TREE CLEARING AND SEDIMENT POLLUTION IN GREAT BARRIER REEF CATCHMENTS 2018 TO 2022

2nd Edition

A technical report prepared for the Australian Marine Conservation Society by Martin Taylor and Imogen Zethoven AO

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by

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ACKNOWLEDGEMENT: The Australian Marine Conservation Society acknowledges the sea country management and custodianship of the Great Barrier Reef by Aboriginal and Torres Strait Islander Traditional Owners, whose rich cultures, heritage values, enduring connections and shared efforts protect the Reef for future generations. We pay our respects to their Elders, both past, present and emerging leaders. We acknowledge that the Great Barrier Reef was and always will be Aboriginal land and sea.

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EXECUTIVE SUMMARY

World Heritage concerns about tree clearing in Reef catchments

Tree clearing in catchments adjacent to the Great Barrier Reef (GBR) is recognised as a primary biophysical driver of anthropogenic sediment and particulate nutrient loss to the World Heritage listed property.[1] Fine sediment causes turbidity and can smother seagrasses and inshore corals, which provide habitats for threatened species such as turtles and dugongs.

In 2025, the GBR report by the World Heritage Centre and IUCN to the World Heritage Committee concluded that to improve Reef water quality, "it is critical that clauses under existing laws are strengthened to ensure that all remnant and high value growth areas are protected, in line with the recommendation from the 2022 mission to the property". The Committee requested Australia to take action to:

> *"Strengthen clauses under existing laws to ensure that all remnant and high value growth areas are protected, including Category X vegetation (under the Queensland Vegetation Management Act) and other high priority areas including riparian zones, lands vulnerable to degradation and areas contributing to sediment and nitrogen pollution."*

The purpose of this study is to examine native vegetation clearing in the Great Barrier Reef Catchment, focusing on:-

- areas that can be and are cleared 'as of right' but should be subject to clearing restrictions;
- areas vulnerable to soil erosion and sediment runoff, including riparian areas.

The study is structured into the following sections:

Section 1: Regulation of tree clearing in Queensland

The Queensland Vegetation Management Act (VMA or "the Act") regulates clearing of native woody vegetation in Queensland. Clearing for some purposes like fences and firebreaks or clearing of non-native vegetation is exempt from the Act. Native vegetation exempt from the Act is explicitly mapped as "Category X". As of July 2024, 36% of the GBRC land area was mapped as Category X (15.3 million ha). However, only about three million hectares (20% of the category X land area) had woody vegetation cover in 2022. These areas are mapped as exempt because at some point in the past they had been cleared and in most cases have since been "locked in" as forever exempt on a Property Map of Assessable Vegetation (PMAV) and clearing there can occur 'as of right', regardless of whether it has grown back to maturity, whether it is of high conservation value or whether it is on land vulnerable to soil erosion and sediment runoff.

PMAVs are difficult to reverse without the consent of the landholder. However, where Category X is not "locked-in" by a PMAV, the Queensland Government can readily remap Category X into a regulated category, if it meets criteria to belong to those Categories.

Although clearing may be exempt from the VMA, this does not mean it is exempt from all legal restrictions. The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* may still apply if a Matter of National Environmental Significance, such as the Great Barrier Reef Marine Park or World Heritage area, is impacted by the clearing.

Section 2: Exempt vs regulated tree clearing in Reef catchments

Over the four years 2018-2022, 684,008 hectares of woody vegetation were cleared across the GBRC. As this figure excludes plantation harvest, most woody vegetation cleared was native vegetation. Nearly 82% (559,858 ha) was exempt from the VMA.

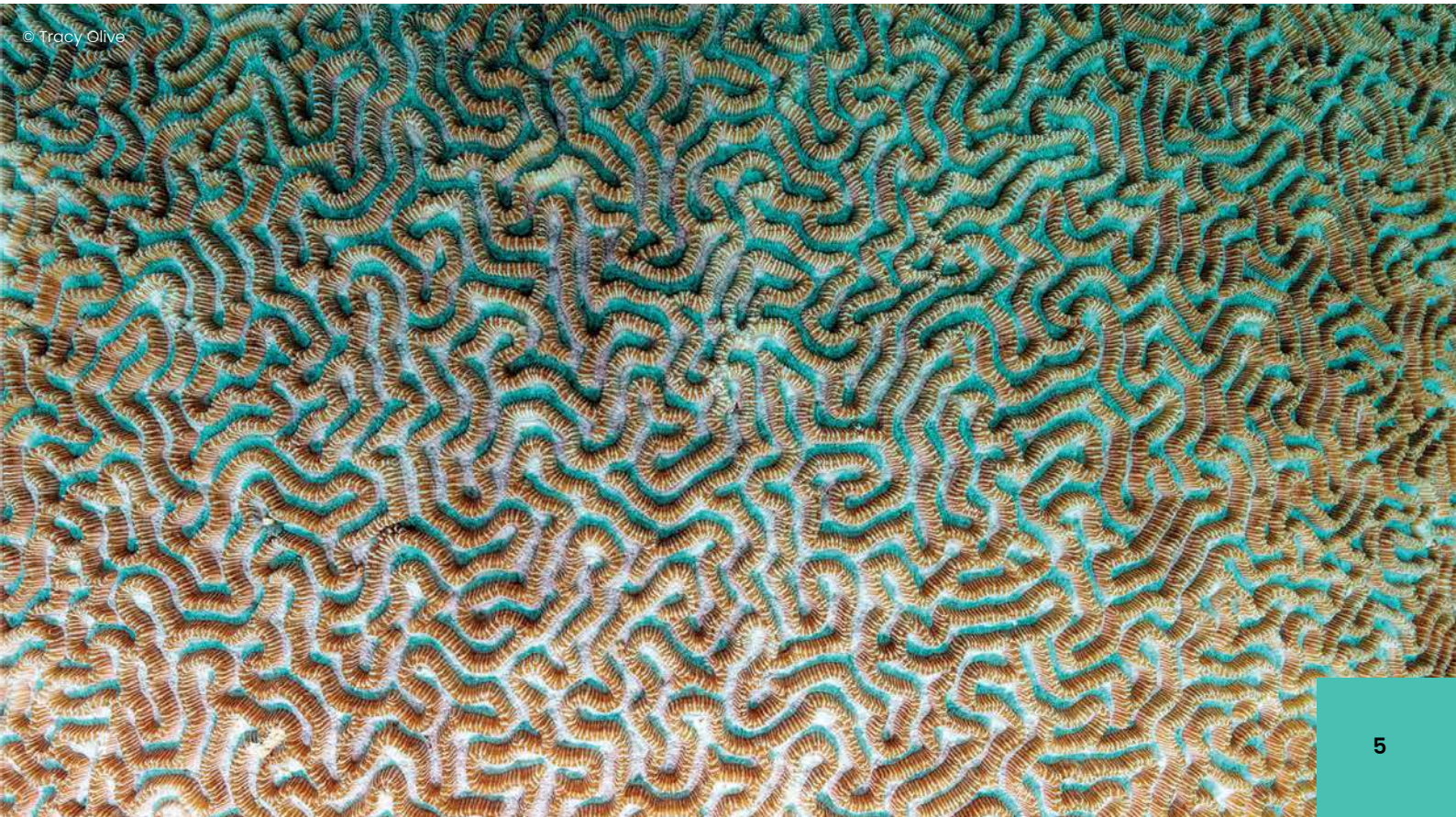
In 2018-19, total annual clearing within the GBRC reached 212,993 ha. Subsequently, total clearing declined incrementally from 172,994 ha in 2019-20 to 139,153 ha in 2021-22. Of all clearing, 88% was for livestock pasture development.

A total of 108,075 ha of regulated remnant (mature or intact) vegetation and regulated regrowth - both of which are subject to restrictions under the VMA - were also cleared. This occurred despite the VMA being amended in 2018 to remove weaknesses introduced by the previous government.

Section 3: Clearing of exempt vegetation that should not be exempt

The majority (82%) of exempt Category X vegetation that was cleared in the GBRC during the four-year study period potentially should have belonged to regulated Categories prior to clearing. This represented 67.5% of all woody vegetation clearing in the GBRC over the four-year study period.

Currently, over three million hectares of the Category X land area in the GBRC potentially belong in VMA regulated Categories B (remnant), C (high value regrowth) or R (Reef watercourse regrowth). However, as of July 2024, only a fraction of this area (359,269 ha) was not covered by PMAVs.



Section 4: Clearing of areas of high sediment pollution risk

The Reef Water Quality Report Card 2021 and 2022 found that an area of 47,519 hectares of riparian vegetation was cleared in the three years 2018-21. However the Queensland Government's own riparian area spatial data, we find the area cleared to be significantly higher at 55,730 ha over the 2018-21 period, and higher again for the four year 2018-22 period at 70,796 ha. This is because the report card uses change in net woody extent as the measure of change rather than actual clearing activity.

Using published Queensland Government modelling, this study also identified and mapped sub-catchments of the GBRC that are at Very high or High risk of fine sediment runoff to the Great Barrier Reef. Sediment loads entering the GBR derive either from Hillslope erosion or Gully and Streambank erosion.

Of Hillslope sediment loads entering the GBR, 75% derive from sub-catchments that have Very high or High fine sediment export rates. These subcatchments occupy only 16.5% of the whole GBRC land area, and account for 8.5% of all woody vegetation clearing from 2018 to 2022. Just over a quarter (28%) of the land area of these sub-catchments is classified as Category X and of this, half is not covered by PMAVs and so can readily be protected by reclassifying the areas as protected.

Of Gully and Streambank sediment loads entering the GBR 75% derive from sub-catchments that have Very high or High fine sediment export rates, but which occupy only 14% of total GBRC land area and account for only 7.3% of all woody vegetation clearing from 2018 to 2022. Just under a quarter (23%) of the land area of these sub-catchments is classified as Category X and of this, one third is not covered by PMAVs and so can readily be protected by reclassifying the areas as protected.

Recommendations

Fully implement Paragraph 5 of the Great Barrier Reef decision adopted by the 47th Session of the World Heritage Committee, with immediate effect. This should include protection of all remnant native vegetation, all high value regrowth native vegetation, all native vegetation in riparian zones and Category X native vegetation on lands vulnerable to degradation and in areas contributing to sediment and nitrogen pollution.

1. At the State level, Category X native vegetation that is not covered by Property Maps of Assessable Vegetation and which this study has found potentially belongs to regulated Categories under the Queensland Vegetation Management Act 1999 should be assessed and moved into regulated Categories as a matter of urgency. Granting exemptions over these areas via new PMAVs should be suspended until assessment and remapping is complete.
2. At the Federal level,
    a. Amend the significant impact guidelines to clarify that downstream impacts of clearing on MNES, which include clearing of sensitive areas in riparian (watercourse vegetation within 50m) and degraded areas (high erosion subcatchments) are significant impacts.
    b. Reform the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) to remove or constrain the Section 43B exemption that allows clearing in Great Barrier Reef catchments and/ or introduce a land clearing trigger into the EPBC to include scale, sensitivity and high conservation value, which specifically include:
        - Scale: proposals to clear 20 hectares or more of native vegetation in any two-year period.
        - Sensitivity: clearing in sensitive areas, including riparian vegetation (up to 50m from watercourse) and degraded areas.

INTRODUCTION

Tree clearing – the bulldozing, felling or killing of trees and woody vegetation in forests, woodlands and shrublands – in catchments feeding into the World Heritage listed Great Barrier Reef is recognised as a major driver of soil erosion and fine sediment pollution of inshore ecosystems such as coral reefs and seagrass.

Following concerns expressed by the World Heritage Committee regarding poor water quality, in mid-2018 the Queensland Government strengthened the state *Vegetation Management Act 1999* to curb tree clearing throughout the state. Unfortunately levels of clearing remain high.

In this study, Queensland Government spatial data are used to quantify the level of tree clearing in Great Barrier Reef catchments over the four years since the law was amended from 2018/19 to 2021/22.[2] We quantify how much clearing occurred in areas subject to clearing restrictions and how much in areas mapped as exempt, where clearing is unrestricted.

For the first time, we identify areas that are mapped exempt but which potentially should not be, because they may meet criteria for Categories for which the law restricts clearing.

We also quantify clearing in riparian areas and in subcatchments with the highest contributions to fine sediment pollution entering the Great Barrier Reef.

BACKGROUND

Tree clearing and fine sediment pollution of the Great Barrier Reef

Tree clearing is recognised in the scientific literature as a major enabler of soil erosion and consequent fine sediment and nutrient pollution entering the Great Barrier Reef. The recently released Scientific Consensus Statement[3] is currently the best and most authoritative source of information to support evidence-based decisions for better water quality in the Great Barrier Reef World Heritage Area.

The Scientific Consensus Statement finds that:

> *"The most important biophysical drivers of anthropogenic sediment and particulate nutrient export to the Great Barrier Reef are vegetation degradation and soil surface disturbance. … Vegetation degradation is caused by tree clearing (or more generally, land clearing) associated mainly with grazing and cropping land uses, low ground cover primarily from overgrazing and drought, and changes in the structure and function of vegetation including a shift to non-native grass species."*

World Heritage concerns about tree clearing in Reef catchments

The Great Barrier Reef was inscribed on the UNESCO World Heritage list in 1981. More than 40 years later, the Reef is facing unprecedented challenges from the cumulative impacts of climate change, land-based sources of pollution, coastal development and overfishing.

In 2022, a joint UNESCO/IUCN Great Barrier Reef Reactive Monitoring Mission report[4] highlighted the continued rate of native vegetation clearing in the Great Barrier Reef Catchment is driving sediment and nutrient runoff into the World Heritage area. The mission report recommended that the Australian Government:

> *"Prioritise the protection of remnant native vegetation across the GBR catchments through strengthened native vegetation clauses under existing laws, and through improved identification and enforcement of permissible activities in areas of high conservation value (HCV) forests and woodlands. This would include review of sites where clearing is currently allowed without permits (Category X under the Vegetation Management Act 1999) and updating zonation and corresponding permits which limit conversion of HCV areas. Such advances should also incorporate full consideration of traditional owner land management principles."*

In September 2023, the 45th Session of the World Heritage Committee urged the Australian Government *"to fully implement all the recommendations of the mission, including as a matter of utmost priority … d) Prioritise the protection of remnant native vegetation across the GBR catchments"*. The Committee also requested Australia *"to submit to the World Heritage Centre, by 1 February 2024, a progress report on the implementation of the commitments made".*

The former Minister for the Environment and Water, the Hon. Tanya Plibersek, had earlier made a series of commitments in a letter dated 25 May 2023 to the Director General of UNESCO. The key commitment made regarding tree clearing was:

> *"4. By July 2024: expand the implementation of 2018 land clearing legislation and further strengthen protection to remnant and high value conservation areas, including, through an accelerated and enhanced compliance program to secure*

the protection of remnant native vegetation in areas of high conservation value in the Reef catchments."

The Australian Government's 1 February 2024 progress report to the World Heritage Centre did not identify any measures to strengthen *"native vegetation clauses under existing laws".*[5]

In July 2024, the 46th Session of the World Heritage Committee noted *"with serious concern the remaining high rates of land clearing"* in the Great Barrier Reef Catchment (GBRC). The Committee considered this was inconsistent with the objectives set out in the Reef 2050 Water Quality Improvement Plan to achieve water quality targets.

The Australian Government's 1 February 2025 progress report to the World Heritage Centre stated that the Queensland government had "no proposal to further regulate Category X.

In both 2024 and 2025, the Committee requested Australia to take urgent action to:

"Strengthen clauses under existing laws to ensure that all remnant and high value regrowth areas are protected, including Category X vegetation (under the Queensland Vegetation Management Act) and other high priority areas including riparian zones, lands vulnerable to degradation and areas contributing to sediment and nitrogen pollution."[6]

The Reef 2050 Water Quality Improvement Plan

The bilateral Australian and Queensland Governments' *Reef 2050 Water Quality Improvement Plan 2017–2022* ("WQIP" or "the Plan") sets water quality targets for each of the 35 river catchments, grouped into six regions in the GBRC (Fig. 1, App. 1). The five-yearly Plan is to be updated by 2025.

The largest regions are the Fitzroy and Burdekin which extend hundreds of kilometres inland and account for approximately 65% of the GBRC land area. The Burnett-Mary region at the southern end of the GBRC accounts for 14% and all other coastal catchments account for 21% of total land area (Fig. 1, App. 1).

The 35 individual river catchments have been given priorities in the Plan based on the desired reductions in contributions of anthropogenic load of fine sediment to the Reef (Fig.2). Of the catchments, only one is classed as "Very High Priority" for fine sediment pollution reduction – the Burdekin River. Three are classed as "High Priority" – Herbert, Fitzroy and Mary; three are classed as "Moderate Priority" – Johnstone, O'Connell and Burnett; 10 are classed as "Low Priority"; and 18 as "Minimal Priority" (Fig. 2, App. 1).

The Reef Water Quality Report Card 2021 and 2022 (published 30 May 2024) details progress towards the WQIP targets.[7] For the fine sediment targets, the report finds that of all catchments for which a grade was given, only the Murray and Endeavour River catchments had good grades, the rest were graded as "Poor" or "Very Poor". Of five northern catchments for which sediment reduction estimates were reported but not graded, Lockhart, Stewart and Jeannie had shortfalls from the reduction target, while only Normanby and Mulgrave-Russell catchments had met the target (Fig. 3, App. 1).

FIGURE 1

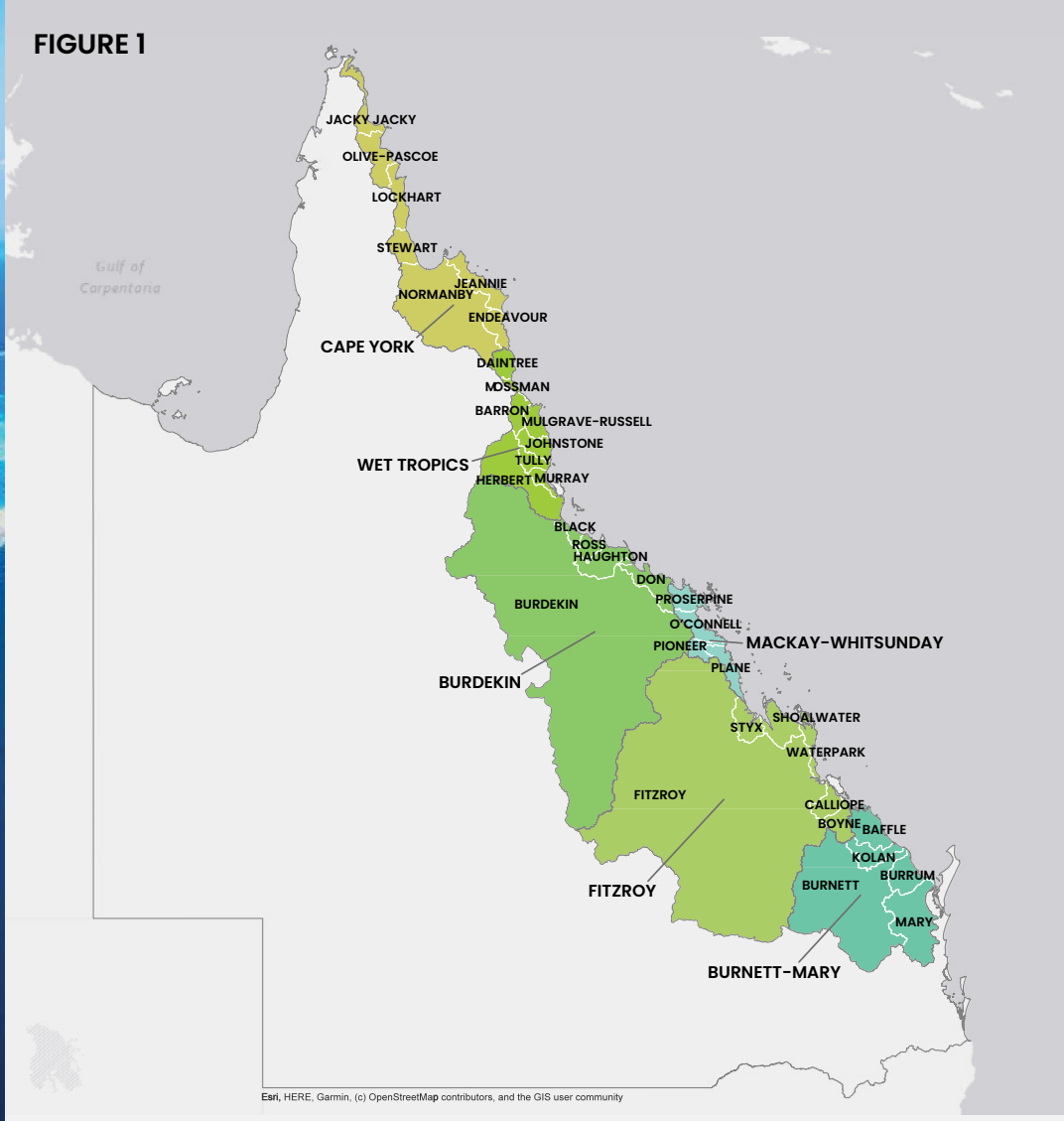


FIGURE 2

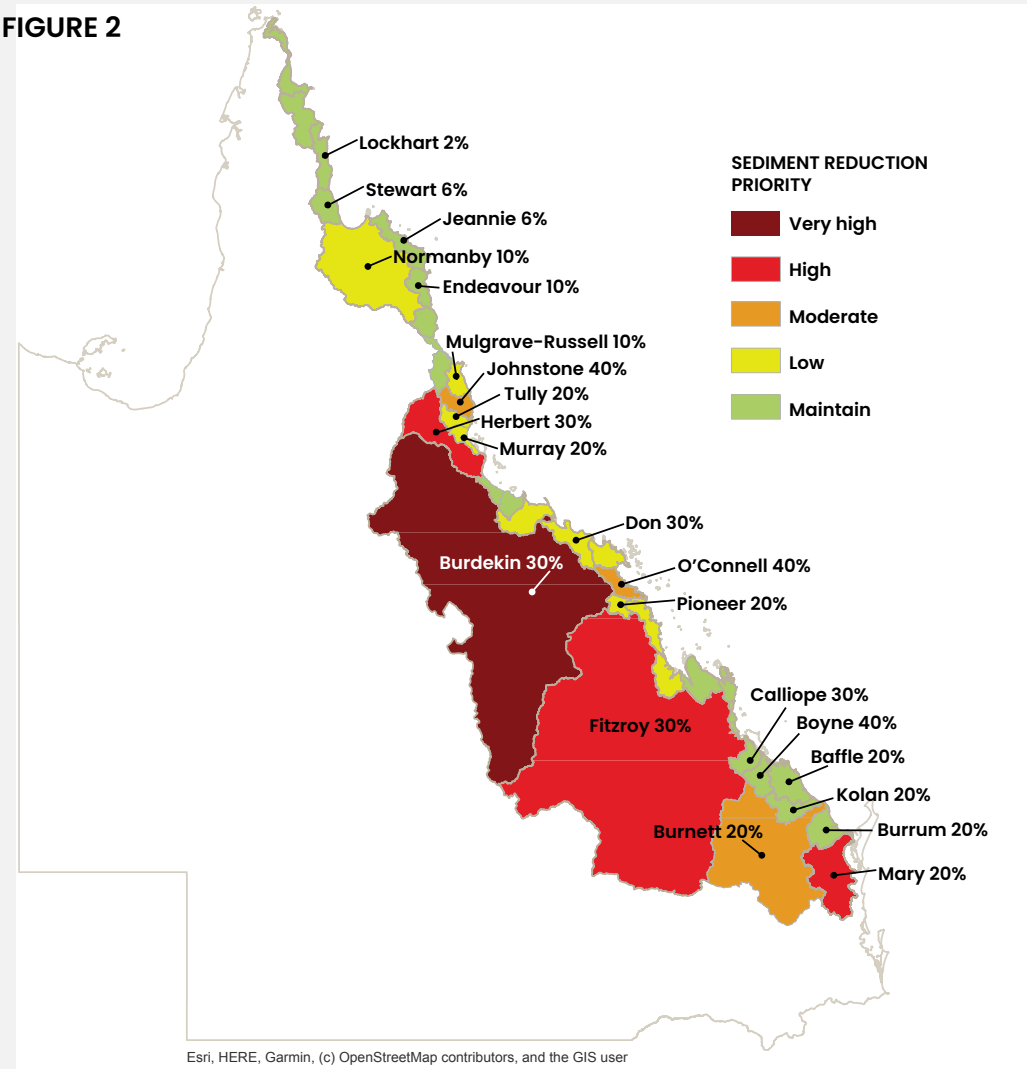


FIGURE 3

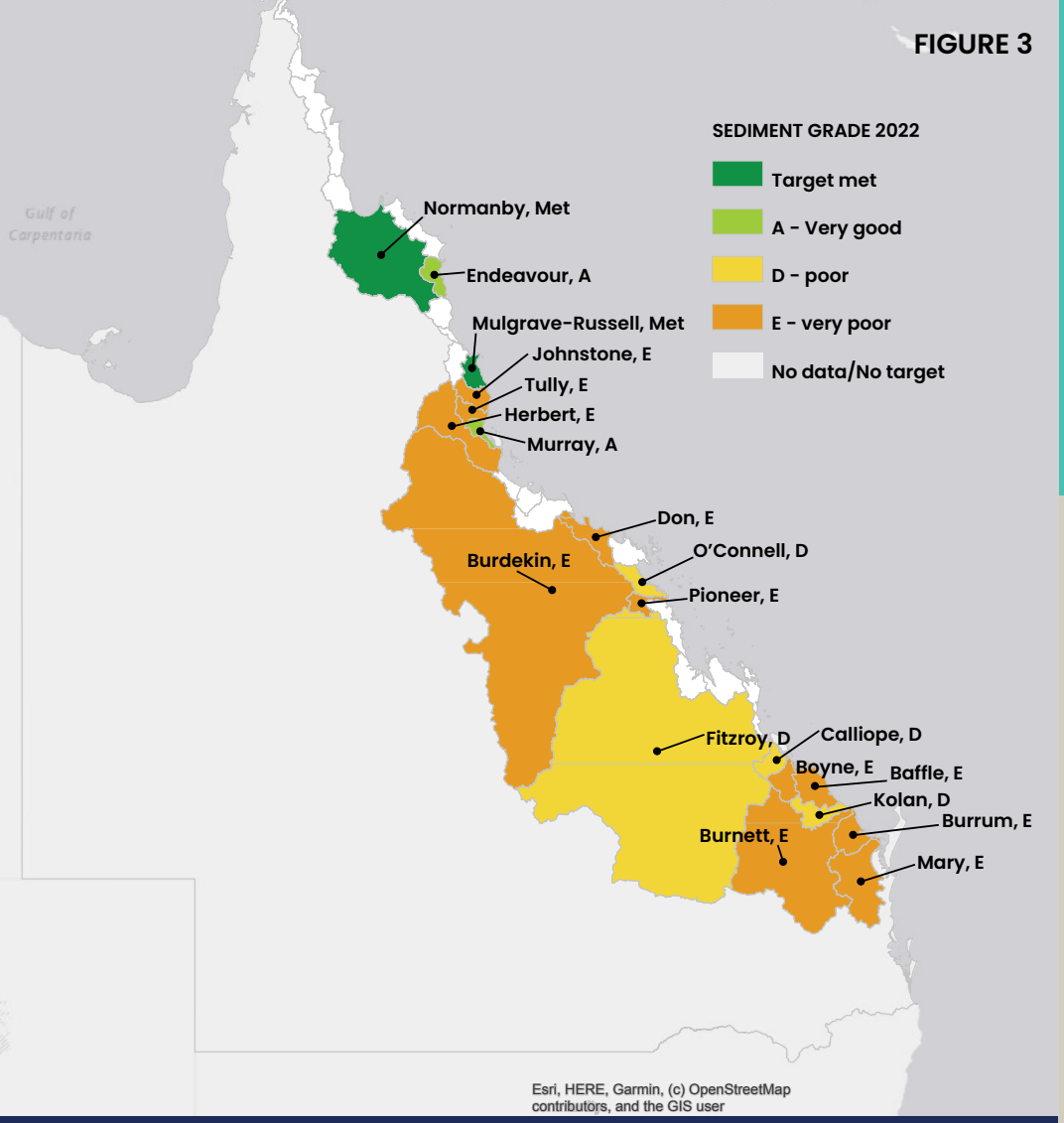


Fig. 1. The 35 river catchments flowing into the Great Barrier Reef, grouped into the six regions used in the Reef Water Quality Improvement Plan (See table of areas and targets in App. 1).[8]

Fig. 2. Priorities of GBR catchments for fine sediment pollution reduction and percentage reduction targets in the 2017-2022 GBR Water Quality Improvement Plan.[9] If unlabelled, the target is "Maintain Current Load" (App. 1).

Fig. 3. 2022 Reef Water Quality Report Card grades for progress towards fine sediment pollution reduction targets.[10] Note: Unlabelled catchments did not have data or the target is "Maintain current load" (App. 1).

This study

This study has the following objectives:-

Section 1: Regulation of tree clearing in Queensland

- Quantify the areas within the GBR catchments which are exempt from or regulated by the state's *Vegetation Management Act* (VMA).

Section 2: Exempt vs regulated tree clearing in Reef catchments

- Quantify the extent of recent clearing in the GBR Catchment over the four-year period 2018/19 to 2021/22.
- Quantify how much of this clearing was in regulated Categories B, C or R areas where there were restrictions (at the time) on clearing under the state *Vegetation Management Act* (VMA), and how much in areas exempt from the Act.

Section 3: Clearing of exempt vegetation that should not be exempt

- Identify areas mapped as exempt Category X that nonetheless potentially meet the criteria to be mapped as regulated Categories B, C, or R.
- Quantify the areas of exempt Category X that potentially meet the criteria to be mapped as regulated Categories B, C, or R that were cleared in the four-year study period.

Section 4: Clearing of areas of high sediment pollution risk

- Quantify clearing in riparian areas of the GBRC.
- Identify sub-catchments with highest modelled levels of fine sediment pollution of the GBR.
- Quantify and map how much of these high pollution risk subcatchments are also in areas of exempt Category X.
- Quantify areas of these high pollution risk subcatchments that were cleared in the four-year study period.

Box 1: Terminology

There are important distinctions among different terms for land cover, vegetation and vegetation change relevant to figures presented below.

- **Land area:** Figures quoted below for land areas in regard to the Regulated Vegetation Map do not necessarily include any native woody vegetation. Land area includes land under any cover, buildings, bare ground, crop fields or forests.
- **Vegetation:** The common understanding of vegetation is any plant cover of any kind. However under the *Vegetation Management Act* it is constrained to mean *"a native tree or plant other than the following— (a) grass or non-woody herbage; (b) a plant within a grassland regional ecosystem prescribed under a regulation; (c) a mangrove."*[11] Note that vegetation means native woody vegetation under this definition but also excludes trees or woody native plants growing in designated grasslands or mangroves.
- **Land/tree/vegetation clearing/clearance/management:** Under the VMA these various terms mean: *"(a) remove, cut down, ringbark, push over, poison or destroy* [vegetation as defined in the VMA above] *in any way including by burning, flooding or draining; but (b) does not include destroying standing vegetation by stock, or lopping a tree."*[12] Note however that the Queensland Government's Statewide Land and Tree Study (SLATS) does not include burned areas in its statistics on woody vegetation clearing.
- **Woody vegetation:** for this analysis we used the Queensland Government's Statewide Land and Tree Study (SLATS) maps of woody vegetation extent which is defined as:- *"stands of woody vegetation greater than 0.5 ha with a canopy density greater than 10% crown cover will be classified as woody. A minimum width of 20 metres applies to linear features."*[13] Note that this SLATS definition may include *non-native* woody vegetation but it also excludes woody vegetation below the patch size and crown cover thresholds specified above.
- **Native vegetation:** Native vegetation is vegetation composed of or mostly of native species. These may be woody or non-woody. Even a pasture cleared of trees or shrubs may be native vegetation dominated by non-woody native grasses and forbs. Although it is possible for SLATS to map woody vegetation and woody vegetation change using satellite photos, it is only possible to be certain that it is also native woody vegetation by ground surveys. In this analysis we have used proxy information from land-use mapping to reduce the risk that woody vegetation clearing detected by SLATS includes significant areas of non-native woody vegetation. In particular, we have excluded plantations as mapped by the Queensland Government from all clearing figures.
- **Remnant vegetation:** Defined in the VMA as vegetation (as defined above) in a regional ecosystem (whether endangered, of concern or least concern), for which *"the predominant canopy of the vegetation— (i) covering more than 50% of the undisturbed predominant canopy; and (ii) averaging more than 70% of the vegetation's undisturbed height; and (iii) composed of species characteristic of the vegetation's undisturbed predominant canopy."*[14] Note that remnant here is not the same as old growth or never-cleared primary forest or woodland. Regrowth vegetation can return to remnant status if it meets the above threshold criteria. However the Queensland Government does not have any comprehensive program for monitoring and mapping return of regrowth to remnant status.
- **Forest:** The Australian Government definition is:- *"an area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding 2 metres and with existing or potential crown cover of overstorey strata about equal to or greater than 20%."*[15] Note that such a forest may include both native and non-native forests such as pine plantations, and does not include all woody vegetation. The VMA does not define or concern itself with forests as such.

- **Section 1: Regulation of tree clearing in Queensland**

Tree or land clearing in Queensland is governed by the state's *Vegetation Management Act 1999* (VMA). Clearing restrictions are constrained spatially by the certified *Regulated Vegetation Map* (RVM) of Queensland. The RVM divides the state's land area into five Categories (Figure 4):

- Category A - Vegetation where any clearing for any purpose is banned, usually because it is the subject of a compliance action or is an offset against clearing elsewhere.
- Category B - Vegetation that is remnant, i.e. intact or mature or if cleared previously, has regrown to maturity. The exceptions are: a) mulga (*Acacia aneura*) forest which can be subjected to so-called "fodder harvest" and which is deemed to still be remnant even after it is cleared; and b) "thickened vegetation" for which clearing is undertaken ostensibly to return the vegetation to a "natural" remnant density and composition.
- Category C - High value regrowth vegetation on freehold, indigenous or leasehold land used for grazing stock that was cleared more than 15 years ago and has been regrowing naturally since then, and so is at least 15 years of age.
- Category R - Reef regrowth watercourse vegetation, including any regrowing natural woody vegetation within 50 metres of a watercourse in the Great Barrier Reef Catchment.
- Category X - Vegetation that is exempt from all VMA clearing restrictions. This can be further broken down into areas "locked-in" as exempt on a "Property Map of Assessable Vegetation" (PMAV) as well as smaller areas mapped exempt on the statewide RVM but not yet "locked-in" as such on a PMAV.

In addition to the above, there are areas that fall outside the jurisdiction of the VMA because they are not subject to the Act but to other legislation, principally state protected areas, state forests and water bodies.

A common misconception is that clearing of remnant vegetation is prohibited. Only Category A is fully protected from clearing and often only as a penalty after unauthorised clearing has already occurred.

Clearing of the regulated Categories, B, C or R may still proceed for:-

- Exempt purposes (such as fences and firebreaks);
- For an allowable ("relevant") purpose as specified under the VMA, with authority under
  - "Accepted Development Codes" appropriate to that purpose, or
  - a "Development Application" made and approved under the *Planning Act*.[16]

Land managers clearing under an "Accepted Development Code" are only required to notify the regulator -- the Resources Department -- of their intent to clear under that code on their property and to keep records as specified in the code. No prior assessment or permit issuance by the regulator is required. Clearing under exemptions (mainly Category X) and Accepted Development Codes accounts for almost all land clearing in Queensland.[17]

FIGURE 4: Example of the Regulated Vegetation Map regulatory Categories A, B, C, R and X west of Mackay, Qld. Source: Queensland Globe web map service.

Table 1: Land areas (ha) in regulated vegetation map Categories, by GBRC regions, as of July 2024.[18]

CATEGORY	CAPE YORK	WET TROPICS	BURDEKIN	MACKAY – WHITSUNDAY	FITZROY	BURNETT – MARY	TOTAL	WOODY%
A	3,195	580	71,022	426	41,865	2,444	119,533	73%
B	2,784,699	814,132	9,786,481	332,944	4,881,859	1,330,216	19,930,331	91%
C	6,348	16,281	105,069	13,304	256,217	161,228	558,448	92%
R	1,851	52,978	76,170	41,981	136,752	162,527	472,258	39%
X	34,206	387,205	3,443,213	329,109	8,522,258	2,599,723	15,315,714	20%
Other	1,468,071	900,194	584,446	181,681	1,734,449	1,046,601	5,915,442	95%
TOTAL	4,298,370	2,171,370	14,066,400	899,445	15,573,400	5,302,740	42,311,725	65%

KEY:
A – Protected vegetation, could be a penalty for illegal clearing or by agreement as exchange/offset area, future clearing banned.
B – "Regulated Remnant" (does not include all actual remnant) vegetation, clearing restricted by codes or development approvals.
C – High Value Regrowth, clearing restricted by codes or development approvals.
R – Reef Watercourse Regrowth, clearing restricted by codes or development approvals.
X – Exempt, clearing unrestricted, unregulated.
Other – outside VMA jurisdiction- waterbodies, State Forests, parks or other state reserves.

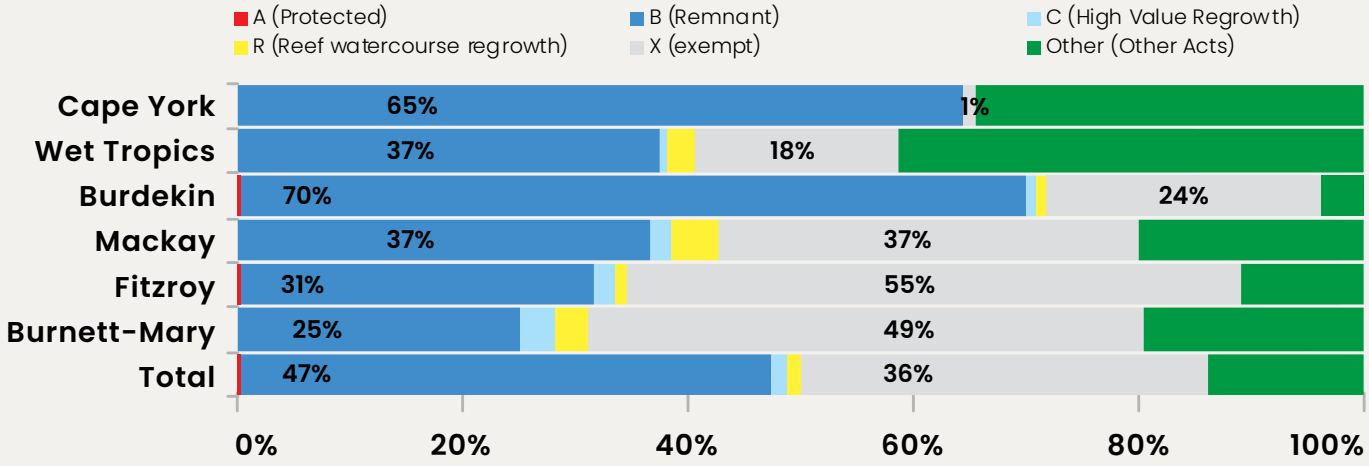


FIGURE 5: Land areas (%) in regulated vegetation map Categories, by GBRC regions, as of July 2024. NOTE: Only B and X are labelled.

According to the *Regulated Vegetation Map* incorporating the PMAVs current as of July 2024, of the 42.3 million ha total land area within the GBRC (Table 1, Fig. 5):–[19]

- almost 20 million hectares were in "remnant" category B (47%);
- almost 0.6 million hectares were in "high value regrowth" category C (1.3%);
- about 0.47 million hectares were in Reef watercourse buffer areas, category R (1.1%) of which only 39% had woody cover as of 2022; and
- 15.3 million hectares were exempt from the Act as Category X (36%), of which only 20% had woody cover in 2022.

Category X is mostly bare of woody vegetation, having already been mostly developed as pasture, cropland or other intensive uses. Only about three million hectares of the total Category X land area of 15.3 million hectares (representing only 20% of all Category X and 7% of total GBRC area) had exempt woody vegetation cover in 2022 according to the SLATS map of woody vegetation extent for that year (Table 1).

Note conversely that just because vegetation is remnant, does not mean it has to be woody. All but 9% of remnant Category B had woody cover in 2018 (Table 1). Non-woody remnant vegetation cover may be below the 10% canopy cover threshold used by SLATS or may comprise grass or forb-lands or naturally bare areas.

Category B "Remnant" for purposes of the VMA paradoxically may also include areas that have been cleared. Areas of mulga cleared for "fodder harvest" and forests partly cleared ostensibly to "manage thickened vegetation" may still be mapped as remnant for regulatory purposes even if all or most of the trees have been removed. The Queensland Herbarium in contrast maps such areas as non-remnant.

Section 2: Exempt vs regulated tree clearing in Reef catchments

Trend and purpose of clearing

Woody vegetation clearing within the GBRC has fallen in every year of the four year period. After a peak of 212,993 ha in 2018/19, total area cleared in 2019/20 dropped by 19% to 172,994 ha, and then declined incrementally by another 19% over two years to 139,513 ha in 2021/22. Over the four-year study period, a total of 684,008 ha of woody vegetation was cleared, excluding repeat clearing and plantation harvest (Table 2). Woody vegetation includes native woody vegetation but may also include exotic species. In this analysis, we have excluded tree plantations from all clearing figures, whether of native or non-native species. Clearing figures are therefore likely to be composed mostly of native tree species.

The Fitzroy and Burdekin regions accounted for 82% of all GBRC clearing over the four year period. Clearing of woody vegetation increased slightly in Cape York, Wet Tropics and Mackay-Whitsunday regions, but declined substantially in other regions. However, absolute area cleared in these three smaller regions was minor compared with other regions amounting to less than 3% of all clearing (Table 2).

The purpose of clearing was overwhelmingly for pasture development in all years ranging from 83% in 2019/20 to 90% in 2018/19, and 88% across all four years. Clearing for all other or for unspecified purposes was uniformly low, and only forestry clearing showed any increase over the period (Fig. 6A). Clearing missed in a year but detected in the next, and minor partial clearing had no purpose specified by SLATS. These are the Unspecified classes of Figs 6A and B. Unspecified classes are likely also to be dominated by pasture development. The primary driver of pasture development is beef production in Queensland.[20]

Full or total clearing declined over the period both absolutely and proportionally (196,391 ha/92% to 122,415 ha/79%, but partial clearing has fluctuated and was significantly higher in 2021/22 than in 2018/19 Fig. 6B).

Table 2. Areas of woody vegetation cleared in GBRC regions from 2018 to 2022, excluding plantations (ha).

YEAR	CAPE YORK	WET TROPICS	BURDEKIN	MACKAY - WHITSUNDAY	FITZROY	BURNETT-MARY	TOTAL	% OF ALL CLEARING
2018/19	286	1,117	76,291	1,191	104,407	29,702	212,993	31%
2019/20	465	1,285	55,666	1,517	82,166	31,895	172,994	25%
2020/21	293	969	50,710	1,274	77,079	28,544	158,868	23%
2021/22	322	1,127	35,165	1,570	79,043	21,926	139,153	20%
TOTAL	1,366	4,498	217,832	5,552	342,694	112,066	684,008	100%
% OF ALL CLEARING	<1%	1%	32%	1%	50%	16%	100%	

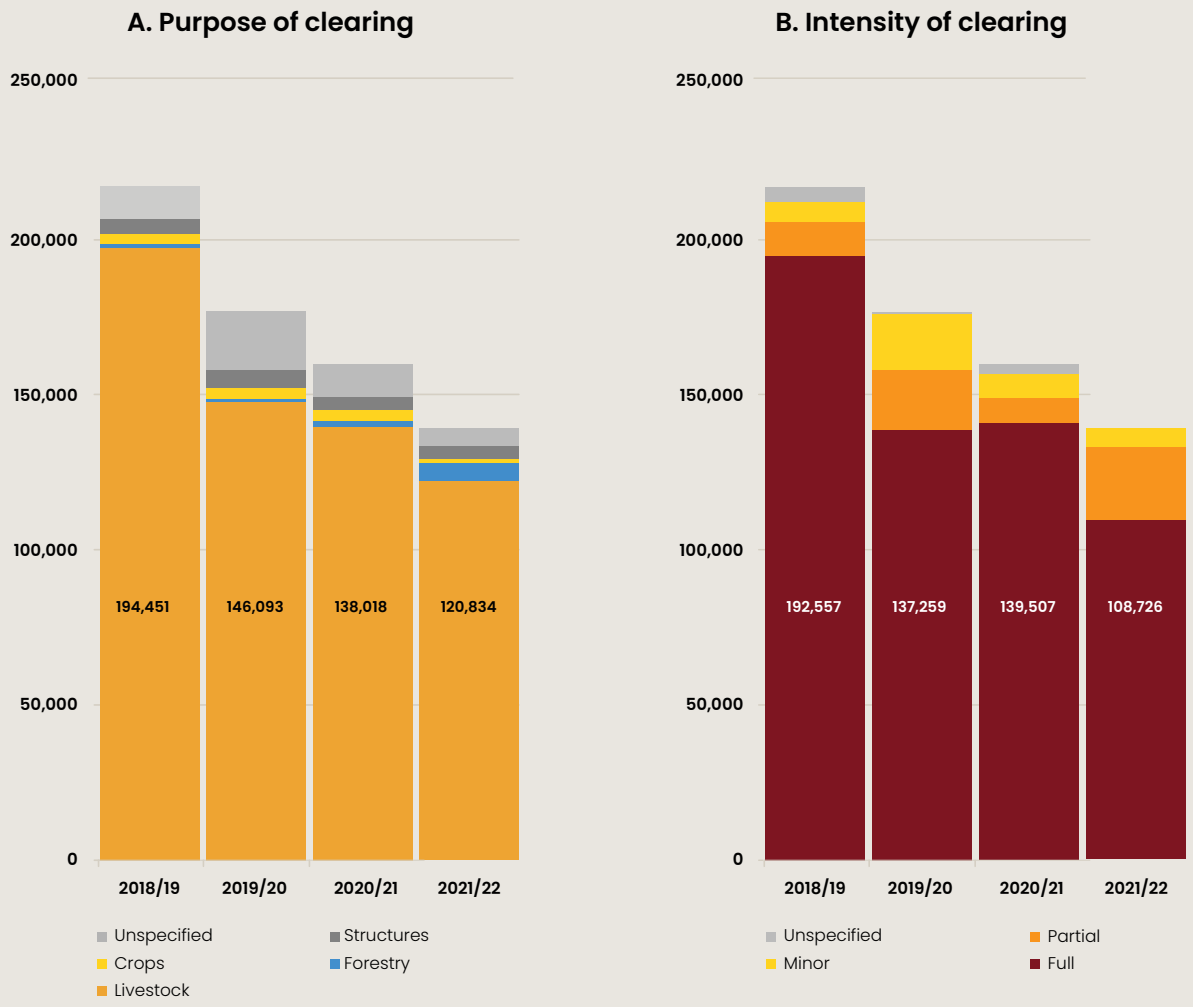


Fig. 6. (A) Purpose and (B) Intensity of woody vegetation clearing in the four successive SLATS reporting years from 2018/19 to 2021/22.[21]

Clearing of VMA vegetation Categories

The overwhelming majority of clearing in the GBRC over the four-year study period was of exempt vegetation (82%) (Table 3, Fig. 7). Of all Category X cleared 84% (or 69% of the total area cleared) was "locked-in" as exempt on a Property Map of Assessable Vegetation or PMAV (Fig. 7). Exempt clearing as a fraction of all clearing was least in Cape York catchments and greatest in southern catchments (Fig. 7).

Clearing of regulated Categories B, C and R was comparatively minor at 12.5%, 2.2% and 1.1% respectively of all clearing over the four-year period (Fig. 7). The areas cleared in the three regulatory Categories varied greatly among regions (Fig. 7). The greatest absolute area of Category B (remnant) cleared was in the Fitzroy region (37,236 ha, Table 3). A total of 46,712 ha of all regulated vegetation was cleared in the Fitzroy region. Before and after satellite images further below show examples of clearing of regulated vegetation (Figs 13-15).

TABLE 3: Areas cleared 2018-2022 (ha) by regions and RVM Categories as of June 2018.

	REGION							
CATEGORY	CAPE YORK	WET TROPICS	BURDEKIN	MACKAY-WHITSUNDAY	FITZROY	BURNETT-MARY	TOTAL	% OF ALL CLEARING
A (Protected)	0	6	34	0	240	11	292	0.0%
B (Remnant)	862	1,428	29,113	1,659	37,236	15,045	85,345	12.5%
C (High Value Regrowth)	23	150	2,667	382	6,841	4,971	15,033	2.2%
R (Reef Watercourse Regrowth)	24	177	2,680	229	2,635	1,660	7,405	1.1%
X (Exempt)	265	2,607	183,207	3,193	286,019	84,565	559,858	81.8%
Other	191	129	131	89	9,722	5,814	16,076	2.4%
Total	**1,366**	**4,498**	**217,832**	**5,552**	**342,694**	**112,066**	**684,008**	**100.0%**

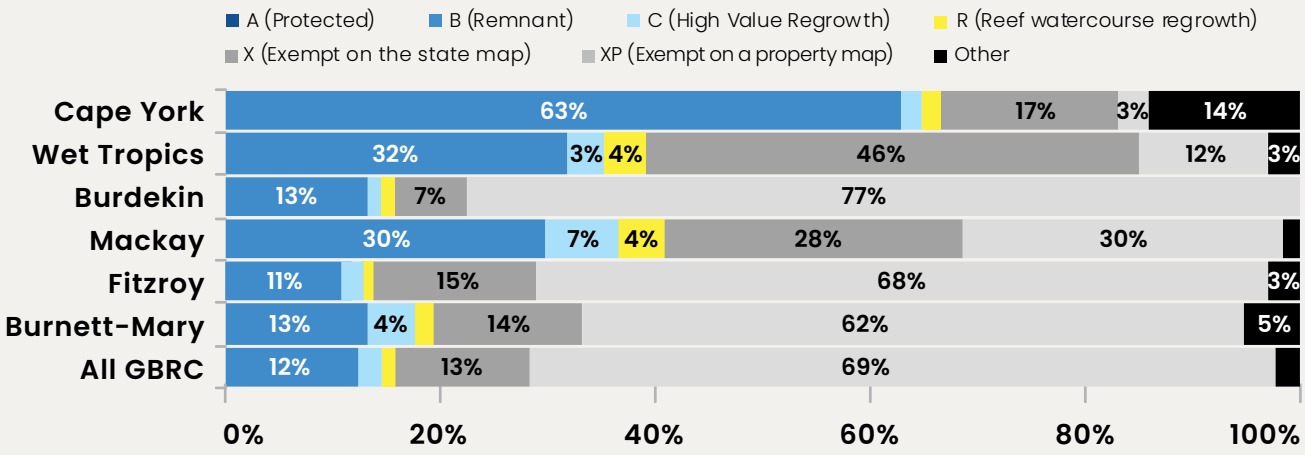
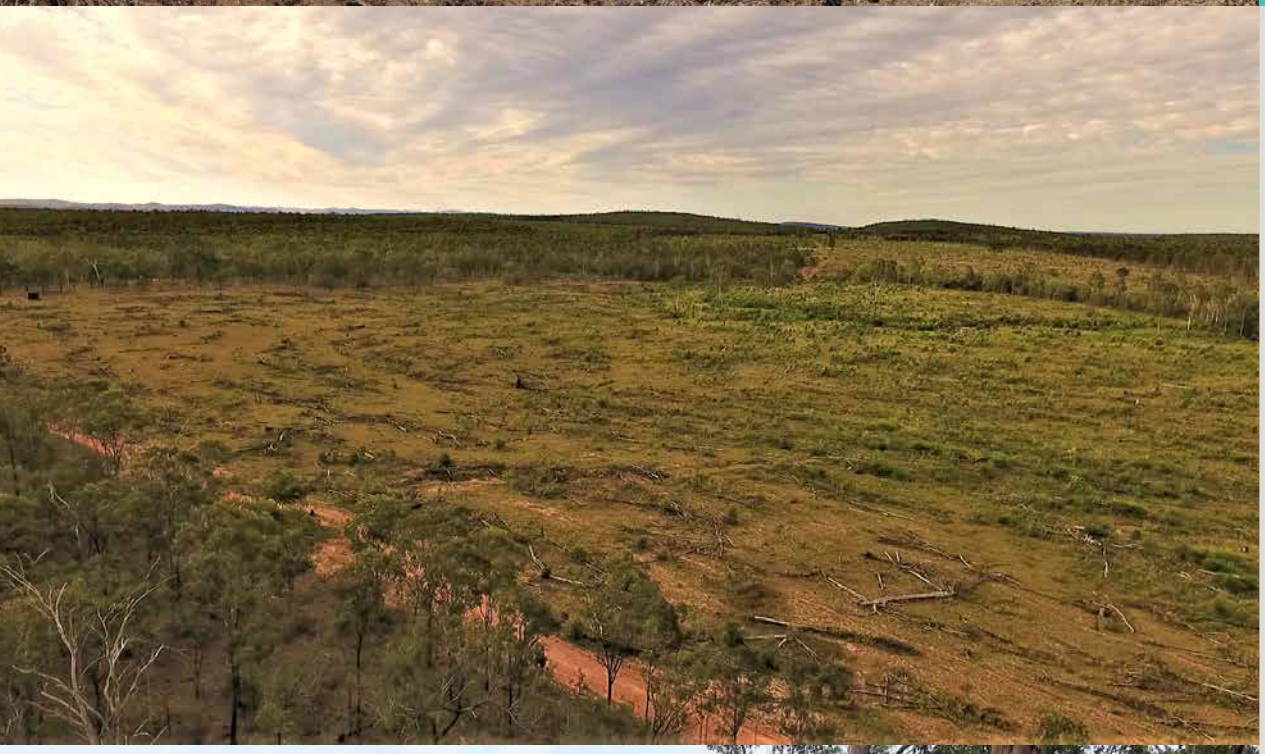


Fig. 7. Areas cleared 2018-2022 (%) by regions and RVM Categories as of June 2018. Elements 2% or less not labelled.

Small areas of Category A appeared to have been cleared (Table 3). No Category A at all should be detected as cleared because all such clearing is, in theory, banned. However, the regulatory map is not static and is continually revised through new and revised PMAVs and appeals of the regulatory map by landholders. Areas of Category A in June 2018 subsequently cleared may have been remapped as other than A prior to clearing through new or revised PMAVs which were made after June 2018 but within the period of the study.



TOP: Forest cleared for pasture near Moonford, Qld in the Burnett R catchment. © 2020 Martin Taylor.

MIDDLE: Forest cleared for pasture near Marlborough in the Fitzroy R catchment © 2016 Martin Taylor.

BELOW: Tall eucalypt forest mapped X on a PMAV and bulldozed in 2019 near Nanango, Burnett R catchment. © 2019 Martin Taylor.

Section 3: Clearing of exempt vegetation that should not be exempt

Exempt areas that should be in Categories B or C

Some woody vegetation mapped as exempt (Category X) in the regulatory map may meet criteria to belong to one of the regulated vegetation Categories B (remnant) or C (high value regrowth).

Age since last disturbance of regrowing woody vegetation as mapped by SLATS, confined to undeveloped and unprotected land uses[22] was used to map Category X areas that should potentially be B or C (App. 2).

Woody vegetation currently mapped exempt (X) but imputed to be 30 or more years old (28 years old as of 2022) or remnant[23] as of July 2024, and in undeveloped and unprotected land uses, was deemed to potentially belong to Category B (remnant).

If an area currently mapped exempt (X) was imputed to be 15 -29 years old (13 to 27 years old as of 2022) also in undeveloped and unprotected land uses, it was deemed to potentially belong to Category C (high value regrowth), the definition of which is 15 years or older in the VMA.

We found that nearly 1.5 million hectares (nearly 10%) of the total Category X area potentially should be remapped as remnant woody vegetation (X pot'l B, Table 4). A further 863,123 hectares met criteria to be remapped as high value regrowth woody vegetation (X pot'l C, Table 4). The Burnett-Mary and Fitzroy regions account for 80% of all X potentially B or C. Of all X potentially B or C, 81% is "locked in" exempt on PMAVs (Table 4).

Exempt areas that should be Category R

The VMA criterion for Category R has neither an age threshold nor a requirement that woody cover be present. Indeed, we found that only 39% of Category R areas on the Regulated Vegetation Map in July 2024 also had woody vegetation cover as of 2022, although some of this may since have been cleared (Table 4).

Any area that is mapped exempt in July 2024 but lies within 50 metres of a Reef watercourse in an undeveloped land use was deemed to have potential for native woody vegetation to naturally regenerate and so potentially meets criteria to belong to Category R (Reef watercourse regrowth). What could potentially be R was further restricted by confining the 50m buffers to the GBRC Riparian Areas layer provided by the Queensland Government. This layer is used to report the amount of clearing in GBRC riparian areas for the Reef report cards and is discussed further below.[24]

TOP: Forest near Dalga within 50m of the Kolan River, a GBR watercourse, mapped exempt (X) on the regulatory map. © 2019 Martin Taylor.

BELOW: Forest near Coominglah, Burnett River catchment, mapped exempt on the regulatory map. © 2019 Martin Taylor.

Forest near Eidsvold, in the Burnett River catchment, exempt on the regulatory map and partly cleared at left. © 2019 Martin Taylor.

Mapping of X potentially B or C took precedence over X potentially R in this analysis. Hence, there are areas within 50m buffer zones that meet criteria to be X potentially R, but if they have woody cover over 15 years old they instead are mapped as X potentially B or C.

Of total exempt area in July 2024, 712,242 ha is mapped here as X potential R. Almost all of this area (709,310 ha) is "locked-in" as forever exempt on a PMAV. The Burnett-Mary and Fitzroy regions accounted for 86% of all X potentially R (Table 4). Only about 8% of all X potential R actually had woody cover in 2022, the most recent data available (Table 4). This is likely to be an underestimate in reality because woody cover as mapped by SLATS excludes woody vegetation below patch size and canopy cover thresholds.

Of the approx. 3 million ha of woody vegetation as of 2022 that was mapped exempt in July 2024 (as distinct from total land area), 80% meets criteria to be remapped as remnant, high value regrowth or Reef watercourse buffer regrowth (2.4 million hectares). Note that this assumes no clearing between 2022 and 2024 in these Categories. If clearing had occurred, these numbers would need correcting.

Table 4. Exempt Category X land areas (ha), that potentially belong in regulated Categories, at July 2024.[25]

	REGION								
CATEGORY	**CAPE YORK**	**WET TROPICS**	**BURDEKIN**	**MACKAY-WHITSUNDAY**	**FITZROY**	**BURNETT-MARY**	**TOTAL**	**% OF ALL X**	**% WOODY**
X pot'l B	3,882	25,540	168,056	25,029	709,822	562,595	1,494,922	9.8%	100%*
X pot'l C	4,620	7,190	232,309	5,934	443,870	169,199	863,123	5.6%	100%*
X pot'l R	398	1,650	89,456	7,663	407,014	206,061	712,242	4.7%	7.9%
X other	25,306	352,825	2,953,392	290,483	6,961,552	1,661,869	12,245,427	80%	4.9%
X total	34,206	387,205	3,443,213	329,109	8,522,258	2,599,723	15,315,714	100%	20%
X % in PMAVs	38%	9%	86%	33%	86%	74%	81%		

Key:

* 100% woody by definition in 2022

X pot'l B - Exempt, wooded and imputed to be remnant or 30 years or older regrowth in undeveloped land uses as of July 2024 (28+ in 2022).

X pot'l C - Exempt and wooded imputed to be 15-29 years or older regrowth in undeveloped land uses as of July 2024 (13-27 in 2022).

X pot'l R - Exempt including both wooded and unwooded within 50m of a Reef watercourse within Queensland Government's defined riparian areas, in undeveloped land uses and so deemed to have potential for native vegetation regrowth..

X other - Exempt but without evident potential for above three Categories.

Clearing of exempt areas that should not be exempt

Most of the clearing of Category X (82%) in the four years 2018-2022 was of woody vegetation that potentially belongs in Categories B, C or R (305,606, 149,604 and 5,908 ha respectively, Table 5, Fig. 8). Thus, a total of 461,118 ha representing 67% of all woody vegetation clearing in the GBRC (exclusive of plantations) over the four-year period was mapped as exempt in 2018, despite potentially meeting criteria to be mapped in a restricted category. Of this 84% was locked in as exempt on property maps (Table 5).

When added to clearing of exempt Category X that potentially should be restricted as B, C or R, a total of 277,828 ha of actual or potentially "should be" restricted woody vegetation was cleared over the four-year period in the Fitzroy region alone (Table 5).

Table 5. Areas cleared 2018-2022 (ha) of Category X, that potentially belonged in regulated Categories, at June 2018, by regions.

CATEGORY	CAPE YORK	WET TROPICS	BURDEKIN	MACKAY-WHITSUNDAY	FITZROY	BURNETT-MARY	TOTAL	% OF ALL CLEARING	% X ON PMAV
All X potl B	157	1,352	81,354	2,110	160,878	59,755	305,606	44.7%	82%
All X potl C	59	335	70,612	639	67,049	10,910	149,604	21.9%	89%
All X potl R	1	25	1,099	59	3,188	1,537	5,908	0.9%	91%
All X other	48	896	30,143	385	54,904	12,364	98,740	14.4%	85%
All X	265	2,607	183,207	3,193	286,019	84,565	559,858	81.8%	84%

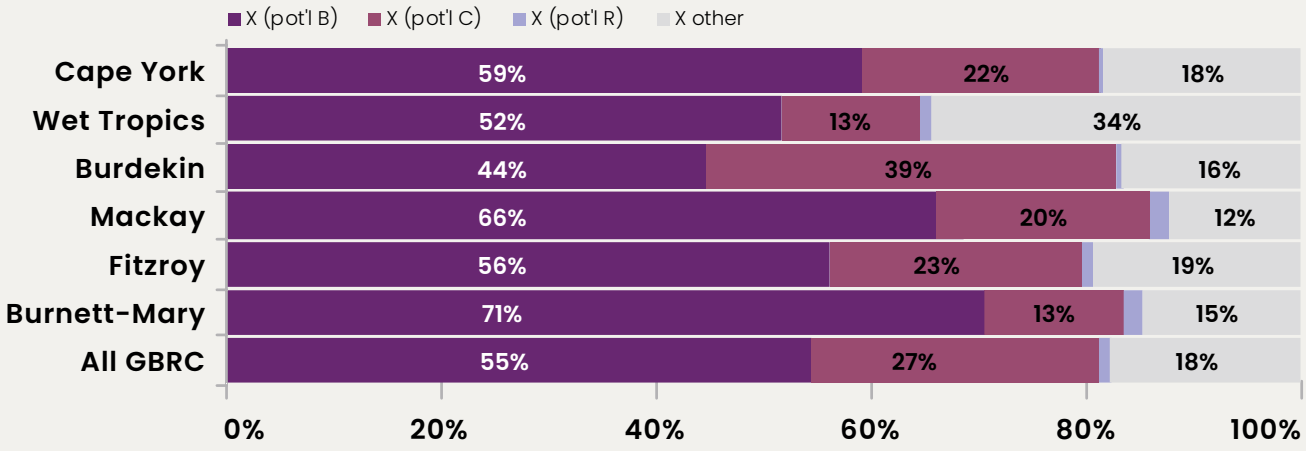


FIGURE 8: Areas cleared 2018-2022 (%) of Category X, that potentially belonged in regulated Categories, at June 2018, by regions.

Section 4: Clearing of areas of high sediment pollution risk

Clearing in riparian areas

The Queensland Government has a map of GBRC Riparian Areas which is a combination of 50m watercourse buffers (some of which are in Category R under the VMA), and riverine wetlands.

The Riparian Areas footprint covers nearly 15% of the GBRC land area (6.3 million ha). Of the total area, 78% (4.9 million ha) had woody cover as of 2022 and 21% is mapped exempt under the VMA as of July 2024, of which 95% is exempt on a PMAV.

The Reef Water Quality Report Card for 2021 states that *"Loss of riparian woody vegetation extent across the Great Barrier Reef catchments was 47,519 hectares (0.78%) between 2018 and 2021, mostly in the Burdekin, Fitzroy and Burnett Mary regions."*

We estimate the area cleared based on the same Queensland Government spatial data[26] to be significantly higher at 55,875 ha over the 2018-21 period, and higher again for the four year 2018-22 period at 70,796 ha. As with all these figures, these exclude harvesting of forest plantations. The discrepancy is due to the Report Card reporting a net change in woody extent rather than areas actually subjected to tree clearing. A net change in woody extent underrepresents the real impact of clearing.

Clearing in subcatchments of high fine sediment pollution risk

Here we map subcatchments that contribute the most fine sediment pollution to the Reef. McCloskey et al. (2021) kindly provided comprehensive and detailed results of modelling of fine sediment export rates in 5,588 subcatchments of the GBR.[27]

Fine sediment export is broken down into three major sources of erosion:-

- **Hillslope erosion:** erosion of surface soils by overland rainfall runoff before it reaches a stream channel.
- **Gully erosion:** erosion of subsoil where water flowing within the stream channel cuts downward.
- **Streambank erosion:** erosion of subsoil from the streambanks as rainfall runoff flows from the adjacent hillslope down sides of the channel or as water running along the channel cuts into the streambank from the sides.

We grouped subcatchments into four severity Categories based on modelled fine sediment export rates:- *Very high, High, Medium* and *Low* (See App. 2 Methods).

We grouped subcatchments by severity for hillslope sediment export separately from those for combined gully and streambank sediment export because they derive from different parts of the landscape (off-stream vs in-stream) and produce quite different groupings of subcatchments as shown below.

Hillslope fine sediment pollution risk subcatchments

Each year erosion from hillslopes contributes an estimated 2.23 million tonnes of fine sediment to the Great Barrier Reef. This represents 26% of the total estimated load (8.45 million tonnes) of all fine sediment entering the Reef (Table 6).

Fine sediment loads from hillslopes range from 1,955 -15,902 tonnes per year per subcatchment for *Very high* risk subcatchments and 848 - 1,965 tonnes per year per subcatchment for High risk subcatchments (Table 6). These two groups combined by definition account for 75% of all hillslope fine sediment runoff to the Reef and dominate the Wet Tropics and Mackay regions (Table 6, Figs 9-10).

Only 28% of High and Very high export subcatchments land area is exempt under the VMA, and of that area, only about half is exempt on a property map, opening up the possibility of immediately protecting the other half not yet locked in on a property map (Table 6).

Table 6. Subcatchments grouped from Very High to Low contributions to overall hillslope fine sediment export to the Great Barrier Reef.

GROUP	AREA (M HA)	% OF GBRC	MIN EXPORT (T/SUB-CATCHMENT /YR)	MAX. EXPORT (T/SUB-CATCHMENT /YR)	TOTAL EXPORT (KT/YR)	% THAT IS X EXEMPT	% OF X IN PMAVS	CLEARING 2018-22 (HA)	% OF ALL CLEARING
Very high	3.1	7%	1,966	15,902	1,114	27%	45%	23,619	3.5%
High	3.9	9%	848	1,965	557	28%	53%	34,507	5%
High + V. High	7	17%	848	15,902	1,671	28%	49%	58,126	8.5%
Medium	5.4	13%	317	847	334	33%	72%	54,901	8%
Low	29.9	71%	0	316	223	39%	87%	570,687	83.5%
Total	42.3	100%	0	15,902	2,228	36%	81%	683,714	100%

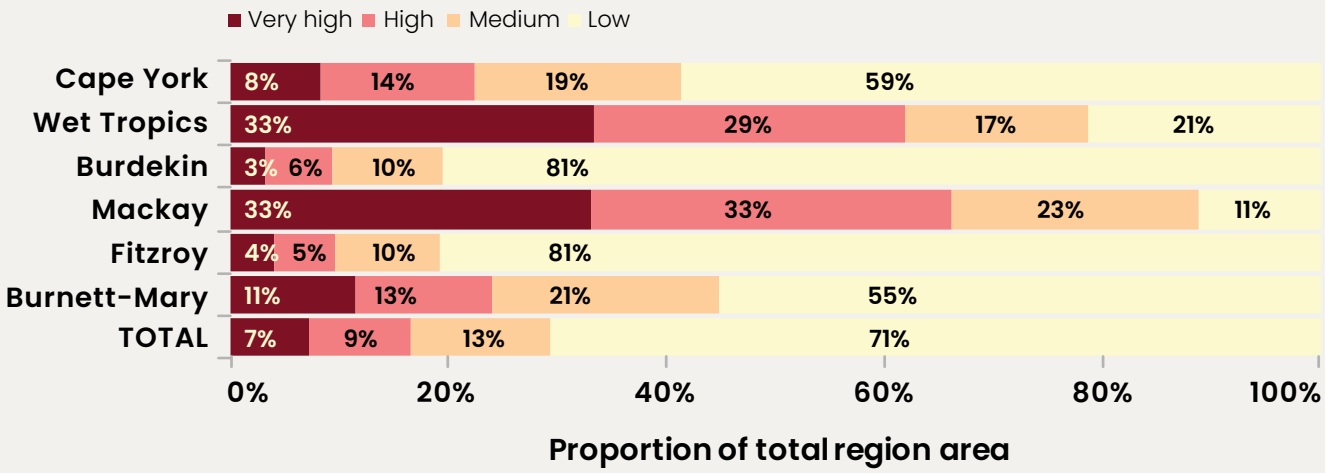


FIGURE 9: Regional areas (%) in subcatchments grouped from Very high to Low hillslope fine sediment export to the Reef.

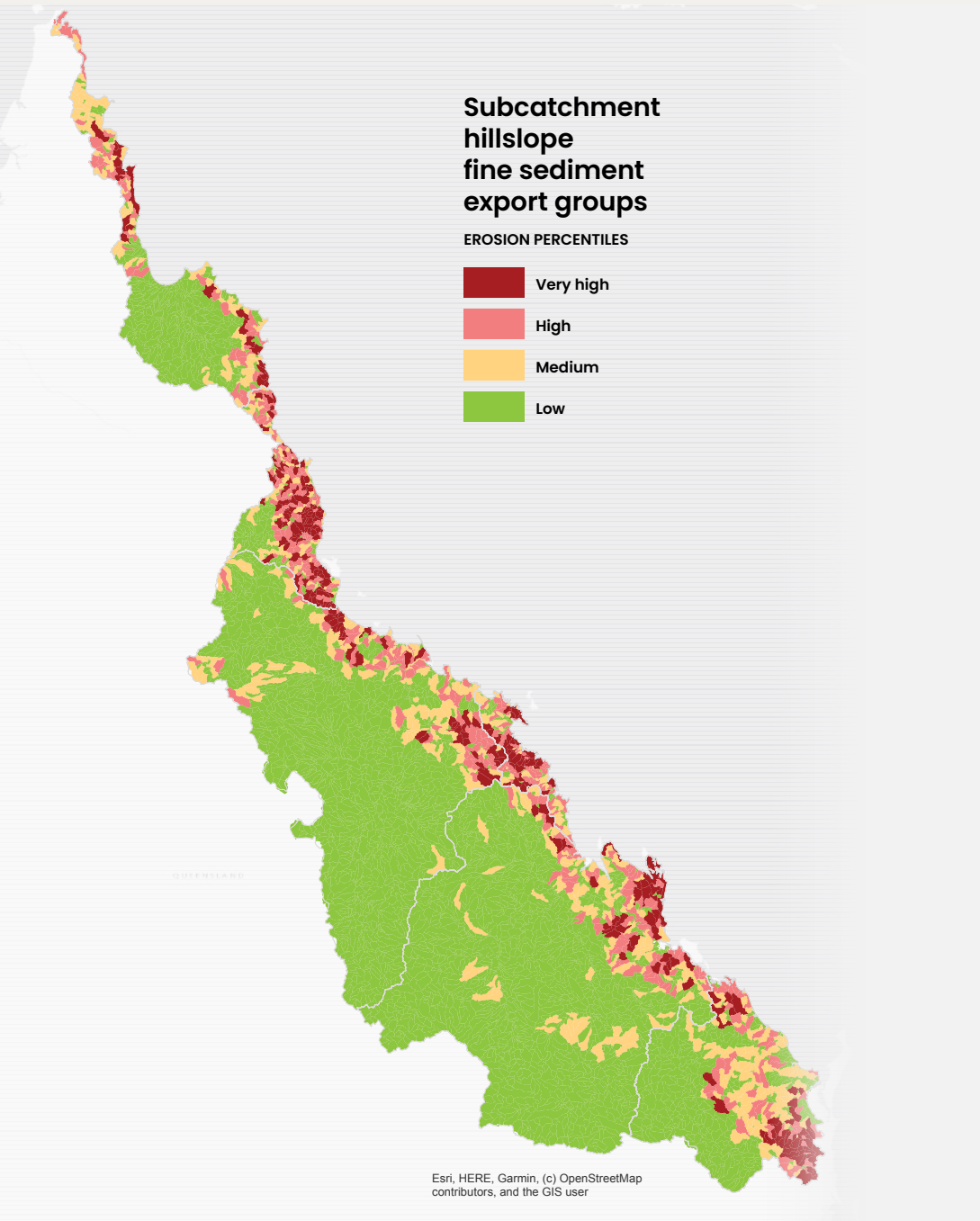


FIGURE 10: Subcatchments of the GBRC in four classes of hillslope fine sediment export to the Reef.

Gully and streambank fine sediment pollution risk subcatchments

Each year gully and streambank erosion contribute 3.77 and 2.45 million tonnes respectively of fine sediment runoff to the Great Barrier Reef. This represents almost three quarters, 73.6% of the total estimated load of fine sediment entering the Reef.

Fine sediment loads range from 7,006 - 117,554 tonnes per year per subcatchment for *Very high* risk subcatchments and 2,321 - 6,971 tonnes per year per subcatchment for *High* risk subcatchments (Table 7).

These two groups combined account for 75% of all hillslope fine sediment runoff to the Reef (by definition) and are concentrated almost entirely in the Burdekin region where they cover 28% of land area (Figs. 11-12).

Only 23% of High and Very high export subcatchment land areas are exempt under the VMA, and of that area, 66% is exempt on a property map, opening up the possibility of immediately protecting the other 34% not yet locked in on a property map (Table 7).

TABLE 7: Subcatchments grouped from Very High to Low contributions to combined gully and streambank fine sediment export to the Great Barrier Reef.

GROUP	AREA (M HA)	% OF GBRC	MIN EXPORT (T/SUB-CATCHMENT /YR)	MAX. EXPORT (T/SUB-CATCHMENT /YR)	TOTAL EXPORT (KT/YR)	% THAT IS X EXEMPT	% OF X IN PMAVS	CLEARING 2018-22 (HA)	% OF ALL CLEARING
Very high	2.1	4.9%	7,006	117,554	3,113	18%	58%	13,077	1.9%
High	3.7	8.8%	2,321	6,971	1,552	26%	70%	36,838	5.4%
High + V. High	5.8	13.7%	2,321	117,554	4,665	23%	66%	49,915	7.3%
Medium	7.4	17.4%	655	2,311	931	41%	79%	125,086	18.3%
LOW	29.1	69%	0	655	622	38%	83%	508,713	74.4%
TOTALS	42.3	100%	0	117,554	6,218	36%	81%	683,714	100%

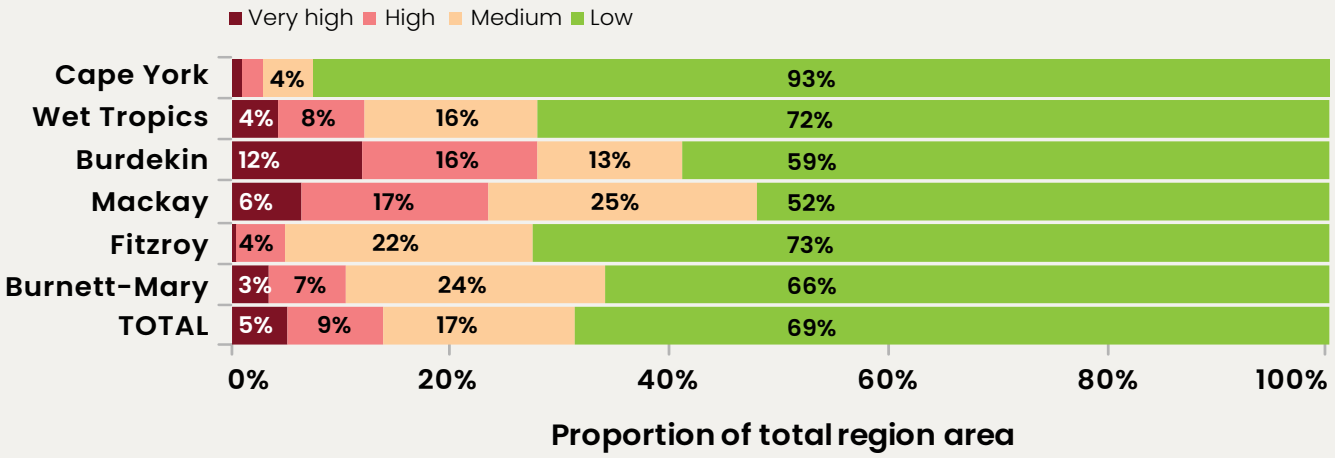


FIGURE 11: Regional areas (%) in subcatchments grouped from Very high to Low gully and streambank fine sediment export to the Reef.

FIGURE 12: Subcatchments of the GBRC in four classes of gully and streambank fine sediment export to the Reef.

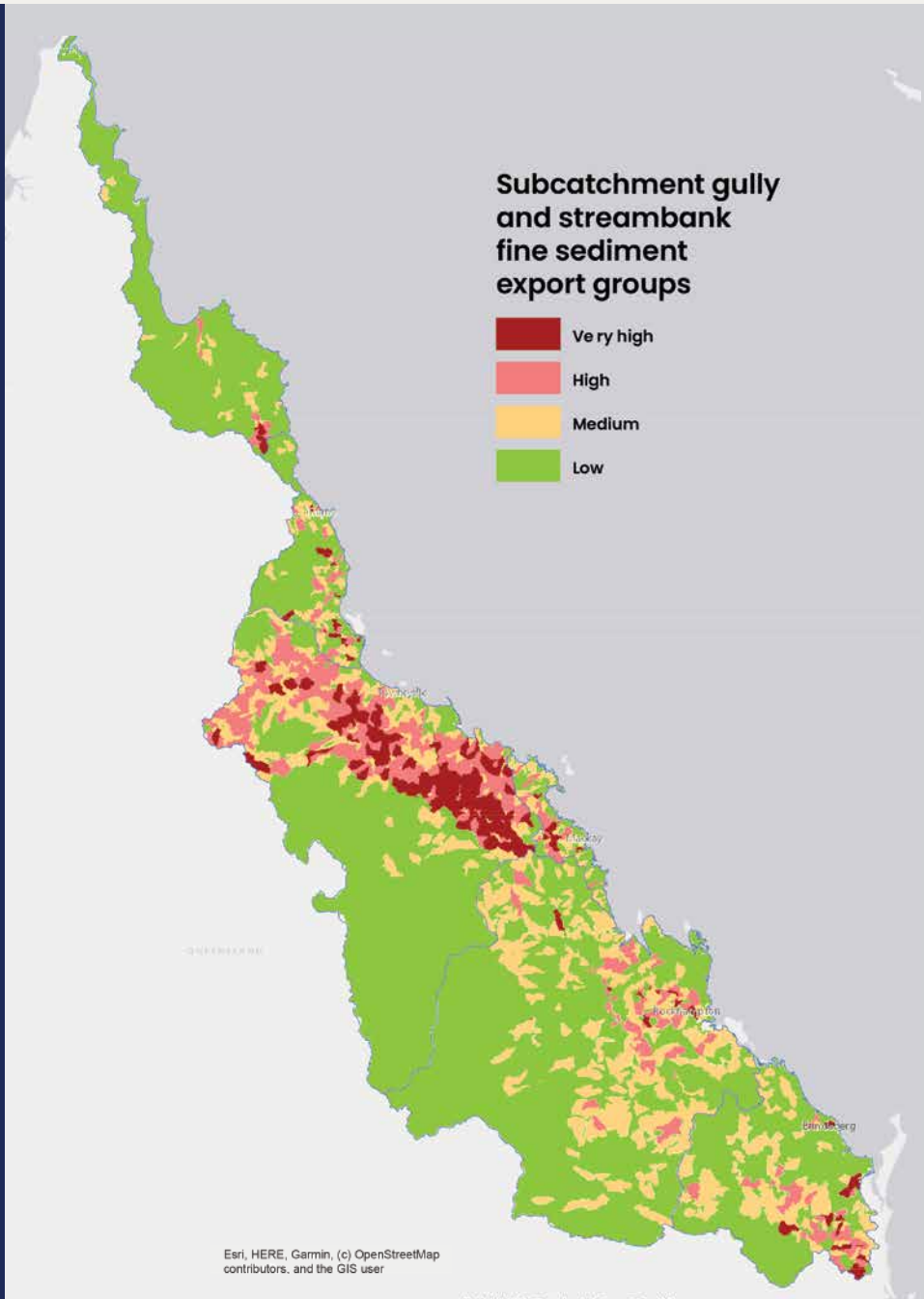


FIGURE 13: Left August 2018, Right August 2020. Example showing thinning or partial clearing of Category B (Remnant) for pasture detected by SLATS, in a High hillslope fine sediment export subcatchment of the Mary River catchment. Imagery from PlanetLabs.

Clearing in high sediment pollution risk subcatchments

Very high and *High* subcatchments for export of Hillslope erosion sediments into the Reef are those that account for 75% of all hillslope erosion fine sediment loads to the Reef, but they cover only 16.5% of the GBRC land area, and account for only 8.5% of all woody vegetation clearing from 2018 to 2022 (Table 6).

Very high and *High* subcatchments for export of Gully and Streambank erosion sediments into the Reef, are those that account for 75% of all gully and streambank fine sediment loads to the Reef, and yet they cover only 14% of the GBRC land area and account for only 7.3% of all woody vegetation clearing from 2018 to 2022 (Table 7).

Nonetheless, clearing in these subcatchments is likely to have a disproportionate contribution to fine sediment pollution relative to clearing in other subcatchments. Estimation of how much extra fine sediment runoff would result from observed woody clearing is, however, beyond the scope of this analysis.

Examples of clearing of remnant woody vegetation, high value regrowth and Reef watercourse regrowth in *Very high* or *High* risk subcatchments for fine sediment runoff are shown in Figs 13-17. Examples of exempt areas that should not be exempt are shown in Figs. 18-19.

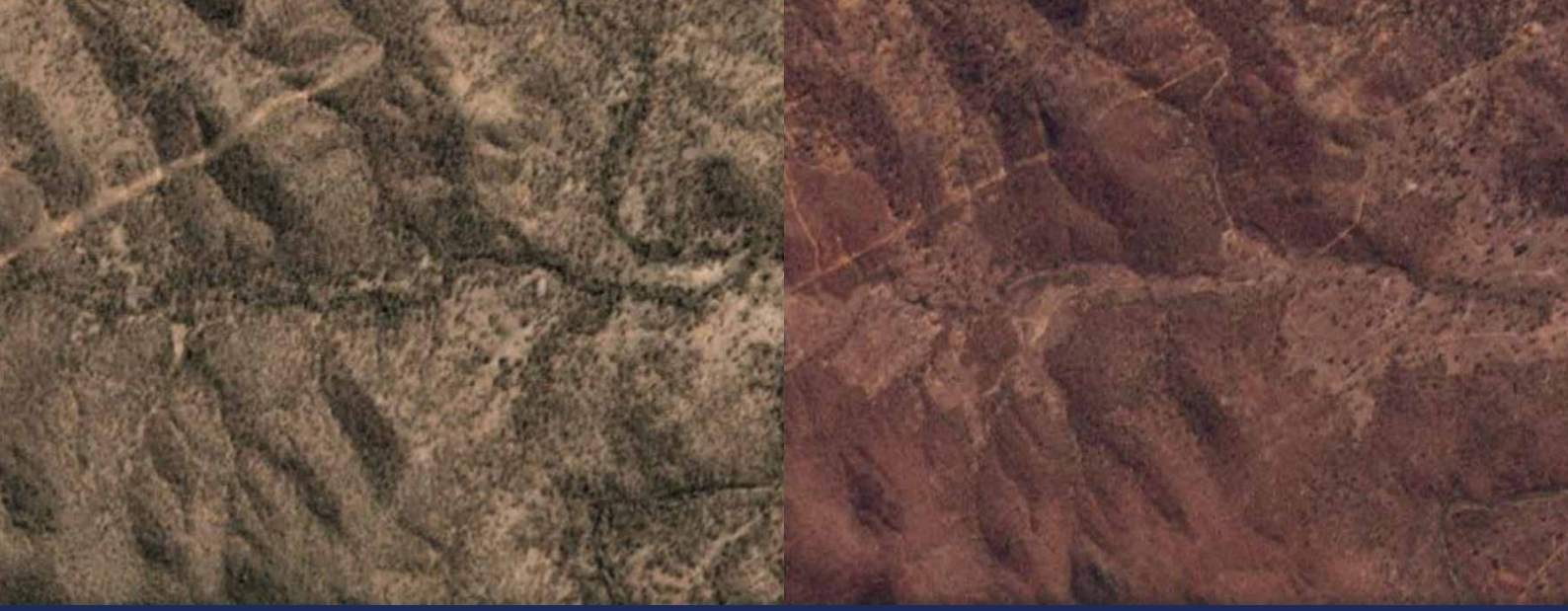


FIGURE 14: Left August 2018, Right August 2020. Example showing clearing of Category C (High Value Regrowth), in a Very high for hillslope fine sediment export subcatchment of the Fitzroy River catchment. Imagery from PlanetLabs.

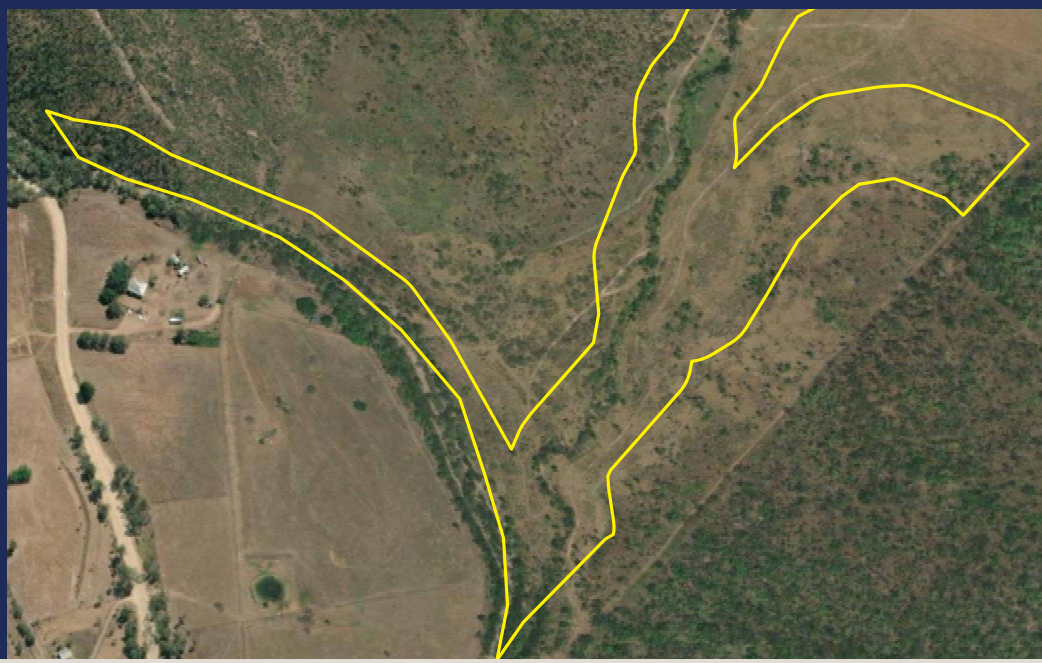
FIGURE 15: Left August 2018, Right August 2020. Example showing clearing of Category R (Reef Watercourse Regrowth) and Category C (High Value Regrowth), in a High gully and streambank fine sediment export subcatchment of the Mary River catchment. Imagery from PlanetLabs.

FIGURE 16: Left August 2018, Right August 2020 example showing clearing of woody vegetation that is mapped Category X (Exempt) but potentially should have been Category C (High Value Regrowth), in a High hillslope fine sediment export subcatchment of the Burrum River catchment. Imagery from PlanetLabs.

FIGURE 17: Left August 2018, Right August 2020, Example showing clearing of woody regrowth vegetation mapped as Category X (Exempt) but potentially should have been Category C (High Value Regrowth) or Category R (Reef Watercourse Regrowth) in 2018, in a Very high Gully and Streambank fine sediment export subcatchment of the Burdekin catchment. Imagery from PlanetLabs.

FIGURE 18: The yellow outline is an example of a forested hill mapped Category X (exempt) that potentially belongs in B (Remnant) or C (High Value Regrowth), in a Mary River subcatchment which has the highest hillslope fine sediment export rate of all subcatchments of the GBRC.

FIGURE 19: An example of forest and woodland mapped Category X (exempt) that potentially belongs to Category R (Reef Watercourse Regrowth, yellow outline), in the Fitzroy Basin subcatchment which has the highest gully and streambank combined fine sediment export rate of all GBRC subcatchments.



CAVEATS

The Australian Marine Conservation Society funded this research.

The analysis and conclusions herein and any errors made are solely the authors' and in no way attributable to the University of Queensland or the Australian Marine Conservation Society.

All estimates of areas mapped as X potentially B, C or R are based solely on desktop analysis. There are certain to be some errors in attribution that can only be resolved by ground-truthing of desktop results.

Geoprocessing required pixelation of the original polygon boundaries of government spatial data which also results in minor differences in area calculations from those based on the original polygons.

APPENDIX 1: CATCHMENT WATER QUALITY IMPROVEMENT PLAN RELEVANT STATISTICS

REGION	CATCHMENT	AREA (HA)	WOODY COVER (% IN 2018)	CLEARED 2018-22 (HA)	WQIP PRIORITY	SEDIMENT TARGET (KT/YR)	REDUCTION TARGET (%)	REDUCTION 2022 (%)	GRADE 2022	% REDUCTION SHORTFALL	FINE SEDIMENT EXPORT (KT/YR)	HILLSLOPE EXPORT HIGH & V. HIGH CLASSES	GULLY/ STREAMBANK HIGH & V. HIGH CLASSES
Cape York	Jacky Jacky	296,330	96%	20	Minimal	MCL			No data		20	33%	0%
	Olive-Pascoe	417,950	99%	55	Minimal	MCL			No data		45	45%	0%
	Lockhart	288,329	98%	26	Minimal	1	2%	0%	No data	2%	61	67%	0%
	Stewart	274,279	98%	19	Minimal	2	6%	0%	No data	6%	22	31%	0%
	Normanby	2,439,490	95%	756	Low	15	10%	17%	Target met	0%	156	3%	5%
	Jeannie	363,752	93%	139	Minimal	2	6%	1%	No data	5%	31	46%	0%
	Endeavour	218,243	96%	352	Minimal	3	10%	8%	A, V good	2%	81	69%	0%
Wet Tropics	Daintree	210,672	95%	42	Minimal	MCL			No data		44	66%	0%
	Mossman	47,243	83%	55	Minimal	MCL			No data		10	61%	0%
	Barron	218,882	74%	852	Minimal	MCL			No data		148	73%	15%
	Mulgrave-Russell	198,397	78%	147	Low	16	10%	19%	Target met	0%	92	80%	16%
	Johnstone	232,391	64%	324	Moderate	100	40%	20%	E , V poor	20%	187	89%	15%
	Tully	168,355	77%	92	Low	17	20%	10%	E , V poor	10%	115	93%	16%
	Murray	110,839	71%	180	Low	8	20%	20%	A, V good	0%	40	70%	8%
	Herbert	984,589	87%	2,807	High	99	30%	10%	E, V poor	20%	518	42%	13%
Burdekin	Black	105,965	88%	1,040	Minimal	MCL			No data		49	62%	33%
	Ross	160,202	69%	2,408	Minimal	MCL			No data		35	38%	9%

REGION	CATCHMENT	AREA (HA)	WOODY COVER (% IN 2018)	CLEARED 2018-22 (HA)	WQIP PRIORITY	SEDIMENT TARGET (KT/YR)	REDUCTION TARGET (%)	REDUCTION 2022 (%)	GRADE 2022	% REDUCTION SHORTFALL	FINE SEDIMENT EXPORT[39] (KT/YR)	HILLSLOPE EXPORT HIGH & V. HIGH CLASSES	GULLY/ STREAMBANK HIGH & V. HIGH CLASSES
	Haughton	415,670	60%	2,915	Low	MCL			No target		145	49%	43%
	Burdekin	13,010,944	72%	204,008	Very high	840	30%	20%	E, V poor	10%	3,335	6%	26%
	Don	373,623	70%	7,460	Low	55	30%	17%	E, V poor	13%	213	39%	75%
	Proserpine	249,441	67%	1,390	Low	MCL			No data		72	45%	10%
Mackay/ Whit-sunday	O'Connell	238,764	60%	2,335	Moderate	96	40%	20%	D, poor	23%	212	91%	40%
	Pioneer	157,365	69%	378	Low	35	20%	6%	E, V poor	14%	149	78%	49%
	Plane	253,875	53%	1,448	Low	MCL			No data		88	56%	5%
Fitzroy	Styx	301,344	57%	3,444	Low	MCL			No data		81	51%	33%
	Shoalwater	360,181	72%	2,582	Minimal	MCL			No data		55	42%	4%
	Waterpark	183,652	85%	957	Minimal	MCL			No data		33	86%	0%
	Fitzroy	14,254,483	50%	329,356	High	390	30%	13%	D, poor	19%	1,369	6%	4%
	Calliope	224,063	63%	3,196	Minimal	15	30%	3%	D, poor	29%	42	52%	0%
	Boyne	249,633	82%	3,159	Minimal	6	40%	4%	E, V poor	36%	14	13%	0%
Burnett-Mary	Baffle	408,475	80%	7,014	Minimal	11	20%	7%	E, V poor	13%	65	65%	0%
	Kolan	290,449	71%	5,386	Minimal	6	20%	14%	D, poor	6%	34	13%	5%
	Burnett	3,321,171	63%	81,801	Moderate	85	20%	9%	E, V poor	11%	328	8%	7%
	Burrum	336,240	76%	5,626	Minimal	3	20%	16%	E, V poor	4%	20	22%	0%
	Mary	946,399	69%	12,240	High	130	20%	13%	E, V poor	7%	582	66%	34%

APPENDIX 2: METHODS

Great Barrier Reef Catchments scope

The Queensland Government's Great Barrier Reef Catchment and river basins spatial data layer was used as the study area (Fig. 1).[28] These catchments combined are denoted GBRC. We use the term "layer" here generally to refer to any two-dimensional spatial dataset either composed of polygons (a shapefile) or a pixellated, geo-referenced grid or raster in .tif format.

The FPC raster for 2022 published by the Queensland Government's Statewide Land and Trees Study (SLATS) was used as the template for all conversions and geoprocessing.[29]

Regulated vegetation maps

The Protected Areas, Property Maps of Assessable Vegetation ("PMAV") and Regulated Vegetation Map ("RVM") and Protected Areas (PAs) layers from mid July 2024[30] as well as archived layers for June 2018 were kindly provided by the Dept of Resources, were converted to rasters aligned to the common template with 10m pixel size in the Australian Albers GDA94 projection.

Because PMAVs take precedence over the statewide regulatory map, they were substituted into the regulatory map before rasterising. Similarly, parks and reserves areas under the Nature Conservation Act and State Forests are subject to their own legislation and so were clipped out and substituted into the regulatory map.

The final raster consisted of eight levels (excluding water bodies):-

1. Category A
2. Category B
3. Category C
4. Category R
5. Category X (outside of PMAVs)
6. Category X (inside PMAVs)
7. National parks and nature reserves under the Nature Conservation Act
8. State Forests under the Forestry Act.

Pixelation introduces small errors in area calculations compared with using the original polygon source files but has the major advantage of avoiding the generation of large numbers of tiny slivers that result from intersecting multiple polygon layers that might be slightly misaligned. We compared sums of areas of the RVM calculated from original shapefiles with those from pixellated shapefiles and found they differed by at most 0.1%.

Purpose and intensity of clearing and age of vegetation cleared

The SLATS woody vegetation change layers[31] were downloaded and corrections in the later years of previous years layers were applied to those earlier layers. The corrected shapefiles were coded by year (1-4) and the purpose/intensity descriptors used by SLATS (8 levels). The shapefiles were then rasterised to the common template and mosaiced into a single layer for all four years. If a pixel was cleared in more than one year, the year assigned was the earlier year.

The Queensland Government's Forestry - current forestry plantations layer current to 2019[32] was also rasterised to the common template and excised from the combined SLATS raster derived above, leaving what should primarily be native vegetation clearing. This may have excised some conversions of native forest to plantations that may have occurred in 2018/19.

Category X potentially belonging to remnant (Category B) or high value regrowth (Category C)

Category X areas were remapped as potentially regrown to Category B or C if they were mapped as:

- Exempt according to the rasterised Regulated Vegetation Map for June 2018 and July 2024 respectively as described above;
- had woody cover in 2018 or in 2022 according to the Woody *extent* layers published by SLATS for respective years;[33] and
- not in an already developed land-use (crops, settlements, plantations, mines, infrastructure) nor in already protected land uses (parks and reserves). This was determined from the Land use mapping - *1999 to Current - Queensland* published 14 Jun 2019, which is current to the time range 2011 to 2017[34] prior to the study period and rasterised to the common template.

If a pixel passing the above three filters was aged 15-29 years or older, it was deemed potentially Category C, or if older (30+ years) or remnant potentially in Category B.[35]

Category X potentially Reef watercourse regrowth (Category R).

Any area that was mapped exempt in 2018 or 2024 but lay within 50m of a Reef watercourse in an undeveloped land use potentially meets criteria for Category R, "regrowth watercourse vegetation".

Undeveloped but exempt areas within 50m of a Reef watercourse may still qualify as R despite lacking woody cover at present. Woody cover can change from year to year, decreasing if cleared, burnt or lost through natural means and increasing due to regrowth. The criteria for Category R does not include an age threshold nor even a requirement that woody vegetation be present. Thus, X potential R was not confined to areas with woody cover.

The shapefiles:

- *Watercourse areas - Queensland* (published 28/10/2022),
- *Vegetation management watercourse and drainage feature map (1:25000) - South East Queensland Version 6.00* (published 8/9/2022) and
- *Vegetation management watercourse and drainage feature map (1:100000 and 1:250000) - Queensland except South East Queensland Version 6.00* (published 8/9/2022)

were downloaded and clipped to GBRC. Then 50m buffers were drawn around all features, and all buffers for all features combined and dissolved and rasterised to the common template.

This was then clipped to Category X on the June 2018 RVM, to the undeveloped and unprotected land use rasters as described above and also to the Riparian Area layer provided by the Queensland Government which is used for Reef Report Card reporting.

Actual and potential regulated vegetation

The 8 level rasters for the Regulated Vegetation Map in June 2018 and July 2024 respectively described above were modified to include X potentially B, C or R to take the following 14 values:-

1. Category A (Protected)
2. Category B (Remnant)
3. Category C (High Value Regrowth)
4. Category R (Reef watercourse buffers)
5. Category X (outside of PMAVs exclusive of 9-11 below)
6. Category X (in PMAVs exclusive of 12-14 below)
7. National parks and nature reserves under the *Nature Conservation Act*
8. State Forests under the *Forestry Act.*
9. X outside of PMAVs potentially category B (exclusive of 5 and 6)
10. X outside of PMAVs potentially category C (exclusive of 5 and 6)
11. X outside of PMAVs potentially category R (exclusive of 5 and 6)
12. X in PMAVs potentially category B (exclusive of 5 and 6)
13. X in PMAVs potentially category C (exclusive of 5 and 6)
14. X in PMAVs potentially category R (exclusive of 5 and 6)

Where a pixel met the criteria to be both 9 or 10 and 11, or to be both 12 or 13 and 14 the smaller of the values took precedence.

Clearing of regulatory categories

The clearing rasters described above were intersected with the *Actual and potential regulated vegetation in 2018* just described using raster arithmetic and zonal histograms based on the GBRC regions used to calculate and tabulate areas.

Grouping subcatchments by fine sediment export rates

We obtained from McCloskey et al (2021) their spatial data for fine sediment export rates in all 5,583 subcatchments of the GBR.[36] We grouped subcatchments into four percentile groups according to aggregated hillslope or gully and streambank fine sediment exports.

We ordered subcatchments from highest to lowest fine sediment export rates and, running down the list, grouped that collectively account for 50% of the total export summed across all subcatchments into a "Very high" fine sediment contribution group.

Continuing down the list, we grouped those that together account for the next 25% of total fine sediment export into a "High" group, the next group that together account for the next 15% into a "Medium" group and finally collecting the remaining low export rate subcatchments that together account for 10% of total fine sediment export into a "Low" fine sediment contribution group.

We grouped subcatchments this way for hillslope fine sediment erosion separately from combined gully and streambank erosion sourced exports because they derive from different parts of the landscape: off-stream vs in-stream.

We then intersected these two groupings of subcatchments by the layers produced above: clearing from 2018 to 2022, X potentially B, C or R and tabulated areas by the four groups of subcatchments.

ENDNOTES

1 Waterhouse, J et al. 2022. Scientific Consensus Statement on land-based impacts on Great Barrier Reef water quality and ecosystem condition. Commonwealth of Australia and Queensland Government.

2 Clearing detection in Queensland generally runs from August of a given year to August of the next.

3 Waterhouse J et al. 2022. Scientific Consensus Statement on land-based impacts on Great Barrier Reef water quality and ecosystem condition. Commonwealth of Australia and Queensland Government.

Note that although the publication date is 2022, it was not actually published until August 2024. (https://www.reefplan.qld.gov.au/science-and-research/the-scientific-consensus-statement)

4 Carter E, Thulstrup H, 2022. Report on the Joint World Heritage Centre/IUCN Reactive Monitoring Mission to the Great Barrier Reef (Australia) from 21 to 30 March 2022 (https://whc.unesco.org/en/list/154/documents/).

5 https://www.dcceew.gov.au/parks-heritage/great-barrier-reef/publications/great-barrier-reef-progress-report

6 Decisions Adopted by the 46th Session of the World Heritage Committee: (https://whc.unesco.org/en/sessions/46COM.) See pp. 184-85.

7 https://www.reefplan.qld.gov.au/tracking-progress/reef-report-card

8 Spatial data source:- Queensland Government 2018, Great Barrier Reef catchment and river basins (Spatial data published 5/5/2018, https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={C3E7CB1D-5881-4EB4-A9C1-9DADABA0E10B} and https://www.qld.gov.au/__data/assets/pdf_file/0019/105247/gbr-catchment-river-basins-map.pdf for regions).

9 https://www.reefplan.qld.gov.au/water-quality-and-the-reef/the-plan

10 https://www.reefplan.qld.gov.au/tracking-progress/reef-report-card/2021-22

11 Queensland Government, 2023. Vegetation Management Act 1999. Sect 8 (https://www.legislation.qld.gov.au/view/html/inforce/current/act-1999-090)

12 Queensland Government, 2023. Vegetation Management Act 1999. Schedule dictionary. (https://www.legislation.qld.gov.au/view/html/inforce/current/act-1999-090#sch)

13 Queensland Government Statewide Landcover And Trees Study (SLATS) 2021. Sentinel-2 - 2018 woody vegetation extent - Queensland - Whole of State (spatial data https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={EB9B9234-D19E-440A-AEF2-1CD98245FE3E})

14 See note 12 above.

15 Australian Government Department of Agriculture Fisheries and Forestry, 2023. Australia's National Forest Inventory (webpage https://www.agriculture.gov.au/abares/forestsaustralia/australias-national-forest-inventory)

16 Queensland Government, 2022. Understanding Queensland's native vegetation clearing laws. (Webpage https://www.qld.gov.au/environment/land/management/vegetation/clearing-laws)

17 Taylor M, 2018. Bushland destruction in Queensland since laws axed. WWF-Australia Briefing, January 2018.

18 Note that these figures are land areas and include non-vegetated and developed areas, not just woody vegetation. Note that on Nature Conservation Act and Forestry Act areas (Parks and State forests) any clearing is regulated under those Acts not under the VMA (sect 7 Application of Act). These areas are included in Other.

19 Note: figures have been rounded so when summed may differ from the rounded total.

20 Taylor MFJ, Fletcher R, 2022. What's at Steak: Deforestation for beef widespread in Queensland. Report prepared for the Queensland Conservation Council and The Wilderness Society, Brisbane. (https://www.wilderness.org.au/images/resources/DeforestationReport2022.pdf)

21 KEY: Pasture clearing means removing woody vegetation to expand or enhance pasture grass coverage for livestock. Partial clearing for pasture means there was still woody vegetation left after clearing. Major partial means over half of crown cover was removed and minor means less than half. Unspecified purpose clearing includes missed clearing and partial minor clearing not attributed to a purpose.

22 See Methods:- Excluding water, cropping, sown pastures, plantations, mines, infrastructure and settlements.

23 According to the Queensland Herbarium's Remnant Cover layer for 2021 and not having subsequently been cleared. Note that ecological remnant is not the same as Category B under the VMA.

24 https://www.reefplan.qld.gov.au/tracking-progress/reef-report-card/2021-22

25 Units are hectares. Note that these figures include non-vegetated and developed areas, not just woody vegetation. Note that on Nature Conservation Act and Forestry Act areas (Parks and State forests) any clearing is regulated under those Acts not under the VMA (sect 7 Application of Act). These areas are included in Other.

26 The Queensland Government kindly provided a layer of riparian areas in the GBRC. This area includes most 50m buffers around GBRC watercourses that are used to map category R, but excludes estuarine reaches of rivers and watercourses labelled as "connectors". The layer also includes riverine wetlands not included in Category R, that is wetlands or swamps within the floodplains of the rivers.

27 McCloskey GL et al, 2021. Modelled estimates of fine sediment and particulate nutrients delivered from the Great Barrier Reef catchments. *Marine pollution bulletin*, 165, 112-163.

28 published 5/5/2018 (https://qldspatial.information.qld.gov.au/)

29 Protected areas of Queensland (https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={07E360E3-A191-4C24-9671-1471362F0B1B})

Statewide Landcover And Trees Study (SLATS) Sentinel-2 - 2022 Foliage Projective Cover (FPC) - Queensland (https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={87D4DB36-6B23-49DE-99DE-3EF3C318B840})

30 Vegetation management regulated vegetation management map - version 7.04 (https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={9CC053EC-585B-4C41-A713-E1D04543CCC2})

Vegetation Management Act property maps of assessable vegetation as current 23/7/24 (https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={D96F12B8-D3A3-4D7D-824B-AF2D45805592})

31 Queensland Government Statewide Landcover And Trees Study (SLATS) 2021. Statewide Landcover and Trees Study Queensland Sentinel-2 series. Spatial data collection. (https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={5300BA40-F1DF-4E8E-9A84-99364B8DECDF}).

32 Queensland Government 2021. Forestry - current forestry plantations - Queensland. Spatial data current for 2019 published 25 Nov 2021 (https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={F31E3680-F98D-4374-BEE6-959DBBEEA412}).

33 Ibid

34 Queensland Government 2019. Land use mapping - 1999 to 2017 - Queensland. Spatial data Archived.

35 Queensland Government Statewide Landcover And Trees Study (SLATS) 2022, Sentinel-2 - 2018 Woody Vegetation Age Since Disturbance - Queensland. Spatial data (https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={A8107FCC-683A-4FC1-BD7E-C1E173507BCD}).

36 Displayed in Fig. 12 of McCloskey GL et al, 2021. Modelled estimates of fine sediment and particulate nutrients delivered from the Great Barrier Reef catchments. Marine pollution bulletin, 165, 112-163.