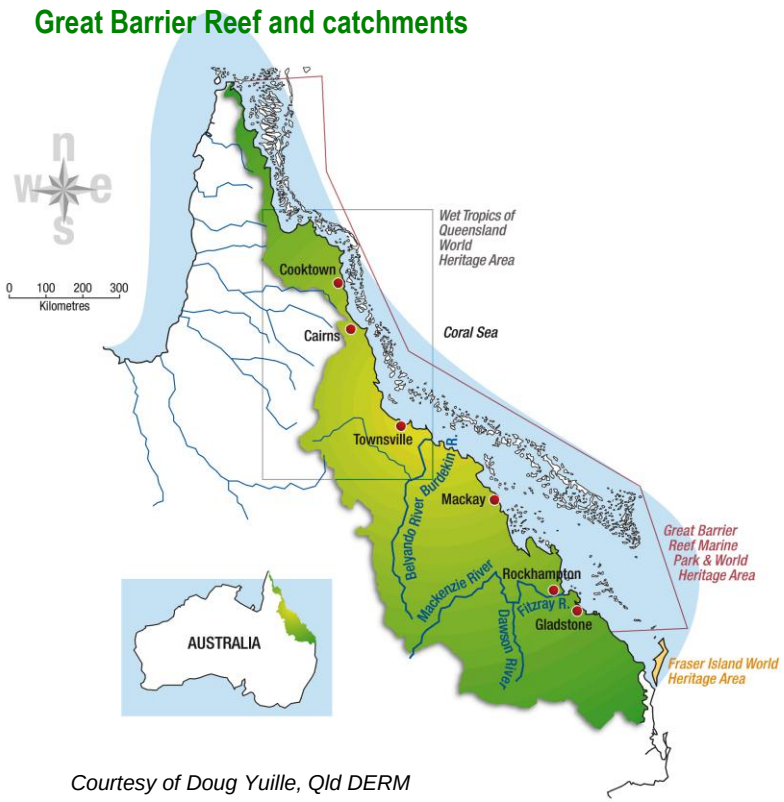








Evaluating effects of different management strategies on production and water quality



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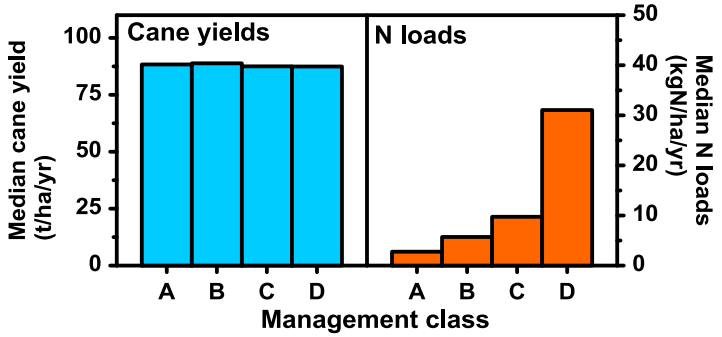

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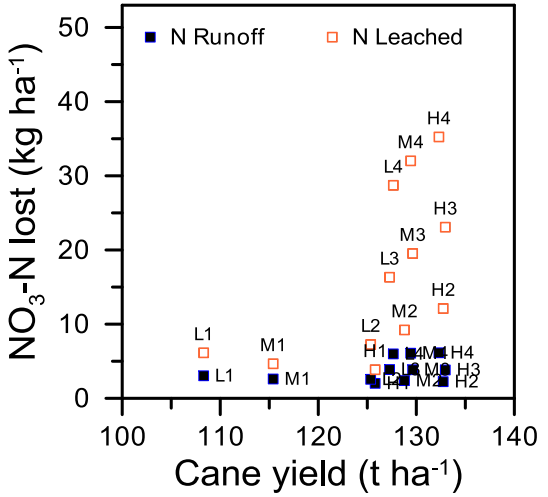

N losses and yields under 12 different managements (L, M H x 1, 2, 3, 4): Burdekin (*Thorburn et al, 2011*)