Wetland Condition 2023 and 2024

Great Barrier Reef Catchment Wetland Monitoring Program

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July 2025

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Main cover image

Wetland Condition Science, Department of the Environment Tourism, Science and Innovation.

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Contents

Executive summary

The Wetland Condition Monitoring Program (the Program) tracks progress towards an objective of improved wetland condition, focussing on natural, freshwater floodplain wetlands (hereafter 'wetlands') in major aggregations within the Great Barrier Reef catchment area (GBRCA). The Program uses a rapid assessment tool called Wetland Tracker to gather data on a sample of wetlands each year using a suite of indicators. Indicators are aggregated into overall indices and subindices of wetland condition, whose scores are then analysed to estimate the annual status of wetland condition at GBRCA and Natural Resource Management (NRM) region scales. Scores range from 1 to 5, with lower scores indicating better condition, associated with lower pressure on wetlands and/or a better state of wetland environmental values.

This Wetland Condition 2024 report details the wetland condition assessment methods and results for the January 2023 to December 2024 (2023 and 2024) reporting period. Sample sizes in 2023 were larger than in 2024, enabling within-group analyses using the 2023 data. As such, wetland condition by land use intensity and hydrological modification categories and within NRM regions is based on analysis of data from the 2023 survey year, and for the GBRCA overall on the 2024 survey year.

At the GBRCA scale, the estimated score for the overall state of wetlands was 2.58, with a 95% confidence interval (CI) of 2.52 to 2.64. The estimated score for the overall pressure on these wetlands was 2.89 for 2024 (95% CI: 2.85 to 2.93). These scores suggest the GBRCA wetlands are, *on average*, in moderate but not good condition. The overall moderate condition of GBRCA wetlands was clearly influenced (offset) by the overall good condition of wetlands in the Cape York NRM region.

When wetlands were grouped by the intensity of their dominant land use (low, moderate or high), the score estimates tended to be higher (reflecting poorer condition) in the moderate- and high-intensity groups than in the low-intensity group. Local physical integrity was an exception, however, having poorer condition in the moderate- and low-intensity groups than the high-intensity group. Indicators contributing to this subindex are mostly associated with soil disturbance from hooved animals. Wetlands with local hydrological modification tended to have scores indicative of poorer condition than those without such modification.

At the NRM region scale, the score estimates for wetland condition differed among the Cape York, Wet Tropics, Burdekin, Fitzroy and Burnett Mary NRM regions. Scores were not estimated for the Mackay Whitsunday NRM region due to sample-size constraints. Score estimates for state and pressure indices and subindices for the Cape York NRM region were lower (reflecting better condition) than for other NRM regions, except for local physical integrity, which was driven strongly by hooved animal activity. The Burnett Mary NRM region had the lowest score estimate for local physical integrity, and the second lowest score estimate (after the Cape York NRM region) for overall state and pressure. The Wet Tropics, Burdekin and Fitzroy NRM regions often had the highest score estimates among NRM regions.

Pressure from pest plants and animals contributed towards higher overall pressure in all NRM regions, as did pressure from habitat modification in the Wet Tropics and Fitzroy NRM regions. Land use within wetlands and their 1 km buffers associated with the introduction and spread of pest species (e.g. grazing, mining, urban, aquaculture), along with historical and recent clearing of native vegetation within wetlands and their 5 km buffers were likely contributing substantively to those respective pressures.

The moderate to poor state of biotic integrity in the Burdekin NRM region (associated particularly with plant species composition and vegetation structure in wetlands) and of landscape vegetation connectivity of wetlands in the Wet Tropics, Fitzroy and Burdekin NRM regions contributed most strongly towards poorer scores for overall state in those NRM regions. Soil deformation in wetlands by hooved animals (pugging and wallows) also had a strong negative impact on wetland environmental values, particularly in the Cape York and Fitzroy NRM regions.

Findings suggest that management actions focussed on protecting and re-establishing native vegetation in wetland riparian buffer areas and wildlife corridors may improve wetland habitat, biotic integrity and connectivity. Actions to control and manage access by hooved animals should improve wetland physical integrity. Actions to manage water abstraction and reduce barriers and impacts of hydrological modification on water flow should improve wetland hydrological integrity and safeguard against water regime change. Actions to manage nutrient, sediment and pesticide run-off should help to reduce impacts of pollutants on water quality and aquatic habitat and wildlife, in wetlands and other receiving waters.

More specifically within NRM regions, coordinated landscape scale actions could be prioritised in relation to the subindex scores and the indicators driving them, from highest to lowest score. For example, in the Cape York NRM region, this might involve focus on managing access of hooved animals to wetlands. The discussion provides more detail on management options for NRM regions.

The Program is designed to detect improvement in wetland condition in response to management actions undertaken at the landscape scale. Therefore, to detect whether these targeted actions are having the desired effect they should be implemented in the monitored wetland aggregations.

Introduction: Assessing wetland condition

The Wetland Condition Monitoring Program (the Program) tracks progress towards the improved wetland condition objective of the Reef 2050 Long Term Sustainability Plan, including the Reef 2050 Water Quality Improvement Plan.

The Program focuses on monitoring the condition of natural, freshwater floodplain wetlands (hereafter 'wetlands') in major aggregations within the Great Barrier Reef catchment area (GBRCA) (**Figure 1**), using a rapid assessment tool called Wetland Tracker (Tilden and Vandergragt 2022). This enables the Program to monitor and report on *wetland condition*, defined as anthropogenic pressure on wetlands and the current state of their environmental values. Monitoring and reporting are done for Natural Resource Management (NRM) regions within the GBRCA, as well as for the GBRCA overall.

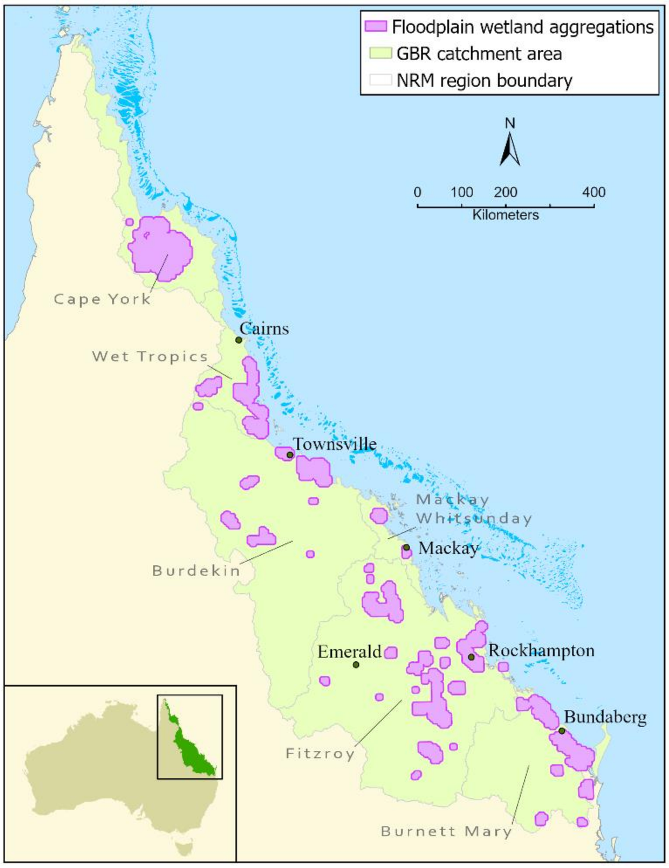

Figure 1: *Major aggregations of natural, freshwater floodplain wetlands in the GBRCA.*

The Program assesses and reports on two overall indices of wetland condition: anthropogenic pressure and state. In addition, four standalone subindices that describe specific types of anthropogenic pressure are assessed and reported on: pest plants and animals; habitat modification; water regime change; and pollutant inputs. Likewise, four standalone subindices that describe wetland environmental values (i.e. 'state') are also assessed and reported on: biotic integrity; local physical integrity; local hydrology; and connectivity.

In sum, there are two overall indices, four pressure subindices and four state subindices, which are each calculated separately from suites of individual pressure and state indicators. Tilden et al. (2023) provide the evidence base supporting the conceptual and ecological links between the condition of wetlands and each of the Program's pressure and state indicators, subindices and indices.

Annual wetland condition data have been collected by the Program since 2016, when the baseline pressure and state data for the GBRCA overall were reported as a component of the 2016 Reef 2050 Water Quality Report Card.

The present report details the wetland condition methods and results for the 2023 and 2024 reporting period (i.e. the two calendar-year period from January 2023 to December 2024), focussing on the annual status of wetland condition at NRM region and GBRCA scales.

Methods

Sampling design

The Program monitors a spatially balanced random sample of over 200 wetlands from the subpopulation of natural, freshwater floodplain wetlands in high density aggregations within the GBRCA (**Figure 1, Table 1**). The sample was selected using a method known as Generalised Randomised Tessellation Stratified (GRTS) sampling (Stevens and Olsen 2003, 2004).

Table 1: Panel design, and numbers of wetlands monitored in those panels, for the Great Barrier Reef catchment area (GBRCA) Wetland Monitoring Program 2016-2025.*

Panel	Year								
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
1	21	22	21	21	28	36	50	50	28
2	20		20				44		
3		20		20				48	
4					27				28
5						32			
Year total	41	42	41	41	55	68	94	98	56

*Some wetland sample sizes per panel differ due to factors such as attrition, replacement and intensification. For example, Panel 1 originally comprised 21 wetlands, but only 19 of these have been assessed repeatedly; two have dropped out and been replaced. Since 2020, more wetlands have been added to panels as part of the intensification process for Natural Resource Management regions.

Wetlands are monitored according to a design schedule known as an 'augmented serially alternating panel design,' where panels are groups of wetlands that have the same revisit schedule across years. The Program has five panels, each comprising up to fifty wetlands from across the NRM regions. Panel 1 wetlands are monitored every year, with wetlands in the remaining four panels monitored on a rotating basis, such that up to around 100 wetlands are monitored each year from across two panels (**Table 1**). At the end of every four years, a cycle of the four rotating panels is completed and the four-year schedule starts again (noting that the first four-year rotational schedule started in earnest from 2018).

The number of wetlands monitored annually (up to ~100) increased from the ~40 wetlands monitored each year for the first four years of the Program (**Table 1**). The increase was implemented gradually since 2020 to eventually enable assessment of and reporting on wetland condition at the NRM region scale, in addition to the GBRCA scale.

The process of 'intensification' commenced in the Fitzroy NRM region in 2020 and in the Wet Tropics NRM region in 2021. In 2022 and 2023, additional wetlands were monitored in the Wet Tropics, Burdekin, Fitzroy and Burnett Mary NRM regions, and in 2024 in the Fitzroy NRM region. Intensification has not occurred in Mackay Whitsunday or Cape York NRM regions due to constrained sample size and logistical constraints, respectively. However, the number of wetlands monitored annually in the Cape York NRM region without intensification (12 - 16 per year) should be sufficient to at least estimate annual condition.

Ninety-eight wetlands were monitored in 2023, and 56 in 2024.

Data collection and analysis for individual wetlands

Wetland Tracker indicators

The Program's condition assessment tool, Wetland Tracker, outlines the field and desktop-based methods used to collect data from wetlands, score each indicator, and generate subindex and overall index scores for individual wetlands (Table 2). These methods are summarised below.

For each wetland due to be monitored in any one year:

- Imagery and spatial data from a range of datasets are analysed to score 15 'desktop' indicators that are mostly related to pressure on wetlands (Sutcliffe et al. 2022).
- Field-based data collection is conducted to score nine additional indicators that are mostly related to the state of wetland environmental values (Johns et al. 2022). Field surveys are conducted annually during the dry season, roughly between March and October.

Integer scores for indicators range between 1 and 5, where 1 reflects a pre-European settlement condition and 5 the most removed from that (Table 3). For example, the lowest score (1) for an indicator reflects a very low pressure or very good state for that indicator; a moderate score (3) a moderate pressure or state, and the highest score (5) a very high pressure or very poor state.

Wetland Tracker subindices and indices

For each wetland, indicator scores are integrated into numeric scores for each of the eight Wetland Tracker subindices (four for pressure and four for state) (Figure 2). The indicator scores are also integrated to generate an overall numeric pressure index score and an overall numeric state index score for each wetland (Figure 2). The numeric subindex and overall index scores range between 1.00 and 5.00, where 1.00 reflects a pre-European settlement condition and 5.00 the most removed from that (Table 4). Tilden and Vandergragt (2022) outline the index and subindex integration methods for individual wetland scores.

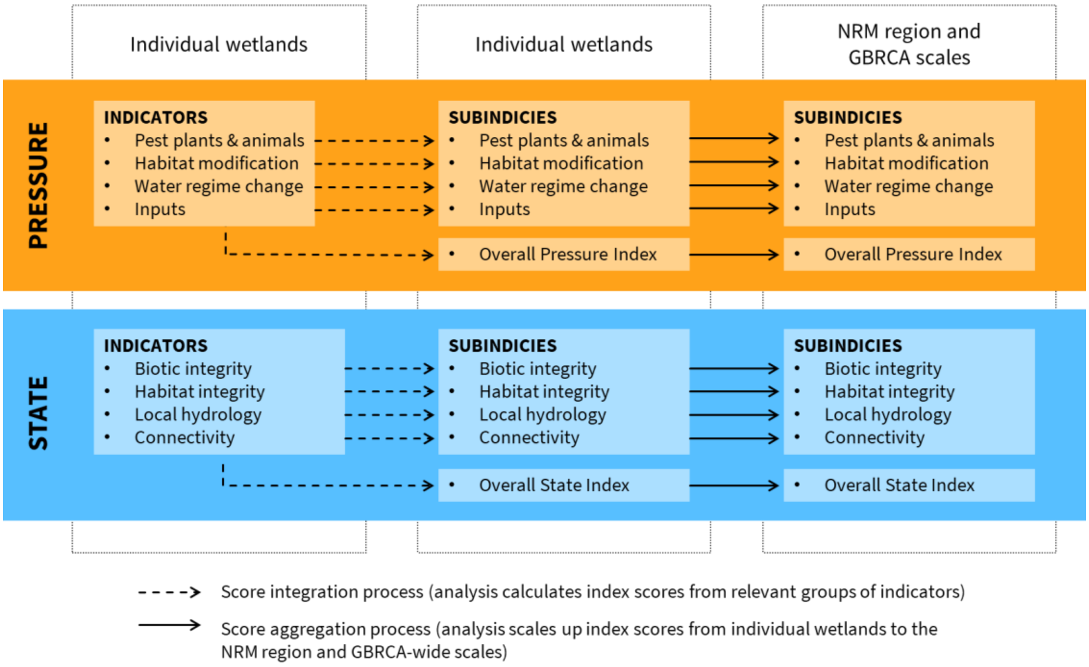

Figure 2: The integration (wetland scale) process, and aggregation process used to score wetland condition at Great Barrier Reef catchment area (GBRCA) and Natural Resource Management (NRM) region scales.

Table 2: Wetland Tracker indicators of pressure (P) and state (S), by sub-index. All pressure indicators contribute to the overall pressure index. All state indicators contribute to the overall state index.

Indicator	Description	Type	Area of interest	Subindex	Overall index
P1	Land use associated with the introduction or perpetuation of pest species	D	WL & 1 km buffer	PC1 Pest plants and animals	Pressure
P7	Plant pest cover	F	WL	PC1 Pest plants and animals	Pressure
P8	Plant pest cover	F	200 m buffer	PC1 Pest plants and animals	Pressure
P2	Modification of native vegetation	D, FV	200 m buffer	PC2 Habitat modification	Pressure
P20	Native vegetation cleared	D	WL & 5 km buffer	PC2 Habitat modification	Pressure
P21	Loss of wetland regional ecosystems	D	WL & 5 km buffer	PC2 Habitat modification	Pressure
P14	Altered surface water flow due to vegetation cleared	D	1 km buffer	PC3 Water regime change	Pressure
P16	Change in landscape hydrological integrity	D	WL & 1 km buffer	PC3 Water regime change	Pressure
P19	Water abstraction, or consumption by hooved animals	F	WL & 200 m buffer	PC3 Water regime change	Pressure
P3	Land use associated with pesticide residue inputs	D	WL & 1 km buffer	PC4 Pollutant inputs	Pressure
P4	Land use associated with nutrient inputs	D	WL & 1 km buffer	PC4 Pollutant inputs	Pressure
P5	Number of septic systems per hectare of mapped wetland	D	WL & 200 m buffer	PC4 Pollutant inputs	Pressure
P10	Sediment supply (modelled, GBRCA)	D, FV	WL & 1 km buffer	PC4 Pollutant inputs	Pressure
P12	Number of stormwater or other point inflows per hectare of wetland	F	WL & 200 m buffer	PC4 Pollutant inputs	Pressure
S1	Floristic composition and vegetation structure	F	WL & 200 m buffer	WEV1 Biotic integrity	State
S3	Exotic plant cover	F	WL & 200 m buffer	WEV1 Biotic integrity	State
S7	Direct disturbance by humans or hooved animals physically impacting soil	F	WL & 200 m buffer	WEV2 Local physical integrity	State
S8	Soil surface deformation from hooved animals	F	WL	WEV2 Local physical integrity	State
S9	Drainage modifications and artificial structures altering natural surface flows	F	WL & 200 m buffer	WEV3 Local hydrology	State
S12	Hydrological modifier code	D, FV	WL	WEV3 Local hydrology	State
S15	Modified and artificial wetlands	D	1 km buffer	WEV3 Local hydrology	State
S16	Altered surface flow due to linear transport infrastructure	D	WL &1 km buffer	WEV3 Local hydrology	State
S13	Landscape vegetation connectivity	D	WL & 32 km buffer	WEV4 Connectivity	State
S14	Native vegetation	D, FV	200 m buffer	WEV4 Connectivity	State

D, desktop; F, field; FV, field verified; WL, wetland.

Table 3: Indicator score scaling.

Condition score	1	2	3	4	5
Pressure	Very low	Low	Moderate	High	Very high
State	Very good	Good	Moderate	Poor	Very poor

Table 4: Subindex and index score scaling.

Condition score	1:00	-	5:00
Pressure	Lower	-	Higher
State	Better	-	Poorer

Data analysis for GBRCA and NRM region scales

For each subindex and index, the numeric scores from all wetlands monitored in any one year are analysed to generate aggregated, numeric subindex and index scores at GBRCA and NRM region scales (**Figure 2**). A score of 1:00 for a region reflects a pre-European settlement condition and a score of 5:00 the most removed from that (**Table 4**).

The analyses use model-assisted design-based methods that account for nonresponse bias and frame error, outlined below, to estimate annual status in wetland condition. Analyses are conducted in R, a language and environment for statistical computing (R Core Team 2024).

Accounting for non-response using multiple imputation

Wetlands in the Program that have been surveyed in the field are referred to as responding wetlands. Wetlands that are approached for inclusion in the program but cannot be surveyed for some reason (besides being in a non-surveyed panel) are referred to as nonresponding wetlands.

There is a high proportion of nonresponse in the Program (Australian and Queensland Governments 2016; **Table 5** and **Table 6**). Reasons for nonresponse are recorded annually and include site inaccessibility (e.g. due to geography); absence of landholder contact information; landholder declining to grant access for sampling; landholder postponement of access for sampling; and no reply from landholder. When this occurs, the nonresponding wetland is replaced from the randomly generated (GRTS) list by the next wetland on the list that can be sampled within the same NRM region. This makes the replacement wetland a responding wetland. As a result, the sample of wetlands on which data are collected represents the subpopulation of responding wetlands rather than wetlands from the entire target subpopulation, and this represents a potential source of what is known as nonresponse bias.

Table 5: Sample sizes, for responding wetlands only, in the Great Barrier Reef catchment area (GBRCA) and Natural Resource management regions (BK, Burdekin; BM, Burnett Mary; CY, Cape York; FZ, Fitzroy, MW, Mackay Whitsunday; WT, Wet Tropics).

	2016	2017	2018	2019	2020	2021	2022	2023	2024
GBRCA	41	42	41	41	55	68	94	98	56
CY	12	16	12	16	16	14	12	16	16
WT	4	4	4	4	5	20	20	20	5
BK	5	4	5	4	6	6	20	20	6
MW	2	3	2	2	2	2	2	2	3
FZ	11	9	11	9	20	20	20	20	20
BM	7	6	7	6	6	6	20	20	6

Table 6: Sample sizes, for responding and nonresponding wetlands combined, in the Great Barrier Reef catchment area (GBRCA) and Natural Resource management regions (BK, Burdekin; BM, Burnett Mary; CY, Cape York; FZ, Fitzroy, MW, Mackay Whitsunday; WT, Wet Tropics).

	2016	2017	2018	2019	2020	2021	2022	2023	2024
GBRCA	68	73	71	77	122	176	270	263	188
CY	12	16	12	16	17	17	12	16	18
WT	7	6	7	7	12	65	84	57	36
BK	9	8	11	8	12	12	73	86	21
MW	7	8	8	8	13	8	8	8	14
FZ	21	19	21	22	49	64	43	57	71
BM	12	16	12	16	19	10	50	39	28

To account for the potential non-response bias, multiple imputation (Little and Rubin 2019) is used to impute subindex and overall index scores for nonresponding wetlands by NRM region. This is because NRM region has been determined as the best predictor of response vs nonresponse (based on logistic regression and the corrected Akaike Information Criterion (AICc) of Burnham and Anderson 2002).

To impute scores for the 2023 and 2024 reporting period, nonresponding wetlands were all treated as missing at random (MAR). As such, index score means and variances for nonresponding wetlands within an NRM region are considered similar to those of responding wetlands in the same NRM region, under the quasi-randomisation assumption (Oh and Scheuren 1983). To this end, ten imputations were drawn for each index and MAR wetland, by NRM region, from the truncated normal distribution, within the bounds of the 95% confidence interval for the responding wetland mean (Rodwell et al. 2014). Imputation was performed using functions the Program's bespoke R package for imputation and status analysis (Starcevich et al. 2025).

Previously, only the nonresponding wetlands that were inaccessible due to geography or had no contact information were treated as MAR (Wetland Condition Science 2023). All other nonresponding wetlands (those for which landowners did not reply to contact or declined or postponed participation) were treated as missing not at random (MNAR) and assumed to be in poorer condition than responding wetlands in the same region. Analysis of nonresponding wetland scores from the 2022 survey year, using on desktop indicator data only (as these can be scored without the need to physically access and survey wetlands in the field) indicated that this assumption of poorer condition was not supported (internal, unpublished report). In general, differences between desktop indicator scores of (i) responding, (ii) MAR-assumed and (iii) MNAR-assumed wetlands were not consistent in significance or direction. In many cases, no evidence of a difference between scores was found, and in some cases, there was evidence contrary to assumptions. For example, there were instances of MNAR-assumed wetlands scoring lower (i.e. being in better condition) than responding and MAR-assumed wetlands, and MAR-assumed wetlands scoring higher (in worse condition) than responding wetlands. Hence all nonresponding wetlands were treated as MAR for the current report. Nevertheless, status estimates were also produced assuming nonresponding wetlands were a mix of MAR and NMAR, based on non-response reason, for the purpose of comparison (see **Appendices**).

Accounting for frame error

Frame error occurs when one or more wetlands in the GRTS list that are approached for inclusion in the Program do not actually belong to the target subpopulation of natural freshwater, floodplain wetlands (e.g. they might have been converted from estuarine to fresh water).

NRM region has been found to be the best predictor of whether a wetland is part of the target subpopulation, based on logistic regression and the AICc. As such, design weights within NRM regions that summed to the total number of target-subpopulation wetlands in each relevant NRM region were calculated using functions in the Program's bespoke R package and 'spsurvey' (Dumelle et al. 2003), and used to account for frame error. This ensured that the wetland sample in an NRM region represented the target subpopulation for that NRM region. Specifically, the weight for a wetland in any one NRM region and year equals the inverse of the probability of its inclusion in the sample for that NRM region and year, as per the Horvitz-Thompson estimator (Horvitz and Thompson 1952; Cordy 1993).

Estimating annual status of wetland condition (pressure and state)

After accounting for nonresponse and frame error, annual design-based estimates of wetland condition status and 95% confidence intervals were computed for each pressure and state index and subindex using functions in the Program's bespoke R package and 'spsurvey', and the neighbourhood variance estimator of Stevens and Olsen (2003, 2004), with plots produced using 'ggplot2' (Wickham 2016). The 95% confidence interval is the range of values for which there is 95% confidence that it contains the true value of the score being estimated, based on the sample of wetlands and the methods used to estimate that score. The narrower the range, the more certainty there is in the estimate.

At the *NRM region scale*, the status of wetland condition in any one year was based on data from responding and nonresponding wetlands *within each respective NRM region* in the panels surveyed that year, as per Table 6. However, status estimates at this scale should only be reported when sample size is sufficient. As such, status estimates at the NRM region scale for the 2023 and 2024 reporting period were based on data from the most recent year of most intense surveying: 2023 (see Sampling design). Note that status for the Mackay Whitsunday NRM region was not estimated due to sample size constraints.

At the *GBRCA scale*, the status of wetland condition in any one year was based on the analysis of data from responding and nonresponding wetlands *across all six NRM regions combined* (i.e. Cape York, Wet Tropics, Burdekin, Mackay Whitsunday, Fitzroy, Burnett Mary) in the panels surveyed that year, as per Table 6. For example, status estimates at the GBRCA scale for the 2023 and 2024 reporting period were based on data from the 2024 survey year (Panel 1 and 4 wetlands).

For the GBRCA in 2024 and each NRM region in 2023, the mean scores for each indicator were also calculated based on responding wetland data only. Indicators within each subindex that had the lowest and highest mean score were then identified for the GBRCA and each NRM region (excluding Mackay Whitsunday due to sample size constraints). Results were used to provide insight on the relative importance of indicators to the status of wetland condition at GBRCA and NRM region scales, and thus insight on potentially appropriate management actions.

Annual status was also estimated at the GBRCA scale by land use intensity (ABARES 2016), i.e. for wetlands with predominantly low-, moderate- or high-intensity land use in its wetland and 200 m buffer area, using data from responding and nonresponding wetlands from the 2023 survey year. Low-intensity land use includes areas of conservation and natural environments. Moderate-intensity land use includes areas of production from relatively natural environments. High-intensity land use includes areas of intensive uses and production from dryland and irrigated agriculture and plantations.

Finally, annual status at the GBRCA scale was estimated by local hydrological modification (unmodified vs modified wetlands) using data from responding and nonresponding wetlands from the 2023 survey year. Based on their local hydrological modification qualifier (Department of Environment and Science, 2019, 2023), wetlands were classified as either hydrologically unmodified (H1 wetlands; no observable local hydrological modification) or modified (non-H1; slightly to highly modified local hydrology from activities including bunding, excavation, partial drainage, cultivation, cropping, controlled surface hydrology or channel construction). Status was estimated separately for unmodified and modified wetlands, for all indices and subindices except for the overall state index and local hydrology subindex. This was because indicator S12 is scored based on the local hydrological modification and contributes to the integrated scores for overall state and local hydrology.

Dominant land use and local hydrological modification

Several other measures and supporting data are collated each year when calculating desktop indicators and undertaking field surveys, which may be used to provide context when interpreting GBRCA and NRM-region scale score results. For this report, land use intensity and hydrological modification data were analysed following the method outlined below.

Wetland condition may be influenced by land use intensity and/or activities that modify wetland water regimes. For example, wetlands with and surrounded by predominantly low-intensity land uses may have lower condition scores (be in better condition), while those with and surrounded by higher-intensity land uses may have higher condition scores (be in poorer condition). Hydrologically modified wetlands may similarly score more poorly in terms of wetland condition than hydrologically unmodified ones. To explore this, the proportion of responding wetlands with (i) a dominant land use of low, moderate or high intensity in their wetland and 200 m buffer area, and (ii) unmodified or modified local hydrology (H1 vs non-H1 wetlands) was calculated for each survey year within NRM regions and at the GBRCA scale.

Results

Status of wetland condition in NRM regions

The NRM-region scale score estimates for the pressure on and state of freshwater floodplain wetlands in 2023 differed among NRM regions (Figure 3), showing similar patterns to those of the previous reporting period (save for the Cape York NRM region scores, which were estimated for the first time this reporting period). Score estimates for the Cape York NRM region were the lowest among NRM regions for all pressure and state indices and subindices, suggestive of good to very good condition, except for pest plants and animals and local physical integrity, whose score estimates were suggestive of moderate condition. Contributing strongly to those two subindex scores were pressure from land use associated with the introduction or perpetuation of pest plants and animals (indicator P1) and soil surface deformation associated with hooved animal activity (indicator S8) respectively (Table 7). While the Cape York NRM region had the lowest score estimate among NRM regions for pest plants and animals, local physical integrity scored highest (most poorly) in the Fitzroy and Cape York NRM regions, and lowest in the Burnett Mary NRM region where its score was suggestive of good condition. Score estimates for subindices and overall indices in the Wet Tropics, Burdekin, Fitzroy and Burnett Mary NRM regions were otherwise suggestive of moderate to poor condition.

The highest (poorest) scoring pressure subindex within NRM regions in 2023 was consistently plants and animals (Cape York, Wet Tropics, Burdekin, Fitzroy, Burnett Mary NRM regions), followed very closely by habitat modification in the Wet Tropics and Fitzroy NRM regions (Figure 3). Based on responding wetland data, scores for these two subindices were most likely driven strongly and respectively by pressure from land use within wetlands and their 1 km buffers associated with pest species introductions and persistence (indicator P1) and loss of native vegetation within wetlands and their 5 km buffers (indicator P20) (Table 7).

The highest (poorest) scoring state subindices within NRM regions in 2023 were connectivity (Wet Tropics, Fitzroy, Burnett Mary NRM regions), local physical integrity (Cape York NRM region) and biotic integrity (Burdekin NRM region) (Figure 3). Based on responding wetland data, these subindex scores were most likely driven strongly and respectively by landscape vegetation connectivity (indicator S13), soil deformation in wetlands by hooved animals (indicator S8) and floristic composition and vegetation structure in the wetland and its 200 m buffer (indicator S1) (Table 7).

Pressure indicators P12 (number of stormwater or other point inflows per hectare of wetland), P3 (land use associated with pesticide residue within 1 km of the wetland) and P5 (number of septic systems within 200 m of the wetland, per ha of mapped wetland) all tended to have relatively low scores in NRM regions (typically < 2.5 on average based on responding wetland data), as did state indicators S7 (direct disturbance by humans or hooved animals physically impacting soil in the wetland and its 200 m buffer), S12 (hydrological modifier code for the mapped wetland) and S16 (linear transport infrastructure within 1 km of the wetland) (Table A 2).

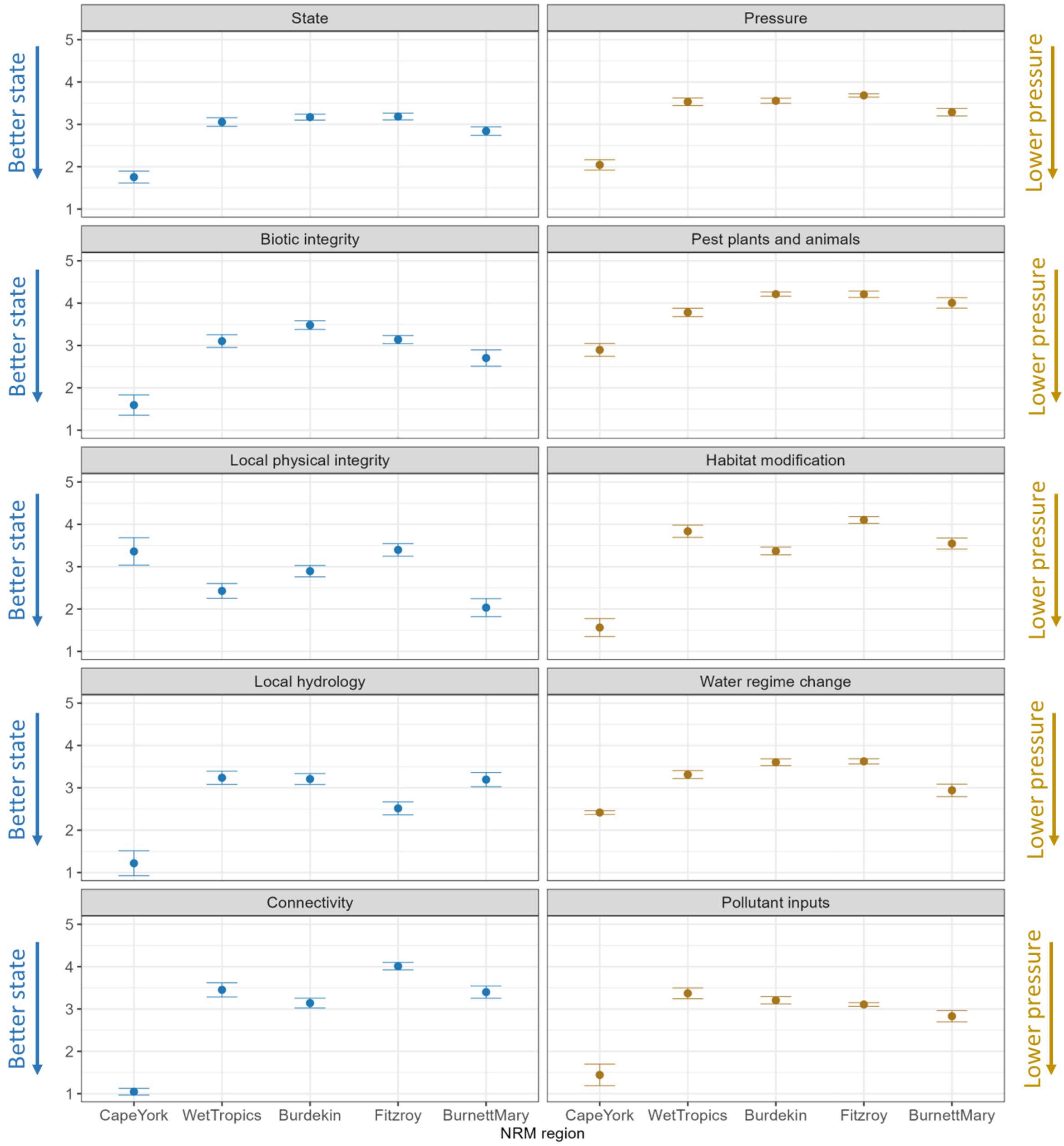

Figure 3: Estimated state (left plots, blue closed circles) and pressure scores (right plots, brown closed circles) at the Natural Resource Management region scale for each overall index and subindex of wetland condition in 2023, with upper and lower bounds of the 95% confidence intervals shown as 'error bars.'

*Table 7: Indicators with the highest mean score per subindex and Natural Resource Management region in 2023, based on responding wetland data only. See **Table A 1** for the mean responding-wetland scores for each indicator. Higher scores indicate poorer condition.*

Subindex	Indicator	Description	NRM region*
Pest plants and animals	P1	Land use associated with introduction or perpetuation of pest plant and animal species within the wetland and its 1 km buffer	CY, WT, FZ and BM
	P8	Exotic pest cover in the wetland's 200 m buffer	BK
Habitat modification	P20	Native vegetation cleared within the wetland and its 5 km buffer	WT, BK, FZ and BM
Water regime change	P16	Change in landscape hydrological integrity within the wetland and its 1 km buffer	WT, BK and BM
	P19	Water abstraction, or consumption by hooved animals in the wetland and its 200 m buffer	CY
	P14	Vegetation clearing in the wetland's 1 km buffer	FZ
Pollutant inputs	P10	Sediment supply within the wetland and its 1 km buffer	WT, BK, FZ and BM
Biotic integrity	S1	Floristic composition and vegetation structure in the wetland and its 200 m buffer	WT, BK, FZ and BM
Local physical integrity	S8	Soil surface deformation from hooved animals in the wetland	CY, WT, BK, FZ and BM
Local hydrology	S9	Drainage modifications and artificial structures altering natural surface flows in the wetland and its 200 m buffer	WT, BK, FZ and BM
Connectivity	S13	Landscape vegetation connectivity	WT, BK, FZ and BM

* BK, Burdekin; BM, Burnett Mary; CY, Cape York; FZ, Fitzroy, MW, Mackay Whitsunday; WT, Wet Tropics. Note, MW was not included in NRM region scale analyses. In the CY NRM region, P1, P19 and S8 were the only indicators with average scores ≥ 2.5; highest scoring indicators for other CY subindices are thus not shown.

Status of wetland condition at the GBRCA scale

Score estimates at the GBRCA scale were reflective of wetlands being under moderate overall pressure and in a moderate state in 2024, with findings generally consistent with those from the NRM region scale analysis and showing similar patterns to those in previous years (**Figure 4**).

In terms of overall state, the score estimate for GRBCA wetlands in 2024 was 2.58, with a 95% confidence interval (CI) of 2.52 to 2.64 (**Figure 4**, State). For the subindices of wetland environmental values, the biotic integrity score estimate was 2.62 (95% CI: 2.52-2.72), local physical integrity 3.11 (95% CI: 2.95-3.26), local hydrology 2.22 (95% CI: 2.11-2.34) and connectivity 2.55 (95% CI: 2.50-2.60) (**Figure 4**, left panel plots). As such, the highest scoring state subindex was local physical integrity. Based on responding wetland data, the scores for local physical integrity were likely driven most strongly by pugging from hooved animals (e.g. cattle, pigs) in wetlands (indicator S8; **Table 8**).

For overall pressure in 2024, the score estimate for GBRCA wetlands was 2.89 (95% CI of 2.85 - 2.93) (**Figure 4,** Pressure). Score estimates for the pressure subindices in 2024 were 3.59 for pest plants and animals (95% CI: 3.54-3.65), 2.94 for habitat modification (95% CI: 2.87-3.02), 2.97 for water regime change (95% CI: 2.93-3.01) and 2.29 for pollutant inputs (95% CI: 2.20-2.37; **Figure 4**, right panel plots). Pest plants and animals was the highest scoring subindex out of all pressure subindices. Based on responding wetland data, the scores for pest plants and animals were likely driven most strongly by pressure from land use associated with their introduction and/or perpetuation in wetlands and their 1 km buffers (indicator P1; **Table 8**).

Corresponding with results from the NRM region analysis, indicators P12, P3, P5, S7, S12 and S16 all tended to have relatively low scores at the GBRCA scale (typically < 2.5 on average based on responding wetland data), along with indicators S15 (modified and artificial wetlands in the 1 km buffer zones around wetlands) and S14 (native vegetation in wetlands and their 200 m buffers; **Table A 2**).

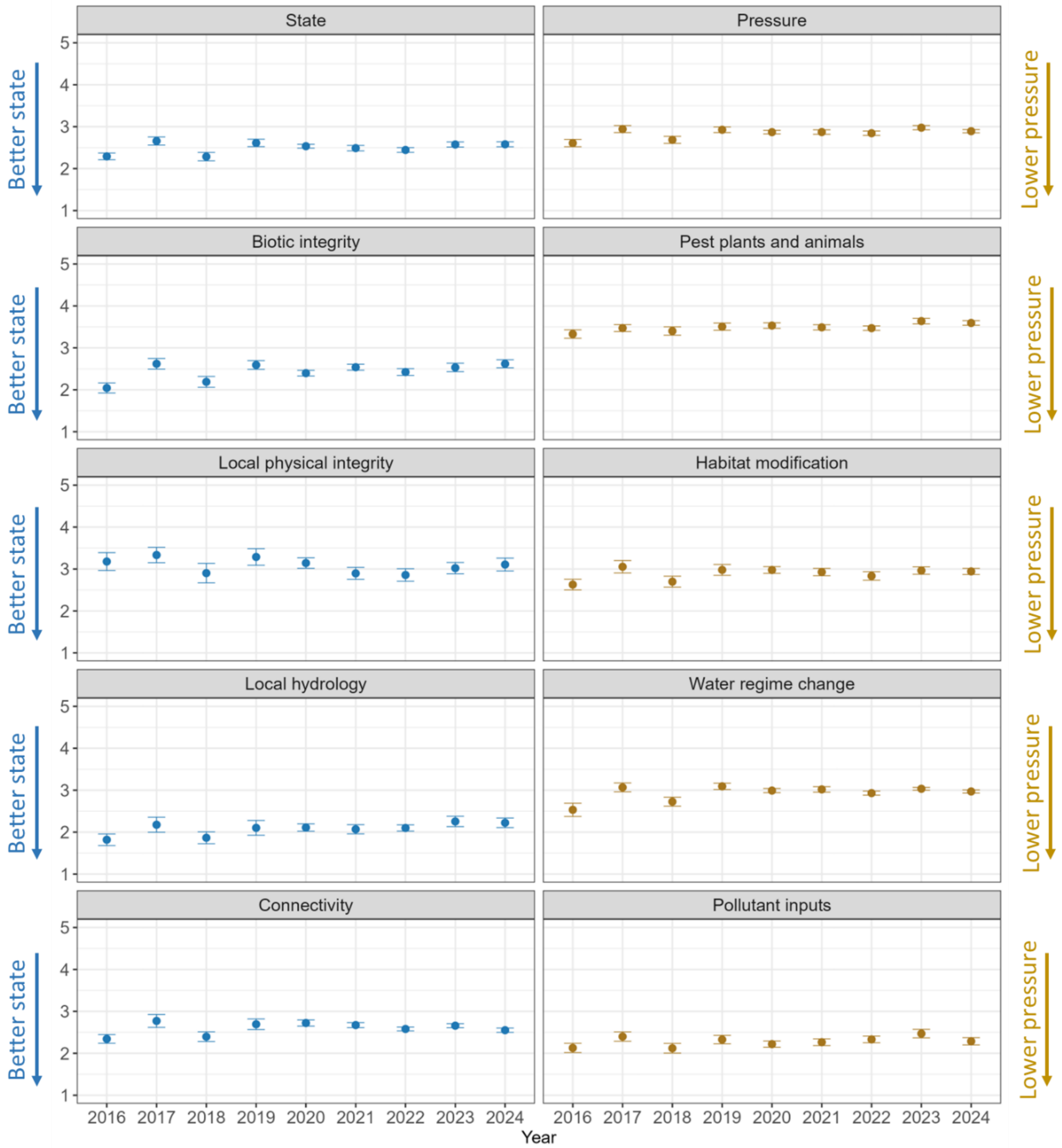

Figure 4: Annual estimates of state (left plots, blue closed circles) and pressure scores (right plots, brown closed circles) for wetland condition indices and subindices, with upper and lower bounds of the 95% confidence intervals shown as 'error bars,' at the Great Barrier Reef catchment area (GBRCA) scale, based on data from survey years 2016-2024 as at end 2024. Higher scores indicate poorer condition and/or greater pressure.

*Table 8: Indicators with the highest mean score per subindex at the Great Barrier Reef catchment area (GBRCA) scale in 2024, based on responding wetland data only. See **Table A 1** for the mean responding-wetland scores for each indicator. Higher scores indicate poorer condition.*

Subindex	Indicator	Description
Pest plants and animals	P1	Land use associated with introduction or perpetuation of pest plant and animal species within the wetland and its 1 km buffer
Habitat modification	P20	Native vegetation cleared within the wetland and its 5 km buffer
Water regime change	P16	Change in landscape hydrological integrity within the wetland and its 1 km buffer
	P19	Water abstraction, or consumption by hooved animals in the wetland and its 200 m buffer
Pollutant inputs	P10	Sediment supply within the wetland and its 1 km buffer
Biotic integrity	S1	Floristic composition and vegetation structure in the wetland and its 200 m buffer
Local physical integrity	S8	Soil surface deformation from hooved animals in the wetland
Local hydrology	S9	Drainage modifications and artificial structures altering natural surface flows in the wetland and its 200 m buffer
Connectivity	S13	Landscape vegetation connectivity

Status of wetland condition by intensity of dominant land use and by local hydrological modification

The 2023 state and pressure scores across the GBRCA generally varied predictably with land use intensity in wetlands and their 200 m buffers. That is, wetlands with predominantly high-intensity land use generally had higher (poorer condition) subindex scores, while those with predominantly lower intensity had lower (better condition) subindex scores (**Figure 5**). However, the local physical integrity subindex was an exception to this pattern. For this subindex, the score was lower in predominantly high-intensity land uses than in predominantly low- and moderate-intensity land uses. The indicators contributing to this subindex are mostly associated with soil disturbance from hooved animals.

In terms of local hydrological modification, wetlands across the GBRCA that were modified according to their local hydrology modifier code (non-H1 wetlands) tended to be in poorer condition than unmodified (H1) wetlands (**Figure 6**). The exceptions were habitat modification, local physical integrity, and connectivity; for these subindices, the non-H1 and H1 confidence intervals overlapped.

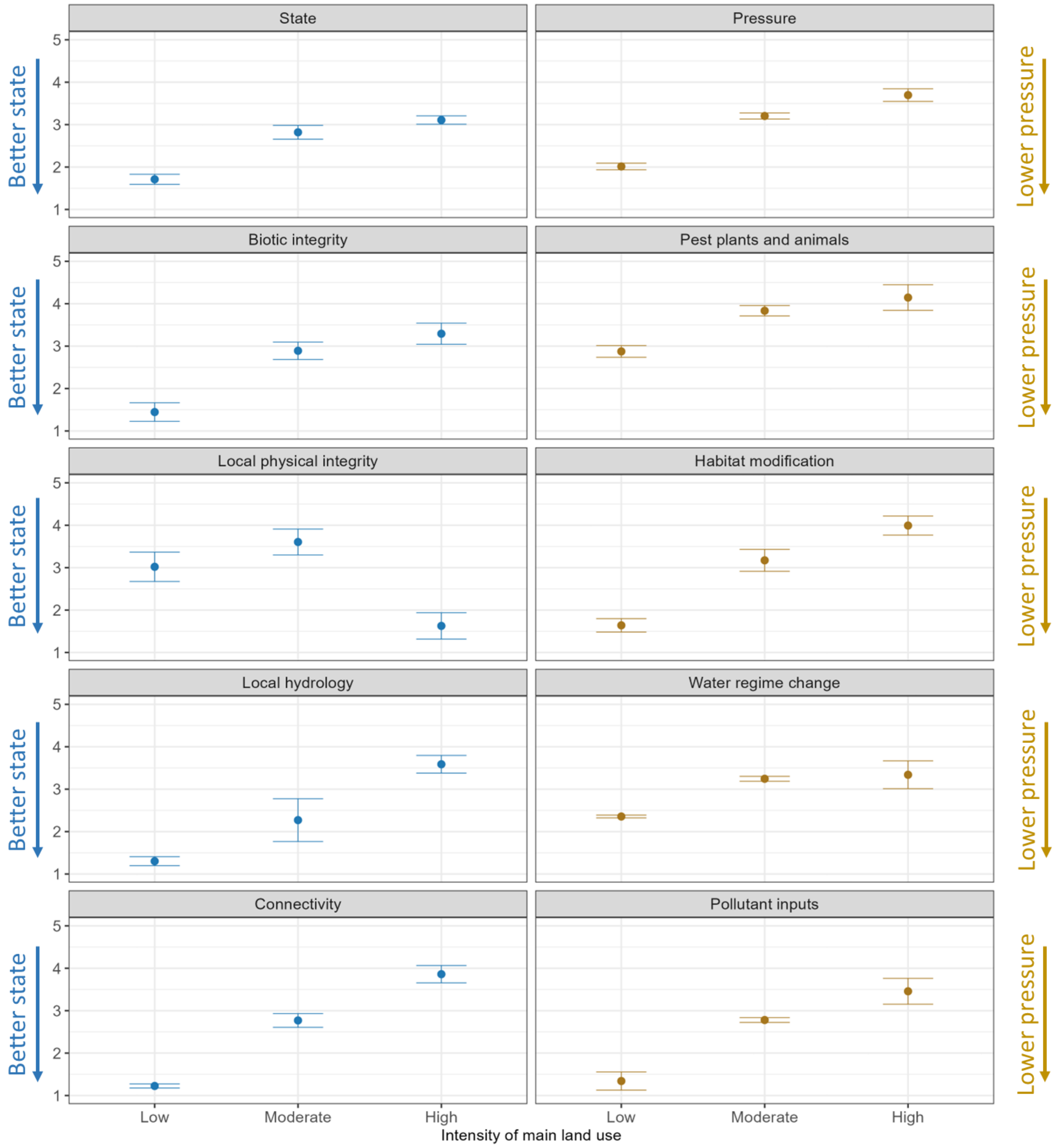

Figure 5: Estimated state (left plots, blue closed circles) and pressure scores (right plots, brown closed circles) at the Great Barrier Reef catchment area (GBRCA) scale for each overall index and subindex of wetland condition in 2023, by intensity of dominant land use in wetlands and their 200 m buffers, with upper and lower bounds of the 95% confidence intervals shown as 'error bars.'

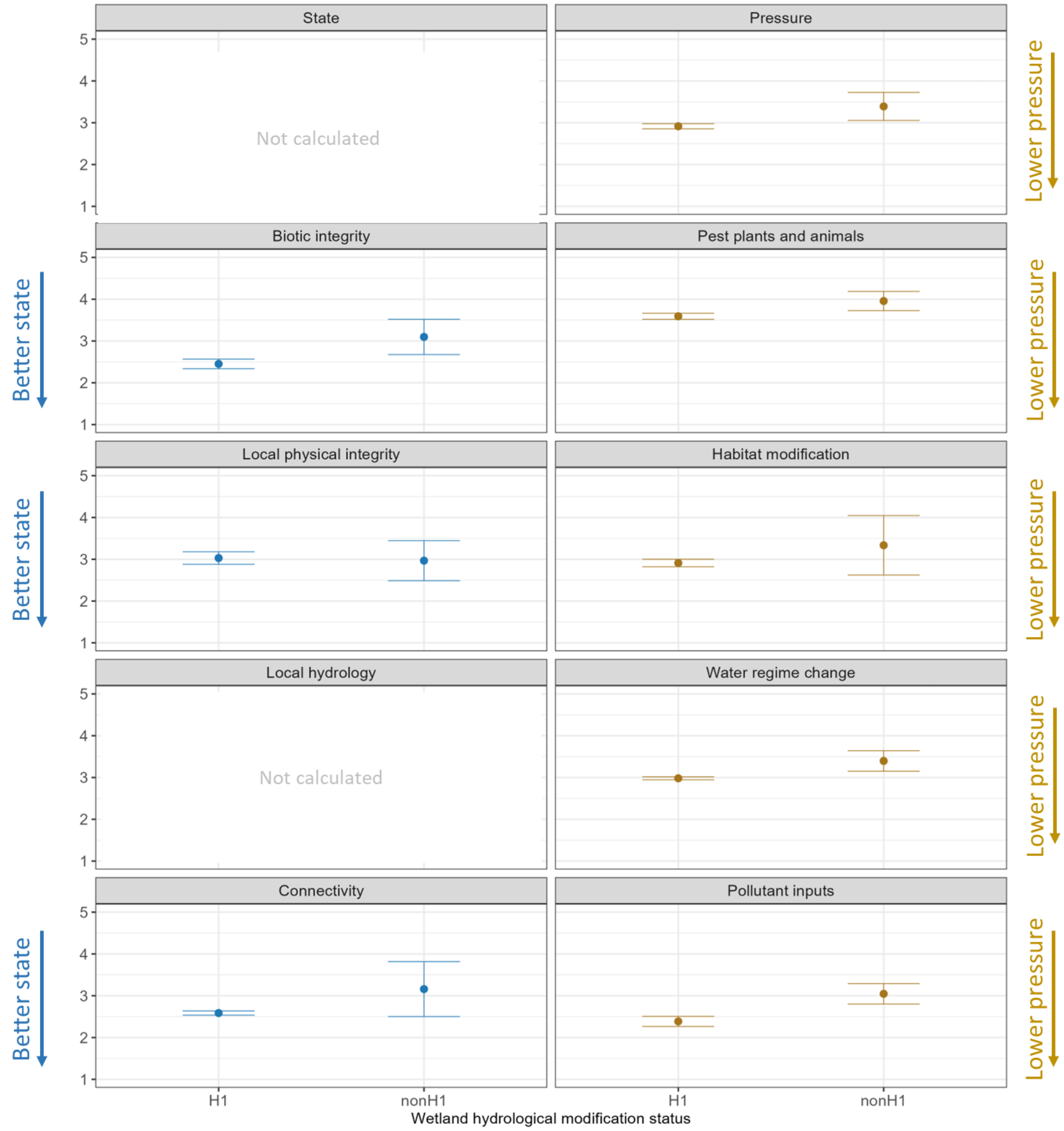

Figure 6: Estimated state (left plots, blue closed circles) and pressure scores (right plots, brown closed circles) at the Great Barrier Reef catchment area (GBRCA) scale for each overall index and subindex of wetland condition in 2023, by local hydrological modification code, with upper and lower bounds of the 95% confidence intervals shown as 'error bars.' H1, hydrologically unmodified wetlands; nonH1, hydrologically modified wetlands. Note, overall state and local hydrology scores were not calculated by hydrological modification code given it is an indicator that contributes to their scores at the wetland scale.

Dominant land use intensity and local hydrological modification

While the dominant land use intensity (%) in responding wetlands and their 200 m buffers varied by region and year (**Figure 7, Figure 8**), findings indicated that GBRCA wetlands have been surveyed across the land use intensity spectrum each year. Responding wetlands were mainly in the predominantly moderate- followed by low-intensity category, reflecting the general composition of main land use types across the GBRCA (Australian and Queensland Governments 2024a), and this was reasonably consistent over time. (Note that due to the augmented serially rotating panel design, the sample of wetlands surveyed each year differs, which creates interannual variation in proportions.) In 2024, the GBRCA had all three intensity categories represented by the 2024 sample of responding wetlands (34% low, 54% moderate, 12% high intensity).

In 2023, responding wetlands in the Wet Tropics, Burdekin, Fitzroy and Burnett Mary NRM regions had all three land use intensity categories represented, while the Mackay Whitsunday NRM region only had the predominantly moderate-intensity category represented, and the Cape York NRM region only the predominantly low- and moderate-intensity categories. Wetlands surveyed across the years in the Cape York NRM region were mostly of predominantly low-intensity land use (75% in 2023), with none in the predominantly high-intensity category. Wetlands surveyed across the years in the Burdekin, Mackay Whitsunday and Fitzroy NRM regions were mostly in the predominantly moderate-intensity category (Burdekin = 55%, Mackay Whitsunday = 100%, Fitzroy = 85% in 2023), with some high- and/or low-intensity land use depending on the year. The Wet Tropics (30% low, 45% moderate, 25% high in 2023) NRM region had wetlands surveyed across all three intensity categories most years, as did the Burdekin NRM region. In some years, the Burnett Mary NRM region had more than 50% of its surveyed wetlands in the predominantly high-intensity category (in 2023, its composition was 35% low, 30% moderate, 35% high).

In terms of local hydrological modification, most wetlands surveyed to date across the GBRCA (63-78% depending on the year) had no observable hydrological modifications (H1 wetlands; **Figure 9**). This was also the case for most NRM regions, with the Cape York NRM region having the highest proportion of hydrologically unmodified wetlands surveyed (**Figure 10**). However, 50% or more of surveyed wetlands in the Burdekin and Wet Tropics NRM regions had local hydrological modification (non-H1 wetlands) most years, including in 2023 and 2024.

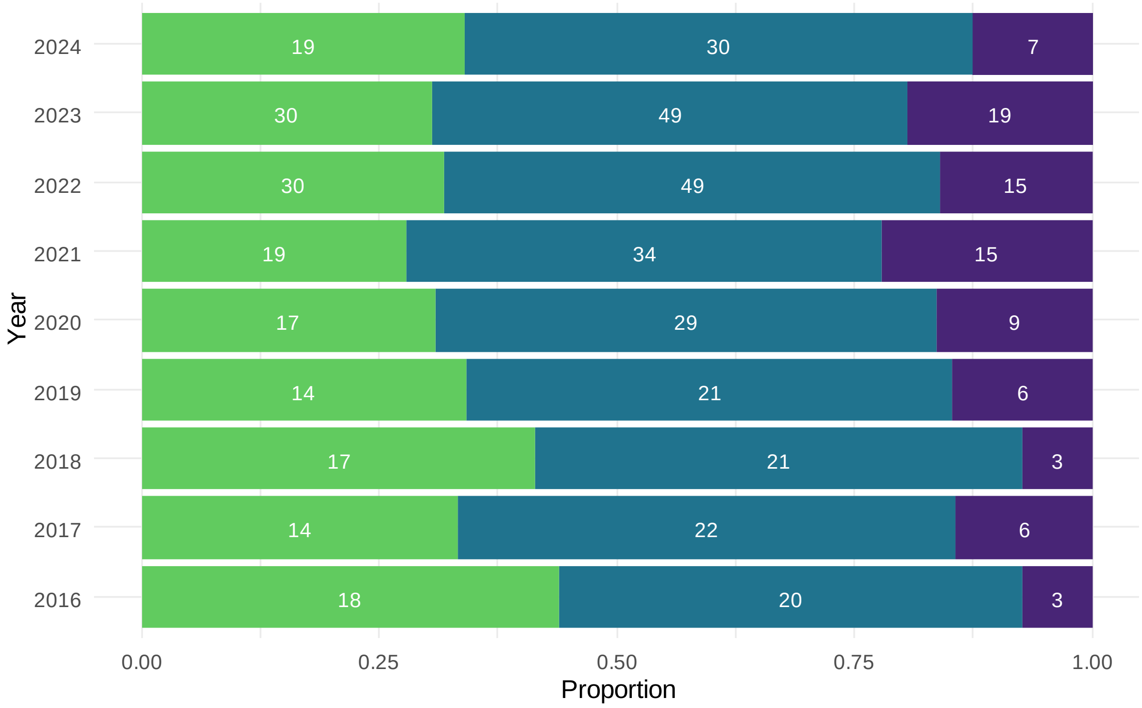

Figure 7: *Proportion of responding wetlands whose main land use intensity was low (light green), moderate (teal) or high (purple), by year at the Great Barrier Reef catchment area (GBRCA) scale. Numbers of wetlands in each category are shown in the bars. Note that due to the augmented, serially alternating panel design, only some wetlands are surveyed each year (annual samples do not include the exact same set of wetlands each year).*

Figure 8: *Proportion of responding (i.e. field-surveyed) wetlands whose dominant land use intensity was low (light green), moderate (teal) or high (purple), by year and Natural Resource Management region. Numbers of wetlands in each category are shown in the bars. Note that due to the augmented, serially alternating panel design, only some wetlands are surveyed each year (annual samples do not include the exact same set of wetlands each year).*

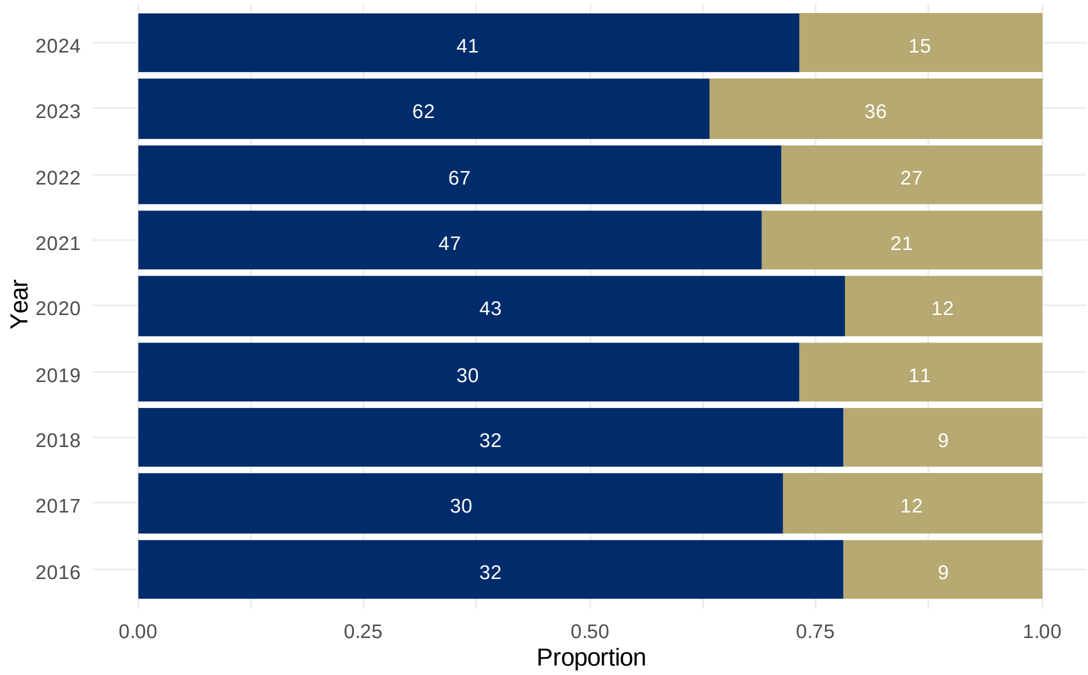

Figure 9: *Proportion of responding (i.e. field-surveyed) wetlands with no observed local hydrological modification (H1 wetlands; dark blue) or with observed local hydrological modification (non-H1 wetlands; yellow grey) by year at the Great Barrier Reef catchment area (GBRCA) scale. Numbers of wetlands in each category are shown in the bars. Note that due to the augmented, serially alternating panel design, only some wetlands are surveyed each year (annual samples do not include the exact same set of wetlands each year).*

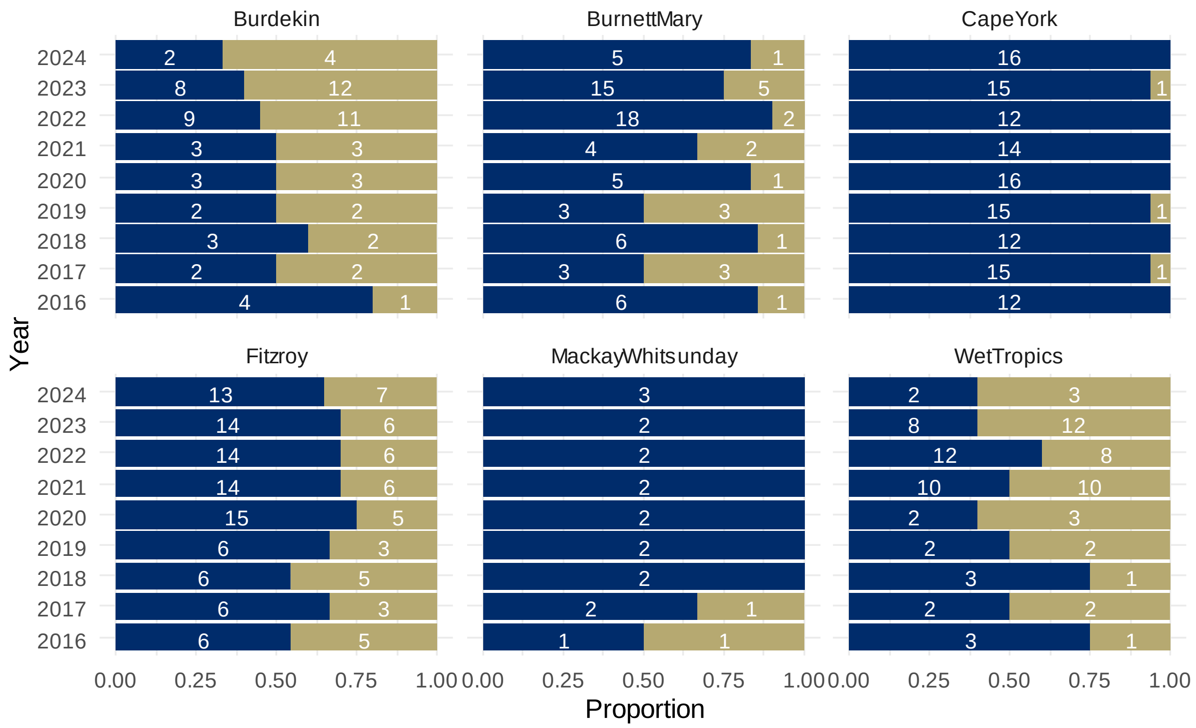

Figure 10: *Proportion of responding (i.e. field-surveyed) wetlands with no observed local hydrological modification (H1 wetlands; dark blue) or with observed local hydrological modification (non-H1 wetlands; yellow grey) by year and Natural Resource Management region. Numbers of wetlands in each category are shown in the bars. Note that due to the augmented, serially alternating panel design, only some wetlands are surveyed each year (annual samples do not include the exact same set of wetlands each year).*

Discussion: Wetland condition in Natural Resource Management regions and the Great Barrier Reef catchment area

Wetland condition in the GBRCA and NRM regions in the 2023 and 2024 reporting period, as based on analysis of the Program's indices and subindices, was largely similar to that previously reported. In NRM regions, wetlands were under moderate to high overall pressure and in a moderate overall state in 2023. The main exception was the Cape York NRM region, which was reported on for the first time and overall in good condition (under low pressure and in a good state). However, subindex scores for NRM regions revealed further exceptions, with the Cape York NRM region being under moderate pressure from pest plants and animals and having moderate local physical integrity, and the Burnett Mary NRM region having good local physical integrity.

Pressure from pest plants and animals contributed towards higher overall pressure in all NRM regions, as did pressure from habitat modification in the Wet Tropics and Fitzroy NRM regions. Land use associated with the introduction and perpetuation of pest species within wetlands and their 1 km buffers, along with historical and recent clearing of natural vegetation within wetlands and their 5 km buffers were likely contributing substantively to those respective pressures given the two indicators had the highest scores within their respective subindices.

The moderate to poor state of biotic integrity (floristic composition and vegetation structure in wetlands) in the Burdekin NRM region and landscape vegetation connectivity of wetlands in the Wet Tropics, Fitzroy and Burdekin NRM regions contributed most strongly towards poorer scores for overall state in those NRM regions. Soil deformation (e.g. pugging, wallows) in wetlands by hooved animals also had a strong negative impact on wetland environmental values, particularly in the Cape York and Fitzroy NRM regions.

Findings at the GBRCA scale were in general consistent with those at the NRM region scale and previous GBRCA-wide results, with wetlands in 2024 being under overall moderate pressure and in a moderate overall state. However, the overall moderate condition score for GBRCA wetlands was clearly influenced by the overall good condition score of wetlands in the Cape York NRM region, as was suspected but unconfirmed previously (Wetland Condition Science 2023) given this report is the first to provide Cape York NRM region results. At the GBRCA scale, scores for all indices and subindices, except local physical integrity, would be higher (reflecting poorer condition) if the GBRCA-wide analysis excluded data from the Cape York NRM region. That is, when estimating wetland condition at the GBRCA scale, the overall low pressure and good state of wetlands in the Cape York NRM region counterbalanced to some extent the higher pressure on and poorer overall state of wetlands in other regions. Differences in condition among NRM regions and the different components of condition (e.g. local physical integrity) should therefore be considered when determining appropriate management actions that aim to maintain or improve wetland condition.

Deviations from the overall moderate condition of wetlands at the GBRCA scale included pressure from pest plants and animals being high and local hydrology being in a good state. Regarding local hydrology, maintaining a relatively low amount of hydrological modification of wetlands and their surrounds (and reducing hydrological modification where relevant) across the GBRCA should therefore contribute towards maintaining (and potentially improving) wetland condition. The finding that hydrologically modified wetlands (non-H1 wetlands) tended to be in poorer condition than unmodified (H1) wetlands supports this contention, with non-H1 wetlands having poorer biotic integrity and being under greater pressure from pest plants and animals, water regime change and pollutant inputs. Hydrologically modified wetlands also had greater variation across the GBRCA in their habitat modification, local physical integrity and connectivity scores. These findings further emphasize the importance of preserving the natural hydrology of wetlands as much as possible and minimising activities and infrastructure that modify it.

In terms of pest plants and animals, which was the highest scoring pressure subindex in 2024 at the GBRCA scale, results suggested that land use associated with the introduction and perpetuation of pest species to wetlands and their surrounds contributed substantively to the anthropogenic pressures faced by GBRCA wetlands. Correspondingly, results suggested that soil deformation from hooved animals, including feral cattle and pigs, negatively affected the local physical integrity of GBRCA wetlands, being the highest scoring state subindex in 2024 at the GBRCA scale. As such, hooved animal access to wetlands is likely an important factor in contributing negatively towards wetland condition and should be a priority for management.

The local physical integrity of GBRCA wetlands was lower in high-intensity than in moderate- to low-intensity land uses. This contrasted with the more general finding that as the intensity of the dominant land use of wetlands increased, pressures on wetlands tended to increase and wetland condition tended to decline. High-intensity land uses include production from dryland and irrigated agriculture, and dryland and irrigated plantations (ABRAES 2016). Therefore, it is possible that those types of high-intensity land uses preclude to some extent hooved animals that cause extensive soil damage to wetlands, and which are prevalent in lower-intensity land uses like cattle grazing (Mihailou and Massaro 2021). Hooved animals such as pigs are also known to use higher-intensity land use areas like sugar-cane farms in northern tropical Queensland and elsewhere to forage and move through the landscape (Barrios-Garcia et al. 2012; Wurster et al. 2012; Froese et al. 2017; Wilson et al. 2023). As such, the relationship between the local physical integrity of wetlands, hooved animal access and activity, and land use intensity may require further investigation to elucidate the specific nature of causal pathways.

The dominant land use of most monitored wetlands and their 200 m buffers across the GBRCA was of moderate intensity, followed by low and then high intensity. This corresponded well with land use composition more broadly across the GBRCA, where grazing constitutes the dominant land use (> 70%), followed by conservation and natural environments (15%), then forestry, dryland cropping and sugar cane (each < 5%), urban, irrigated cropping and horticulture (each < 1%) (Australian and Queensland Governments, 2024b). This confirms the representativeness of the wetlands surveyed across the GBRCA by the Program. Correspondence between the proportions of dominant land uses of wetlands and broader-scale land use composition was also apparent within NRM region regions. For instance, land uses in the Cape York NRM region are generally low intensity, such as extensive cattle grazing and protected areas (Australian and Queensland Governments, 2024b), whereas the Burdekin, Mackay Whitsunday and Fitzroy regions are dominated by grazing (Australian and Queensland Governments 20214c, d, e). Grazing, sugarcane cropping and (some) horticulture are the dominant land uses in the Wet Tropics NRM region (Australian and Queensland Governments 2024e) while land use in the Burnett Mary NRM region, whose surveyed wetlands had the highest proportion of high-intensity land use, comprises a mix of grazing, dairy, horticulture, sugarcane and other cropping such as macadamia and avocado tree cropping (Australian and Queensland Governments 2024f).

The above findings, and that wetlands with predominantly higher-intensity land use and hydrological modification tended to be in worse condition, suggest that knowing the dominant land use and/or hydrological modification status of a wetland, and/or the relative proportion of different land uses in a region, may to some extent indicate wetland condition (as reflected by the Program's indices and subindices) at local and broader scales. Therefore, avoiding land use intensification and minimising the hydrological modification of wetlands and their near surrounds should help to improve wetland condition. If these actions are not possible, then protecting wetlands from pressures associated with moderate to high-intensity land uses and hydrological modification are even more critical to improving condition. Establishing or maintaining native vegetation (including grassland, woody grassland and other woody species) cover in buffer zones of reasonable width (e.g. 200 m) around wetlands is one example of such protective actions. In addition, given the exception to the correlation between land-use intensity and wetland condition was local physical integrity (which was poorer in less intense land uses, and associated with hooved animal activity), controlling hooved animal access to wetlands and their near surrounds should also help to improve wetland condition. Maintaining the relatively low prevalence of direct stormwater and other point inflows into wetlands, and of septic systems and linear infrastructure in areas surrounding wetlands (as indicated by the low scores of associated indicators at GBRCA and NRM scales) should also be a priority to help prevent decline in condition.

More generally, given the types of pressures and environmental values the Program monitors, the following actions, some of which have been mentioned previously, should collectively contribute to reducing the overall pressure on wetlands and improving the state of wetland environmental values in the GBRCA and NRM regions: reducing pressures from pest plant and animal species in wetlands and surrounding areas; reducing barriers to flow to restore natural water flow patterns; reducing impacts of hydrological modifications and managing water abstraction and hooved animal (including livestock) access; restoring native vegetation in buffer areas and habitat corridors; and managing nutrient, pesticide and sediment run-off.

More specifically within NRM regions, coordinated landscape scale actions could be prioritised in relation to the pressure subindex scores and the indicators driving them, from highest to lowest score. For example, in a region with a high score for pest plants and animals, actions to reduce pressures from pest species could be implemented as a priority. Drawing on results from this report (Table 7 and Table 8) and the Great Barrier Reef Water Quality Decision Support Framework (Waterhouse et al. 2025), suggested management options for wetlands in NRM regions are outlined in Table 9.

Finally, the monitoring program aims to detect improvement in wetland condition in response to management action undertaken at the landscape scale. Therefore, to detect whether actions aimed at improving wetland condition in the GBRCA and NRM regions are having the desired effect, they should be implemented and prioritised in the monitored wetland aggregations.

Table 9: Suggested priority management options for wetlands and monitored aggregations, based on each Natural Resource Management (NRM) region's highest (worst) scoring indicators likely contributing most strongly towards poorer wetland condition, as represented by each pressure and state subindex.

Subindex	Indicator	Indicator description	NRM region*	Suggested management actions to plan and implement†
Pest plants and animals	P1	Land use associated with introduction or perpetuation of pest plant and animal species within the wetland and its 1 km buffer	CY, WT, FZ and BM	Control and reduce spread of plant and animal pest species in wetlands and 1 km buffers within monitored wetland aggregations. Avoid further introductions.
	P8	Exotic pest cover in the wetland's 200 m buffer	BK	Control and reduce spread of wetland pest plants (as listed in Waterhouse et al. 2025) in wetlands. Avoid further introductions.
Habitat modification	P20	Native vegetation cleared within the wetland and its 5 km buffer	WT, BK, FZ and BM	Avoid clearing within 5 km buffers of wetlands in historically woody areas.
Water regime change	P16	Change in landscape hydrological integrity within the wetland and its 1 km buffer	WT, BK and BM	Improve floodplain flows and hydrological connectivity of wetlands.
	P19	Water abstraction, or consumption by hooved animals in the wetland and its 200 m buffer	CY	Reduce water abstraction from wetlands for use by humans or hooved animals.
	P14	Vegetation clearing in the wetland's 1 km buffer	FZ	Avoid clearing within 1 km buffers of wetlands in historically woody areas.
Pollutant inputs	P10	Sediment supply within the wetland and its 1 km buffer	WT, BK, FZ and BM	Reduce anthropogenic sedimentation of wetlands, for example through establishment of vegetated buffers and maintaining ground cover.
Biotic integrity	S1	Floristic composition and vegetation structure in the wetland and its 200 m buffer	WT, BK, FZ and BM	Encourage regeneration/establishment of regional ecosystems (historical regional ecosystems, where practicable) and manage exotic vegetation in wetlands and their 200 m buffers.
Local physical integrity	S8	Soil surface deformation from hooved animals in the wetland	CY, WT, BK, FZ and BM	Control and reduce hooved animal access to wetlands.
Local hydrology	S9	Drainage modifications and artificial structures altering natural surface flows in the wetland and its 200 m buffer	WT, BK, FZ and BM	Reduce the impact of modifications within 500 m of wetlands that affect their natural water flow.
Connectivity	S13	Landscape vegetation connectivity	WT, BK, FZ and BM	Expand, establish, and connect patches of native vegetation surrounding wetlands starting from areas closest to wetlands and working outwards.

* BK, Burdekin; BM, Burnett Mary; CY, Cape York; FZ, Fitzroy, MW, Mackay Whitsunday; WT, Wet Tropics. Scores for the MW NRM region were not estimated due to sample size constraints. †Waterhouse et al. (2025).

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Appendices

Differences in score estimates based on imputation assumptions

An analysis of desktop indicator score data from the 2022 survey year established that the missing-not-at-random (NMAR) imputation assumption (i.e. that certain types of nonresponding wetlands are in poorer condition than responding wetlands and other types of nonresponding wetlands) was not supported. Nevertheless, score estimates for the 2023 and 2024 reporting period were produced using all imputation assumption methods so results could be compared. That is, imputations were produced using both the uniform and normal distributions, and assuming nonresponse was all missing at random (all-MAR) or a combination of NMAR and MAR (NMAR-MAR). The results for the 2024 survey year are shown in the figures below for each index and subindex as an example.

Apart from where the uniform distribution was used in combination with the NMAR-MAR assumption to impute score data for nonresponding wetlands, which tended to substantially increase the scores relative to all other methods, the estimated scores were similar among methods (confidence intervals overlapped). Consistent with its underlying assumption about poorer condition, the NMAR-MAR with normal distribution method generally produced slightly higher score estimates than the all-MAR method (normal and uniform distribution) and when estimating scores from responding wetlands only. However, confidence intervals around the mean score estimates overlapped for all-MAR (normal and uniform distributions) and the NMAR-MAR (normal distribution) methods, so these methods produced similar results. Although NMAR-MAR (normal distribution) results were reported in the 2021-2022 report and all-MAR (normal distribution) reported in the current report, the impact on their comparability and interpretation is likely negligible.

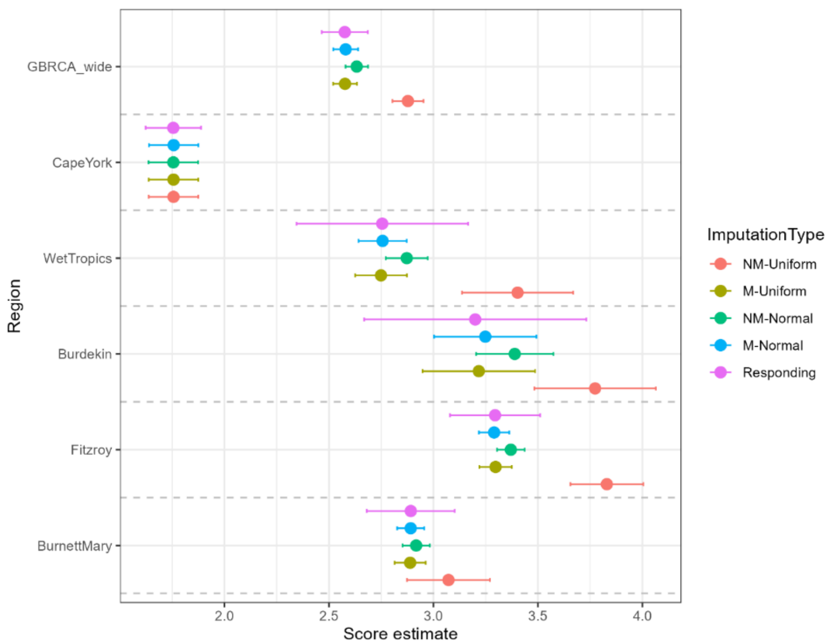

Figure 11: Estimates of overall State for 2024 with 95% confidence intervals as 'error bars' based on the imputation method used. Imputation was conducted using the normal or uniform distribution, assuming nonresponse was either NM (a combination of missing-not-at-random and missing-at-random) or M (all missing-at-random). Responding indicates where scores were estimated from responding wetland data only (no imputation used).

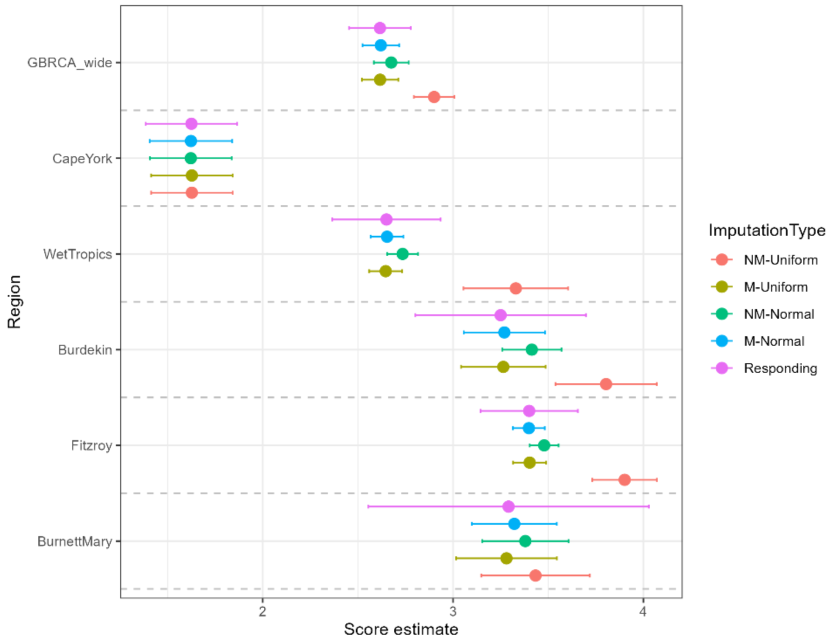

Figure 12: *WEV1(Biotic integrity) estimates for 2024 with 95% confidence intervals as 'error bars' based on the imputation method used. Imputation was conducted using the normal or uniform distribution, assuming nonresponse was either NM (a combination of missing-not-at-random and missing-at-random) or M (all missing-at-random). Responding indicates where scores were estimated from responding wetland data only (no imputation used).*

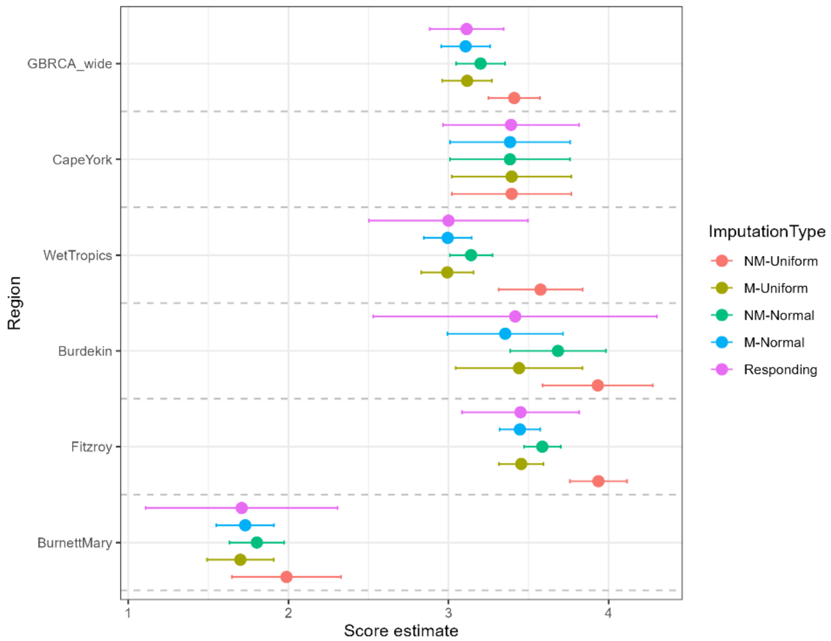

Figure 13: *WEV2 (Local physical integrity) estimates for 2024 with 95% confidence intervals as 'error bars' based on the imputation method used. Imputation was conducted using the normal or uniform distribution, assuming nonresponse was either NM (a combination of missing-not-at-random and missing-at-random) or M (all missing-at-random). Responding indicates where scores were estimated from responding wetland data only (no imputation used).*

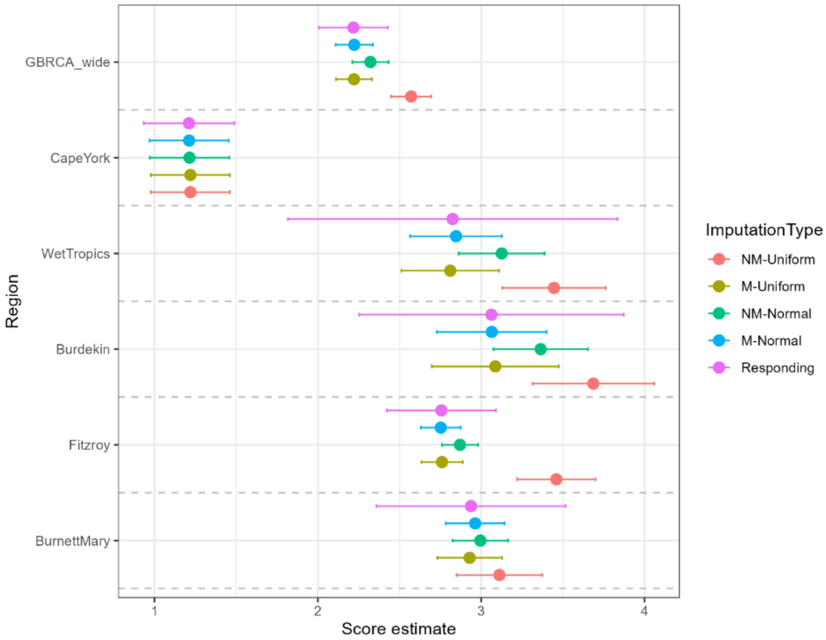

Figure 14: *WEV3 (Local hydrology) estimates for 2024 with 95% confidence intervals as 'error bars' based on the imputation method used. Imputation was conducted using the normal or uniform distribution, assuming nonresponse was either NM (a combination of missing-not-at-random and missing-at-random) or M (all missing-at-random). Responding indicates where scores were estimated from responding wetland data only (no imputation used).*

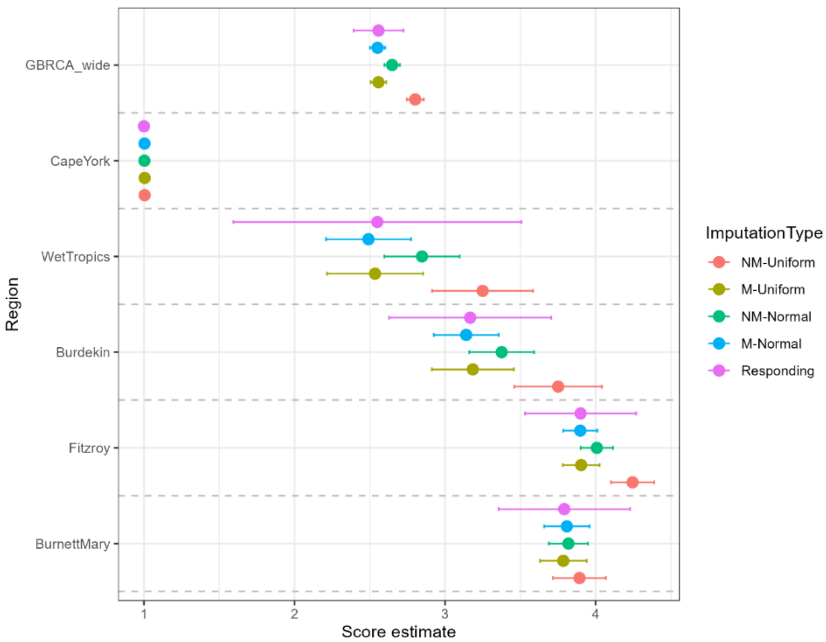

Figure 15: *WEV4 (Connectivity) estimates for 2024 with 95% confidence intervals as 'error bars' based on the imputation method used. Imputation was conducted using the normal or uniform distribution, assuming nonresponse was either NM (a combination of missing-not-at-random and missing-at-random) or M (all missing-at-random). Responding indicates where scores were estimated from responding wetland data only (no imputation used).*

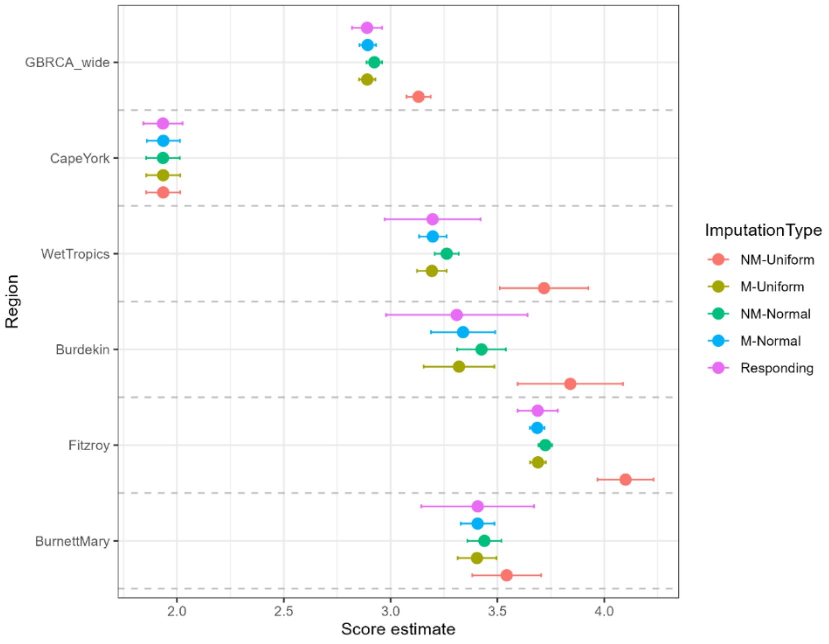

Figure 16: *Estimates of overall Pressure for 2024 with 95% confidence intervals as 'error bars' based on the imputation method used. Imputation was conducted using the normal or uniform distribution, assuming nonresponse was either NM (a combination of missing-not-at-random and missing-at-random) or M (all missing-at-random). Responding indicates where scores were estimated from responding wetland data only (no imputation used).*

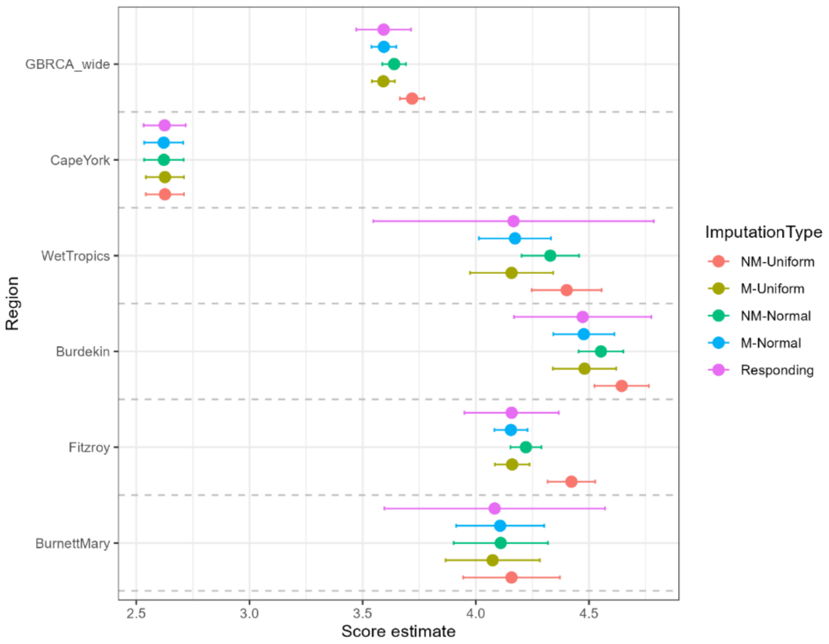

Figure 17: *PC1 (Pest plants and animals) estimates for 2024 with 95% confidence intervals as 'error bars' based on the imputation method used. Imputation was conducted using the normal or uniform distribution, assuming nonresponse was either NM (a combination of missing-not-at-random and missing-at-random) or M (all missing-at-random). Responding indicates where scores were estimated from responding wetland data only (no imputation used).*

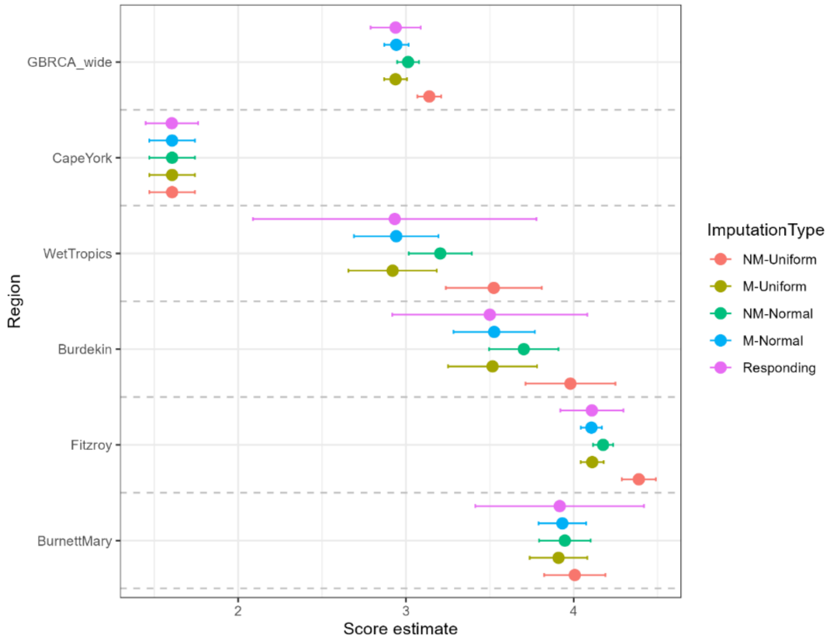

Figure 18: *PC2 (Habitat modification) estimates for 2024 with 95% confidence intervals as 'error bars' based on the imputation method used. Imputation was conducted using the normal or uniform distribution, assuming nonresponse was either NM (a combination of missing-not-at-random and missing-at-random) or M (all missing-at-random). Responding indicates where scores were estimated from responding wetland data only (no imputation used).*

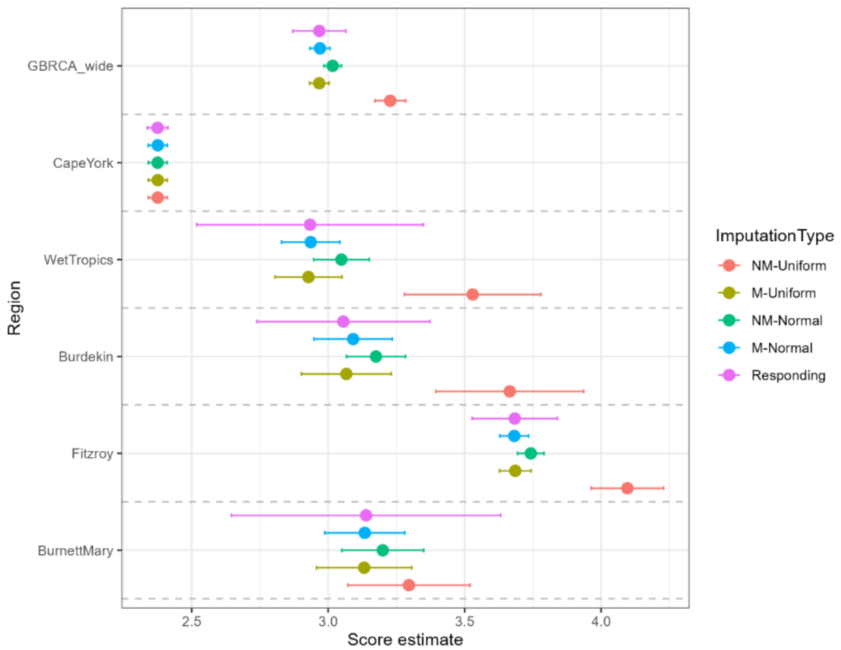

Figure 19: *PC3 (Water regime change) estimates for 2024 with 95% confidence intervals as 'error bars' based on the imputation method used. Imputation was conducted using the normal or uniform distribution, assuming nonresponse was either NM (a combination of missing-not-at-random and missing-at-random) or M (all missing-at-random). Responding indicates where scores were estimated from responding wetland data only (no imputation used).*

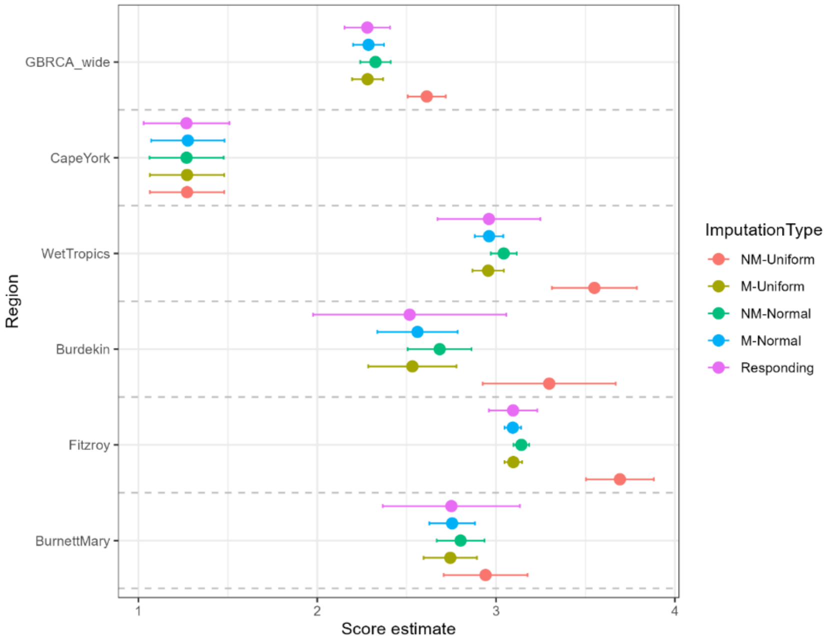

Figure 20: PC4 (Pollutant inputs) estimates for 2024 with 95% confidence intervals as 'error bars' based on the imputation method used. Imputation was conducted using the normal or uniform distribution, assuming nonresponse was either NM (a combination of missing-not-at-random and missing-at-random) or M (all missing-at-random). Responding indicates where scores were estimated from responding wetland data only (no imputation used).

Indicator score summaries (responding wetlands only)

Table A 1: Mean indicator score based on responding wetland data only, by region. Natural Resource Management region means calculated from 2023 data, Great Barrier Reef catchment area (GBRCA) means calculated from 2024 data. n, sample size.

Indicator	Cape York	Wet Tropics	Burdekin	Mackay Whitsunday	Fitzroy	Burnett Mary	GBRCA
	(n = 16)	(n= 20)	(n = 20)	(n = 2)	(n = 20)	(n = 20)	(n = 56)
P1	3.31	3.65	3.80	4.00	4.00	3.90	3.73
P7	2.00	3.20	3.80	5.00	3.90	3.30	3.04
P8	2.13	3.50	3.90	4.00	3.70	3.70	3.32
P2	1.00	3.20	2.70	5.00	3.40	2.65	2.59
P20	1.56	4.00	3.50	4.00	4.40	3.65	3.27
P21	1.56	3.45	2.80	3.50	3.30	3.20	2.70
P14	1.00	3.00	2.80	3.50	3.65	2.70	2.39
P16	1.50	3.25	3.75	4.00	3.50	2.80	2.75
P19	3.00	2.50	3.10	2.00	2.90	2.30	2.86
P10	1.31	4.00	3.60	3.50	3.95	2.75	2.79
P12	1.19	2.10	1.50	1.00	1.50	2.55	1.45
P3	1.00	2.45	2.55	2.00	1.45	2.10	1.45
P4	1.50	3.25	3.50	4.00	3.05	2.55	2.52
P5	1.00	1.30	1.45	1.50	1.10	1.20	1.07
S1	1.75	3.15	3.50	4.00	3.35	2.80	2.84
S3	1.13	2.75	3.05	5.00	2.50	2.25	2.46
S7	2.06	1.50	1.75	1.00	1.80	1.40	1.86
S8	3.75	2.70	3.20	1.00	3.90	2.20	3.45
S12	1.13	2.20	2.35	1.00	1.60	1.50	1.55
S15	1.00	2.75	2.90	3.50	2.25	2.70	2.09
S16	1.06	2.35	2.30	2.50	1.65	2.45	1.66
S9	1.31	3.60	3.35	2.00	2.60	3.75	2.32
S13	1.06	3.75	3.50	5.00	4.45	3.80	3.07
S14	1.00	2.55	2.05	3.00	2.70	2.20	2.09

Table A 2: Standard error around the mean indicator score, based on responding wetland data only, by region. Natural Resource Management region means calculated from 2023 data, Great Barrier Reef catchment area (GBRCA) means calculated from 2024 data. n, sample size.

Indicator	Cape York	Wet Tropics	Burdekin	Mackay Whitsunday	Fitzroy	Burnett Mary	GBRCA
	(n = 16)	(n= 20)	(n = 20)	(n = 2)	(n = 20)	(n = 20)	(n = 56)
P1	0.12	0.13	0.12	0.00	0.07	0.14	0.06
P7	0.26	0.25	0.27	0.00	0.23	0.30	0.22
P8	0.26	0.25	0.23	1.00	0.22	0.22	0.20
P2	0.00	0.39	0.38	0.00	0.34	0.33	0.22
P20	0.13	0.25	0.24	0.00	0.17	0.18	0.18
P21	0.18	0.17	0.16	0.50	0.15	0.14	0.13
P14	0.00	0.31	0.33	0.50	0.20	0.22	0.17
P16	0.22	0.23	0.27	0.00	0.20	0.22	0.17
P19	0.00	0.20	0.18	1.00	0.10	0.26	0.09
P10	0.15	0.27	0.22	0.50	0.09	0.22	0.18
P12	0.19	0.30	0.24	0.00	0.25	0.28	0.13
P3	0.00	0.23	0.34	0.00	0.15	0.19	0.09
P4	0.22	0.23	0.27	0.00	0.17	0.25	0.15
P5	0.00	0.11	0.18	0.50	0.07	0.09	0.03
S1	0.19	0.24	0.20	0.00	0.17	0.25	0.13
S3	0.09	0.27	0.34	0.00	0.20	0.27	0.17
S7	0.06	0.14	0.10	0.00	0.12	0.13	0.08
S8	0.31	0.33	0.38	0.00	0.34	0.30	0.21
S12	0.13	0.22	0.26	0.00	0.21	0.20	0.12
S15	0.00	0.35	0.35	0.50	0.37	0.26	0.20
S16	0.06	0.25	0.24	0.50	0.20	0.21	0.12
S9	0.25	0.29	0.39	0.00	0.34	0.22	0.19
S13	0.06	0.32	0.32	0.00	0.20	0.20	0.23
S14	0.00	0.29	0.26	0.00	0.24	0.22	0.15