Paddock and catchment modelling

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Overview

Paddock models
- Background
- Model updates
- Future plans

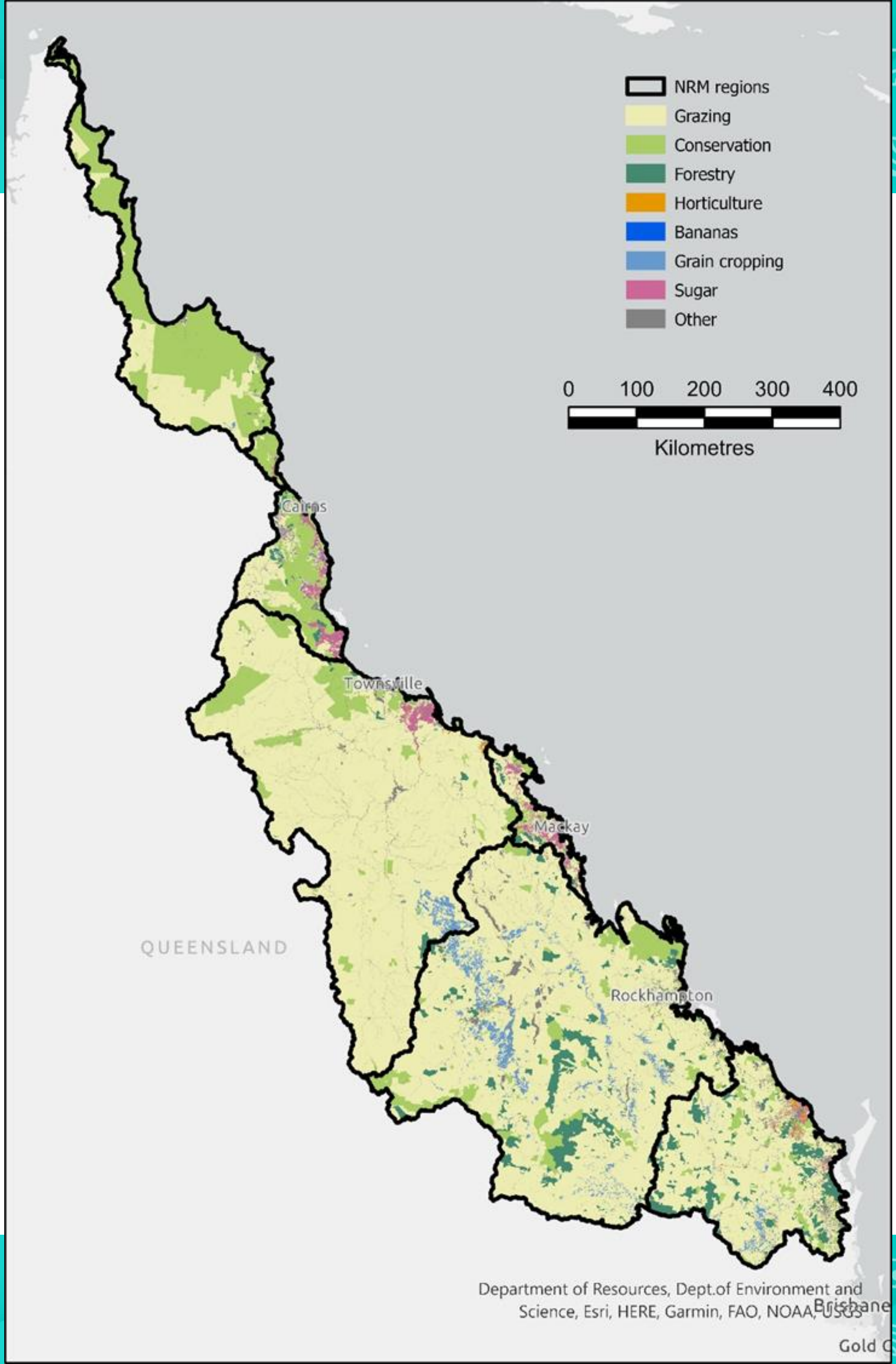
Catchment models
- Background
- Model updates
- Future plans

Cropping in the GBR

GBR catchments = 42M Ha

Grazing = 30M Ha (71%)

Cropping and horticulture	Hectares
Grain cropping	900,000 (2.0%)
Sugarcane	500,000 (1.2%)
Bananas	14,000 (0.03%)
Other horticulture	80,000 (0.2%)



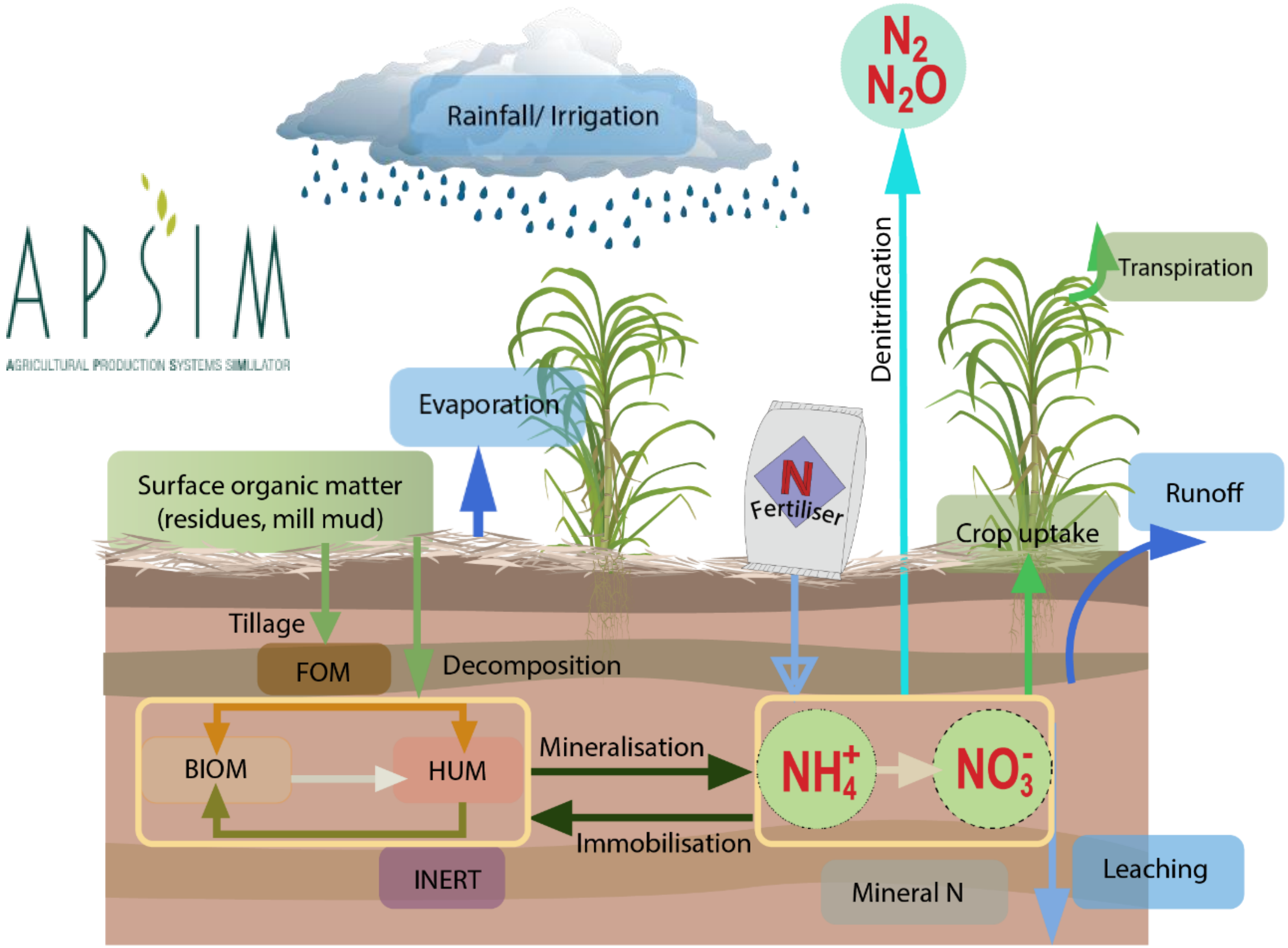
Sugarcane paddock model

Daily time-step

Represents key processes:

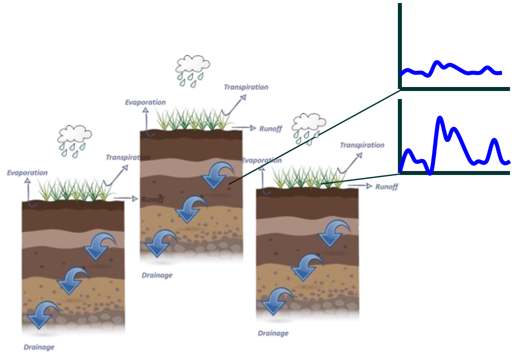
- Water balance
- Carbon & nitrogen dynamics
- Crop growth
- Crop N & water use

Predicts DIN losses

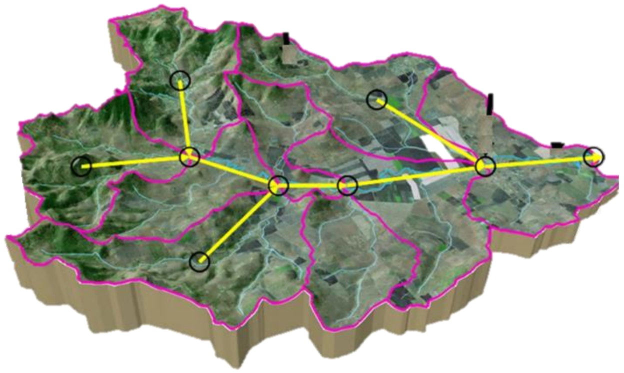


Two modelling pathways

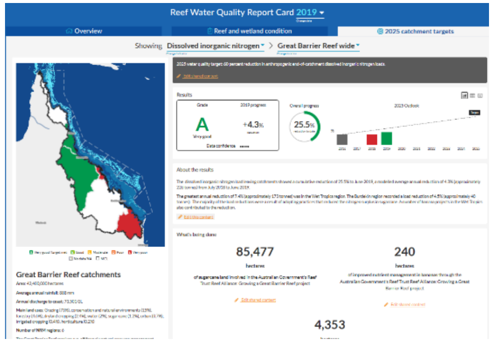
Paddock models



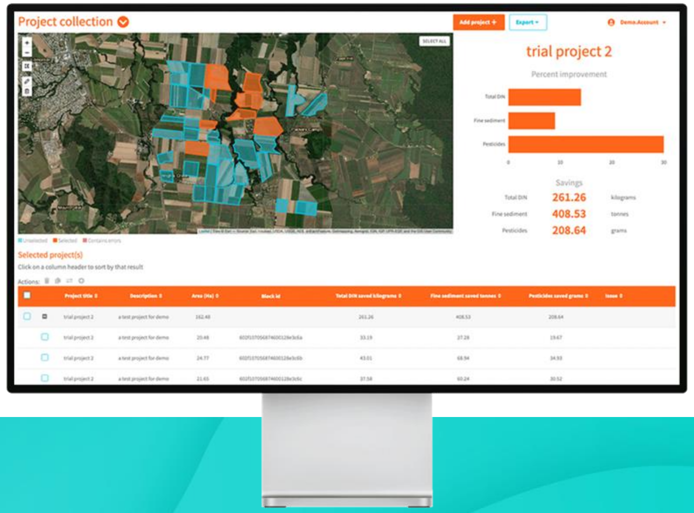
Catchment models



Reef Report Cards



P2R Projector Tool



Investment decision making

Soil maps

Old: soils defined by CSIRO based on well-studied sites, extrapolated broadly

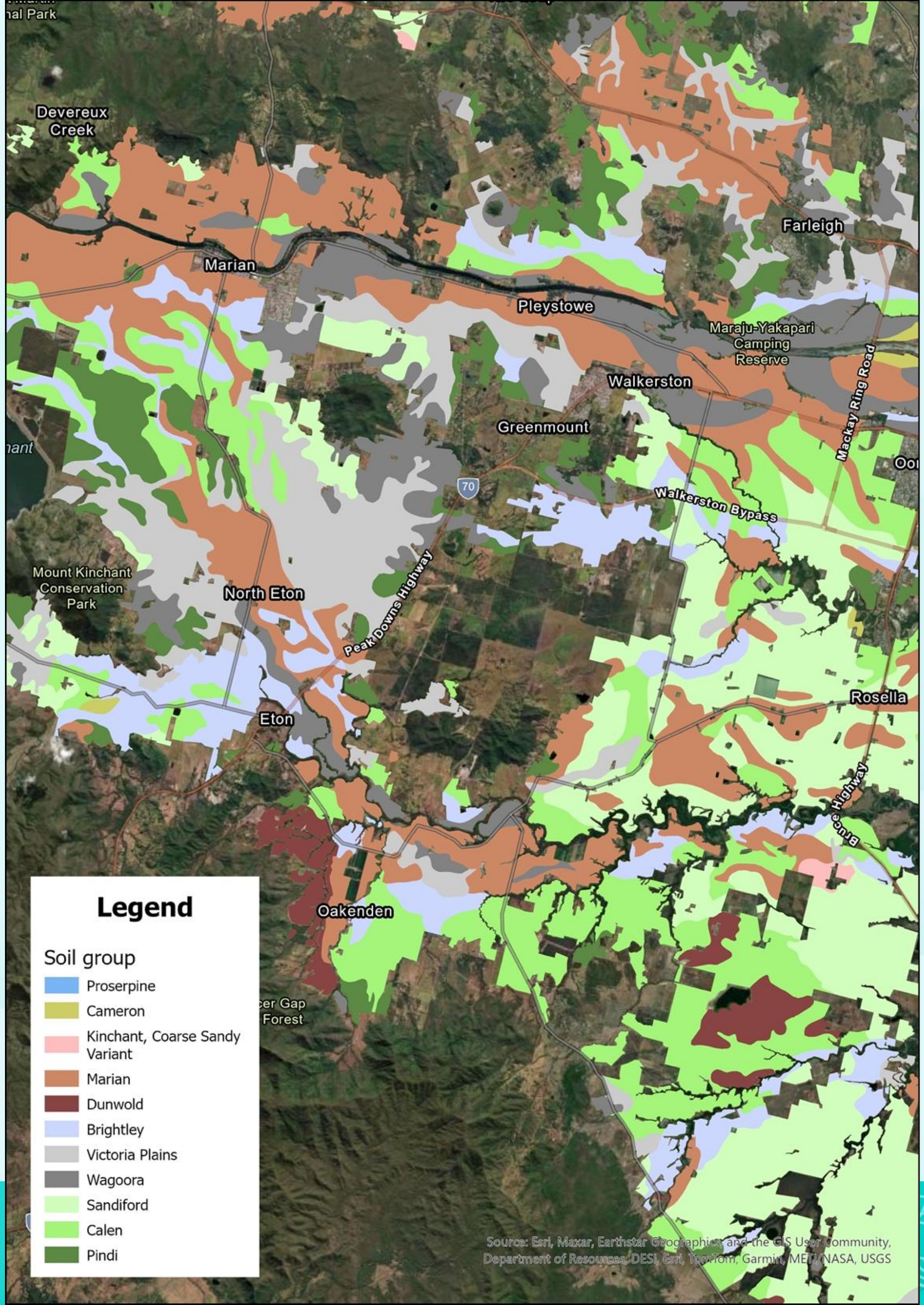
New: soils defined by best-available soil mapping and data

We now model the range of soils that exist across a region, not just those that have been studied at trial sites

Consistent method everywhere

Benefit: more accurate representation of soils and their locations across the region

Soil / climate / mgt interaction



Management maps

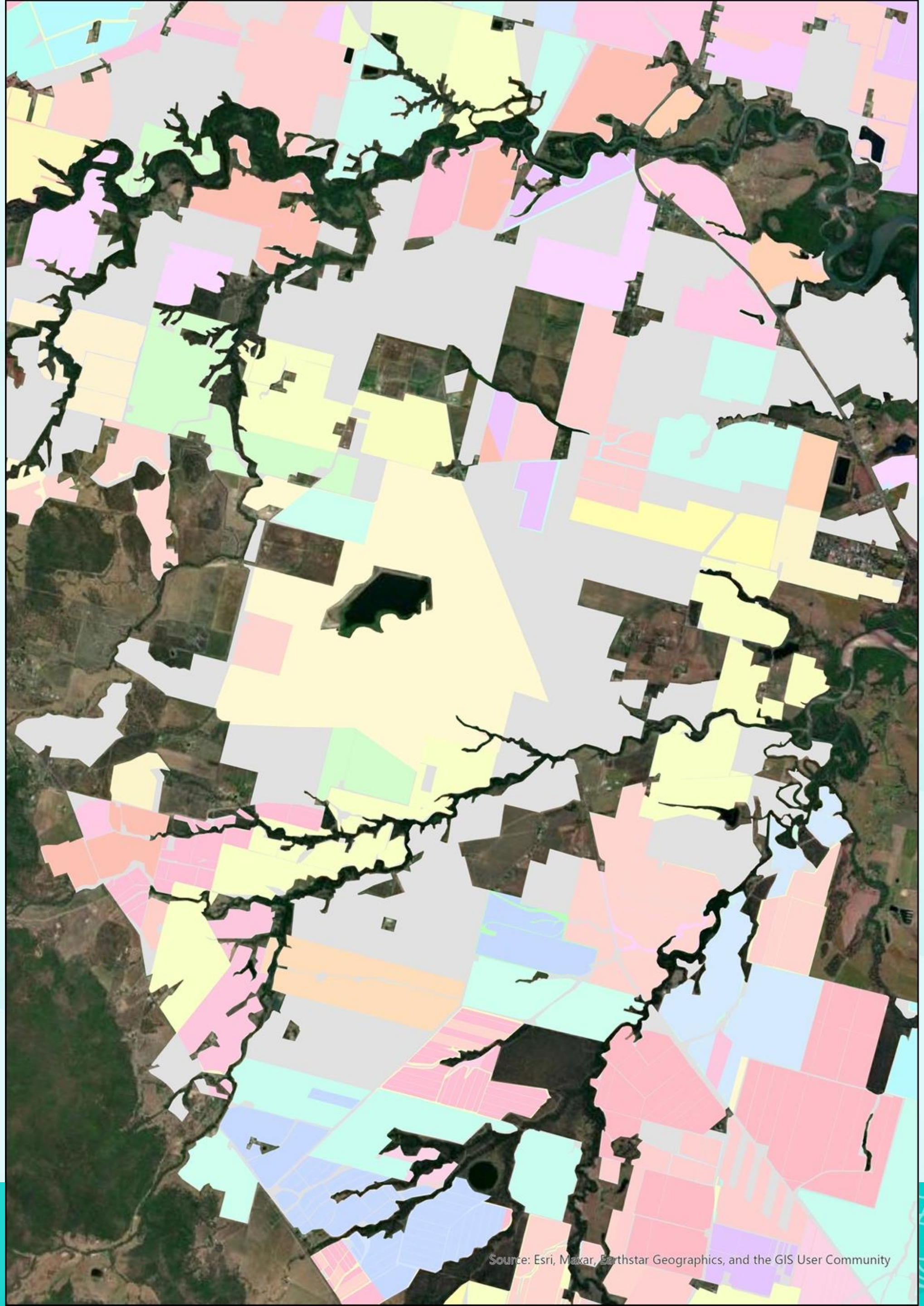
Old: basin-wide estimates of how common different management practices are

New: spatial management map based on Projector project data

53% coverage in Mackay-Whitsunday region

👍 **Benefit:** more accurate representation of management with less model runs!

Soil / climate / mgt interaction



Irrigation scenarios

Old: one irrigation scenario modelled across Mackay-Whitsunday region

New: five scenarios (four irrigation scenarios + no irrigation) modelled

👍 **Benefit**: more realistic representation of irrigation practices

🙁 New scenarios are not mapped out

DIN runoff model

Old: empirical model driven by N fertiliser application rate

New: process-based model driven by soil N concentration, includes organic & inorganic inputs

New model calibrated in Wet Tropics and validated at Mackay

Benefit: more realistic representation of DIN loss processes; accounts for organic N

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ELSEVIER

Ten years of monitoring dissolved inorganic nitrogen in runoff from sugarcane informs development of a modelling algorithm to prioritise organic and inorganic nutrient management

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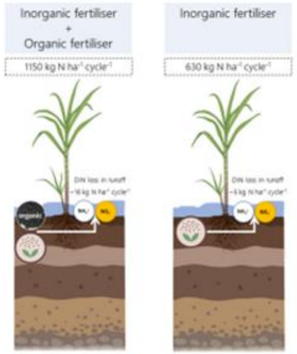
HIGHLIGHTS

- The APSIM model was extended to predict the extraction of soil N into runoff.
- The model simulated well DIN in runoff losses from organic and inorganic fertilisers.
- Application rate had more impact on DIN in runoff losses than timing and placement.

GRAPHICAL ABSTRACT

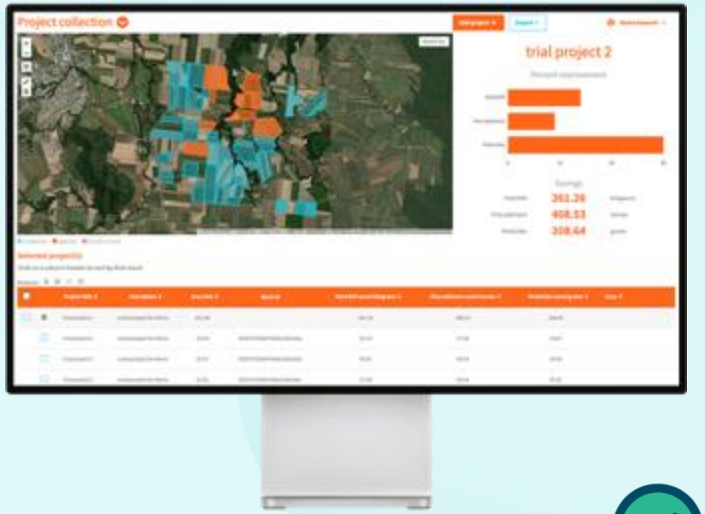


Modelling for Projector

Current: infrequent updates, little flexibility with management options. Update coming in late 2025.

Future: model API to provide live model output

Benefits: Projector models stay up-to-date with Report Card builds. Users can define more specific management scenarios.



Future improvements

New version of the model – runs faster!

Review of management practices

Soil hydraulic conductivity

Subsurface loss pathways

More yield data for model validation

Questions for you

How can we better deliver modelling and information to suit stakeholders' needs?

Practices of interest?

Yield and other trial data?

Comms - what is useful?

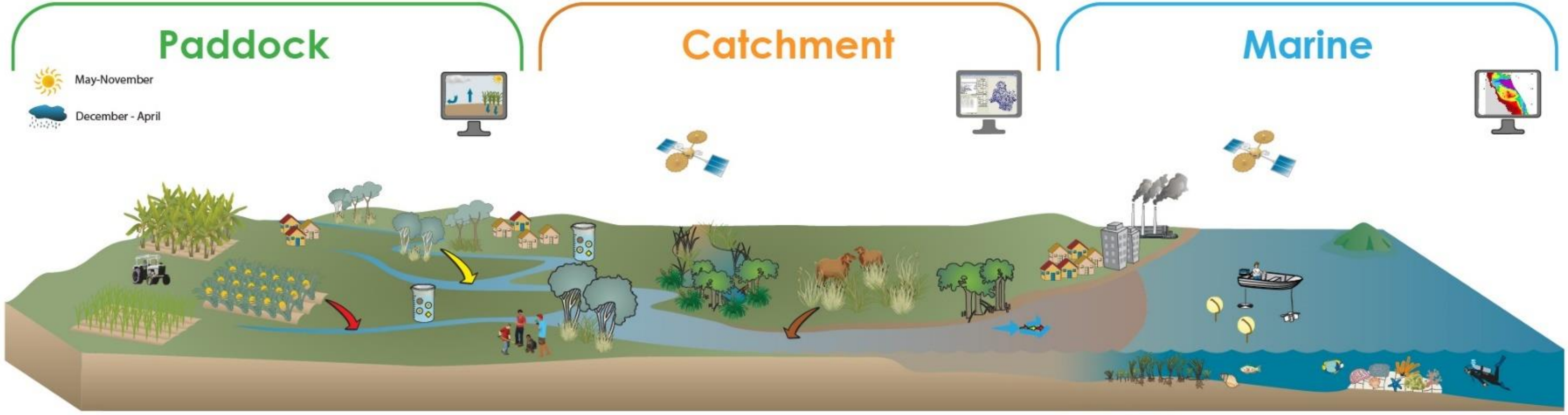
Catchment Modelling

Why model?
Why not just use monitoring?

- Monitoring provides:
  - Pollutant concentration
  - Total pollutant load
  - Monitoring is expensive and difficult
- Models help by:
  - Filling in gaps
  - Removing climate signal
  - Estimate load reductions due to improvement management practice
  - Explore scenarios
    - what will happen if we change management practices
    - What is the catchment source of the sediment and nutrients in this plume?

Image: Copernicus Sentinel-2

Paddock to Reef Integrated Modelling, Monitoring and Reporting



Agriculture
- Paddock monitoring ✓
- Paddock modelling

Stewardship ✓
- Agriculture
- Urban
- Industrial
- Public lands

Catchment monitoring ✓

Catchment modelling

Catchment indicators
- Riparian extent
- Wetland condition
- Wetland extent
- Ground cover

Seagrass monitoring

Water quality monitoring

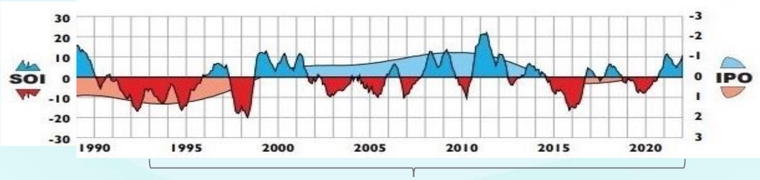
Coral monitoring

eReefs marine modelling ✓

www.reefplan.qld.gov.au

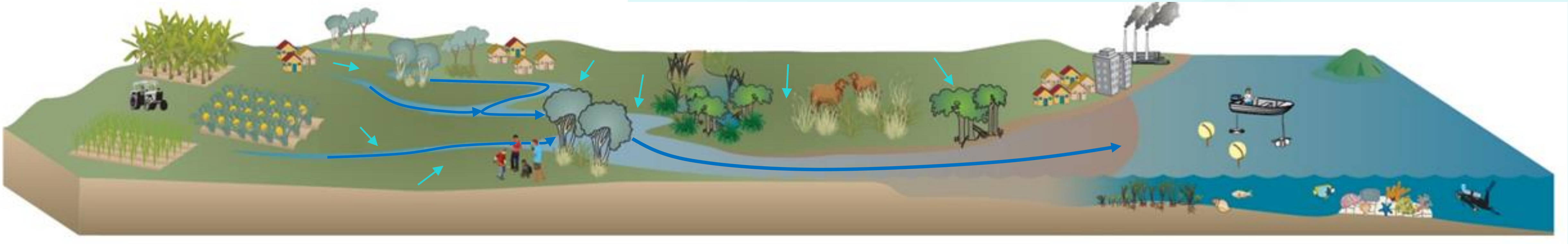
How do Catchment models work?

Baseline
Model



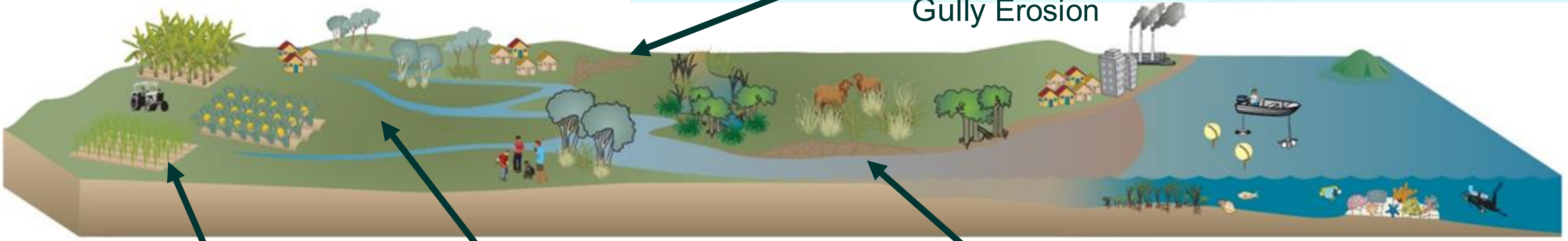
Climate Period

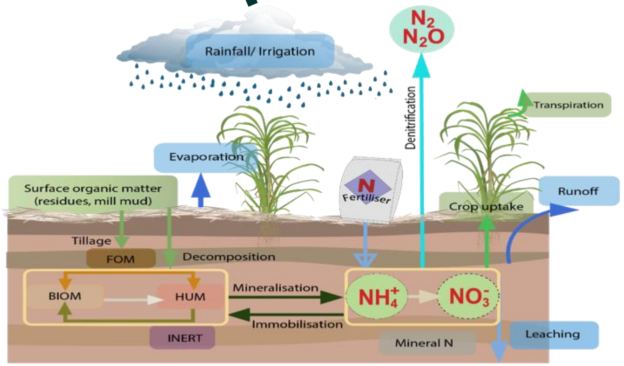
30-year Climate Period



Baseline Model

Gully Erosion



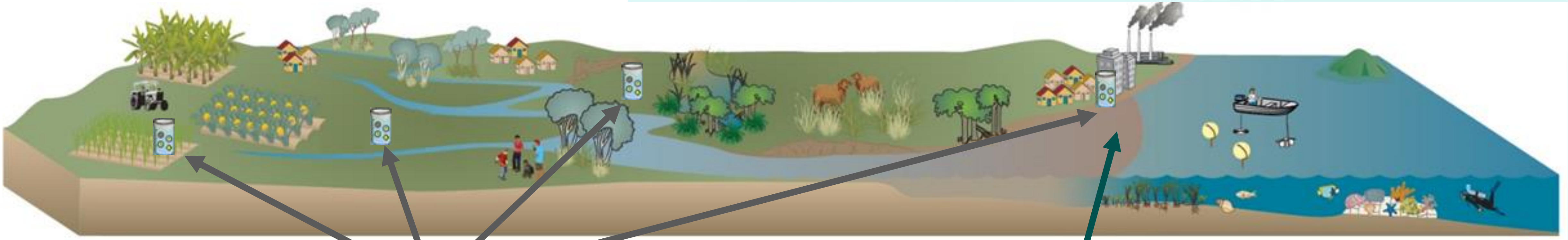


Paddock Models

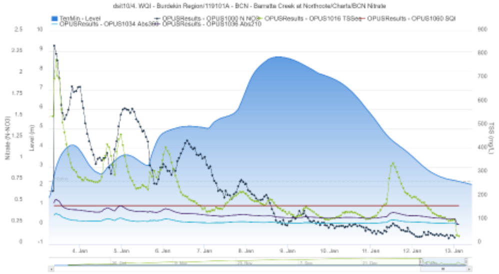
Hillslope Erosion

Streambank Erosion

Baseline Model



WQ Monitoring



Basin Average Annual Loads

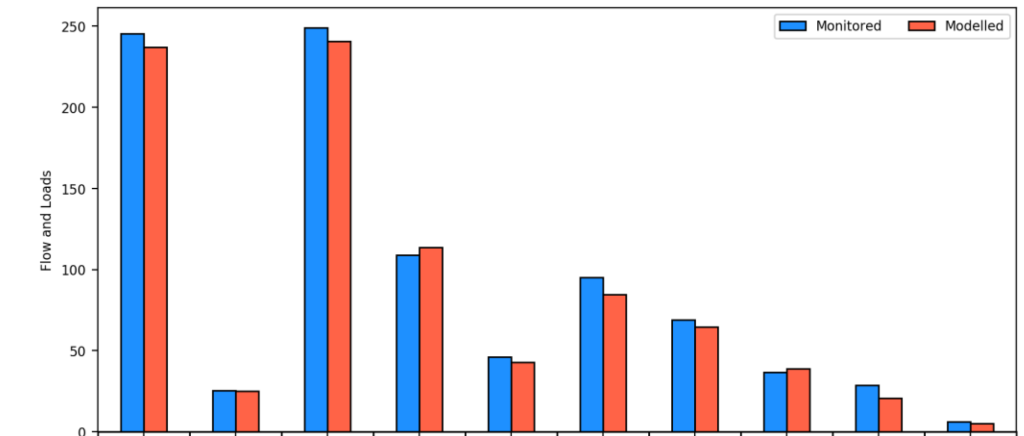
- **Baseline**
  - Fine sediment
  - Nutrients

Baseline Calibration

- Monitored data used for calibrating the model

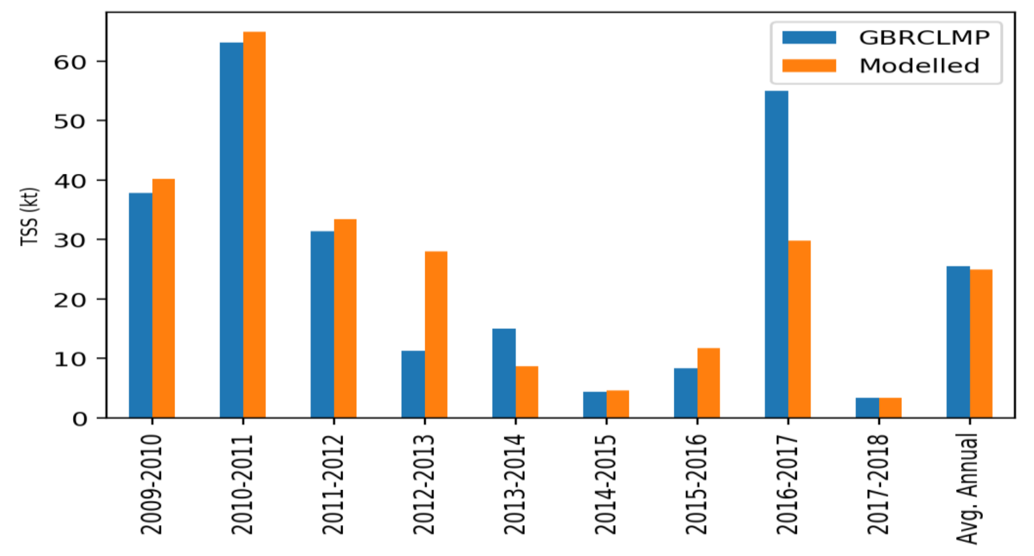
Sandy Creek at Homebush

Average Annual Loads

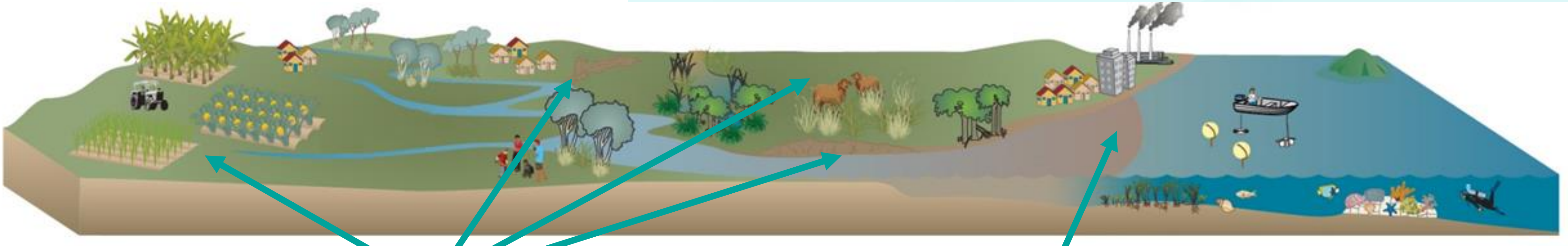


	Flow (GL/yr)	TSS (kt/yr)	TN (t/yr)	PN (t/yr)	DIN (t/yr)	DON (t/yr)	TP (t/yr)	PP (t/yr)	DIP (t/yr)	DOP (t/yr)
Monitored	245	25	248	109	46	95	68	36	28	6
Modelled	236	24	240	113	42	84	64	38	20	5
Years of Data	9	9	9	9	9	9	9	9	9	9

Fine Sediment Annual Loads



Change Model



Practice Change / Landscape repair

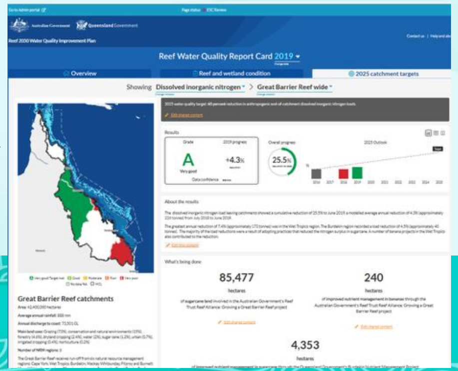
- Improved fertiliser application
- Improved grazing practices
- Gully rehabilitation
- Streambank rehabilitation
- …

Basin Average Annual Loads

- **Change Load**
  - Fine sediment
  - Nutrients

Baseline – Change = Load Reduction

Reef Water Quality Report Card



Model Updates

5-yearly model rebuild

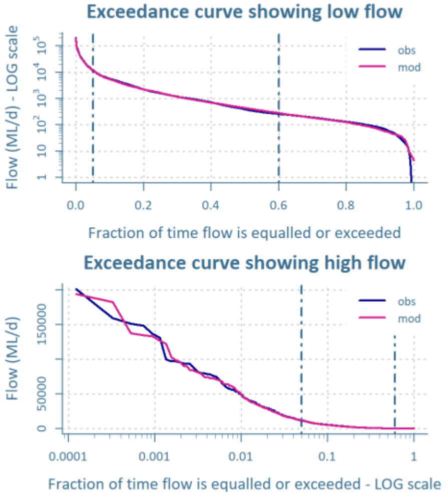
Hydrology Calibration

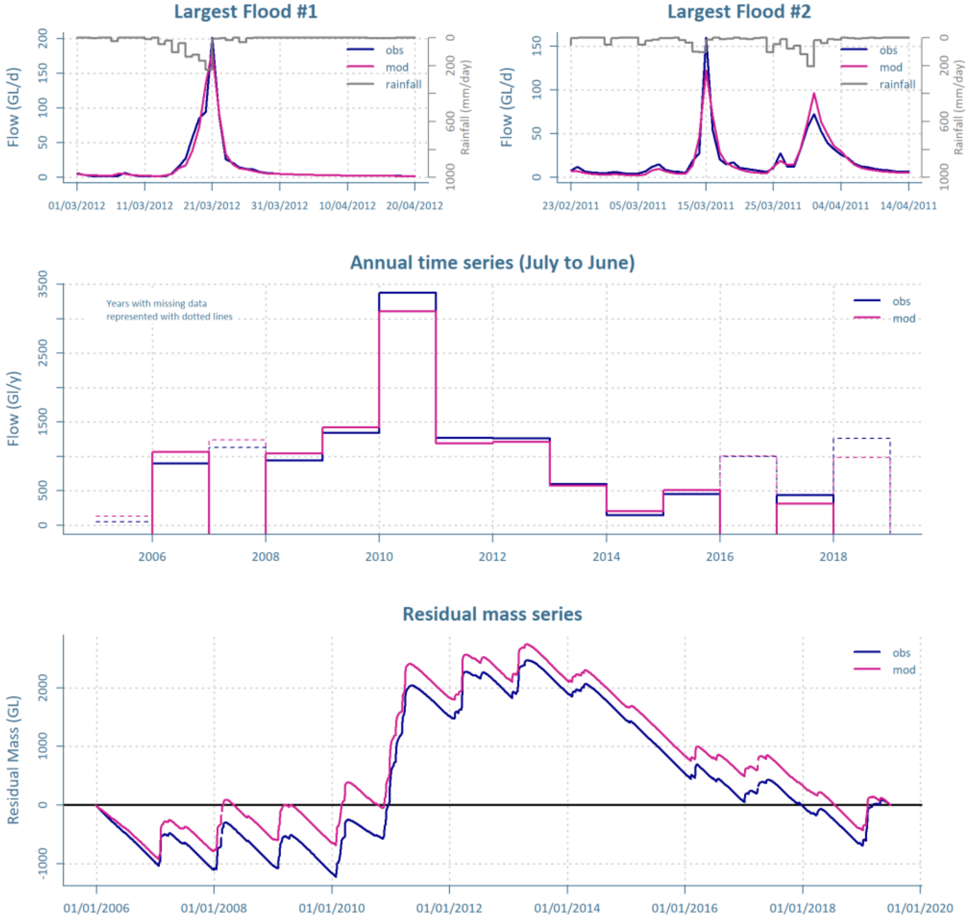
- Increased number of gauges calibrated
  - Old: 167 gauges
  - New: 187 gauges
- New extraction & storage data
- Significantly improved results:
  - PBIAS 4.6% (16.1%)
  - Daily NSE 0.91 (0.73)

gauge_125013A_PioneerRvDumbletonPumpStation

Period of analysis: 1/7/1986 to 29/6/2019

(observed flow is available for 99.9% of days in this period)





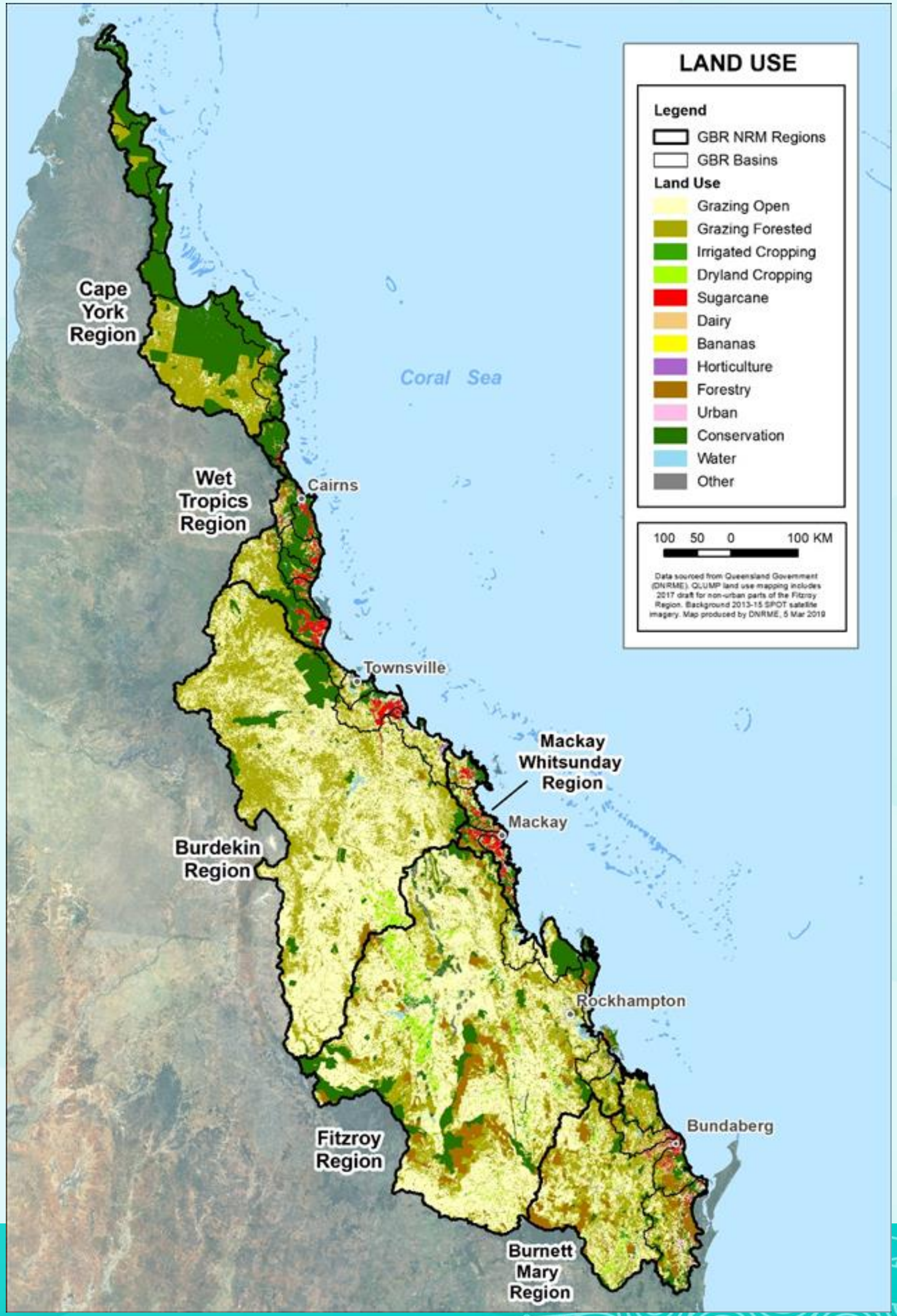
Univariate Statistic	Observed Flow	Modelled Flow Bias	Classification#
Total Flow Volume (ML)	14,166,296	-1.2%	★★★☆☆
Total Low Flow Volume (ML)*	257,583	-2.0%	★★★★☆
Total Medium Flow Volume (ML)*	5,385,355	-1.2%	★★★★☆
Total High Flow Volume (ML)*	8,523,358	-1.1%	★★★★☆
Mean Flow Volume (ML/d)	2,873	-1.2%	★★★☆☆
Driest 3 Year Mean (ML/d)	1,092	7.8%	★★★☆☆
Zero Flow Days (%)+	0.7%	0.8%^	★★★★☆
Standard Deviation (ML/d)	9,878	-0.8%	★★★★★

Bivariate Statistic	Value	Classification#
Nash-Sutcliffe Efficiency(NSE)	0.90	★★★★★
Non-matching Zero Flow Days	0.7%	★★★★★

Number of stars ranges from 1 (Very Poor) to 5 (Excellent)
* Low flow = flow in the 0.6 to 1 exceedance probability range
* Medium flow = flow in the 0.05 to 0.6 exceedance probability range
* High flow = flow in the 0 to 0.05 exceedance probability range
+ Zero flow in this case refers to flow < 1ML/d
^ This is an absolute difference in percentage between observed and modelled

Land Use

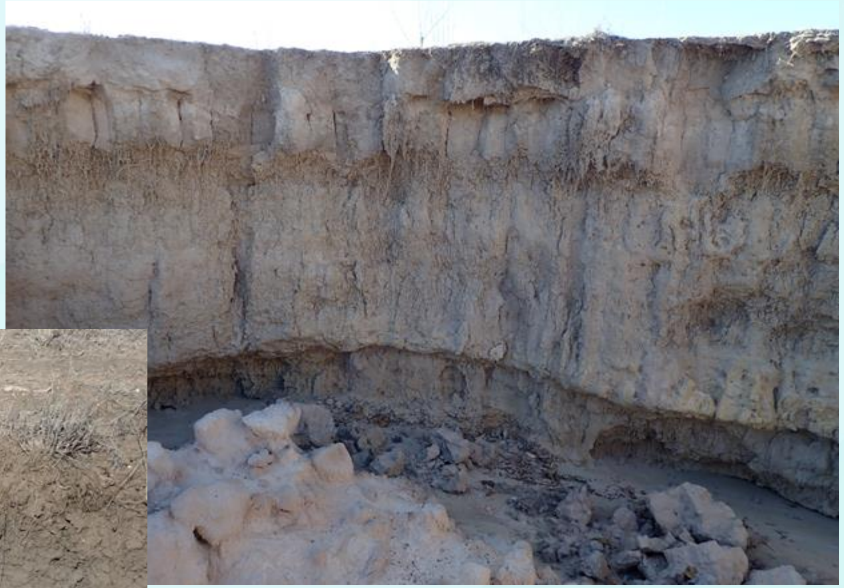
Updated 2021 land use



Soils Data

Improved:

- Scale and spatial representation
- Erodibility
- Particle size
- Nutrient concentrations



Streambank

New:

- Soils data
- Streambank soil erodibility

Improved:

- Stream geometry based on lidar data
- Estimation of bank full flow
- Estimation of floodplain deposition

Oaky Creek Oakenden

O'Connell River

Hillslope

New:

- Soils data
- Groundcover data
- Rock-factor

Gully

Updated:

- Soils
- Gully density
- Gully cross-section

Pristine areas (Lewis et al 2023)

- New nutrients concentration data for near pristine areas
- Applied to:
  - Baseline
  - Predevelopment

Paddock Models

New models:

- Sugarcane
- Broadacres cropping
- Bananas

Results

- Re-scheduled delivery date is late 2025

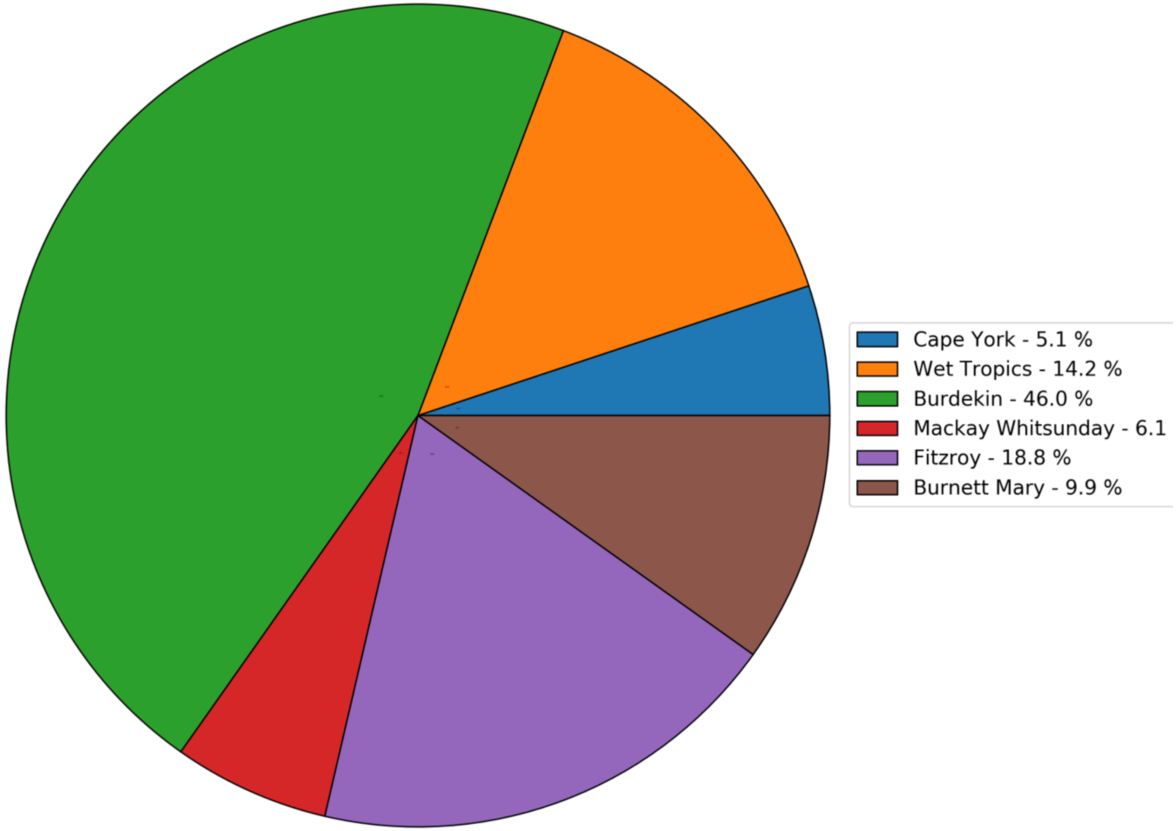
Future Projects

- Groundwater interactions
- Estuarine models
- Streambank mapping

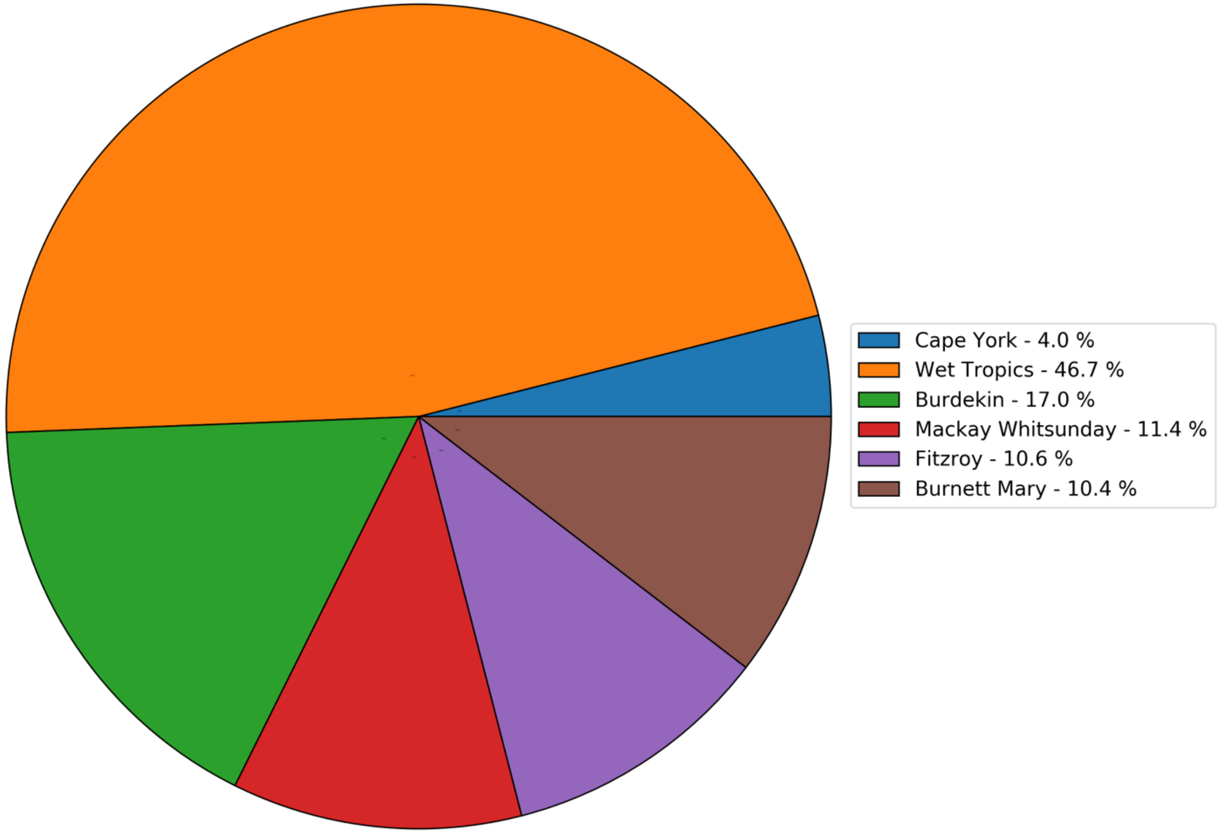
Questions?

Just in case slides

GBR Scale – Export Load By Region

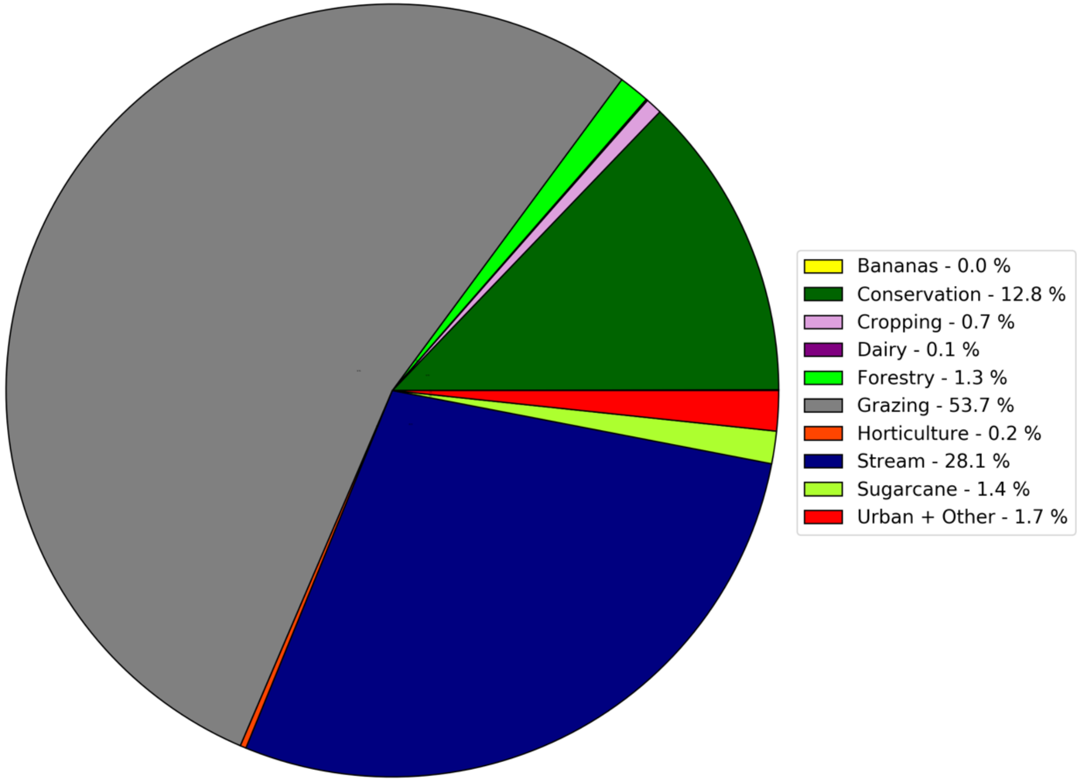


Fine Sediment

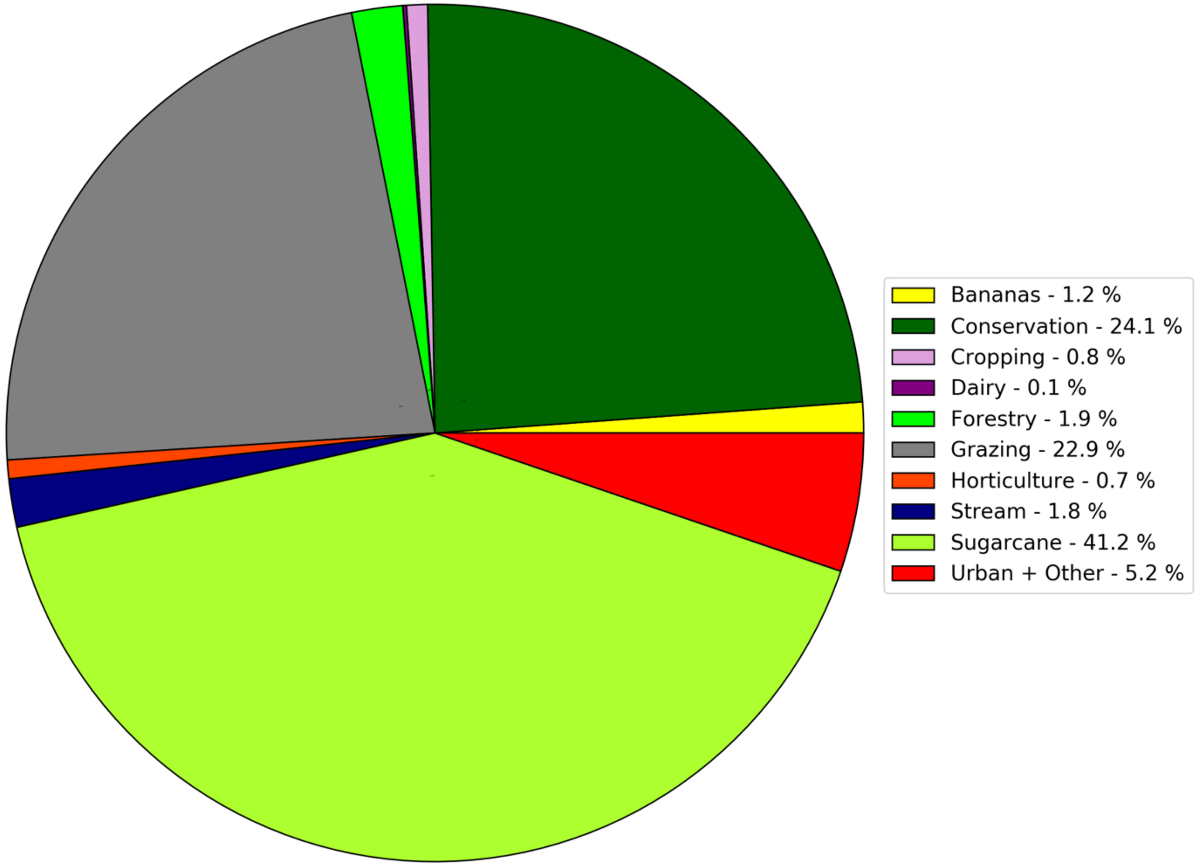


Dissolved Inorganic Nitrogen

GBR Scale – Export Load by Landuse

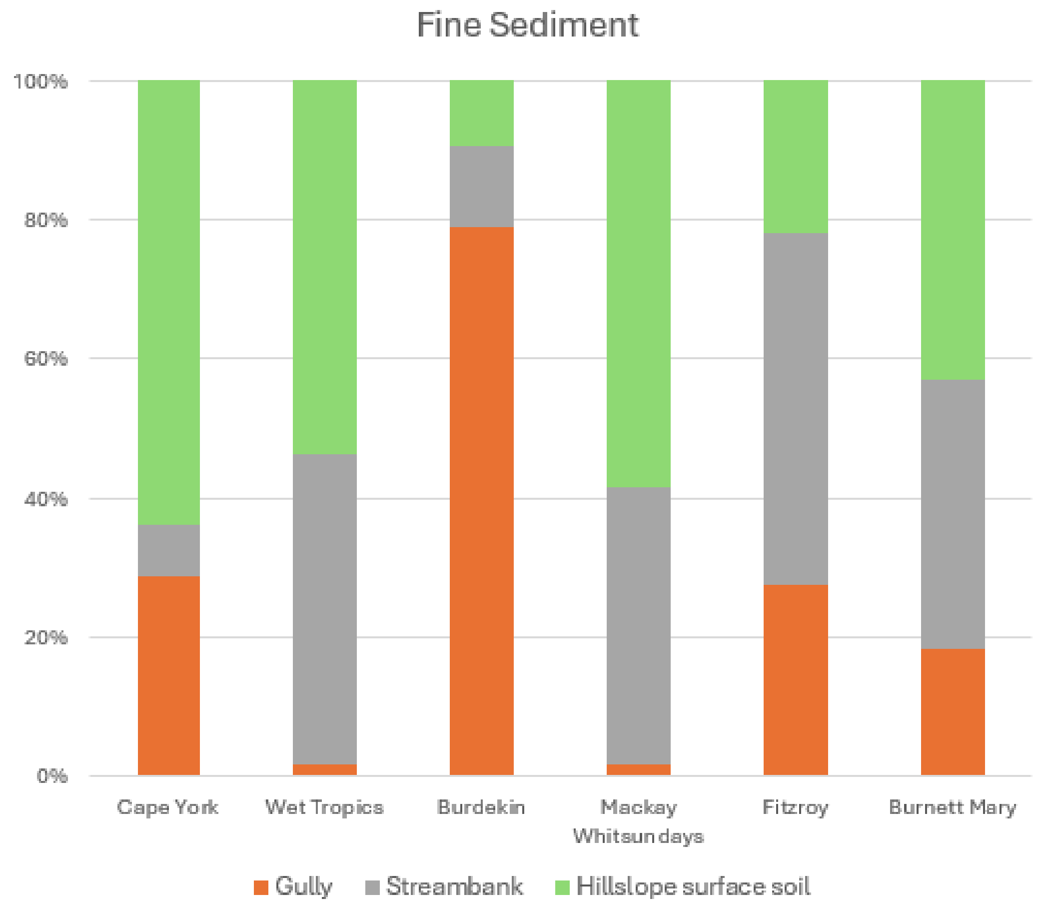


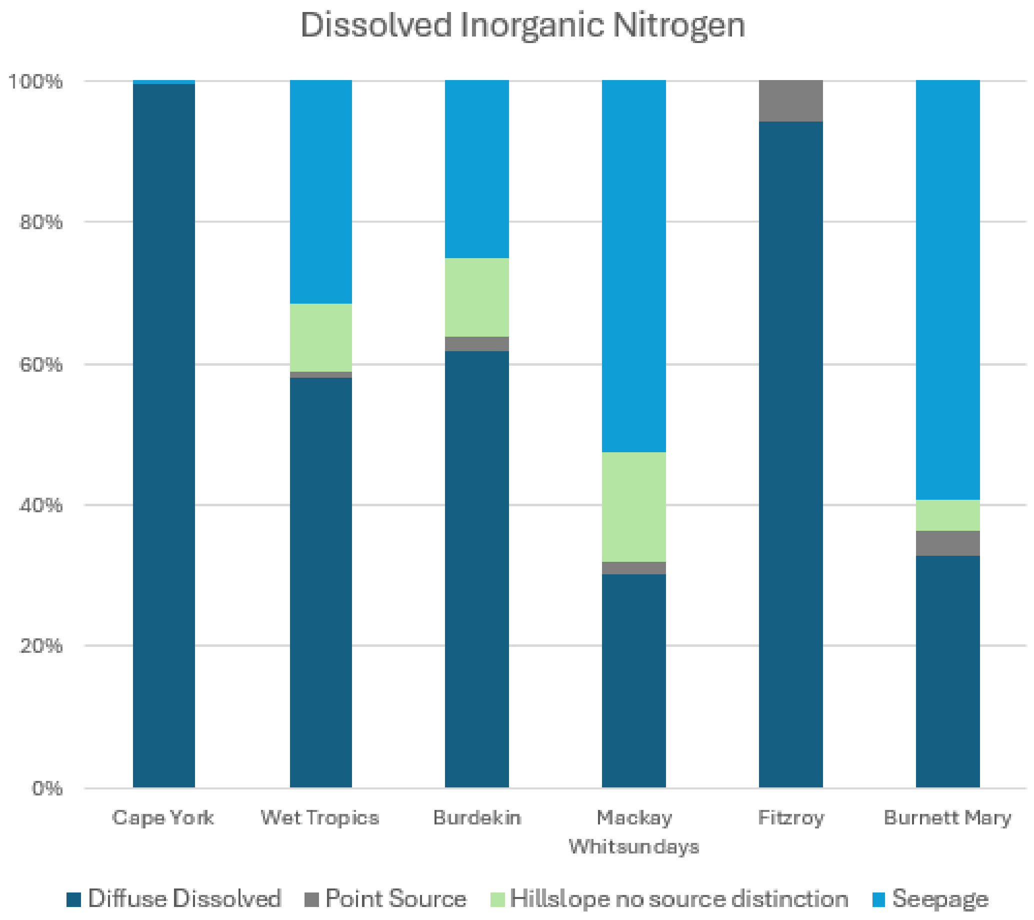
Fine Sediment



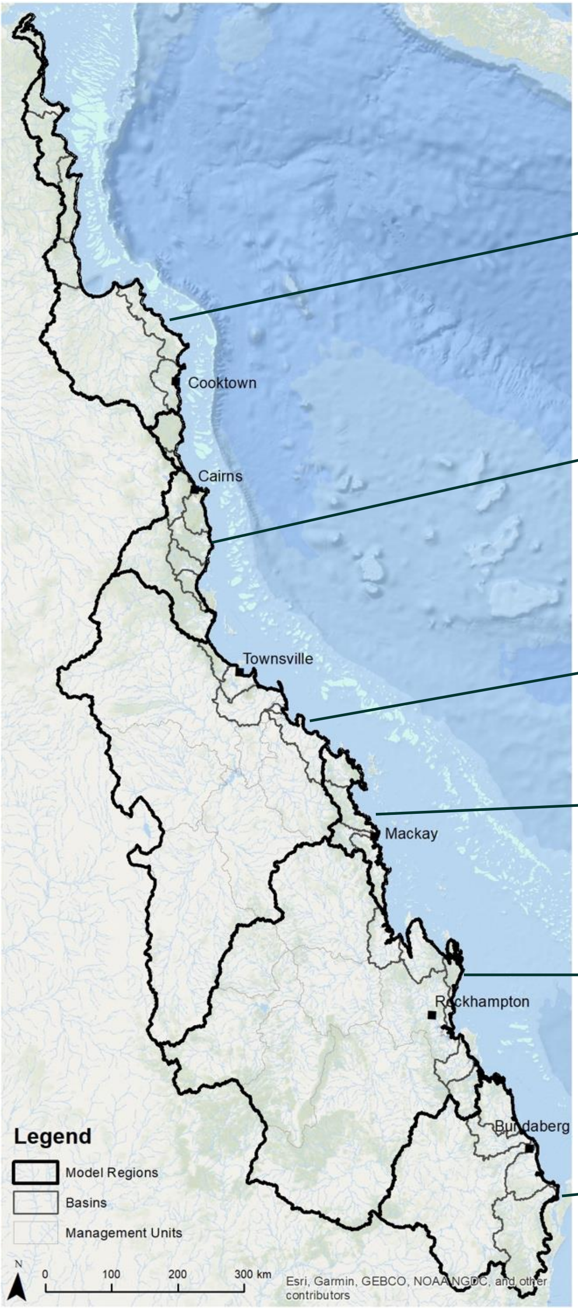
Dissolved Inorganic Nitrogen

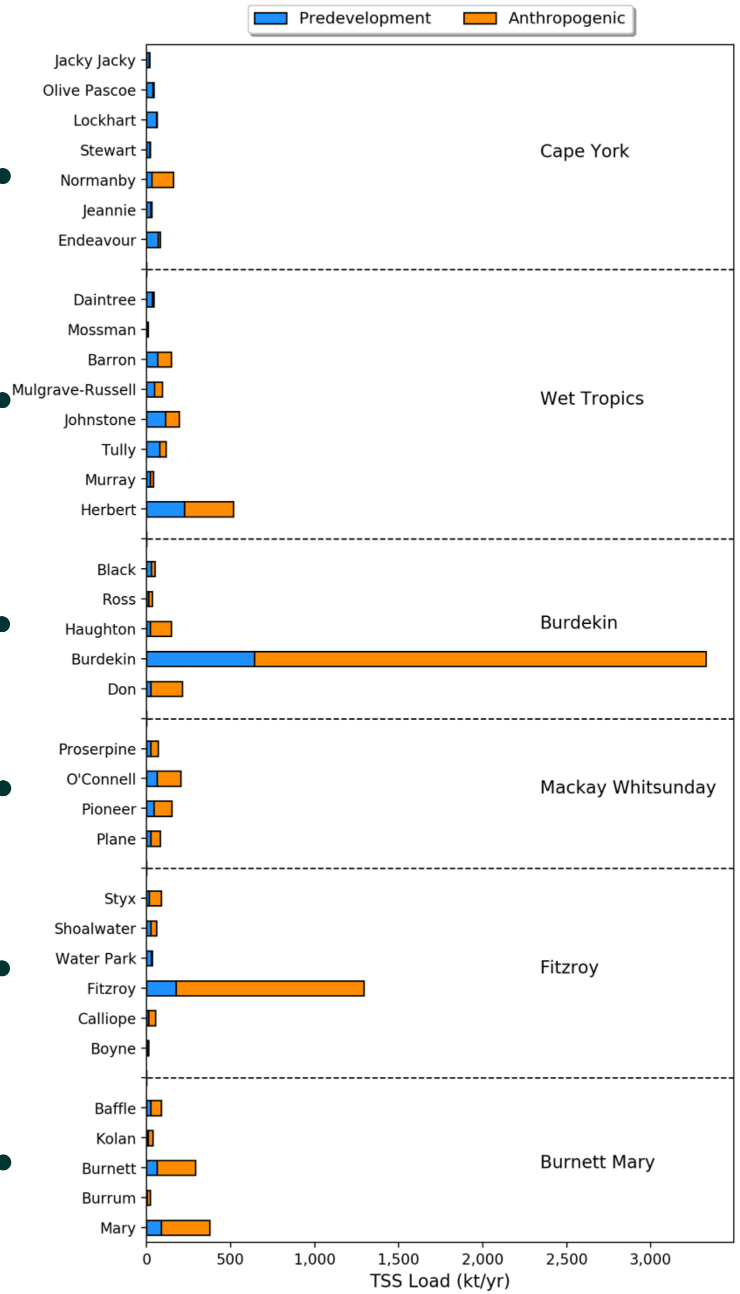
Regional Scale – Export Load By Process

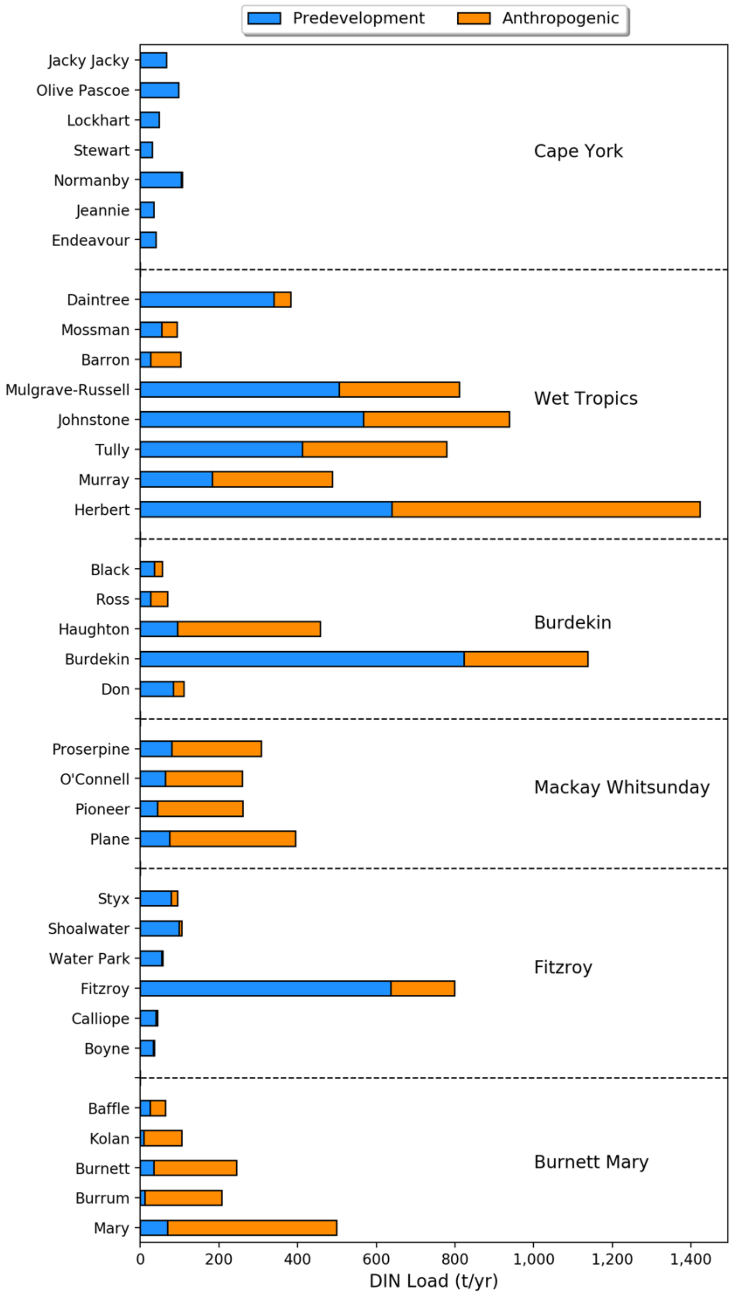




Basin Scale - Anthropogenic Load







Soil groups

	Group	Landscape	Runoff potential	Plant available water capacity
Sandy / loamy	**Proserpine**	Levees	Low	81 mm
	Cameron	Levees	High	97 mm
Non-sodic texture contrast	**Kinchant Coarse Sandy Variant**	Old alluvial plains	Low	65 mm
	Dunwold	Uplands and sediments from igneous rocks	Low	102 mm
	Marian	Alluvial plains	High	116 mm
Clays	**Wagoora**	Uplands on volcanics	High	148 mm
	Brightley			
	Victoria Plains	Alluvial plains	Low	171 mm
Sodic texture contrast	**Sandiford**	Alluvial plains	High	127 mm
	Calen	Alluvial plains	High	116 mm
	Pindi	Uplands on sedimentary rocks	High	80 mm

Management practices

Soil management	Nitrogen management	Irrigation management	Mill mud management
7 classes Management of: • Trash • Tillage • Fallow • Traffic	8 nitrogen application rates Specific to each soil in each district Based on nitrogen use efficiencies from 0.6 to 2.0 kg N / tonne cane	4 irrigation scenarios with varying allocations and application triggers 1 non-irrigated scenario	5 scenarios of varying application rates for plant or ratoon 1 no-mill mud scenario