Australian Government

Department of the Environment, Water, Heritage and the Arts

Marine and Tropical Sciences Research Facility Draft Pathway to Impact Report, April 2009

Program 7: **Halting and Reversing the Decline of Water Quality**

Project 3.7.2: **Connectivity and Risk: Tracing materials from the upper catchment to the reef**

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Introduction

The objectives of this report are to assemble the information layers and conceptual model understanding to allow modelling to prioritise pollutant management on the Great Barrier Reef (GBR) catchment by area and pollutant. The description of the information layers and, where available, a visual representation of the layer are given below.

Assets at Risk

The selected assets at risk are: (a) coral reefs; (b) seagrass meadows; (c) mangrove forests; (d) reefs important to tourism; (e) commercial fisheries; and (f) recreational fisheries. Asset data layers for each of these are identified below.

(a) Coral Reefs

GBR layer – from the Reef Atlas[1] – well verified.

Figure 1: Reef layer.

[1] Reef Atlas is a product of MTSRF Project 1.1.5 Reef Atlas: Risk, Resilience and Response (http://www.rrrc.org.au/mtsrf/theme_1/project_1_1_5.html)

Conceptual model for linking coral condition to water quality – Good.
(Fabricius 2007; De'ath and Fabricius 2008; Brodie *et al.* 2005; Devantier *et al.* 2006; Fabricius 2005; Fabricius *et al.* 2005; Fabricius and De'ath 2004.)

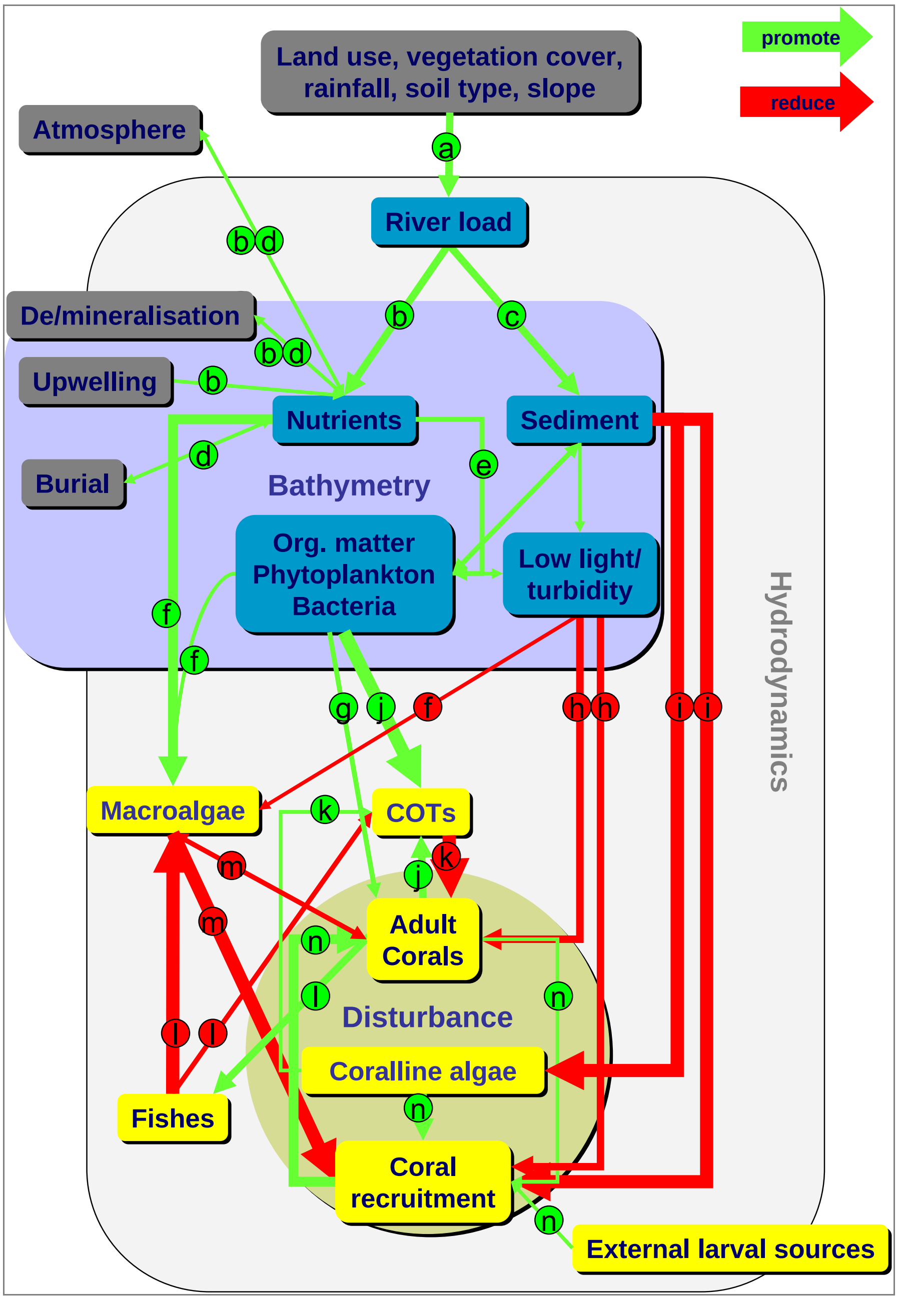

Figure 2: Fabricius model.

Conceptual understanding connecting GBR ecosystem health to terrestrial runoff – Moderate.
(Wooldridge *et al.* 2006; Richmond *et al.*; Wolanski *et al.*; Wolanski and De'ath.)

(b) Seagrass

GBR seagrass layer – from Reef Atlas – approximate due to year-to-year variability and spotty nature of surveys. Risk information from Grech *et al.* 2008:

Grech, A., Coles, R., McKenzie, L. and Rasheed, M. (2008) *Spatial risk assessment for coastal seagrass habitats in the Great Barrier Reef World Heritage Area: A case study of the Dry and Wet Tropics*. Report to the Marine and Tropical Sciences Research Facility. Reef and Rainforest Research Centre Ltd, Cairns.

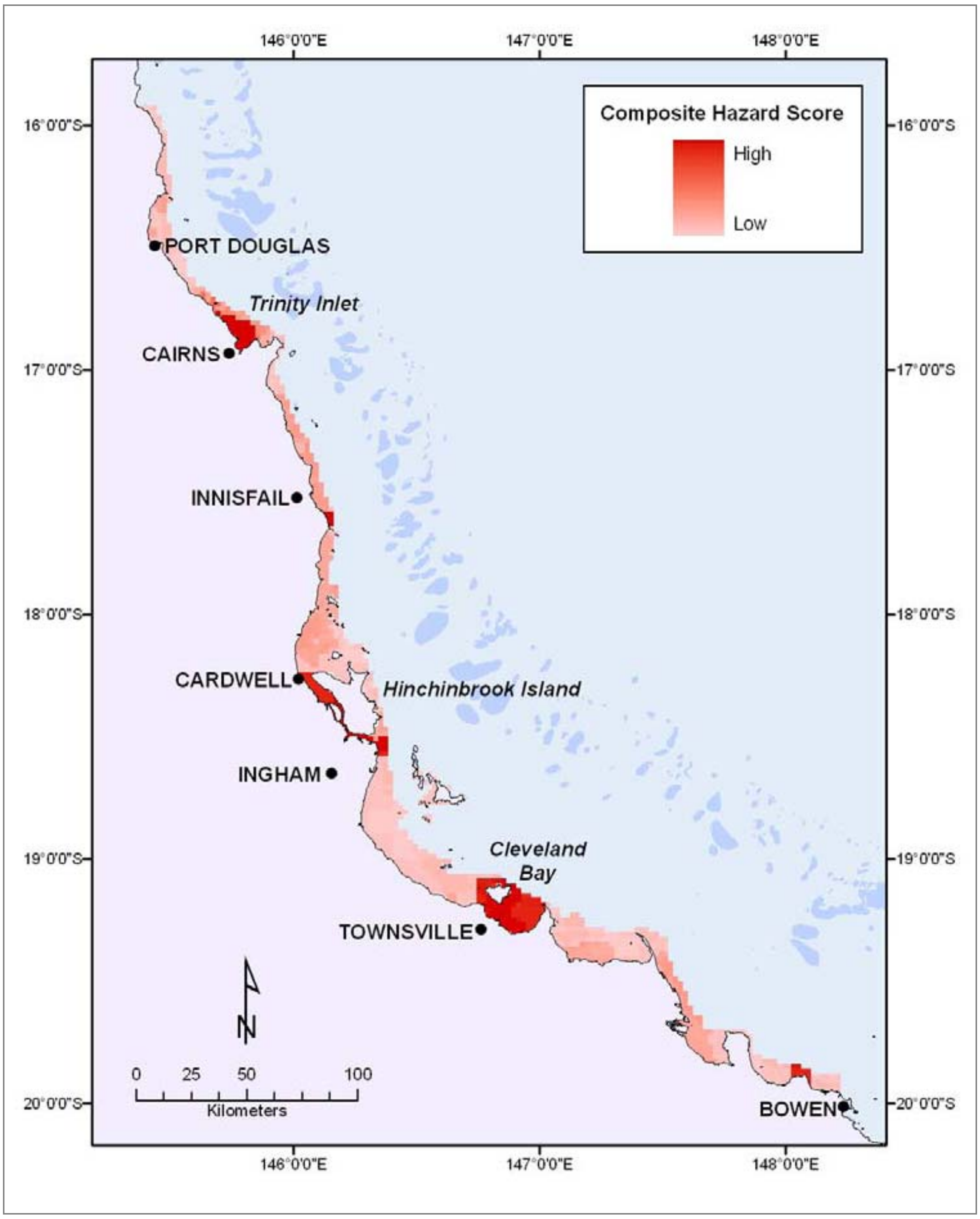

Figure 3: Composite hazard score for the coastal (<15m) region of the Dry and Wet Tropics derived from spatial information on the presence / absence of hazards and the relative hazard scores developed by experts.

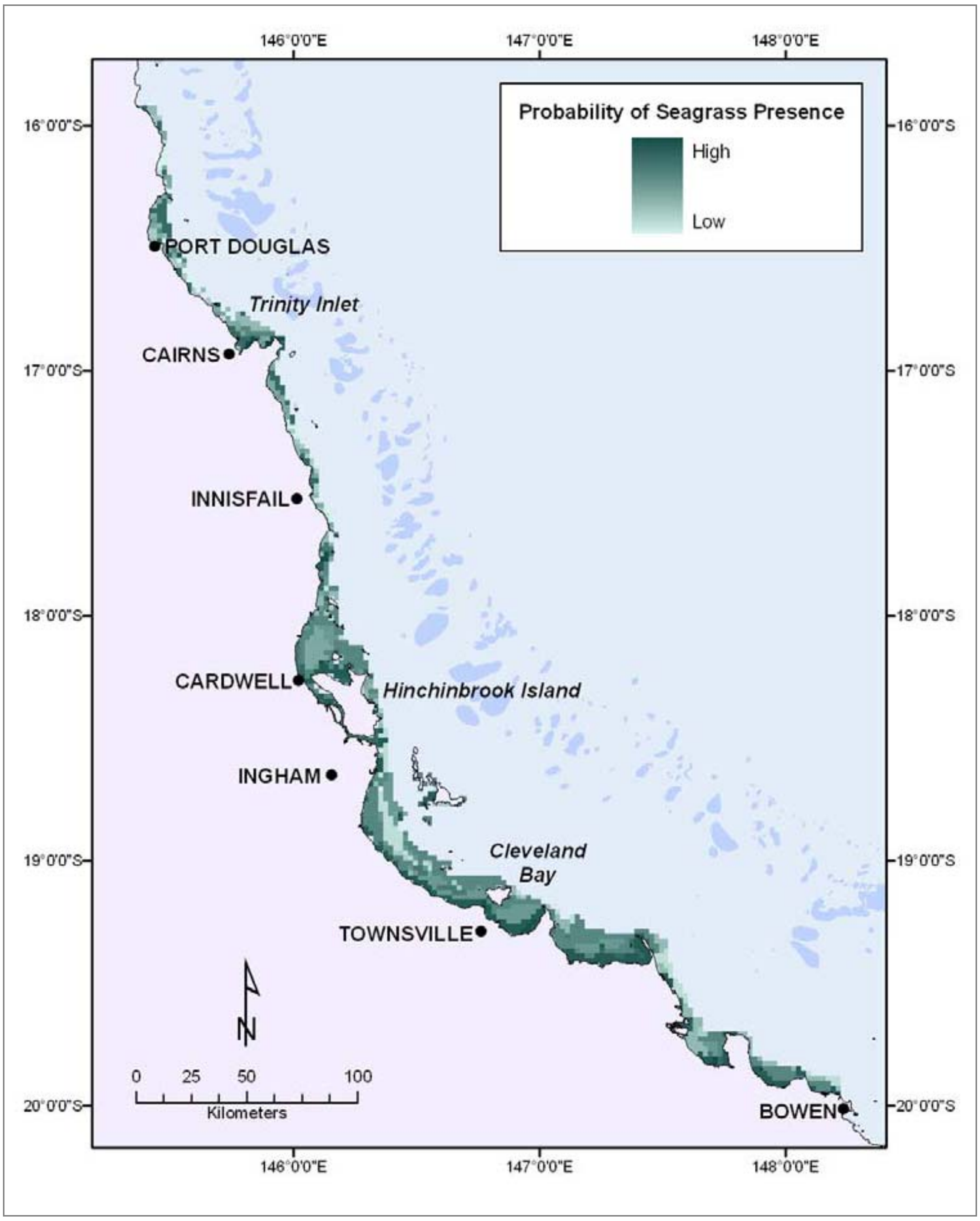

Figure 4: Probability model of coastal (<15m) seagrass presence in the Dry and Wet Tropics developed by Grech and Coles.

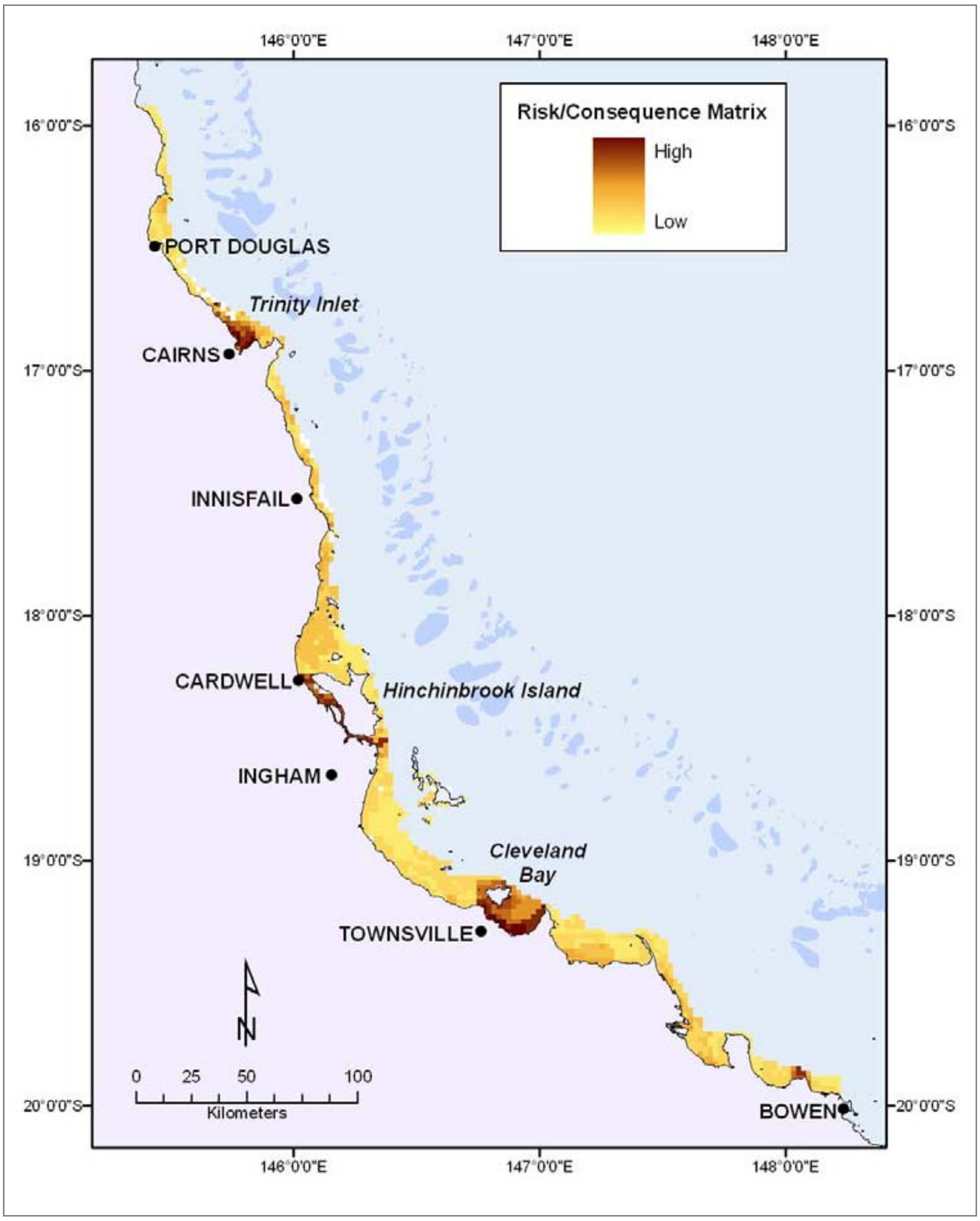

Figure 5: Risk / consequence matrix for the coastal (<15m) region of the Dry and Wet Tropics. A risk / consequence grid that has a high score will have both a high composite hazard score and a high probability of seagrass presence. A grid that receives a low score can have a high composite hazard score and a low probability of seagrass presence or a low composite hazard score and a high probability of seagrass presence.

Conceptual model linking seagrass condition to water quality – Fair.
(Waycott *et al.* 2005; Schaffelke *et al.* 2005.)

(c) Mangroves

Risks to mangroves from herbicides.
(Duke *et al.*; Bell and Duke; Wake 2007, 2008.)

(d) Tourism

Tourism numbers per 'reef' – from Great Barrier Reef Marine Park Authority (maybe Reef Atlas) – approximate due to collection methods. Conceptual model linking tourist visitation numbers to reef condition to water quality – Fair.

(e) Commercial fisheries

Commercial fisheries values per 'area'? – from Great Barrier Reef Marine Park Authority – complicated spatially due to different types of fishery – trawl, line, reef, pelagic, inshore net.

Conceptual model linking fisheries condition to water quality – Poor.

(f) Recreational fisheries

Recreational fisheries from Great Barrier Reef Marine Park Authority – approximate only due to collection methods.

Conceptual model linking fisheries condition to water quality – Poor.

Lagoon Water Quality Information

(a) Current estimated water quality

Water quality layers – from Reef Atlas (De'ath and Fabricius 2008) – useful ones are Secchi depth, chlorophyll a, suspended solids, PN, PP – some limitations in these numbers due to long periods over which data was accumulated. See Figures 6-10.

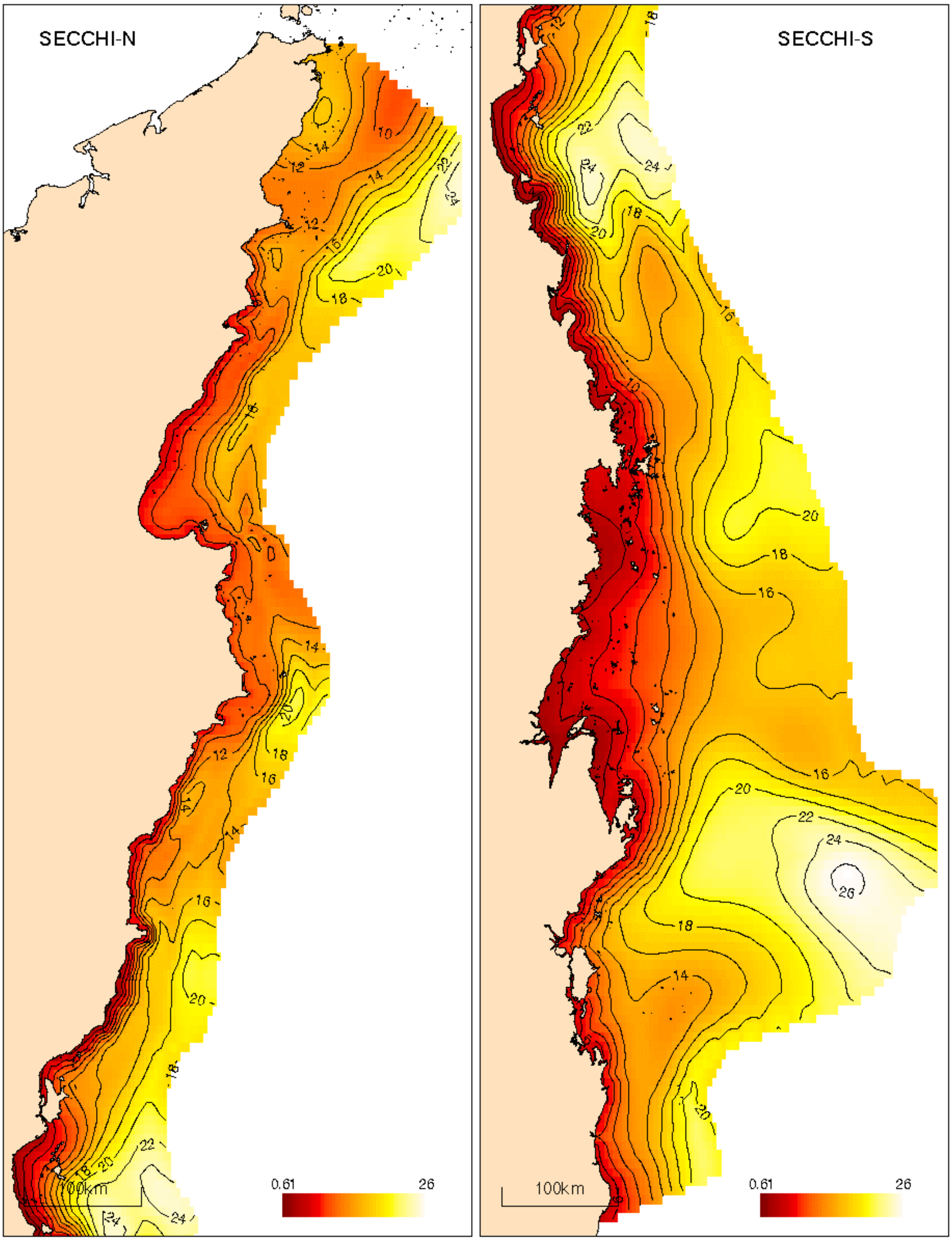

Figure 6: Estimated spatial distribution of Secchi depth (m).

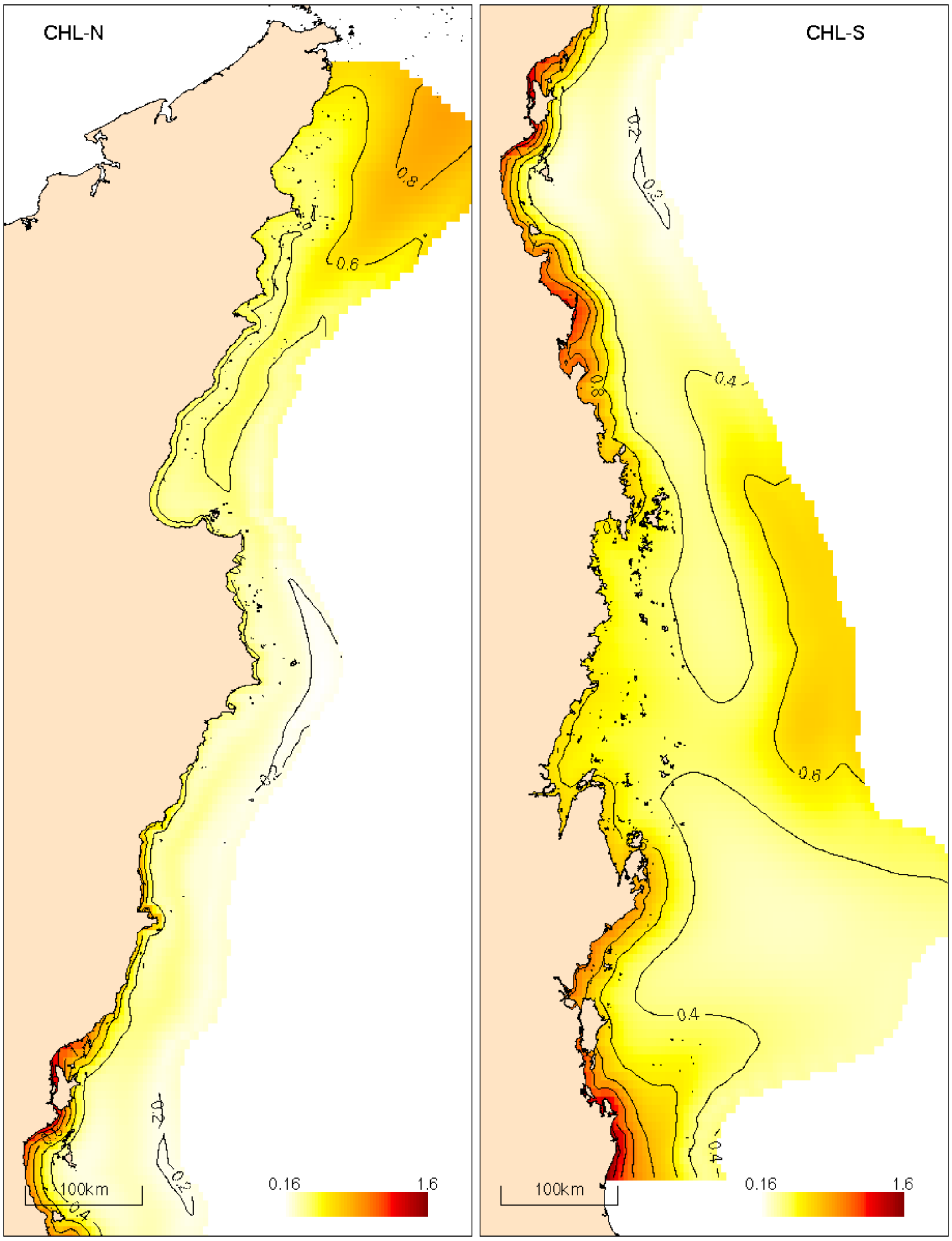

Figure 7: Estimated spatial distribution of chlorophyll (µg L^{-1}).

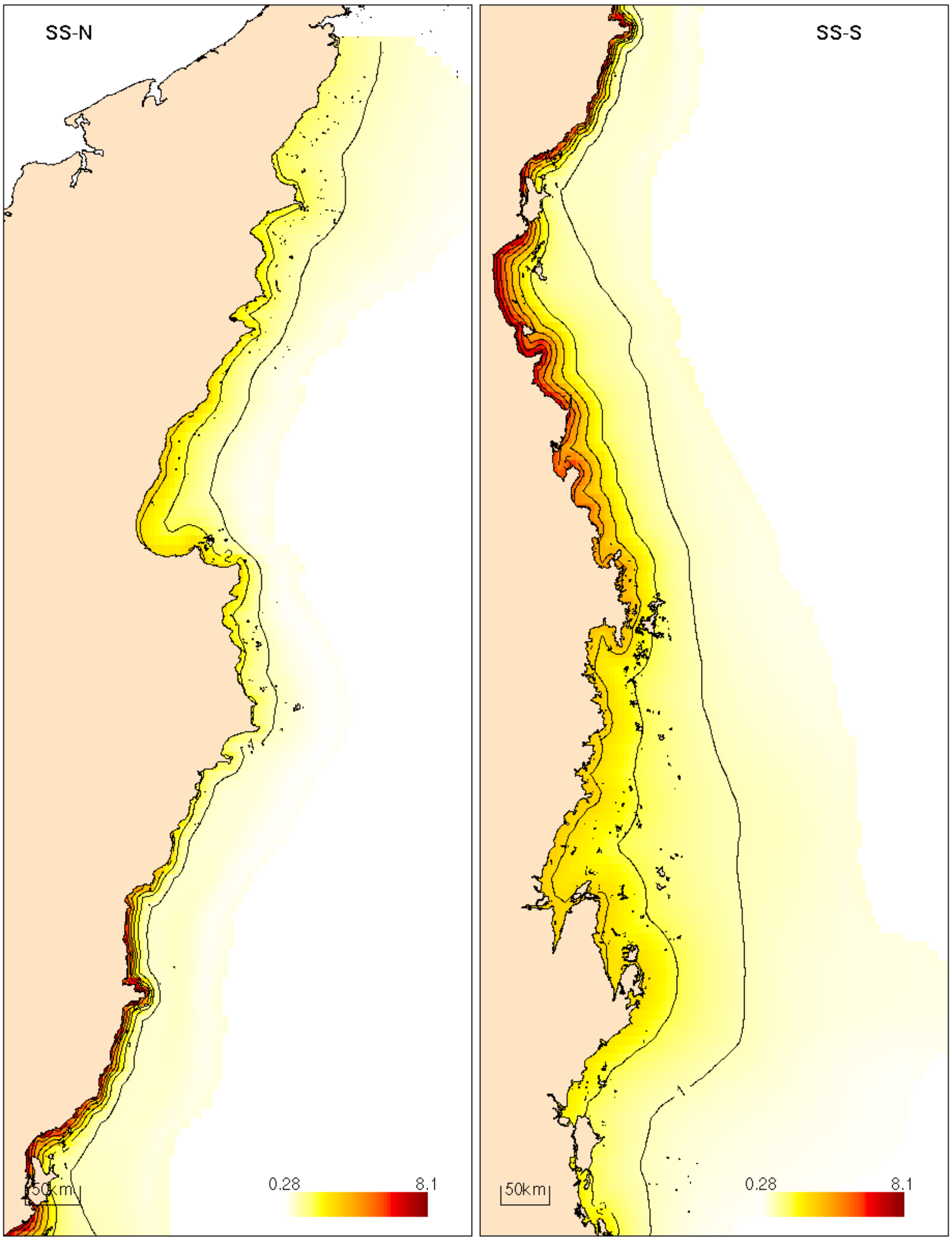

Figure 8: Estimated spatial distribution of suspended solids (mg L $_{-1}$).

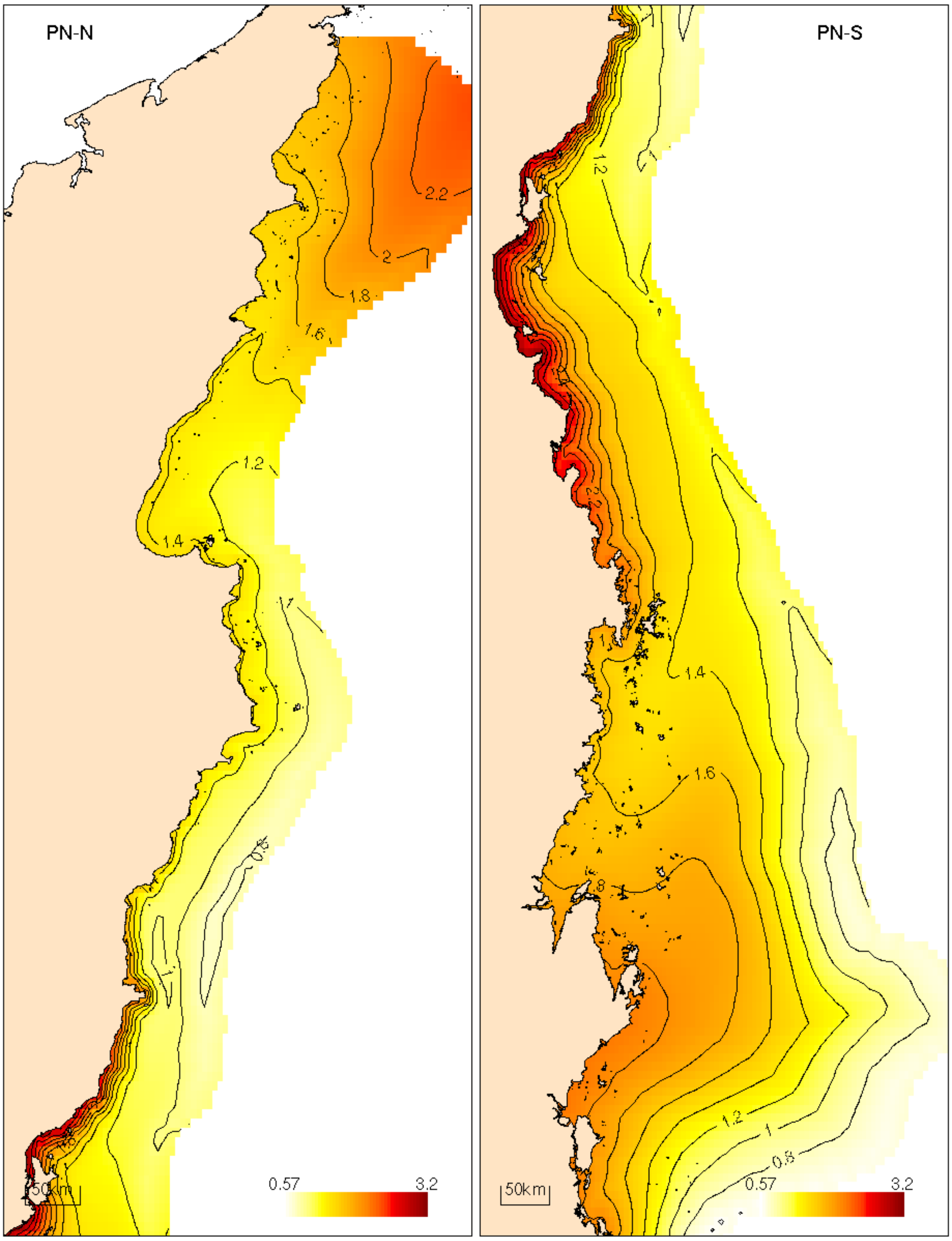

Figure 9: Estimated spatial distribution of particulate nitrogen (μmol L -1).

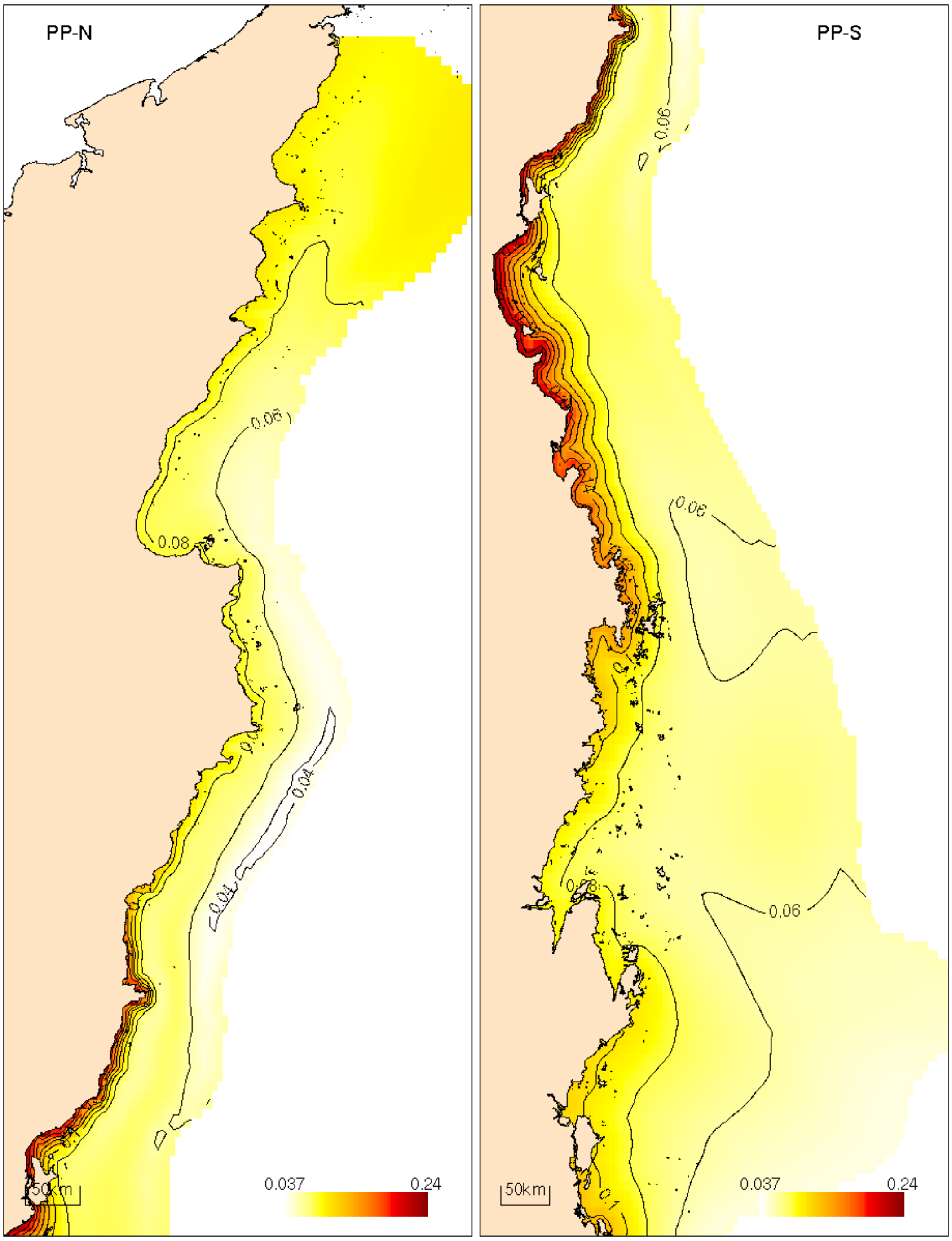

Figure 10: Estimated spatial distribution of particulate phosphorus (μmol L $_{-1}$).

(b) Water quality trigger values

From De'ath and Fabricius 2008.

(c) Trigger value exceedance areas

Mapping trigger values over water quality layers to detect exceedance areas – already done by De'ath and Fabricius 2008 for Secchi depth and chlorophyll a – further analysis of these maps to remove 'natural' high areas. See Figures 11 and 12.

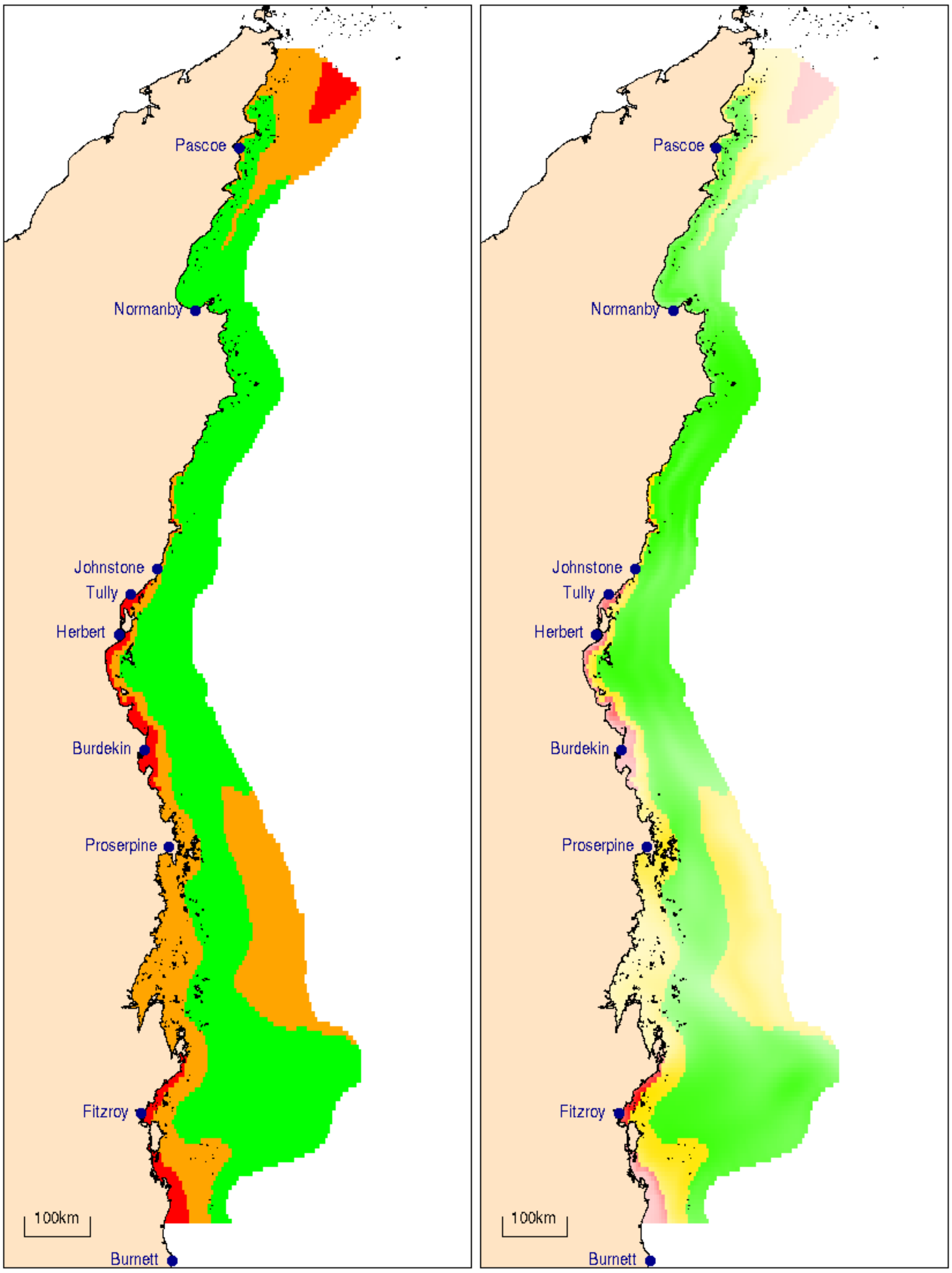

Figure 11: Locations that are presently at less than (green) or exceed (orange and red) the water quality guideline trigger values of a maximum annual mean of 0.45 µg L $_{-1}$ chlorophyll. Orange zones show areas that exceed the guideline trigger values, having chlorophyll values of 0.45-0.8 µg L $_{-1}$. Red zones show areas of greatest concern with >0.8 µg L $_{-1}$ chlorophyll. The level of fading (right panel) indicates the level of confidence in the estimates with faded areas being more uncertain.

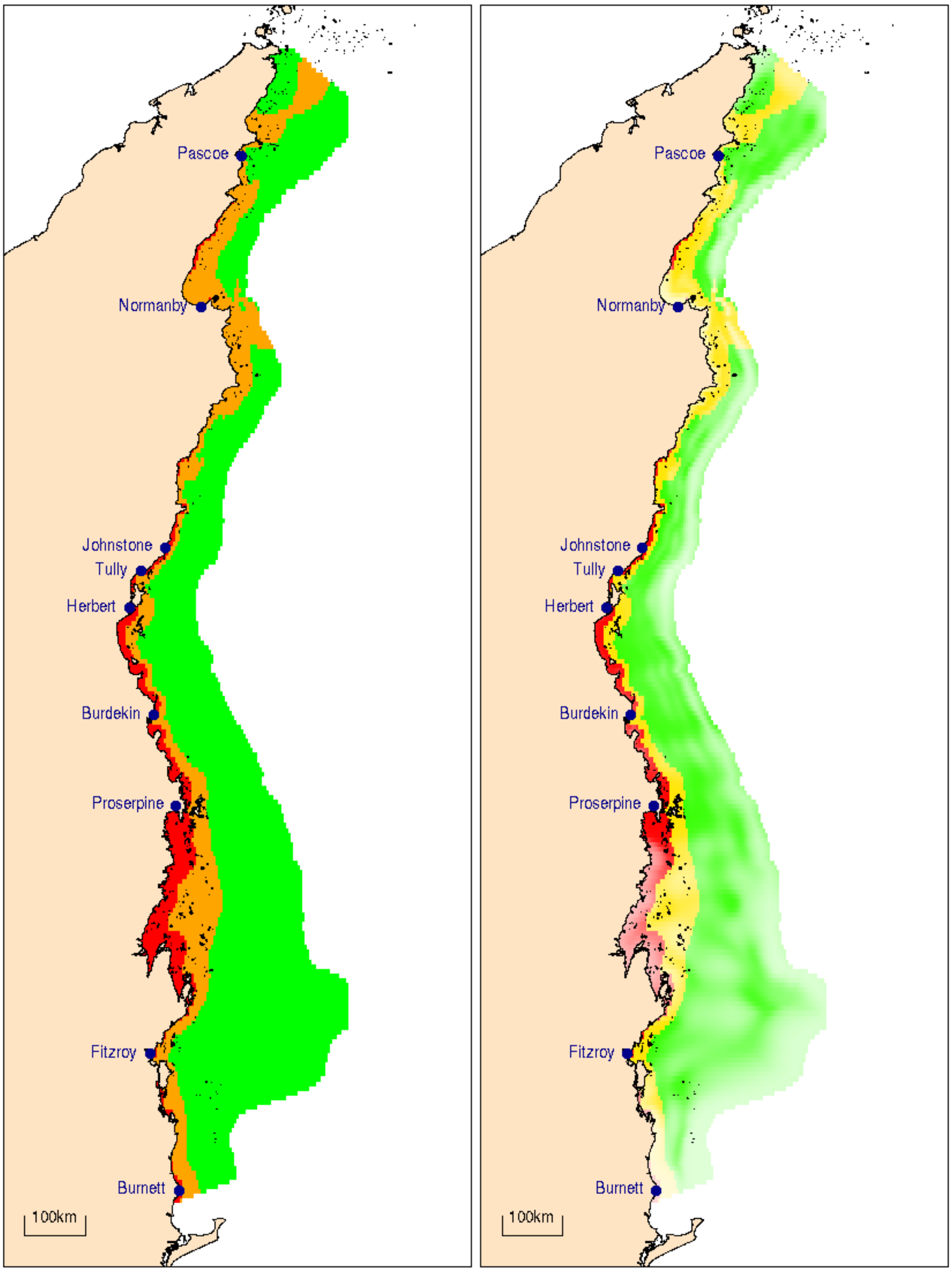

Figure 12: Locations that are presently at less than (green) or exceed (orange and red) the water quality guideline trigger value of a minimum annual mean of ten metres Secchi depth. Orange zones show areas that exceed the guideline trigger values, having Secchi depths of five to ten metres. Red zones show areas of greatest concern with Secchi depth of less than five metres. The level of fading (right panel) indicates the level of confidence in the estimates with faded areas being more uncertain.

(d) Influence area in the Great Barrier Reef lagoon of a single river discharge

Influence area in the GBR lagoon of a single river discharge (river defined as discharge from a defined basin area) – modelled by Maughan *et al.* 2007 for specific pollutants – TSS, DIN, TP and 'total diuron'. There are problems with this due to short-term influence versus long-term influence. For dissolved pollutants every river may influence the whole GBR lagoon in the longer term. A set of pre-European modelled layers are also available to assess changed condition (exposure). See Figures 13-16.

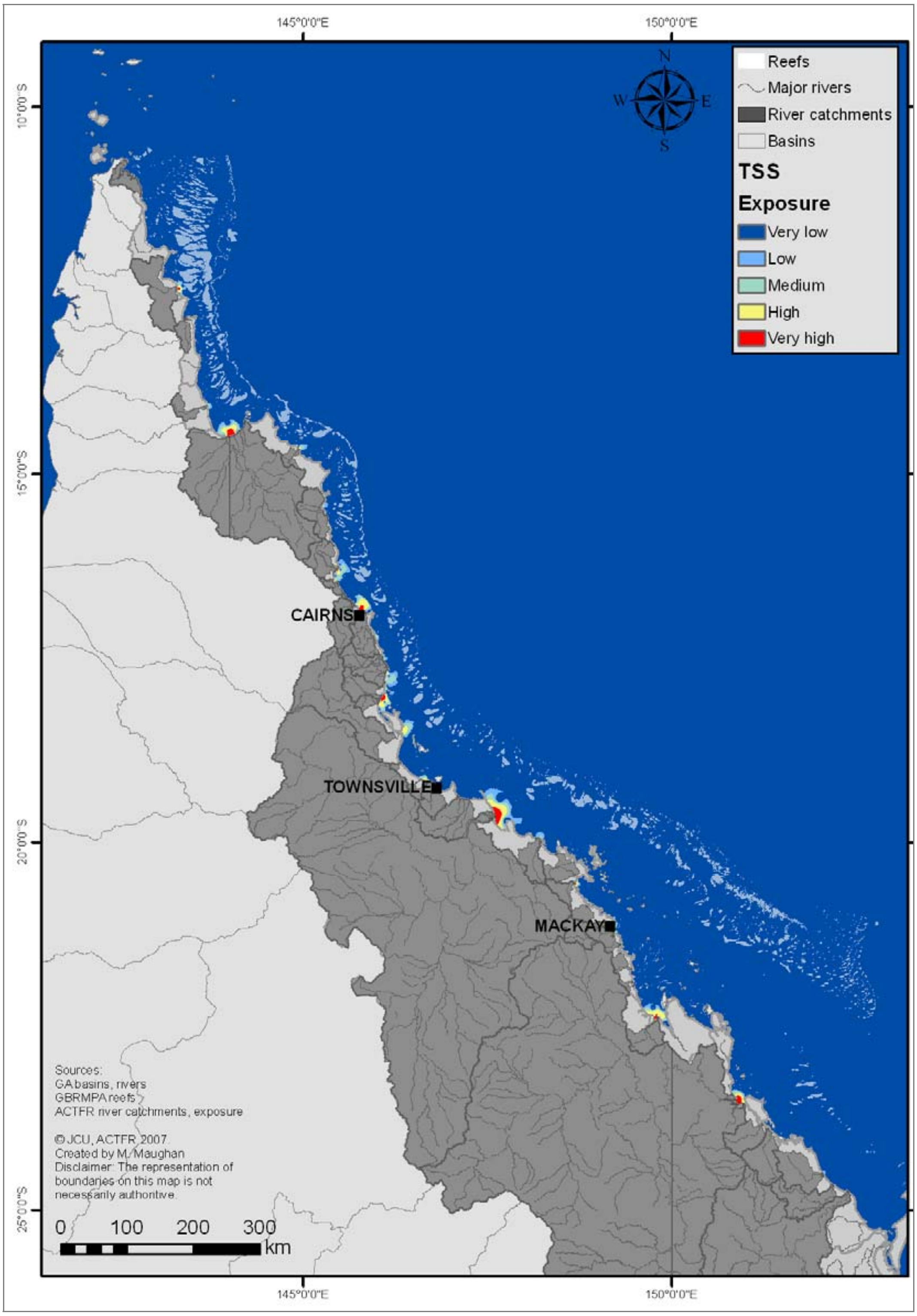

Figure 13: Total suspended sediment exposure, all river influence, current scenario.

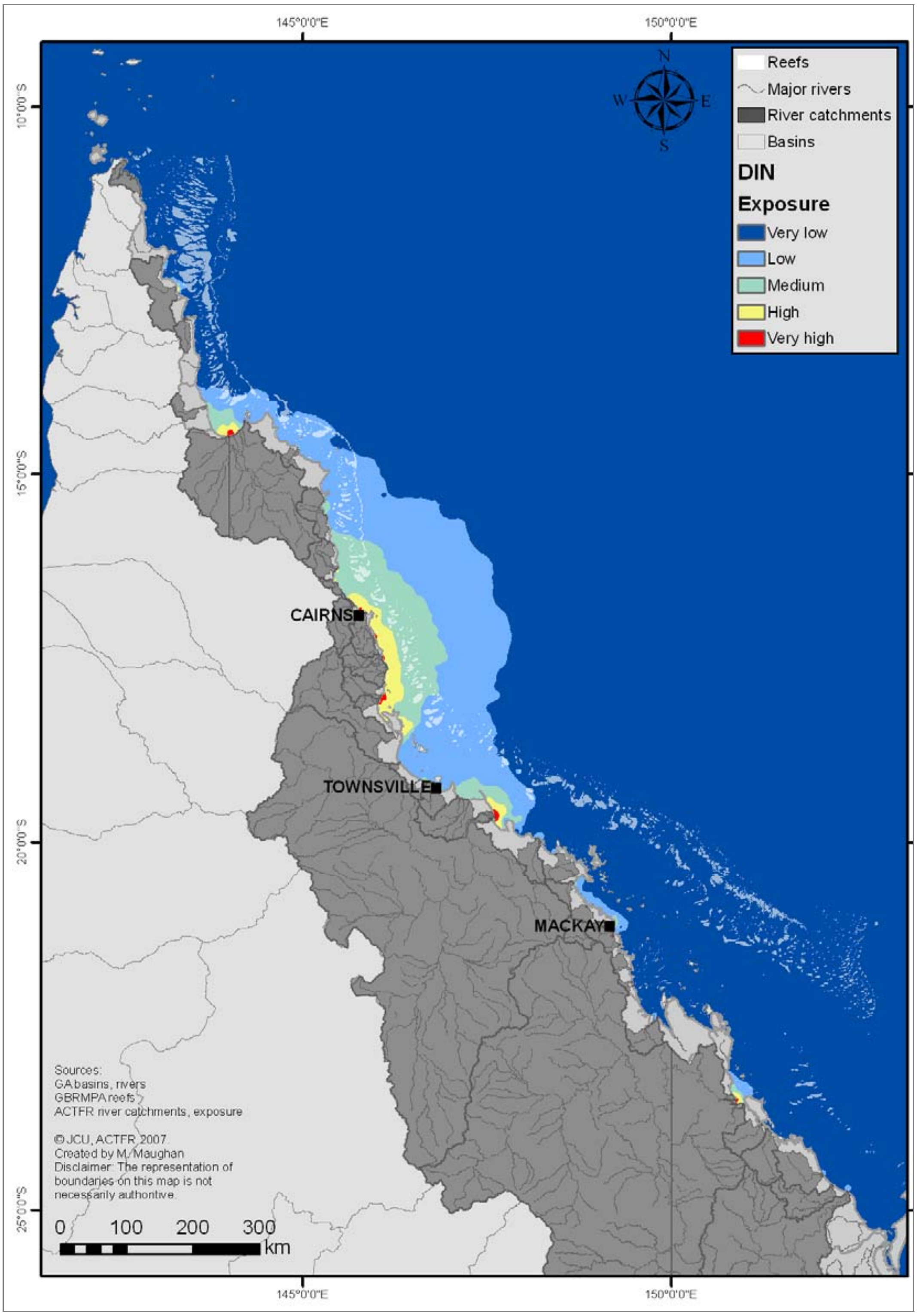

Figure 14: Dissolved nitrogen exposure, all river influence, current scenario.

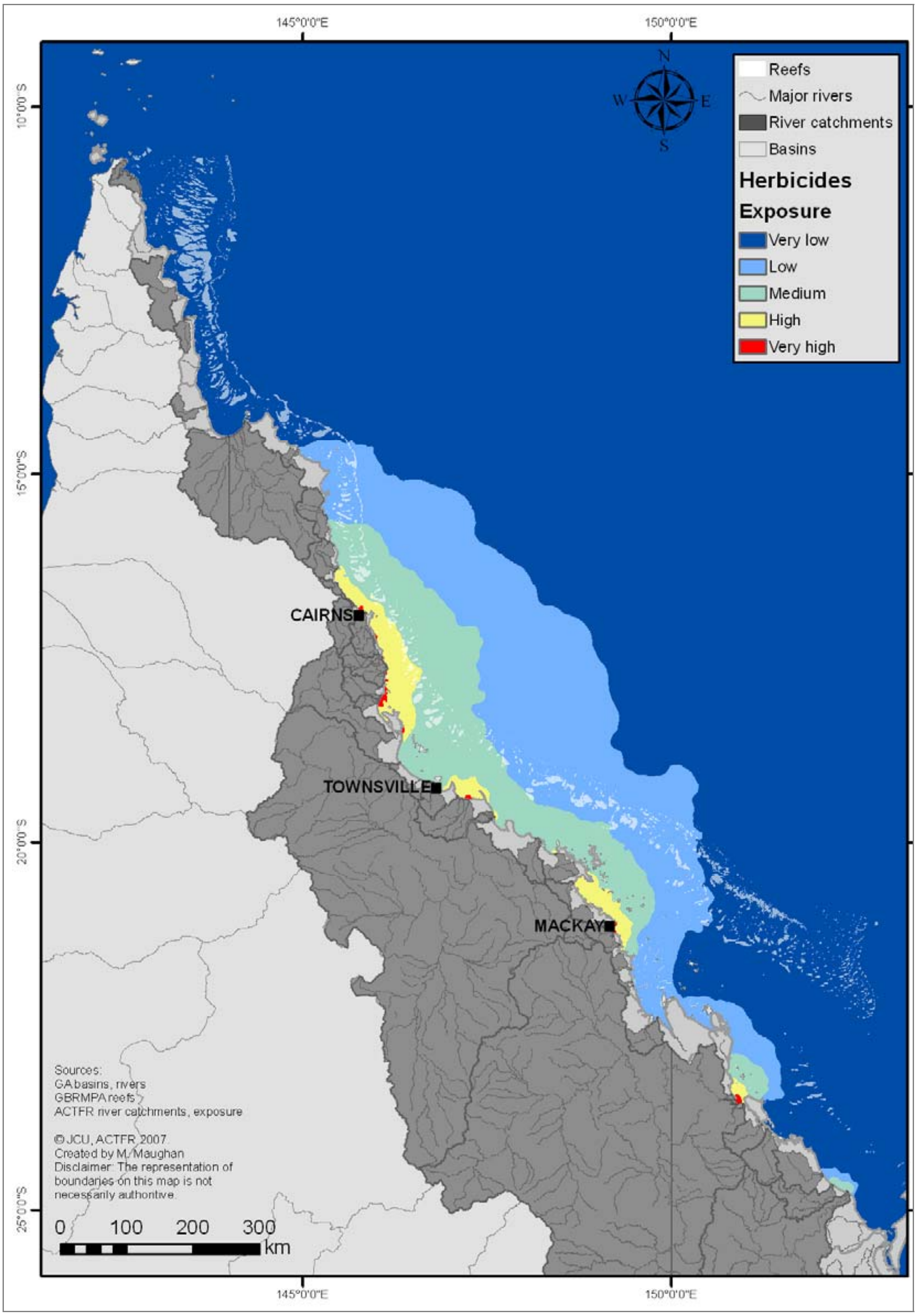

Figure 15: Herbicide exposure, all river influence, current scenario.

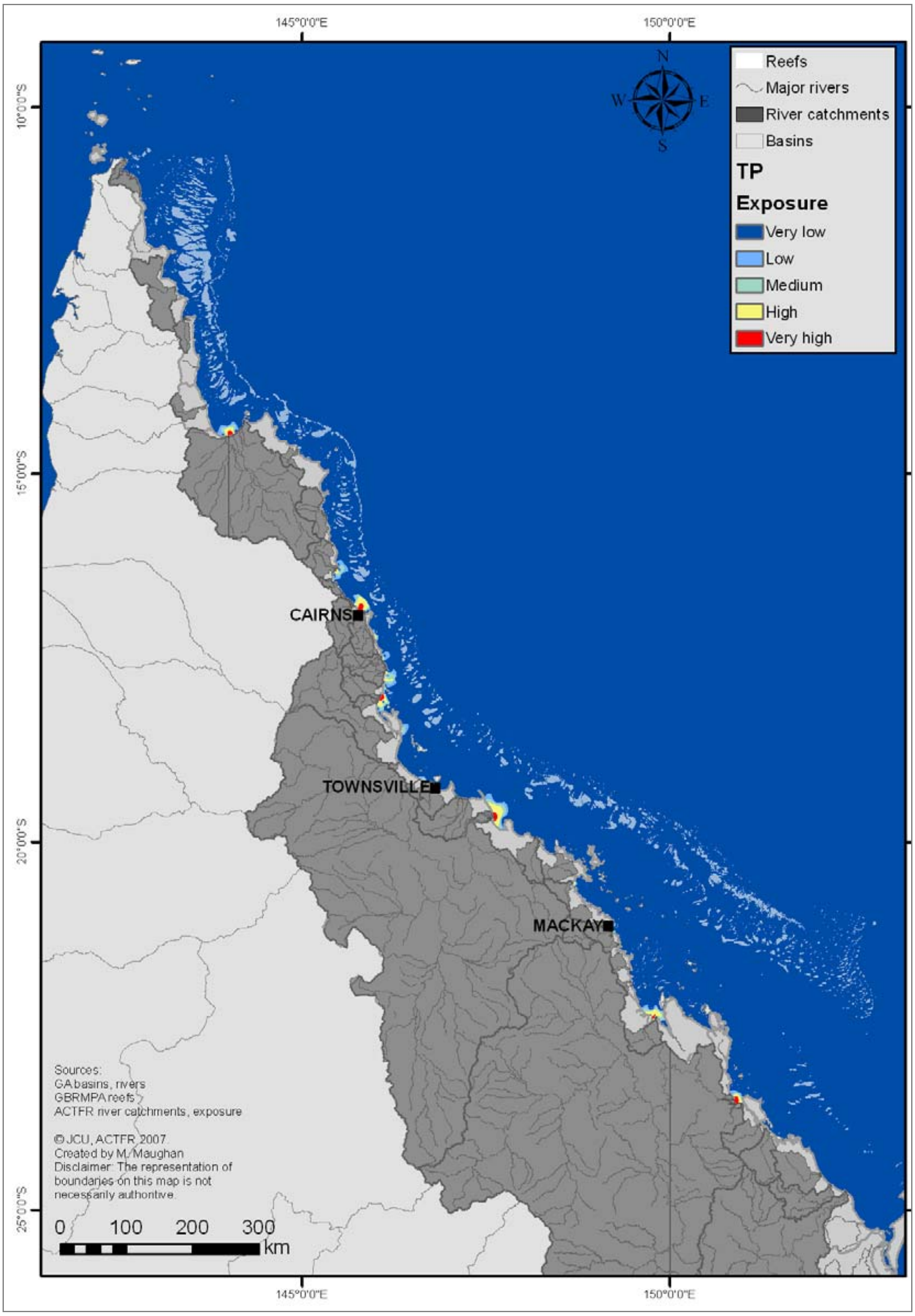

Figure 16: Total Phosphorus exposure, all river influence, current scenario.

(e) Information layers from satellite images

Dispersal of 'visible' suspended sediment, reactive nutrients (via 'green colour') and general flood water (via colour of CDOM). Interpreted signals identifying SS, chlorophyll and CDOM.

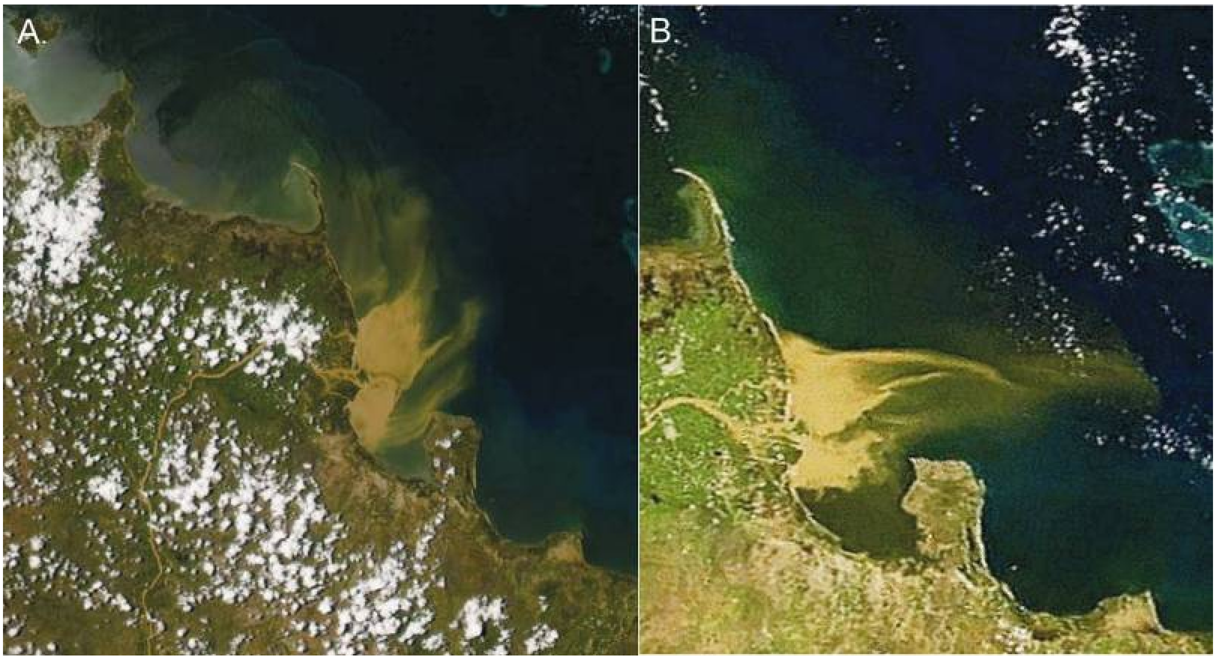

Figure 17: Suspended sediment in Burdekin plumes.

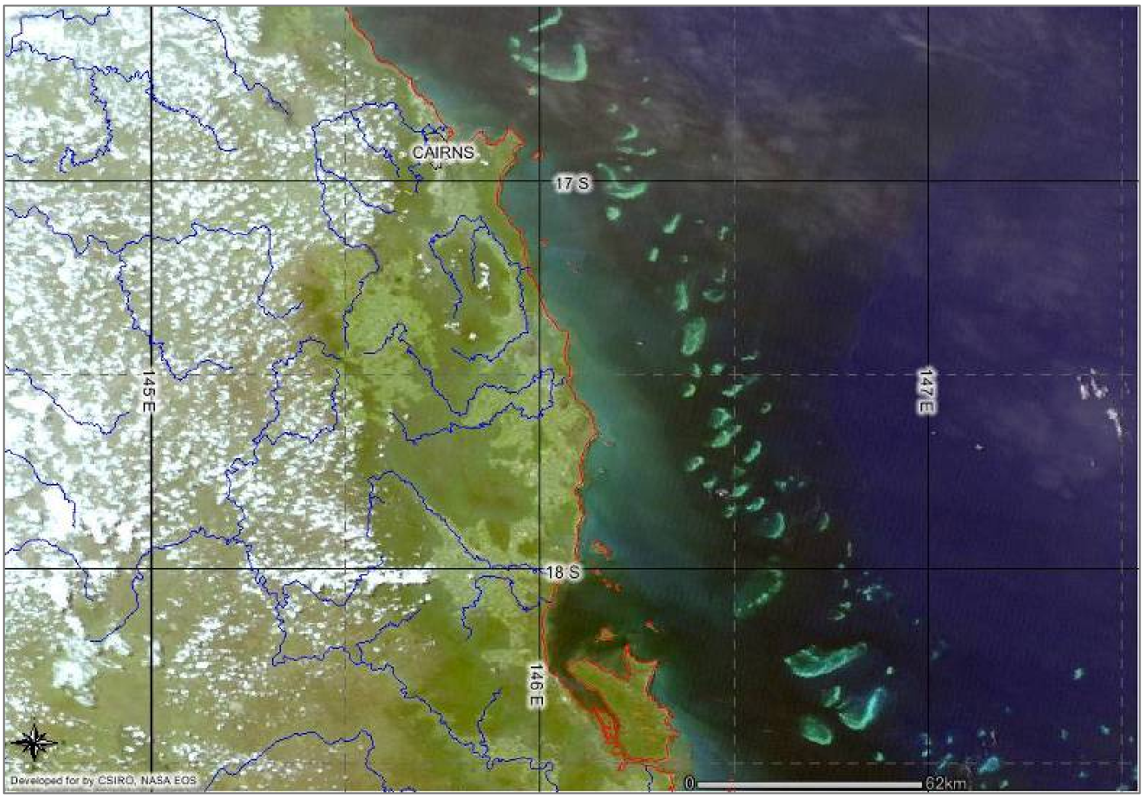

Figure 18: Chlorophyll and CDOM cover, Wet Tropics outer reef.

Figure 19: Algal bloom off Mackay.

Current river loads of pollutants

Current loads of TSS, PN, PP, DON, DIN, DOP, DIP, diuron, atrazine, hexazinone, ametryn, tebuthiuron, simazine, 2,4 –D (diuron – simazine maybe expressed as 'diuron equivalent') for each defined river basin.

First round estimates in Brodie *et al.* 2009.

Selected river basins as in Brodie *et al.* 2003 (Figure 20).

Figure 20: River basins of the Great Barrier Reef.

Map source areas

Map source areas of high loadings to river mouth of each pollutant (as in 10) by catchment. For TSS use SedNet runs. For nutrients use ANNEX runs plus NMZ analysis. For herbicides, use land use.

SedNet analysis

Figure 21 (from Brodie *et al.* 2003) shows TSS delivery to coast in current conditions and Figure 22 in natural conditions.

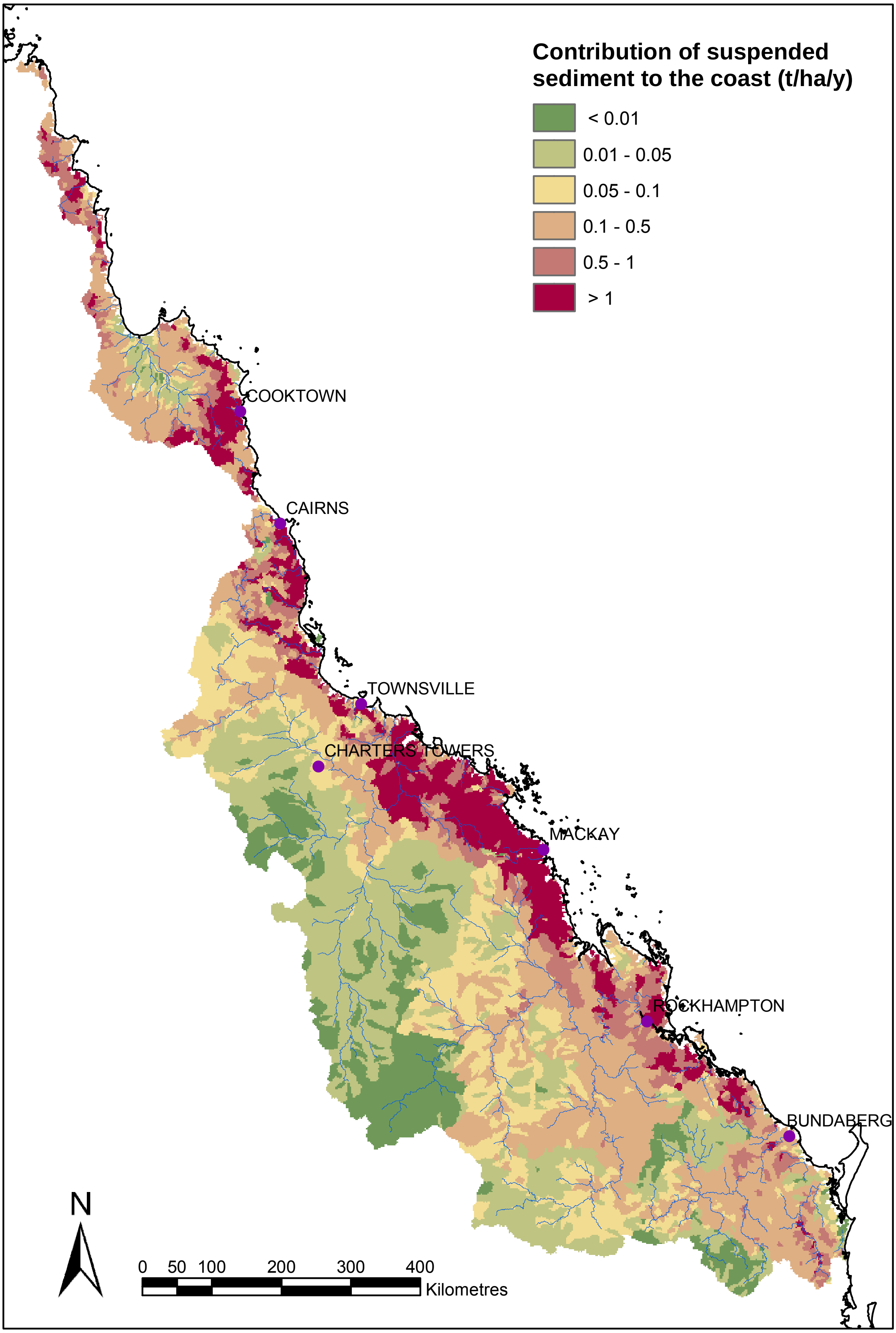

Figure 21: Total suspended sediment delivery to coast – current conditions.

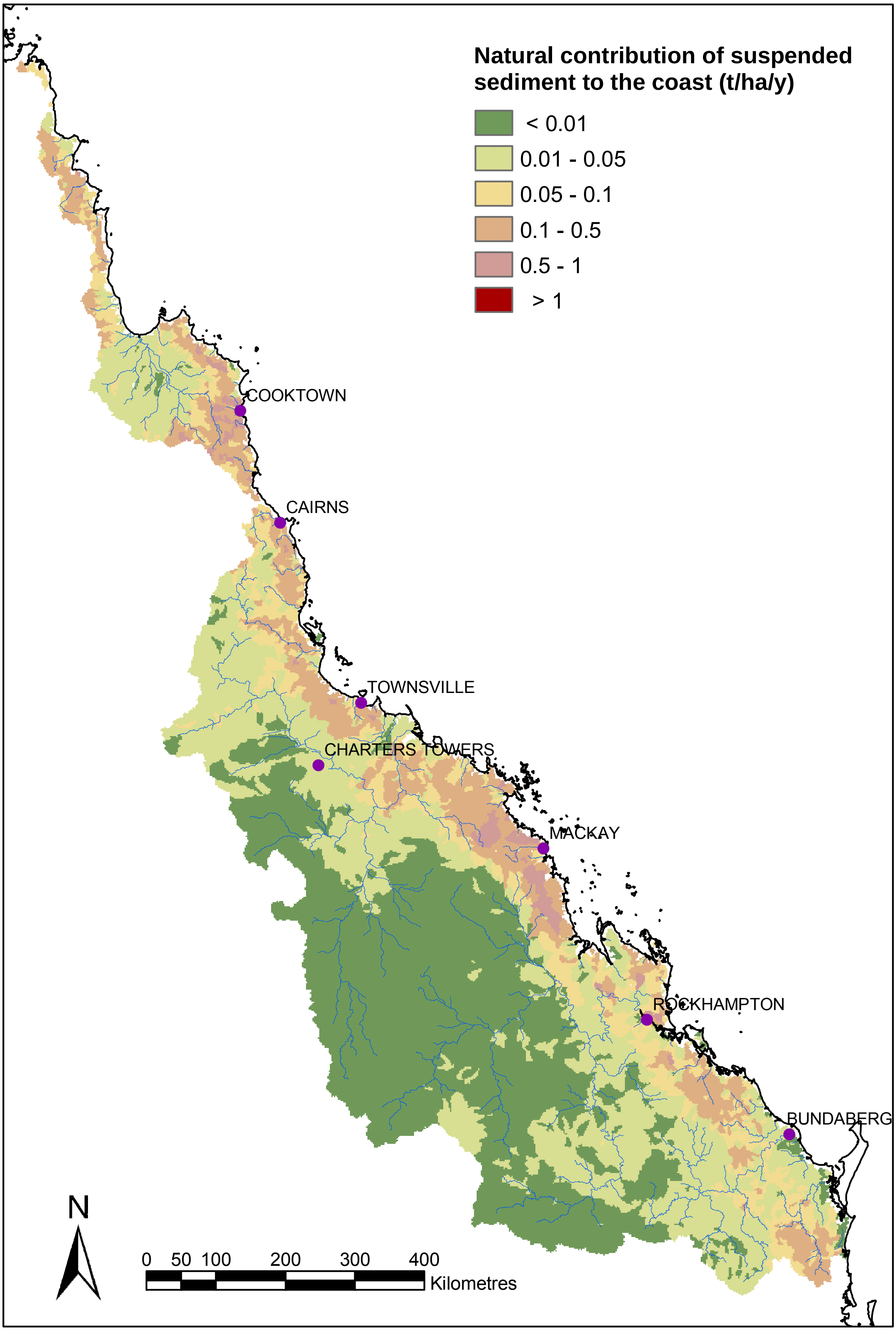

Figure 22: Total suspended sediment delivery to coast – natural conditions.

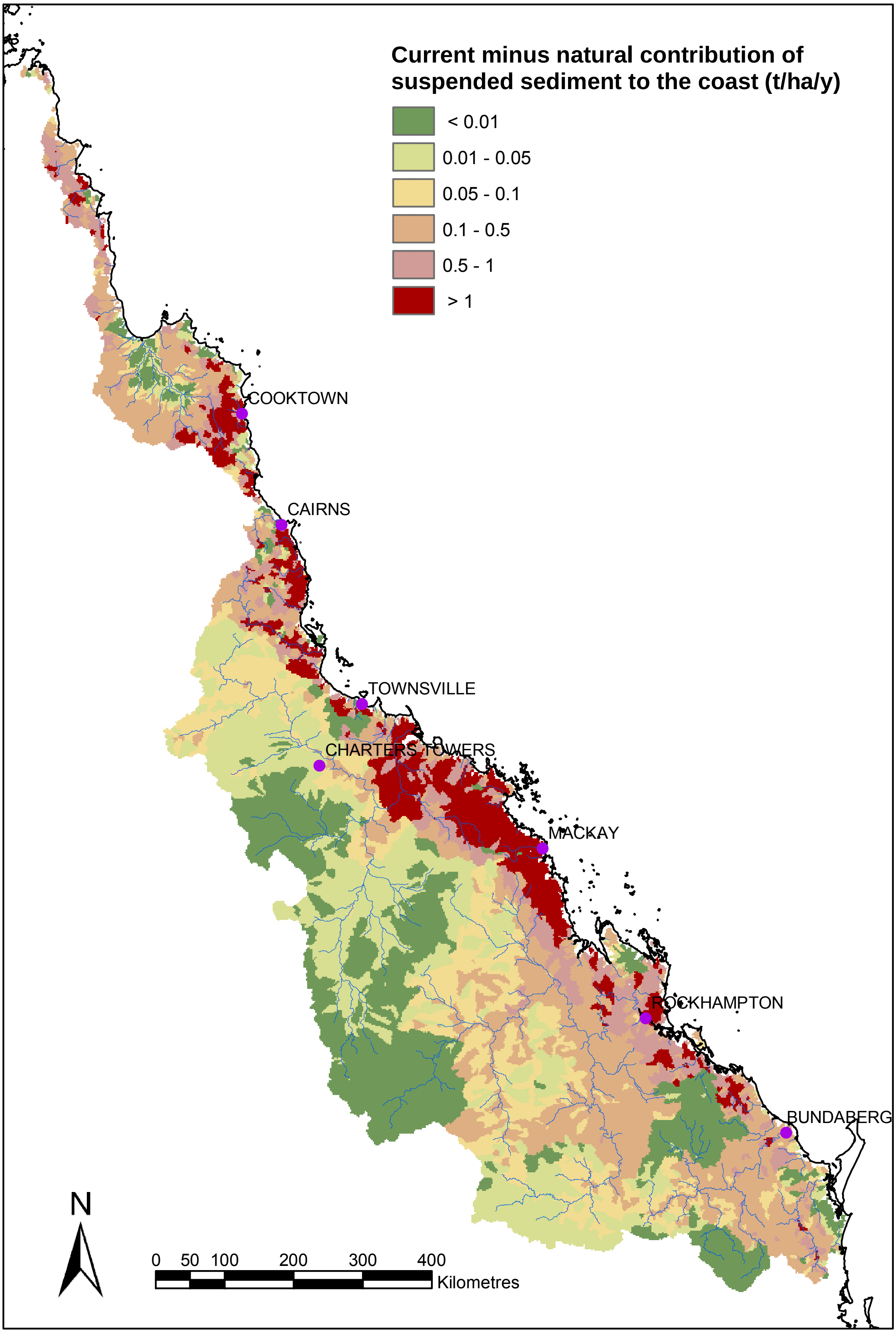

Figure 23: Current minus natural contribution of suspended sediment to the coast.

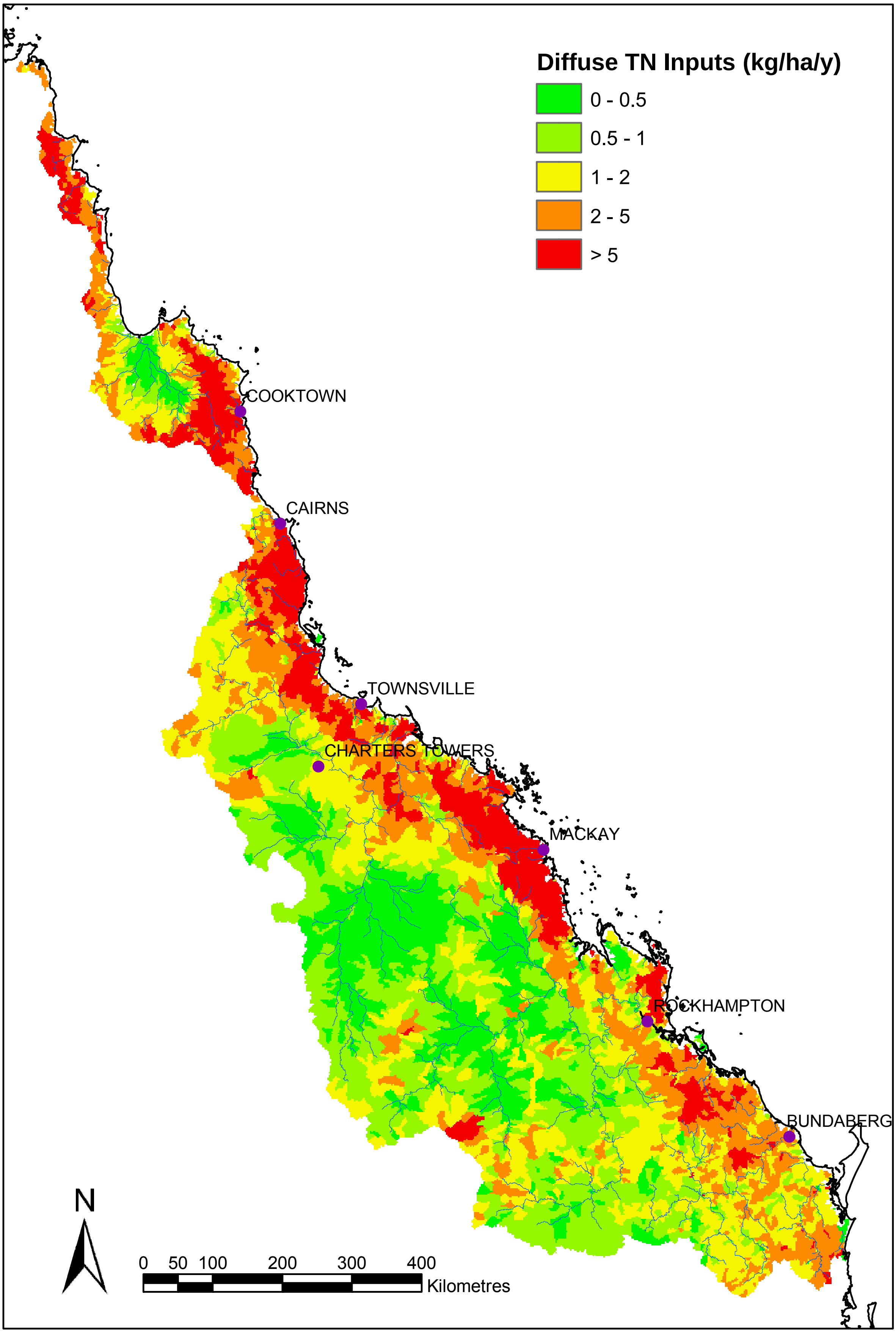

Figure 24: Diffuse total Nitrogen inputs.

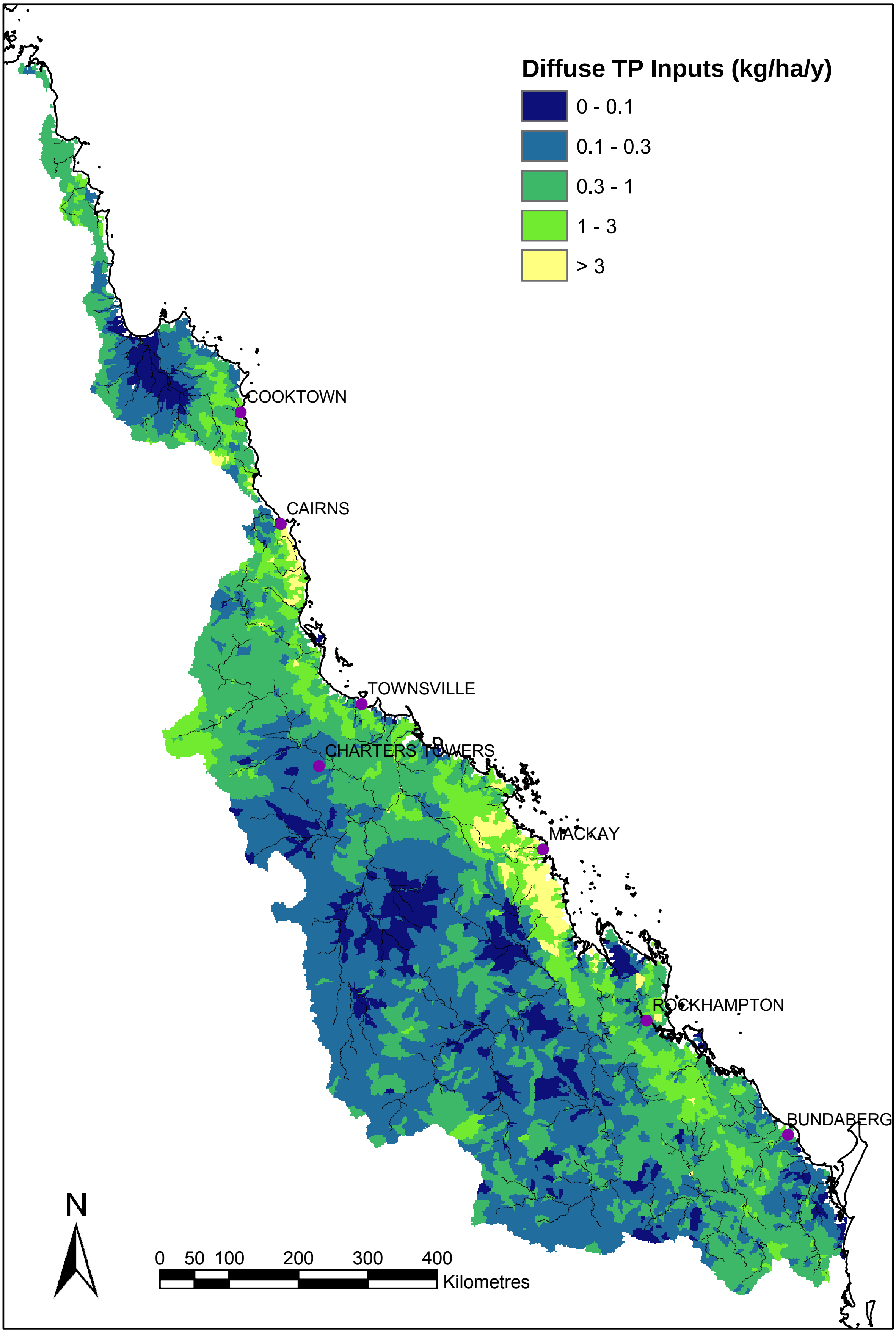

Figure 25: Diffuse total Phosphorus inputs.

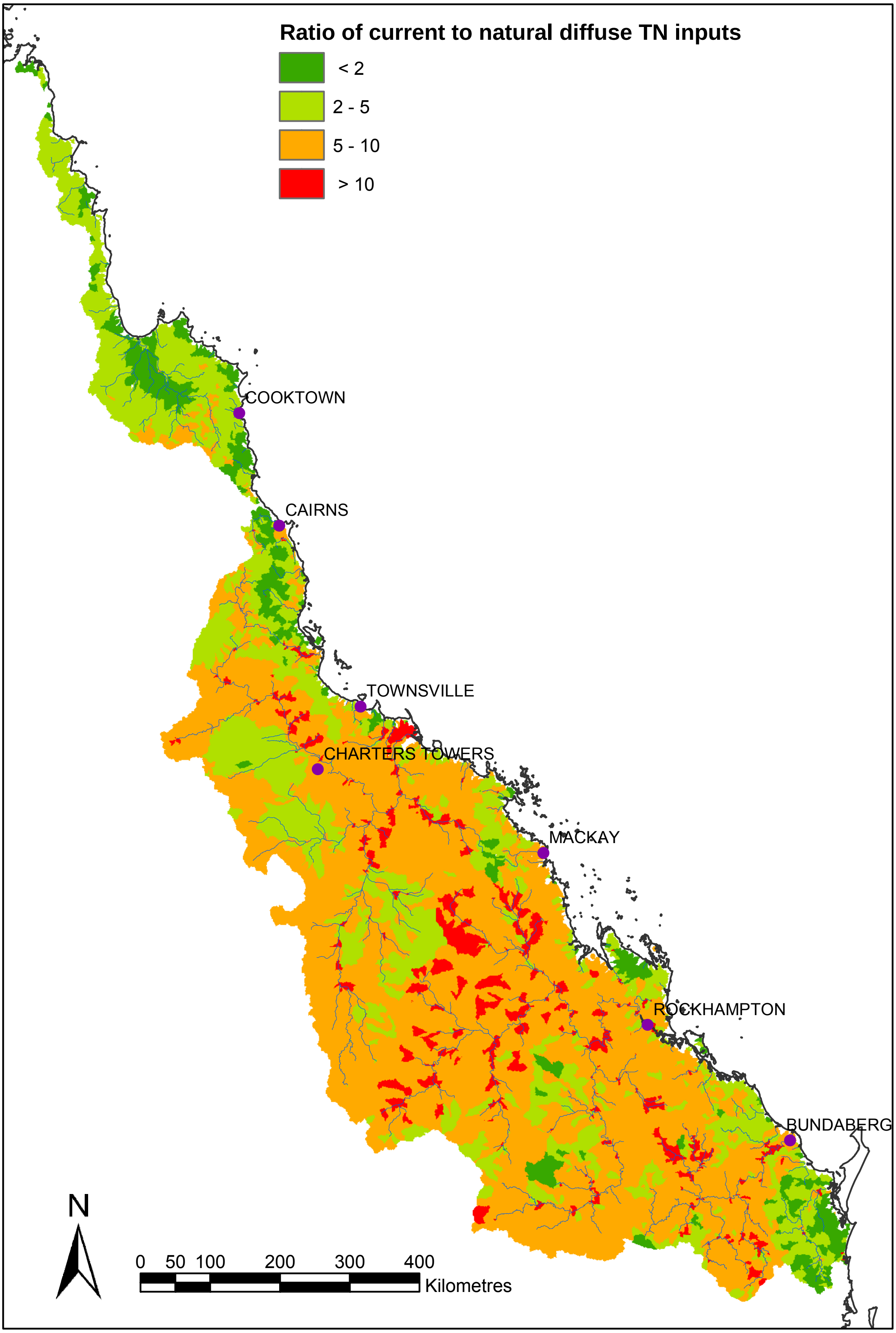

Figure 26: Ratio of current to natural diffuse total Nitrogen inputs.

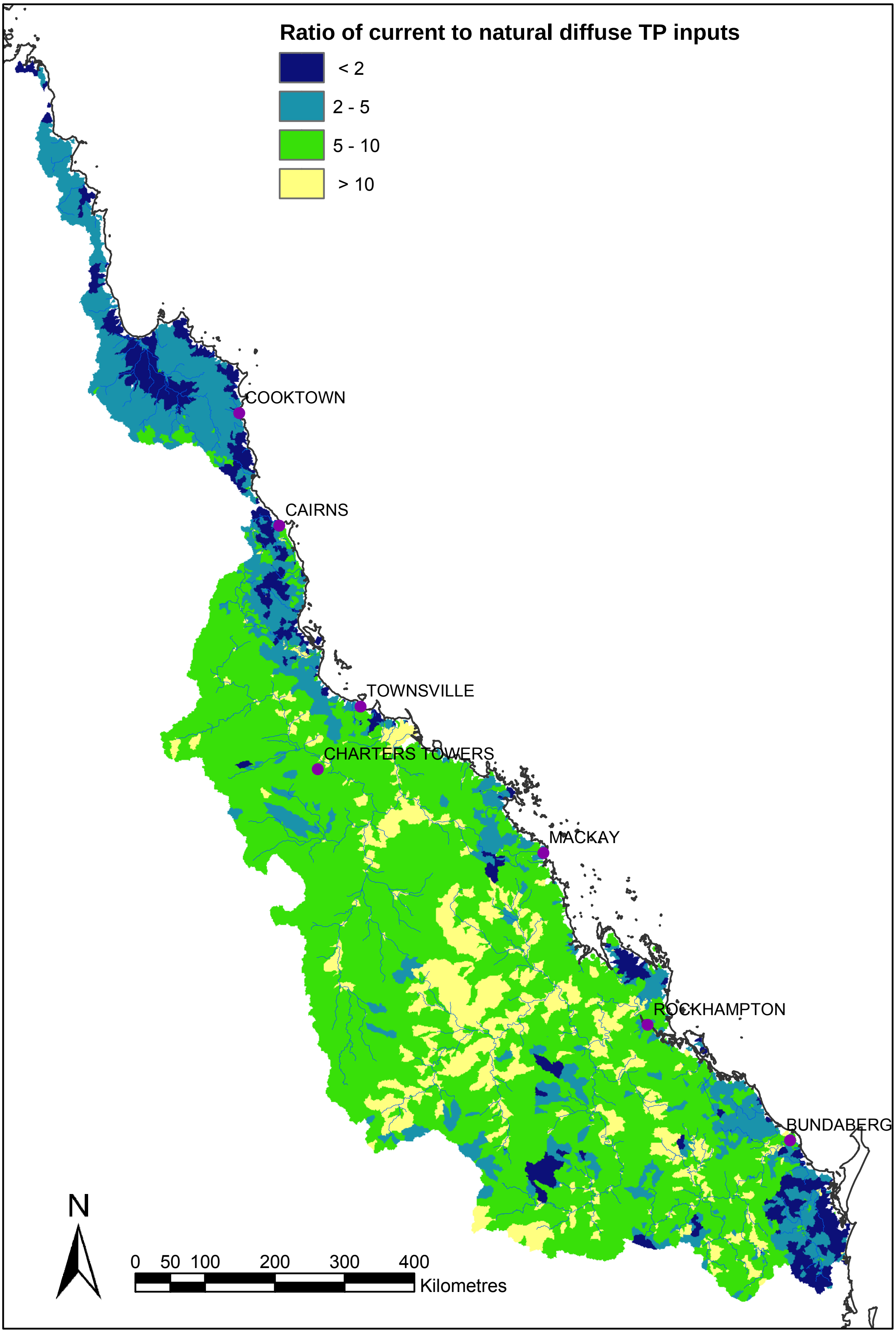

Figure 27: Ratio of current to natural diffuse total Phosphorus inputs.

Fertilised land analysis

Most dissolved inorganic nutrients derive from fertiliser residues. High delivery areas were documented in the NMZ process (Brodie 2007). The areas as mapped are below.

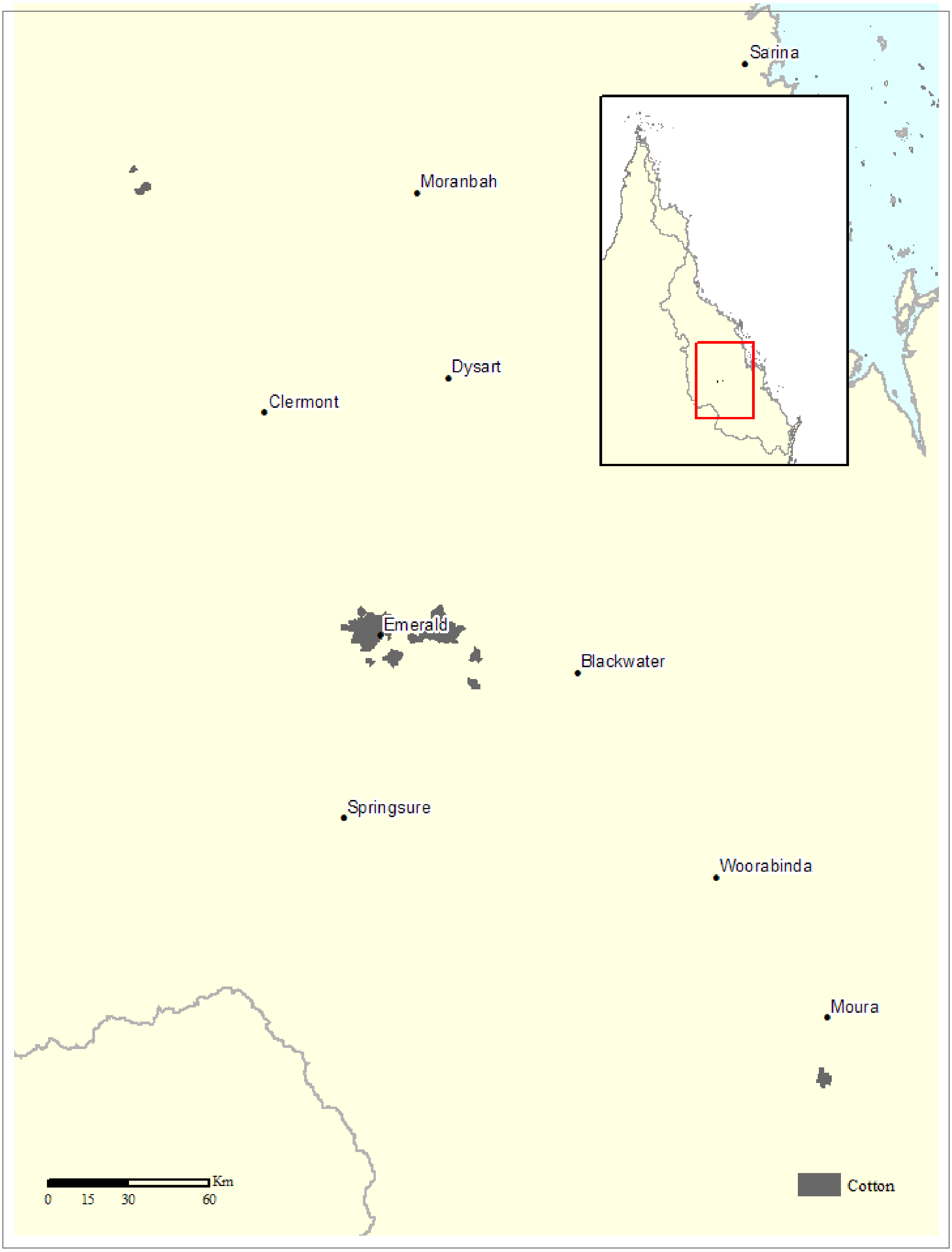

Figure 28: Fertilised land analysis – Cotton.

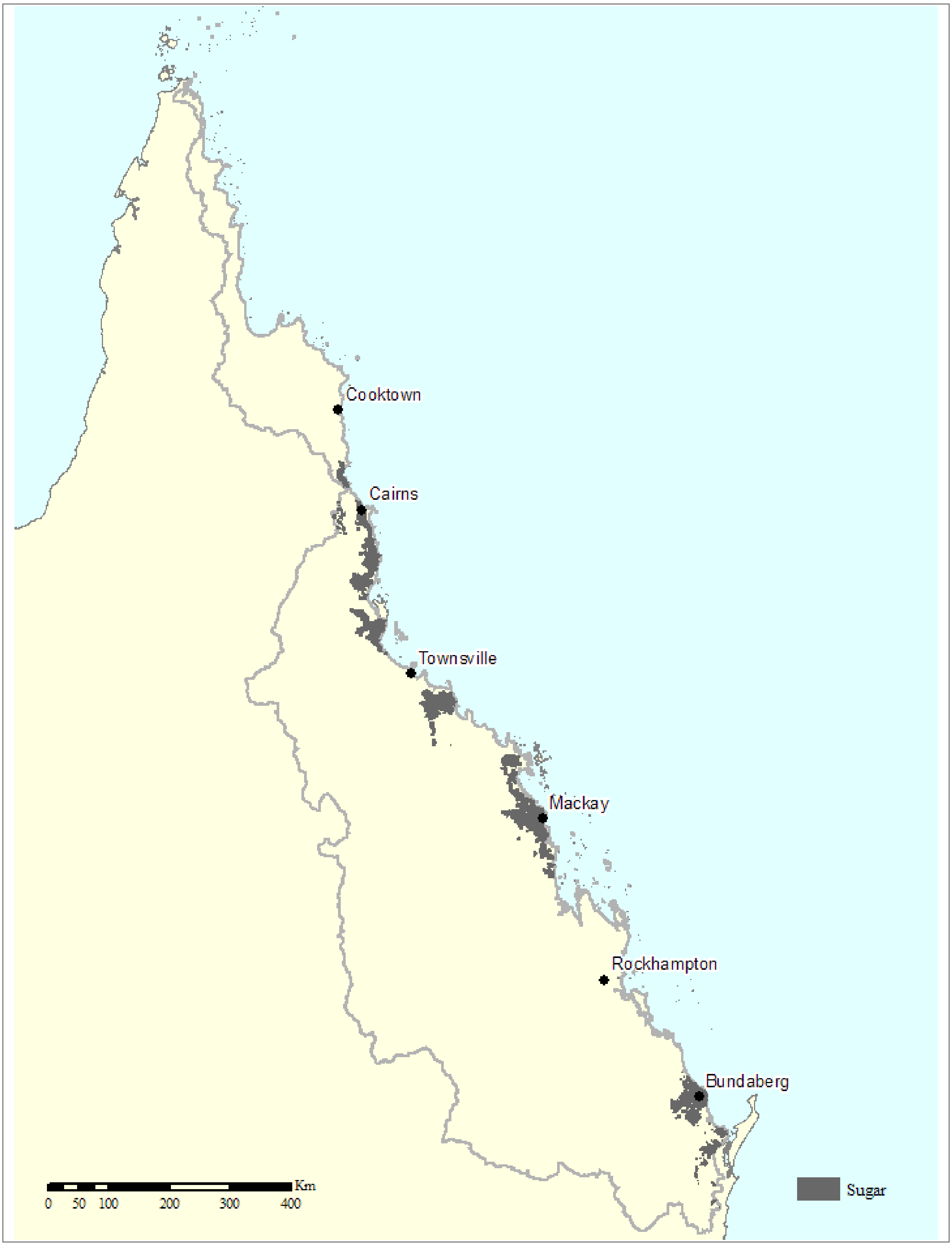

Figure 29: Fertilised land analysis – Sugar.

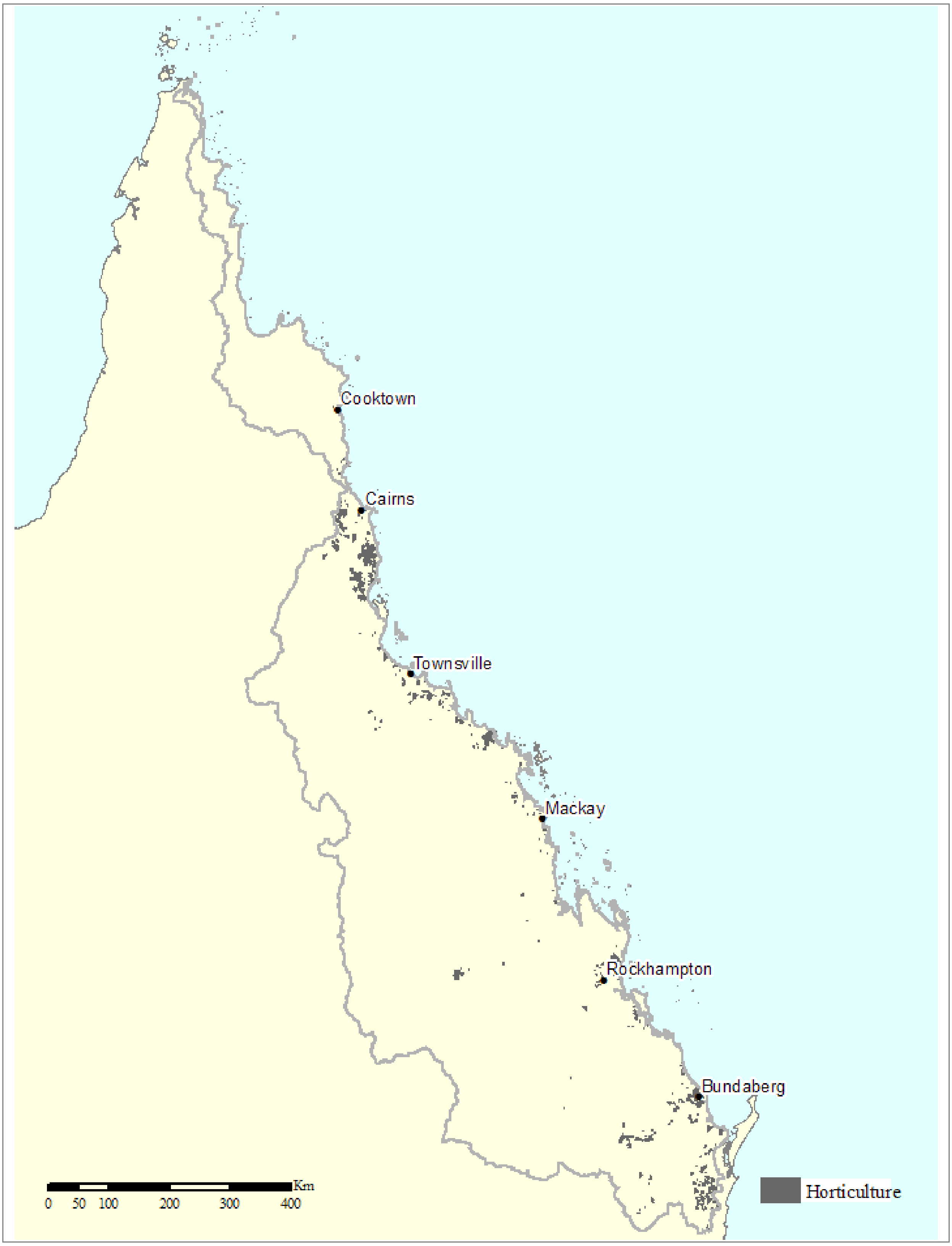

Figure 30: Fertilised land analysis – Horticulture.

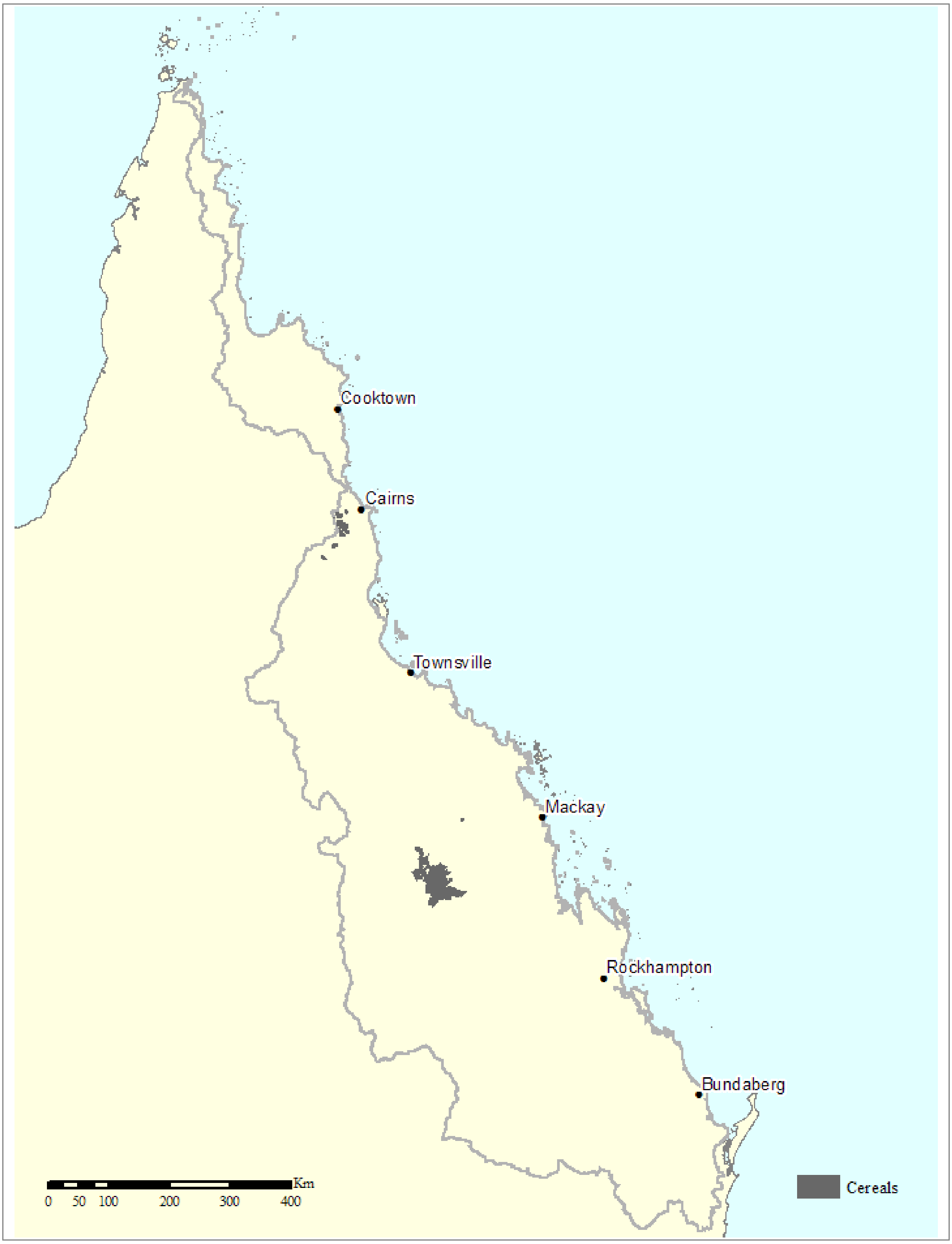

Figure 31: Fertilised land analysis – Cereals.

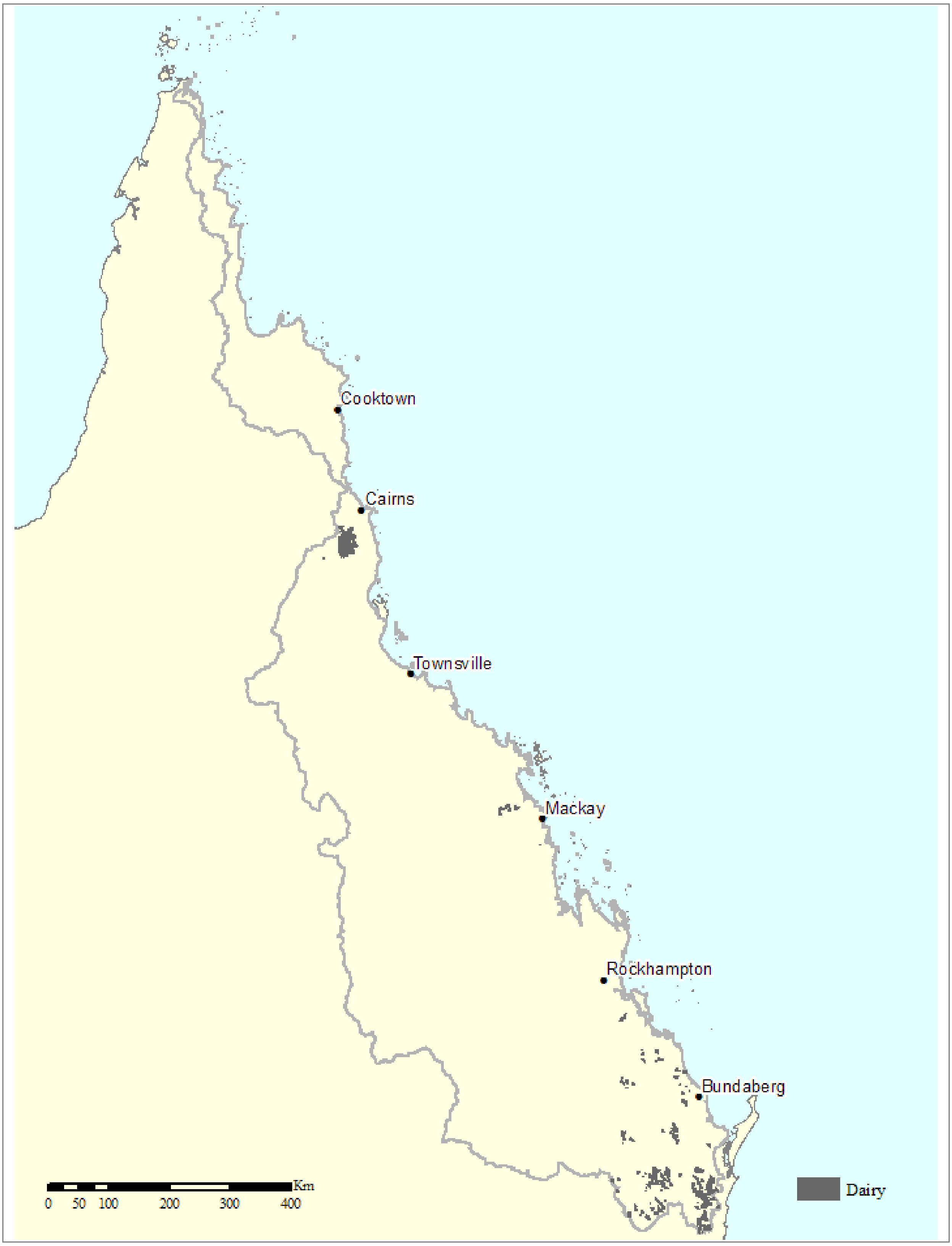

Figure 32: Fertilised land analysis – Dairy.

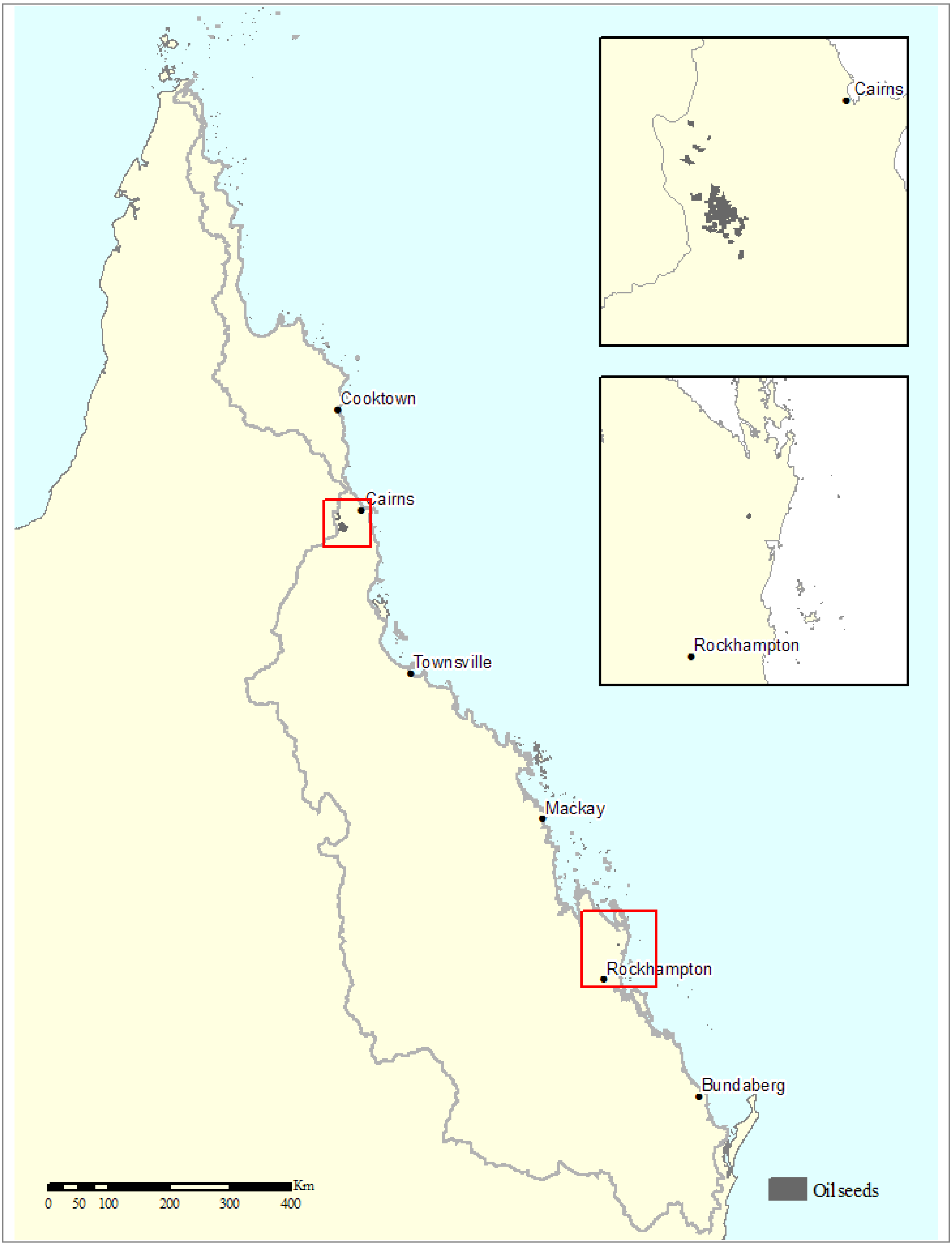

Figure 33: Fertilised land analysis – Oil seeds.

No map is available to show the coverage of fertilised beef pasture. Current QLUMP (1999) methods are unable to distinguish between fertilised and unfertilised pastures (C. Witte, NRW 2006, pers. comm.).

High quality pastures, generally found in higher rainfall areas near the coast, are often used for improving stock condition before sale. The productivity of these 'beef finishing' pastures is often enhanced through fertiliser use, although in general only areas receiving more than 1000 mm of annual rainfall would be fertilised. Beef finishing takes place in the following regions:

- **Wet Coast Tablelands (Johnstone, Herberton, Babinda, Innisfail, Douglas, Mossman, Cairns, Cardwell, Mareeba, Atherton, Eacham):** Approximately 168 000 ha carries approximately 240 000 head of cattle at any one time, with 65 000 turned off per year (Bernie English, Tablelands DPIF 2006, pers. comm.).
- **Fitzroy Basin:** There are approximately 3.5 million head of cattle within a 350 km radius of Rockhampton. Feedlotting is used for finishing more than pasture-based systems. Fertiliser in this industry is mostly used for forage crops such as sorghum, which may be harvested for stock feed or directly grazed. Beef finishing systems generally do not use fertiliser (pondage systems, feedlots, and leucaena are used instead) (Ken Murphy, DPIF Rockhampton 2006, pers. comm.).
- **Mackay-Whitsunday region: A**pproximately 76 per cent (690 400 ha) of the region has grazing as the main land use. However this includes large areas of ranges and tree-covered areas seldom grazed plus native pasture not fertilised, Crown land and public areas etc. DPIF staff estimate that approximately two- to three-hundred thousand hectare would be fertilised (Harry Bishop, DPIF Mackay 2006, pers. comm.).

Significant areas of fertiliser use

For the purposes of this draft technical report, the GBR catchment can be divided into a small number of regions with similar land use types. The significant areas of fertiliser use in the GBR catchment can then be further broken down into ten basically discontinuous regions:

- Inland Normanby;
- Atherton and Evelyn Tablelands;
- Wet Tropics Coastal;
- Burdekin Coastal;
- Inland Burdekin;
- Bowen;
- Mackay–Whitsunday Coastal;
- Fitzroy;
- Inland Burnett; and
- Burnett Coastal.

The Mary catchment is excluded, as its area of major influence, Hervey Bay, is outside the GBR World Heritage Area.