



Darling Baaka River Health Project 2023 to 2025

Chapter 5 Riparian vegetation condition

Department of Climate Change,
Energy, the Environment and Water



Acknowledgement of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the Traditional Custodians of the lands where we work and live.

We pay our respects to Elders past, present and emerging.

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Contents

5.	Riparian vegetation condition	8
5.1	What is riparian vegetation?	8
5.2	Why use riparian vegetation condition in river health?	8
5.3	Assessing riparian vegetation condition	11
5.4	Methods	14
5.5	Results and discussion	36
5.6	Overall Riparian Vegetation Condition Index	64
5.7	Conclusion	68
	Appendices	69
	Appendix A: Community condition analysis schemas	69
	Appendix B: Tree stand condition analysis schema	74
	Appendix C: Recalibrated RARC benchmarks for individual sites	75
	Appendix D: Demographic results at each plot – river red gum	79
	Appendix E: Demographic results at each plot – black box	82
	Appendix F: Number of juvenile river red gum and black box trees	84
	Appendix G: Community condition results at each site	87
	Appendix H: Community stand condition results at each plot	90
	Appendix I: Tree stand condition results at each site	95
	Appendix J: Survey sites	97

List of tables

Table 1	Plant community types (PCTs) surveyed in the Darling Baaka River Health Project in 2024–25	14
Table 2	Metrics collected for the community condition and tree stand condition indicators, as well as individual tree demographic assessments	17

Table 3	Condition classes and scores for tree stand and community condition indicators (one score calculated per sub-indicator)	19
Table 4	Floristic condition indicator scores and associated River Condition Index (RCI)-scores and grades	20
Table 5	Information and metrics collected for rapid appraisal of riparian condition surveys (adapted from Jansen et al. 2005)	24
Table 6	Rapid assessment of riparian condition (RARC) class scores and grades, and associated River Condition Index (RCI) grades	25
Table 7	Plant community types (PCTs) within the study area, and relationship to functional group implemented for remote sensing and spatial modelling	26
Table 8	Spatial vegetation condition indicator scores and associated condition grades	34
Table 9	Results of correlation analysis to compare ground-assessed vegetation with spatially modelled values at the same point locations	35
Table 10	Riparian Vegetation Condition Index scores and associated River Condition Index (RCI) grades	36
Table 11	The average number of juvenile river red gum (<i>Eucalyptus camaldulensis</i>) and black box (<i>Eucalyptus largiflorens</i>) trees <10 cm DBH per hectare (PCTs 10, 11 and 13) in the lower Darling Baaka study area	43
Table 12	Results of community condition analysis for plant community types (PCT) by subcatchment	47
Table 13	Results of tree stand condition analysis for 3 plant community types (PCT) by subcatchment. For site locations see Figure 2	50
Table 14	Combined floristic condition indicator scores for each subcatchment	54
Table 15	Standardised rapid appraisal of riparian condition (RARC) scores by subcatchment. For site numbers see Figure 3.	57
Table 16	Proportion of riparian and floodplain vegetation in different condition classes and overall condition grades	61
Table 17	Riparian Vegetation Condition Index (RvCI) indicators scores and associated River Condition Index (RCI) scores and grades for subcatchments of the lower Darling Baaka study area	65

Table 18	Community condition analysis schemas. Individual metrics (7) are allocated a category based on the benchmarks for individual PCTs. This is then converted into a community score value, all metrics are the added for each PCT to give a total score out of 20	69
Table 19	Tree stand condition analysis schema for all plant community types. Individual metrics (4) are allocated a category based on the benchmarks. This is then converted into a community score value, all metrics are the added to give a total score out of 20	74
Table 20	Recalibrated benchmarks for individual sites using the rapid appraisal of riparian condition (RARC) methodology	75
Table 21	Distribution of river red gum (<i>Eucalyptus camaldulensis</i>) by size class at each plot where the species was recorded (32 from 36 plots, at 17 sites)	79
Table 22	Distribution of black box (<i>Eucalyptus largiflorens</i>) by size class at each plot where the species was recorded (16 from 32 plots)	82
Table 23	Trees <10 cm diameter at breast height (DBH) present in survey sites (PCTs 10, 11 and 13) in the Darling Baaka	84
Table 24	Average number of established seedlings/saplings per hectare in PCTs 10, 11 and 13	86
Table 25	Site-scale results and score for each metric comprising the community condition sub-indicator	87
Table 26	Site-scale results and score for each metric comprising the community condition sub-indicator continued	88
Table 27	Plot-scale results and score for each metric comprising the community condition sub-indicator	90
Table 28	Plot-scale results and score for each metric comprising the community condition sub-indicator continued	92
Table 29	Site-scale results and score for each metric comprising the tree stand condition sub-indicator	95
Table 30	Survey sites	97

List of figures

Figure 1	Good versus poor riparian vegetation condition (Source: DPE 2023a)	10
Figure 2	Full floristic plots for vegetation community and tree stand condition survey sites (19) and additional tree stand condition survey sites (15) for the Darling Baaka Project, totalling 34 survey sites.	16
Figure 3	Rapid appraisal of riparian condition (RARC) survey sites (53) for the Darling Baaka Project	23
Figure 4	Flow chart showing the data inputs and image processing steps adopted to generate the vegetation health index raster dataset	29
Figure 5	Flow chart showing the data sources and image processing steps adopted to generate the vegetation cover raster dataset	30
Figure 6	Flow chart showing the sequence of spatial analyses implemented to calculate riparian vegetation condition for each subcatchment.	32
Figure 7	The mean ($\pm$ SE) river red gum (<i>Eucalyptus camaldulensis</i>) trees per hectare in PCT 11 in the study area	38
Figure 8	The mean ($\pm$ SE) black box (<i>Eucalyptus largiflorens</i>) trees per hectare in PCT 13 in the study area	39
Figure 9	The mean ($\pm$ SE) river red gum (<i>Eucalyptus camaldulensis</i>) (top) and black box (<i>Eucalyptus largiflorens</i>) (bottom) trees per hectare in PCT 10 in the study area	41
Figure 10	Extant population structure and viability of river red gum (<i>Eucalyptus camaldulensis</i>) populations in PCT 11 (27 sites) in the lower Darling Baaka. Confidence is moderate-high, where extant population appears viable	44
Figure 11	Extant population structure and viability of black box (<i>Eucalyptus largiflorens</i>) populations in PCT 13 (4 sites) in the lower Darling Baaka. Confidence is low, where extant population may be viable, but there is a low number of sites	44
Figure 12	Extant population structure and viability of river red gum (<i>Eucalyptus camaldulensis</i> , top panel) and black box (<i>Eucalyptus largiflorens</i> , bottom panel) populations in PCT 10 (5 sites) in the	

	lower Darling Baaka. Confidence for both species is low, where extant population may be viable, but there is a low number of sites	45
Figure 13	Groundwater levels and river discharges at selected groundwater bores in the lower Darling Baaka	52
Figure 14	Comparison of tree stand condition (dark blue) and community condition (light blue) within the study area	56
Figure 15	A: Black box plot near Cawndilla Channel (subcatchment 1474) indicating 3 vegetation layers B: River red gum open forest adjacent to the Darling Baaka at Kinchega National Park (subcatchment 1518)	59
Figure 16	Plant communities in the study area. A: A larger (and older) black box (<i>Eucalyptus largiflorens</i>), with good foliage cover at the crown. B: A younger river red gum (<i>Eucalyptus camaldulensis</i>) tree with good foliage cover at the crown (subcatchment 1518). C: A younger river red gum tree with less foliage cover at the crown, indicating poorer tree health (subcatchment 1484)	59
Figure 17	The 2025 Riparian Vegetation Condition Index grades for the lower Darling Baaka. Numbers refer to subcatchments	67

5. Riparian vegetation condition

5.1 What is riparian vegetation?

Riparian vegetation refers to the trees, shrubs and non-woody vegetation (for example rushes, sedges, grasses) that grow along the edges and banks of rivers, streams and wetlands.

Riparian zones occur at the interface between terrestrial and aquatic ecosystems and tend to have a high density and diversity of vegetation types relative to adjacent terrestrial habitats (Riis et al. 2020). Riparian zones can be impacted by land clearing, geomorphological changes and alterations to water flow.

Riparian vegetation plays a crucial role in stabilising riverbanks and serves to decrease flow velocities during floods (Boulton 1999; Andreoli et al. 2020). Riparian zones also provide critical habitat for faunal biodiversity. In the Darling Baaka River system, riparian and floodplain vegetation communities are crucial hotspots of biodiversity in the semi-arid landscape, and these ecosystems support the overall health and resilience of the Darling Baaka River system.

5.2 Why use riparian vegetation condition in river health?

Healthy riparian zones are essential for protecting water quality, supporting biodiversity and ensuring the overall ecological balance of river systems. By assessing riparian vegetation, we can gain valuable insights into the overall condition of river ecosystems.

Native riparian vegetation provides a range of ecosystem functions (Spencer et al. 1998; Werren and Arthington 2002; Chessman 2003; Brooks et al. 2006; Lovett and Price 2007, Riis et al. 2020), including:

- habitat for native birds, reptiles, frogs, mammals and insects
- temperature regulation through the provision of shade
- input of organic matter and large woody debris to waterways
- bank stability and reductions in flood velocity
- water quality improvement, by encouraging sediment deposition
- nutrient cycling, as plants maintain overall ecosystem productivity.

Riparian vegetation is also susceptible to human impacts. Land clearing, livestock grazing, streamflow regulation, water extraction and invasive species all threaten the viability of riparian zones of the Darling Baaka River system. Human impacts have caused the degradation of riparian vegetation condition throughout New South Wales (Lovett and Price 2007; Riis et al. 2020), which has had implications on the geomorphic condition, biodiversity and water quality of the river system (Figure 1).

If the riparian zone is degraded or absent, it can indicate potential problems such as pollution, habitat loss and increased vulnerability to erosion and flooding. Given the

significant impact of riparian vegetation on river functioning, assessing its condition is essential in any large-scale evaluation of river health.

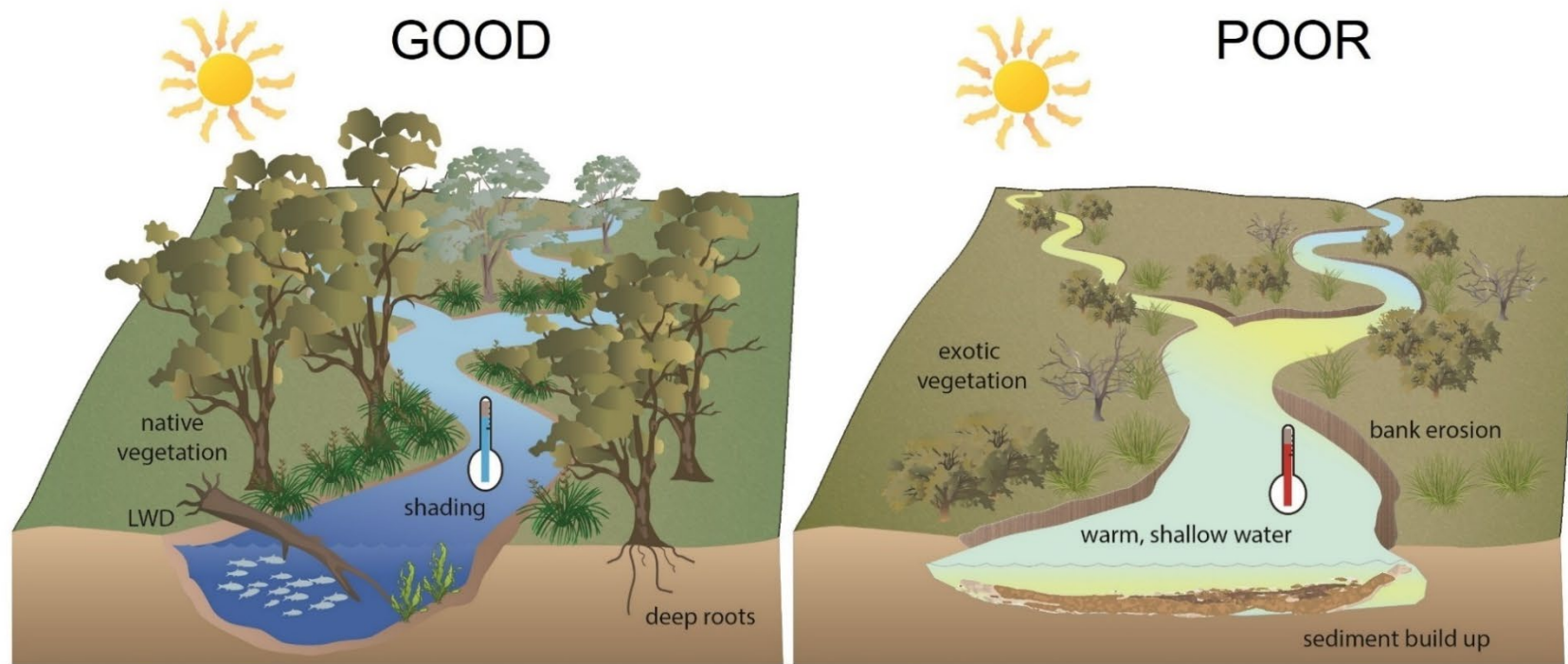


Figure 1 Good versus poor riparian vegetation condition (Source: DPE 2023a)

Left: Good vegetation will contract and deepen the channel. Deep roots help maintain bank structure and stability and reduce erosion. Large woody debris (LWD) provides habitat. Right: Without vegetation, the channel will become wider and shallower. Absence or loss of vegetation increases channel instability and erosion. An absence of large woody debris reduces habitat.

5.3 Assessing riparian vegetation condition

Measurements of riparian habitat characteristics, including widths, exotic species and canopy cover, are commonly completed in assessments of river health (Chessman 2003; Jansen et al. 2005). Native woody vegetation is also used to assess riparian vegetation condition as it contributes to bank stability, provides habitat for native species and can help filter pollutants entering the waterways (Brooks et al. 2006; Chessman 2003).

In broadscale river health assessments, the Riparian Vegetation Condition Index has relied on remotely sensed data (DPE 2023a). However, on-ground vegetation surveys provide important information about vegetation condition and can be used to verify large-scale mapping and modelling. Building on the foundational work developed in the *River Condition Index: method report* (DPE 2023a), referred to as the 2023 River Condition Index (RCI), the 2025 Darling Baaka River Health Project developed an updated methodology for assessing riparian vegetation condition for the lower Darling Baaka River. This was achieved by combining both remote sensing (as was completed in DPE 2023a), as well as field assessments of vegetation condition (Jansen et al. 2005; Bowen 2022) throughout the study area.

Field assessments of riparian condition provide detailed information about vegetation type, health and structure, and are likely to provide a good estimation of river health (Boulton 1999; Huylenbroeck et al. 2020). Field assessment allows for more precise measurements and identification of understorey and canopy vegetation to species level (Lawley et al. 2016). Such data can be used to validate and calibrate remote sensing models. When used together with remotely sensed datasets or other spatial mapping products, field survey data can be extrapolated to larger areas without the need to complete field surveys of individual sites (Lawley et al. 2016; Suir et al. 2020).

Due to the differences in methodologies, comparing the results for the 2023 RCI and 2025 Darling Baaka RCI is not a true indication of changes to riparian condition over time. Despite the differences between the application of the RCI framework, it is important to understand the differences between the 2023 RCI and the 2025 Darling Baaka RCI presented in this report (see Chapter 9).

5.3.1 Data used to assess riparian vegetation condition in the Darling Baaka River

Measurements such as canopy cover, tree demographics, dead wood, leaf litter and disturbances (such as signs of feral animals) are all commonly used field-collected indicators of riparian condition (Johansen et al. 2008). Additionally, riparian condition can be assessed using remotely sensed datasets such as satellite imagery or digital surface models. These remote-sensed data are powerful, cost-effective tools used to map and monitor the extent and condition of riparian vegetation and are mainly based on the ‘greenness’ of trees and canopy cover extent (Huylenbroeck et al. 2020).

Not all aspects of riparian vegetation community can be assessed using remotely sensed data. For example, community composition, structure and the presence of juvenile trees are indicative of the resilience and longevity of the population, however these cannot be assessed by remote methods. For example, adult trees may appear to

be in good condition based on remotely sensed data, however, the community can be species depauperate with low rates of juvenile recruitment which impacts an ability to maintain future viability and long-term sustainability. If recruitment is not assessed, there is a risk that riparian vegetation may appear in good condition when it is not.

To combat some of these issues, the 2025 Darling Baaka RCI combined remote sensing with an extensive field sampling campaign (see section 5.4) to assess riparian condition.

Riparian vegetation condition assessments

Field surveys were conducted for the project to assess the community and overall tree stand condition as well as rapid health assessments. Community condition is a composite score based on the presence of wetland health indicators such as plant species, structural composition of the community (e.g. strata and the presence of juveniles) and the species composition in relation to reference conditions (Bowen 2019; Bowen et al. in prep). Community condition responds quickly to water availability, on a scale of months. Whereas tree stand condition is a composite score based on canopy density and health, tree structural health, and the proportion of dead trees to live trees. Trees take longer to respond to water availability, so tree stand condition results likely reflect changes in water availability over years. The condition is compared to the condition in a site where all the trees have met their watering requirements over an extended period.

New data were collected throughout the study area. This included 49 sites where rapid assessments of riparian condition (Jansen et al. 2005) were undertaken, 19 sites where full floristic plots were completed, and 34 sites where tree condition was assessed (see section 5.4). These new data were used to assess the riparian condition and help verify the spatial modelling data (see section 5.4).

Spatial modelling of riparian vegetation condition

Remotely sensed vegetation indices use high-resolution data from satellites to quantify vegetation cover, condition and biomass. When combined with modelling, remote sensing data can provide a tool for predicting the condition of vegetation and aid in river management (Boothroyd et al. 2021; Xie et al. 2008).

Remote sensing vegetation indicators provide a measurement of vegetation components from the sky. These methods have the advantage of providing consistent data for larger areas (that is, all areas are assessed). They can also provide information on photosynthetic activity, assessing vegetation vigour or drought stress, and total vegetation cover (including all green and brown vegetation components) recorded from above for a unit area on the ground (for example, a 30 × 30 m pixel).

The most recent vegetation spatial layers were used to assess vegetation condition for the spatial component of the Riparian Vegetation Condition Index. These were:

- the 2023 State Vegetation Type Map (DPE 2023c)
- images from Landsat (US Geological Survey n.d.) and MODIS satellites (NASA n.d.)
- Sentinel-1 (synthetic aperture radar) and Sentinel-2 multispectral satellite imagery

- satellite-acquired light detection and ranging (LiDAR) data from the Global Ecosystem Dynamics Investigation.

From these layers, spatial analyses were completed to produce 2 sub-indicators (i.e. raster layers): vegetation cover (assessing photosynthetic activity) and vegetation health (assessing green and brown components of the tree).

The strength of remotely sensed condition assessments is that large areas can be assessed using adult tree measurements. A limitation, however, is that remote sensing methods do not provide information on vegetation composition such as the presence of weed species, population viability, and the species-level characteristics of a community. They also do not provide information on recruitment or tree demographics, such as the number of tree seedlings or the mix of tree ages at a site. To verify the accuracy of the spatial model, field assessments of vegetation condition were undertaken. Detailed methodologies are provided in section 5.4.

5.4 Methods

The Riparian Vegetation Condition Index incorporated 3 indicators:

1. floristic condition indicator (consisting of two subindicators: community condition and tree stand condition)
2. rapid appraisal of riparian condition (RARC) indicator
3. spatial vegetation condition indicator (consisting of two subindicators: vegetation cover and vegetation health).

The first 2 indicators rely on the collection of field data. The third indicator relies on a desktop survey using satellite imagery and spatial modelling. All 3 indicators have been previously used in the assessment of vegetation throughout New South Wales.

Three NSW plant community types (PCTs) that are widespread in the lower Darling Baaka region were sampled in the field component of this study (Table 1). Several other PCTs exist within the study area, however, the total area of these PCTs was minimal compared to the other 3 communities. A broader area of riparian and floodplain vegetation (that is, additional PCTs) was included in the analysis using satellite imagery and spatial modelling. Full descriptions of PCTs are provided in the NSW BioNet Vegetation Classification (Environment and Heritage 2024).

Table 1 Plant community types (PCTs) surveyed in the Darling Baaka River Health Project in 2024–25

NSW plant community type	NSW PCT ID
River red gum (<i>Eucalyptus camaldulensis</i>) – black box (<i>E. largiflorens</i>) woodland	10
River red gum (<i>E. camaldulensis</i>) – lignum (<i>Duma florulenta</i>) forest/woodland	11
Black box (<i>E. largiflorens</i>) – lignum (<i>D. florulenta</i>) woodland wetland	13

5.4.1 Floristic condition indicator

The floristic condition indicator uses scores from 2 sub-indicators:

1. community condition sub-indicator
2. tree stand condition sub-indicator.

These are combined for a final score and grade for each site. Field methods were used to collect data for both sub-indicators.

Field survey methods

A total 36 targeted full floristic field surveys were undertaken at 19 sites located across the study area (Figure 2; Appendix F), using methods described in Bowen (2022). This data was used to assess community condition, as well as tree stand condition (Table 2). Due to logistical constraints (mainly closures of roads due to weather) it was not possible to complete several planned surveys (see section 5.5). Also, no full floristic

sites were located in subcatchments in Talyawalka Creek due to access issues associated with wet-weather.

Each floristic survey plot consisted of a north–south oriented 50 × 50 m quadrat where tree health and individual tree demographic metrics were measured (Table 2). Within each 50 × 50 m quadrat a nested 20 × 20 m plot was placed in the north-east corner. Floristic data including species presence, cover and abundance in each strata (groundcover, understorey, canopy) were collected in these smaller plots to assess community condition (Table 2). The percentage foliage cover of all vascular plant species was recorded for exotic and native species within each of the main strata. All plant species were assigned to a water plant functional group after Casanova (2011). The percentage cover of bare ground and litter was also recorded as were the number of seedlings (that is, trees less than 10 cm diameter at breast height (DBH) and less than 1 m tall), and saplings (trees less than 10 cm DBH and greater than 1 m tall). Grazing pressure was also assessed as being high, medium or low (Table 2). Full methods are in Bowen (2019) and Bowen et al. (in press.). All data was used to assess the general vegetation condition in the study area (section 5.5.1).

The method for tree stand condition assessment was developed based on the tree stand condition method of Cunningham et al. (2007). The tree stand condition schema for PCTs 10, 11 and 13 indicate the grading of each category (Appendix B). Field surveys included assessing trees for indicators listed in Table 2 including canopy cover, dead limbs, hollows and live basal area. In March 2025, a further 15 additional sites were assessed for tree stand condition metrics. At these additional sites, 5 representative trees were assessed within a site to address data gaps for various subcatchments. The field data were then analysed following the method of Bowen (in press) (Table 2).

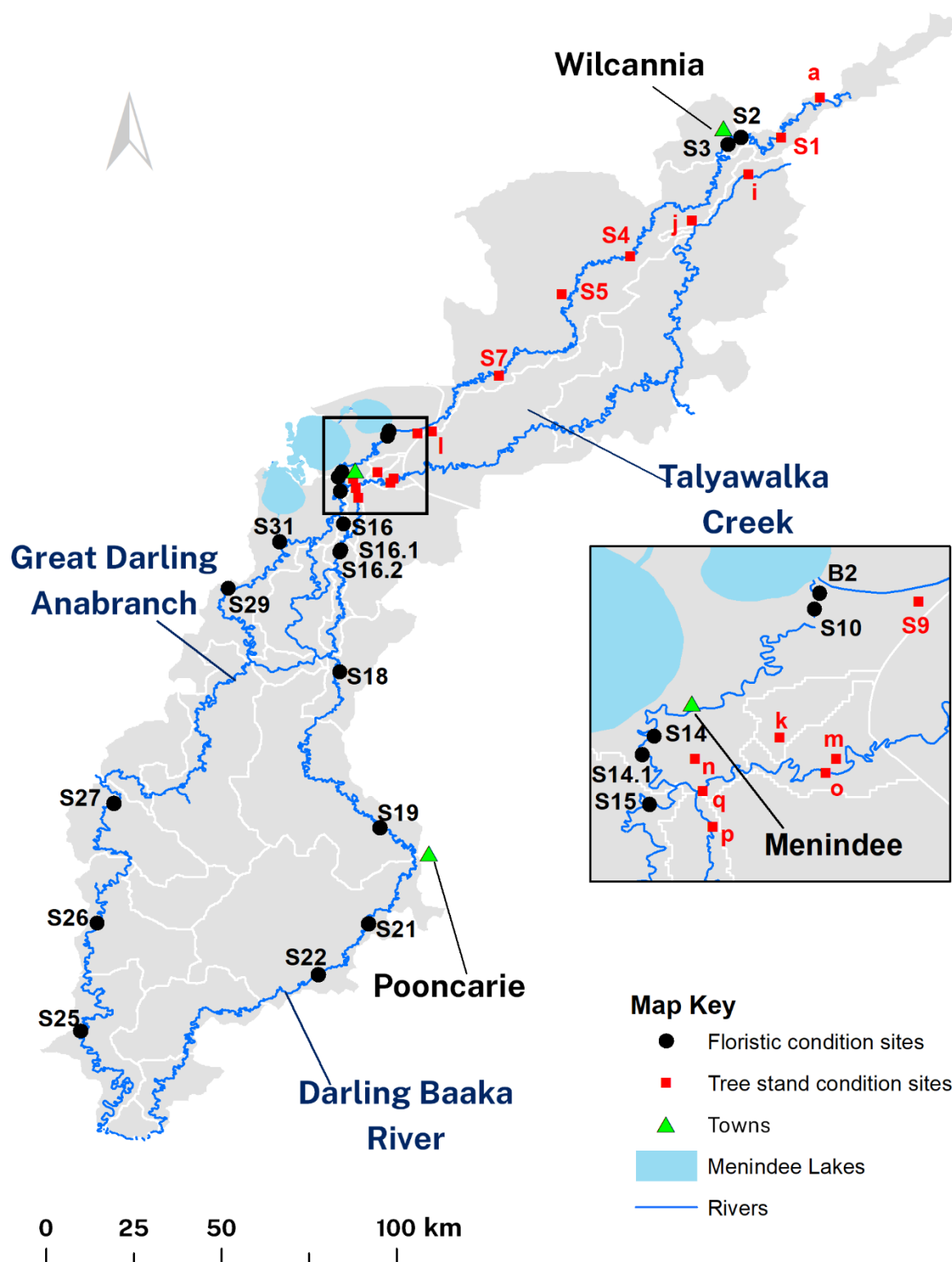


Table 2 Metrics collected for the community condition and tree stand condition indicators, as well as individual tree demographic assessments

Plot information	Details
General plot information	
Plot size	Both 50 × 50 m and 20 × 20 m plots
Photos of plot	Yes/No
Coordinates	Latitude, longitude
Flooding and inundation	Yes/No
Other disturbances	Grazing, fire
Species name	Name of each plant species
Cover score	Cover score for each species
Abundance score	Abundance score for each species
Species growth form	Form type (e.g. tree, shrub, herb)
Species height	Height (cm or m)
Reproductive status	Presence of flowers/fruits
Community condition metrics	
Leaf litter cover	Percentage (%)
Bare groundcover	Percentage (%)
Fallen timber length	Length in metres (m)
Number of tree seedlings*	Count
Number of tree saplings*	Count
Invasive trees	% Foliage cover
Indicator species of PCT	% foliage cover per stratum
Tree stand condition metrics	
Plot size	50 × 50 m
Tree canopy extent	Square metres or percent (%)
Tree foliage cover	Percentage (%)
Tree dead foliage cover	Percentage (%)
Tree dead and live limbs	Count
Tree status	Alive/dead
Tree diameter at breast height	Diameter (cm)
Tree reproductive status	Buds, flowers, fruits, etc.
Tree insect damage	Yes/No

Plot information	Details
Tree hollows	Count
Tree nests	Count

Table notes:

* seedlings are trees less than 10 cm diameter at breast height (DBH) and less than 1 metre tall; and saplings are trees less than 10 cm at DBH and greater than 1 metre tall.

Community condition sub-indicator

The community condition sub-indicator is a composite score based on the presence of plant health indicators (Table 2). Metrics measured include plant species, structural composition of the community (for example, strata and the presence of juveniles) and the species composition in relation to the reference PCT (Bowen 2019; Bowen et al. in press.). In the study area the dominant tree species were river red gum and black box, and the reference values for each NSW PCT were derived from the PCT descriptions (Table 1) in the BioNet Vegetation Classification (Environment and Heritage 2024).

For the community condition analysis, the data from the duplicate 20 × 20 m plots at each of the 19 sites were pooled and averaged for all metrics. Seven individual metrics were allocated a health category based on their PCT (Appendix B), this was then converted into a community score value for each individual site. Sites within the same subcatchment were then averaged to give an overall community condition score at a subcatchment level. A total of 19 sites representing 11 subcatchments were assessed for community condition.

The community condition score and category were calculated for each PCT within each subcatchment and expressed as a score between 0 (zero) and 20 (Table 3; Appendix B). The excellent benchmark grade represents the desirable state for community and tree stand condition, and the poor and very poor grade represents the undesirable state.

Table 3 **Condition classes and scores for tree stand and community condition indicators**
(one score calculated per sub-indicator)

Condition grade	Score	Condition description
Excellent	20/20	Indicates the desirable state of vegetation. It indicates water requirements of the dominant species are being met, and community structure is as expected for that plant community type (PCT); or there is little dead canopy, no dead trees and the percent foliage of the dominant species is within the expected range for the PCT.
Good - Intermediate	18 to 19.9 15 to 17.9	Indicates that water requirements of the dominant species are being met, less often than that required to meet the excellent benchmark, but the community is still in good health.
Moderate	12 to 14.9	Indicates that water requirements of the dominant species are not often being met, and the community contains terrestrial and/or exotic species; or there are dead trees, dead canopy and/or the percent foliage cover is less than expected for that PCT.
Poor - Very poor	9 to 11.9 0 to 8.9	Indicates that water-dependent species have been partly or totally replaced by exotic and/or terrestrial species, trees are dead or dying and the community is no longer functioning effectively as a water-dependent community.

Tree stand condition sub-indicator

The tree stand condition sub-indicator is a composite score based on canopy density and health, tree structural health, and the proportion of dead trees to live trees. Trees take longer to respond to water availability, so tree stand condition results likely reflect changes in water availability over years. The condition is compared to the expected condition in a site where watering requirements for all trees have been met over an extended period.

For tree stand condition, analysis of the data from the duplicate 50 × 50 m plots (that is, the same 19 sites within which community condition was assessed) were pooled and averaged for all metrics listed in the condition schema in Appendix B. At each plot the percentage foliage cover (%FC), tree height, percentage dead canopy (%DC), percentage live basal area (%LBA) and percentage dead limbs (%DL) was recorded for every tree greater than 10 cm DBH. Within the smaller plots the numbers of seedlings (trees less than 10 cm diameter at breast height (DBH)), and less than 1 metre tall, and saplings (trees less than 10 cm DBH) and greater than 1 metre tall, were counted. A number of other metrics, including number of tree hollows were also collected (Table 2)

An additional 15 sites were assessed in March 2025 to fill data gaps throughout the study area, including a number of sites on Talyawalka Creek. At these sites, full floristic plots were not completed, rather a representative stand of 5 trees were assessed for

the relevant metrics and tree stand condition calculated. A tree stand condition score and category were calculated for each PCT within each site, and these are expressed as a score between 0 and 20 (Table 3; Appendix A). Sites were to give an overall subcatchment score.

Combined floristic condition indicator

The community condition and tree stand condition scores were combined to give an overall floristic condition score by averaging the 2 scores at each site using Equation 1. Where community condition is absent, tree stand condition is used alone. This occurred for the 15 additional sites collected in March 2025.

Equation 1:

$$\text{Floristic condition indicator} = \frac{(\text{community condition score} + \text{tree stand condition score})}{2}$$

The combined floristic condition score indicates the level of resilience in vegetation communities, that is, if they can maintain community condition and tree stand condition at intermediate grade or above (Table 3). The combined floristic condition score (Table 4) indicates site condition for the vegetation community, which is influenced by longer term (that is, over several years to decades) patterns of wetting and drying and land-use pressures, as well as more recent disturbances (within the last few years) such as flooding, drought and grazing. The highest floristic condition scores are achieved where both shorter- and longer-term conditions have been favourable, and land-use pressures (such as grazing) have been minimal.

Floristic condition scores were then standardised and transformed into the RCI boundaries for each of the grades using a polynomial fit through the centre of the floristic condition indicator and RCI score classes (Equation 2; Table 4). The resulting r^2 of this fit was 0.9988 with minimal shifts to the resulting grades.

Equation 2:

$$FCI_{norm} = 0.0023 FCI^2 - 0.0024 FCI + 0.0403$$

Table 4 Floristic condition indicator scores and associated River Condition Index (RCI) scores and grades

Floristic condition score	RCI Indicator score	RCI grade
0 to <9	0.0 to <0.2	Very poor
9 to <12	0.2 to <0.4	Poor
12 to <15	0.4 to <0.6	Moderate
15 to <18	0.6 to <0.8	Good
18 to 20	0.8 to 1	Very good

Other riparian condition analyses

Tree demographics

In addition to the information required for the Riparian Vegetation Condition Index for use in the RCI framework, a range of tree population data have been collected to report on the overall condition of the vegetation in the catchment.

The current population structures for 3 PCTs were demonstrated by plotting a histogram of the average number of trees per hectare for each 10-cm size class, beginning with 10 to 20 cm, by measuring DBH at 130 cm from the ground.

Data were pooled from all plots for each PCT and the number of trees per hectare calculated in each size class and converted to trees per hectare. The shape of the plot and the presence of trees in each size class was evaluated for size class spread and relative numbers of trees in each class, both alive and dead.

Population viability

The viability of both the current population as well as future populations was calculated. Established methods for analysing data for demographic condition or 'population viability' include fitting the number of trees in each size class to 'reverse-J curve' distributions (Smith et al. 1997; Niklas et al. 2003; George et al. 2005). Several distributions can potentially represent a 'reverse-J' function, including logarithmic, negative exponential and Weibull distributions (Wang et al. 2009). This approach was agreed to by the Intergovernmental Vegetation Technical Advisory Group under the Murray–Darling Basin Authority's Joint Venture for Monitoring and Evaluation program (VTAG 2019).

The best distributions to model tree demography at the level of PCT or tree species for the data in the Murray–Darling Basin were determined by goodness of fit tests (Bowen et al. in press.). In this study, population viability was determined by fitting the midpoint of the average number of trees per hectare of each size class to a negative log-normal function (the reverse-J curve). The goodness of fit measure (the R^2) was calculated to determine if the fit of the data was statistically significant (p-values) and signal noise (R^2) were reported.

The longevity of healthy trees in each PCT was estimated to assess the long-term viability of PCTs in the study area. The longevity of river red gum trees has been estimated at between 100 and 950 years (Ogden 1978, cited in George et al. 2005). Dendrochronological investigations of coolibah (*Eucalyptus coolabah*) trees in arid South Australia emphasised the slow rate of growth of the species once established and its potential to be a significantly long-lived perennial. Carbon 14 dating of a coolibah tree with a trunk radius of 12.2 cm (24.4 cm DBH) estimated it to be around 114 years old. A tree that was roughly twice the DBH of the sampled tree (42 cm DBH), had a predicted age of over 300 years with a modelled accuracy of 90.2% (Gillen 2017; Gillen et al. 2021). We consider that black box trees live at least as long as coolibah trees.

Population structure is maintained when the number of mature tree deaths is matched by the presence of newly matured trees. The 5–10 cm DBH class (sapling) is considered

the most important for measures of population maintenance and future viability (Fensham and Bowman 1992; Guedje et al. 2003; George et al. 2005).

The average number of established river red gum or black box seedlings (trees <10 cm diameter and <1.3 m tall) and saplings (trees <10 cm diameter and ≥1.3 m tall) per hectare was calculated for each of the PCTs from the data pooled across sites. For each PCT, the number of expected saplings per hectare was estimated based on a prediction at a size class of 5 cm (the midpoint of the 0–10 cm size class), using the intercept value from the fitted non-linear regression equation calculated for each PCT.

5.4.2 Rapid appraisal of riparian condition indicator

Rapid appraisal of riparian condition (RARC) surveys assess the condition of riparian habitats and reflect the degree of disturbances to these ecosystems. Originally developed for south-eastern Australian streams, the RARC surveys incorporate biological and physical properties to reflect ecosystem functioning and overall health (Jansen et al. 2005).

A rapid assessment of multiple metrics was completed at 53 sites throughout the study area (Figure 3). Variables including habitat continuity and extent, vegetation cover, debris and percent native species were recorded (Table 5). Rapid appraisal scores were assessed in 4 transects at each site and averaged to calculate an overall site score (Jansen et al. 2005). The data were assigned grades which assess habitat, cover, natives, debris and features.

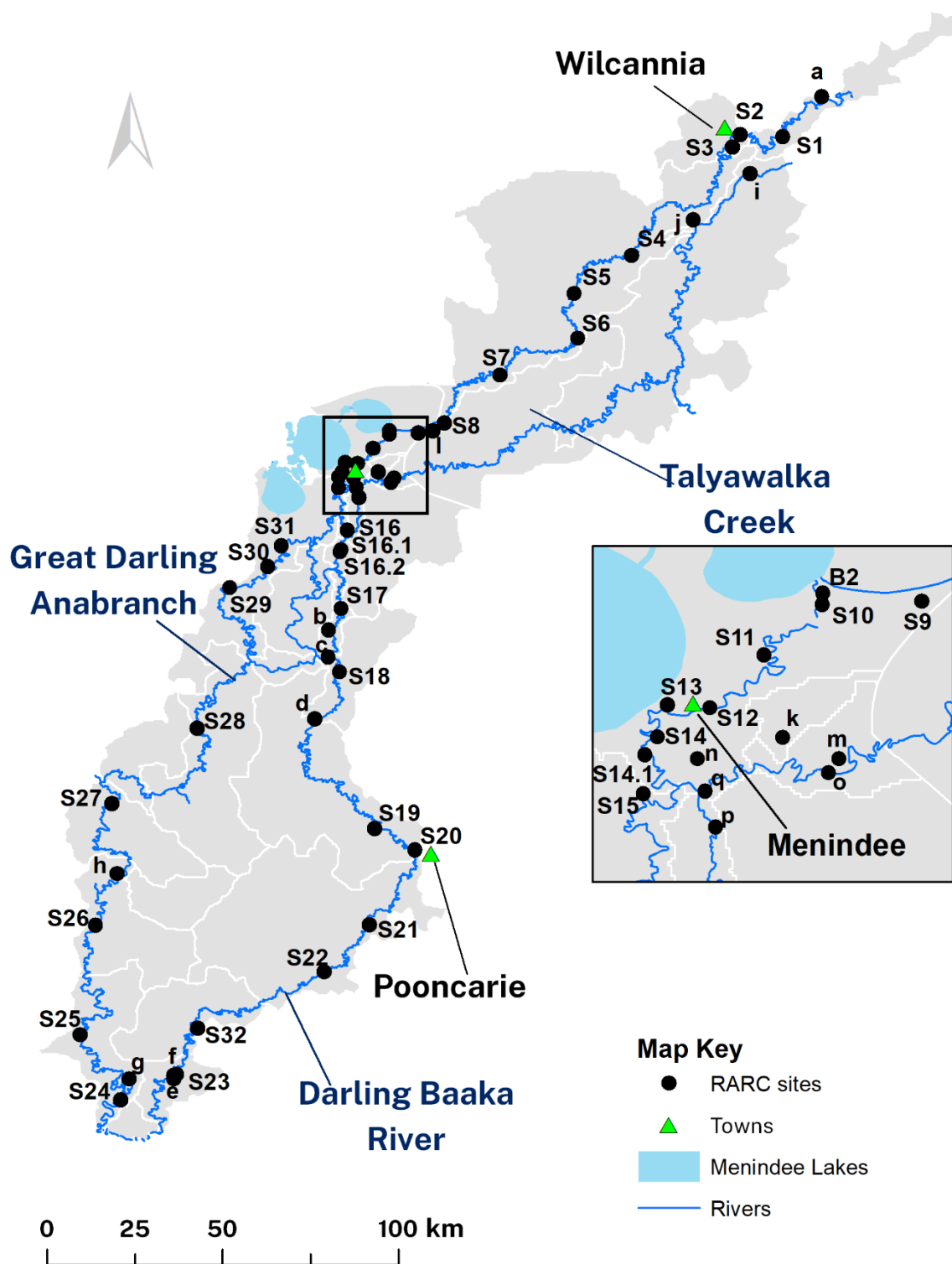


Figure 3 Rapid appraisal of riparian condition (RARC) survey sites (53) for the Darling Baaka Project

Table 5 Information and metrics collected for rapid appraisal of riparian condition surveys (adapted from Jansen et al. 2005)

Feature	Metric
Habitat	Longitudinal continuity of riparian vegetation Width of riparian canopy vegetation Proximity to intact native vegetation
Cover	Canopy Understorey Groundcover Number of layers
Natives	Canopy Understorey Groundcover
Debris	Leaf litter Native leaf litter Standing dead trees Hollow-bearing trees Fallen logs
Features	Native canopy regeneration Native understorey regeneration Large native tussock grasses Reeds

The RARC methodology was originally devised for statewide use in New South Wales with benchmarks devised using averaged data from multiple PCTs (Jansen et al. 2005). These methods suggest benchmarks should be recalibrated for specific vegetation types, so a suitable assessment of local vegetation community health can be performed. To complete this for the lower Darling Baaka sites, recalibration of benchmarks the PCTs were firstly assigned for each individual site using BioNet data (accessed 2025). The benchmarks for these PCTs were then downloaded (DPE 2022) and the Interim Biogeographic Regionalisation of Australia (IBRA) region for each site was located using ArcGIS spatial layers. For each site, the vegetation type listed was cross-checked against field data and a PCT was allocated to each site to confirm that the correct PCT was allocated. Using data collected for each specific vegetation type (DPE 2022b), the individual RARC benchmarks for canopy cover, understorey, groundcover, leaf litter, hollow-bearing trees and fallen logs were readjusted for individual PCT types. Readjusting benchmarks was necessary to account for the naturally low number of shrubs, understorey and groundcover vegetation in these community types, as well as the naturally low number of hollow-bearing trees when compared to other vegetation communities. The readjusted benchmarks for each site can be found in Appendix C.

Scores for this indicator were then calculated using the new benchmarks and converted to a decimal. For example, if a site received a score of 8, against a benchmark of 10, this resulted in the site getting a score of 0.8. This scoring system directly aligned with the standardised RCI scores from 0 to 1 (Table 6).

Table 6 **Rapid assessment of riparian condition (RARC) class scores and grades, and associated River Condition Index (RCI) grades**

RARC class score	RCI condition score	RCI condition grade
0.0 to <0.2	0.0 to <0.2	Very poor
0.2 to <0.4	0.2 to <0.4	Poor
0.4 to <0.6	0.4 to <0.6	Moderate
0.6 to <0.8	0.6 to <0.8	Good
0.8 to 1.0	0.8 to 1	Very good

5.4.3 Spatial vegetation condition indicator

The remote sensing and spatial modelling implemented for this study grouped PCTs into one of 3 broad functional groups: river red gum woodland, flood-dependent woodland or flood-dependent shrubland (Table 7). This enabled evaluation of greater areas of riparian and floodplain vegetation for inclusion into calculations of catchment vegetation condition. The functional groups were determined by grouping PCTs with similar vegetation structure, landscape positions and surface water regimes.

Non-woody wetlands (that is, wetlands with herbaceous plants and no trees) were not included in the spatial modelling of vegetation condition. This is because non-woody wetlands are poorly mapped in the available State Vegetation Type Map (DPE 2023c) for the study area. There has been little field work in these regions and mapping to date is extremely limited. Non-woody wetland vegetation in this far western region also tends to be ephemeral (occurring in less frequently inundated areas during wetter periods) or occurs in small and narrow patches in the shallow water fringing deeper semi-permanent water bodies, thus mapping using remote sensing only has proved difficult.

Table 7 **Plant community types (PCTs) within the study area, and relationship to functional group implemented for remote sensing and spatial modelling**

NSW plant community type	Functional group	Number of field survey
10: River red gum – black box woodland wetland	RRGW	Yes
11: River red gum – lignum very tall open forest or woodland wetland	RRGW	Yes
36: River red gum tall to very tall open forest / woodland wetland on rivers on floodplains	RRGW	NA
41: River red gum open woodland wetland of intermittent watercourses	RRGW	NA
41: River red gum open woodland wetland of intermittent watercourses	RRGW	NA
200: River red gum woodland wetland of lake fringes	RRGW	NA
13: Black box – lignum wood land wetland	FDW	Yes
15: Black box open woodland wetland with chenopod understorey	FDW	NA
16: Black box grassy open woodland wetland of rarely flooded depressions	FDW	NA
37: Black box woodland wetland	FDW	NA
38: Black box low woodland wetland lining ephemeral watercourses or fringing lakes and clay pans	FDW	NA
39: Coolabah – river coobah – lignum woodland wetland of frequently flooded floodplains	FDW	NA
40: Coolabah open woodland wetland with chenopod/grassy ground cover	FDW	NA
630: Black box – silver saltbush chenopod open woodland on terrace rises on alluvial plains	FDW	NA
17: Lignum shrubland wetland	FDSH	NA
25: Lignum shrubland wetland on floodplains and depressions	FDSH	NA
62: Samphire saline shrubland/forbland wetland of lake beds and lake margins	FDSH	NA
63: Spiny lignum – slender glasswort open forbland saline wetland on lake edges	FDSH	NA
64: Samphire – water weed – sea-heath shrubland saline wetland of depressions	FDSH	NA
65: Halosarcia lylei low, open shrubland saline wetland	FDSH	NA
160: Nitre goosefoot shrubland wetland on clays	FDSH	NA

NSW plant community type	Functional group	Number of field survey
161: Golden goosefoot shrubland wetland in swamps	FDSH	NA
166: Disturbed annual saltbush forbland on clay plains and inundation zones	FDSH	NA
198: Sparse saltbush forbland wetland of the irregularly inundated lakes	FDSH	NA
247: Lignum shrubland wetland on regularly flooded alluvial depressions	FDSH	NA
253: Gypseous shrubland on rises in the semi-arid and arid plains (around playas)	FDSH	NA

Table notes: RRGW = river red gum woodland, FDW = flood-dependent woodland, FDSH = flood-dependent shrubland.

Spatial analyses

A spatial modelling approach was developed using remote sensing datasets to generate 2 sub-indicator raster layers representing vegetation condition. These sub-indicators were:

1. vegetation health sub-indicator (Zeng et al. 2023), representing vegetation photosynthetic activity and drought stress for the year July 2023 to June 2024
2. vegetation cover sub-indicator, representing the amount of vegetation cover (biomass) viewed from above for the year July 2023 to June 2024.

The raster layers representing spatial vegetation condition were then intersected with other layers, and a sequence of geographic information system (GIS) spatial analyses were implemented to calculate spatial vegetation condition scores for each subcatchment. Additionally, the relationship between vegetation condition measured using the remote sensing datasets was compared to the field (floristic plot) assessed vegetation condition scores to investigate any correlation and report on the strength and limitations of the remote sensing approach.

Vegetation health sub-indicator

This raster dataset was developed from Landsat and Sentinel-2 satellite imagery (Figure 4), following the methods provided by Zeng et al. (2023). The dataset provides a measure of vegetation health by combining estimations of vegetation moisture and thermal condition (Alahacoon et al. 2021; Zeng et al. 2023).

Landsat imagery provided data for calculation of the Normalised Difference Vegetation Index (NDVI), which is a measure of photosynthetic activity, and land surface temperature, which was integrated to calibrate NDVI to local climatic conditions. The Sentinel land use land cover dataset was used to generate a water mask and remove any grid cells where the measure of reflectance from vegetation and calculation of land surface temperature may have been influenced by flooding. The vegetation health sub-indicator was then calculated from a combination of the NDVI and land surface

temperature. The sub-indicator is widely adopted to identify vegetation health and drought stress in vegetation.

The sub-indicator accounts for local climatic conditions, with each grid cell value providing an estimate of health relative to the history of values for that grid cell. Higher values indicate greater vegetation health (more photosynthetic activity), while lower values represent lower vegetation health (less photosynthetic activity).

Using the Google Earth Engine platform, the vegetation health dataset for the Darling Barka study area was calculated as an annual average of NDVI values for the year 2023–24 (Figure 4). Each annual dataset was developed to provide a 30 × 30 m raster dataset.

Vegetation cover sub-indicator

A vegetation cover dataset was generated to provide a modelled estimate of the area of vegetation covering the ground in each grid cell for the year 2023–24. This raster dataset was developed to provide information on the amount of vegetation (biomass) viewed from above and is considered complementary to the vegetation health sub-indicator raster dataset which provides information the amount of vegetation that is photosynthetically active.

The vegetation cover dataset was generated from Sentinel-1 (synthetic aperture radar) and Sentinel-2 multispectral satellite imagery, and satellite-acquired LiDAR data from the Global Ecosystem Dynamics Investigation (Burns et al. 2024). A water mask was developed from the Sentinel land use land cover dataset to mask out inundated pixels. A random forest regression model was generated for 2022–23. Predictor layers included vegetation indices developed from the Sentinel-1 and Sentinel-2 data, and data points sourced from Global Ecosystem Dynamics Investigation (2022–23).

The random forest model developed from the 2022–23 dataset was then used to predict the vegetation cover for 2023–24. Higher values in the output raster layer indicate greater vegetation cover, while lower values indicate lower vegetation cover and more bare soil. The output vegetation cover raster was generated with a 30 × 30 m pixel size. A flow chart showing the method and processing steps taken to generate the vegetation cover dataset is shown in Figure 5.

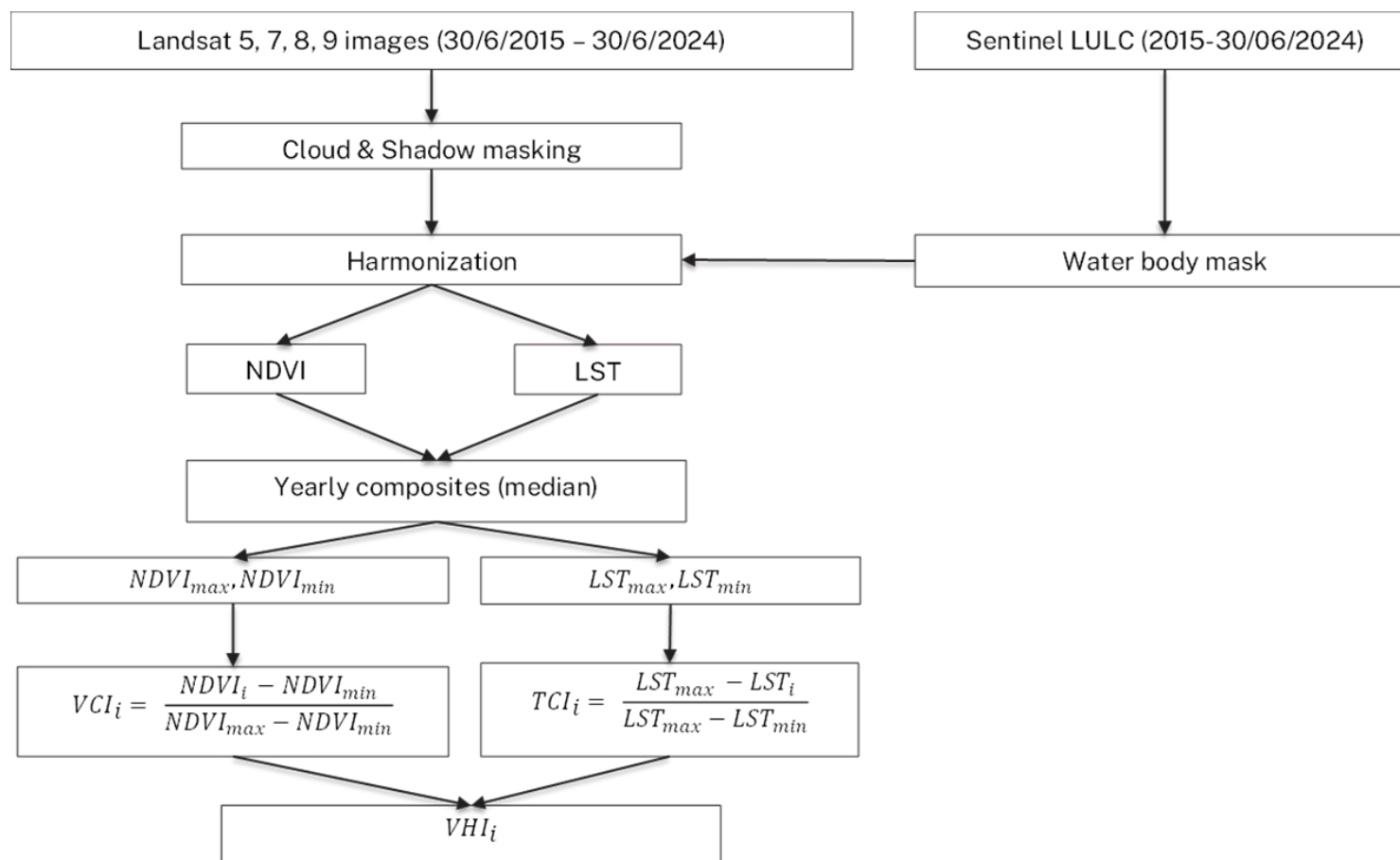


Figure 4 Flow chart showing the data inputs and image processing steps adopted to generate the vegetation health index raster dataset

Figure notes: LULC = land use land cover, NDVI = Normalised Difference Vegetation Index, LST = land surface temperature, VCI = Vegetation Condition Index, TCI = thermal condition index, VHI = vegetation health index, i = year (30 June 2023 to 30 June 2024).

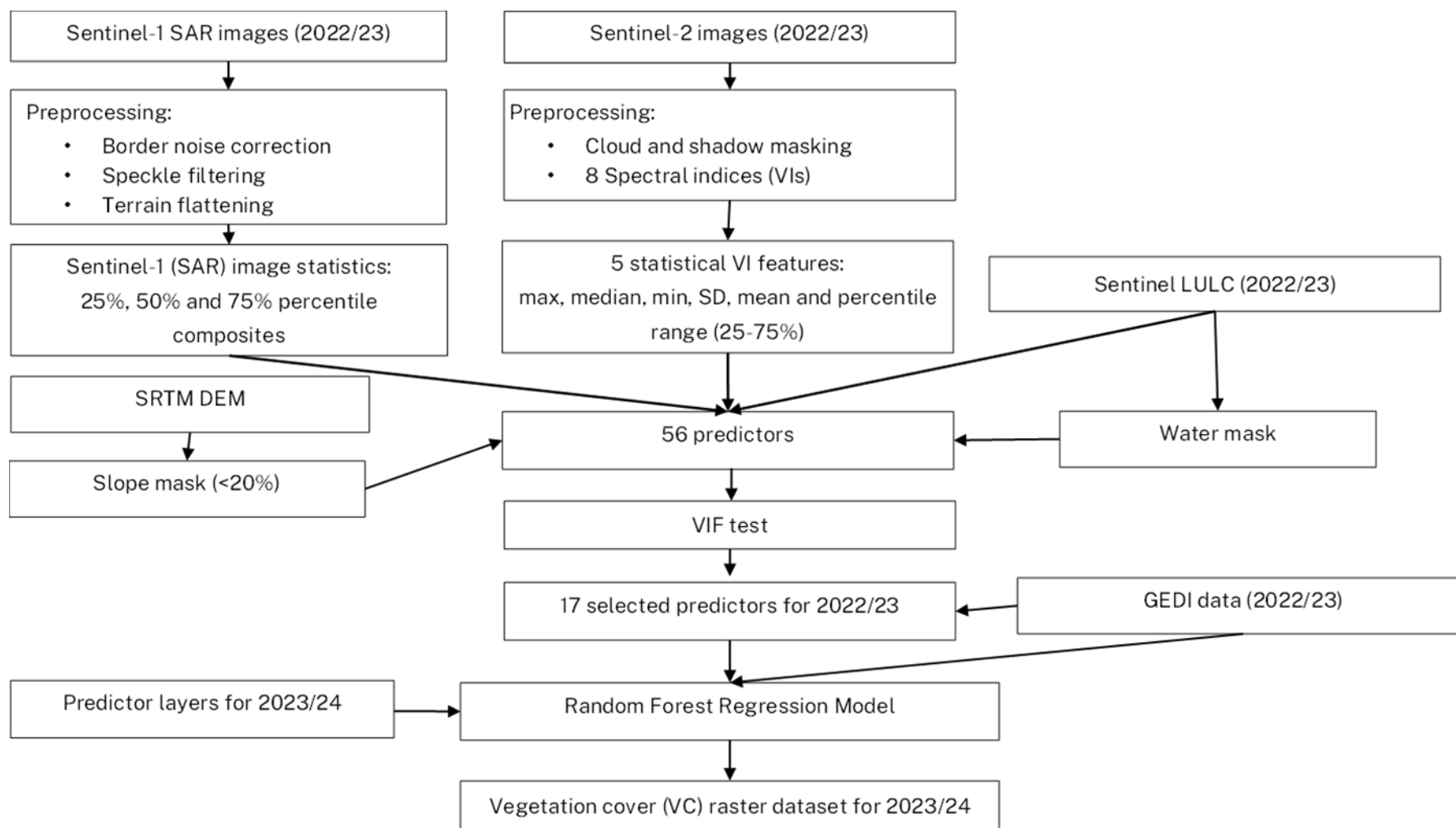


Figure 5 Flow chart showing the data sources and image processing steps adopted to generate the vegetation cover raster dataset

Figure notes: SAR = synthetic aperture radar imagery, VI = Vegetation Index, SD = standard deviation, LULC = land use land cover, SRTM DEM = Shuttle Radar Topography Mission digital elevation model, VIF = Variance Inflation Factor, GEDI = Global Ecosystem Dynamics Investigation, VC = vegetation cover.

Spatial vegetation condition indicator calculation

A spatial vegetation condition indicator value was calculated for each subcatchment integrating a set of spatial layers and a sequence of spatial area analyses in GIS.

The first step was to collate and prepare input spatial datasets. These included:

- vegetation health sub-indicator raster dataset (30-m grid cell)
- vegetation cover sub-indicator raster dataset (30-m grid cell)
- State Vegetation Type Map extant vegetation (polygons)
- study area subcatchment boundaries
- ANZLIC National Nested Grids for NSW (Albers projection) (9-km grid with 30-m cell size) (DCCEE 2023a).

All spatial datasets were imported to ESRI ArcMap 10.8. All polygon and raster datasets were projected to an Albers Equal Area projection suitable for area calculations. All raster datasets were aligned to the 30-m national nested grid implemented for New South Wales.

The State Vegetation Type Map of extant vegetation for the study area was reclassified to provide 3 functional groups of surface water-dependent vegetation communities, namely river red gum woodland, flood-dependent woodland and flood-dependent shrubland (Table). These 3 functional groups were selected to represent important riparian and floodplain wetland vegetation types present within the lower Darling Baaka study area.

Following preparation of the vegetation type spatial layers, a sequence of GIS analyses and calculations were implemented to calculate condition metrics for each of river red gum woodland and flood-dependent woodland communities, and a combined condition score for each subcatchment. An overview of the spatial analyses and calculations implemented to calculate riparian vegetation condition for each subcatchment is illustrated in Figure 6.

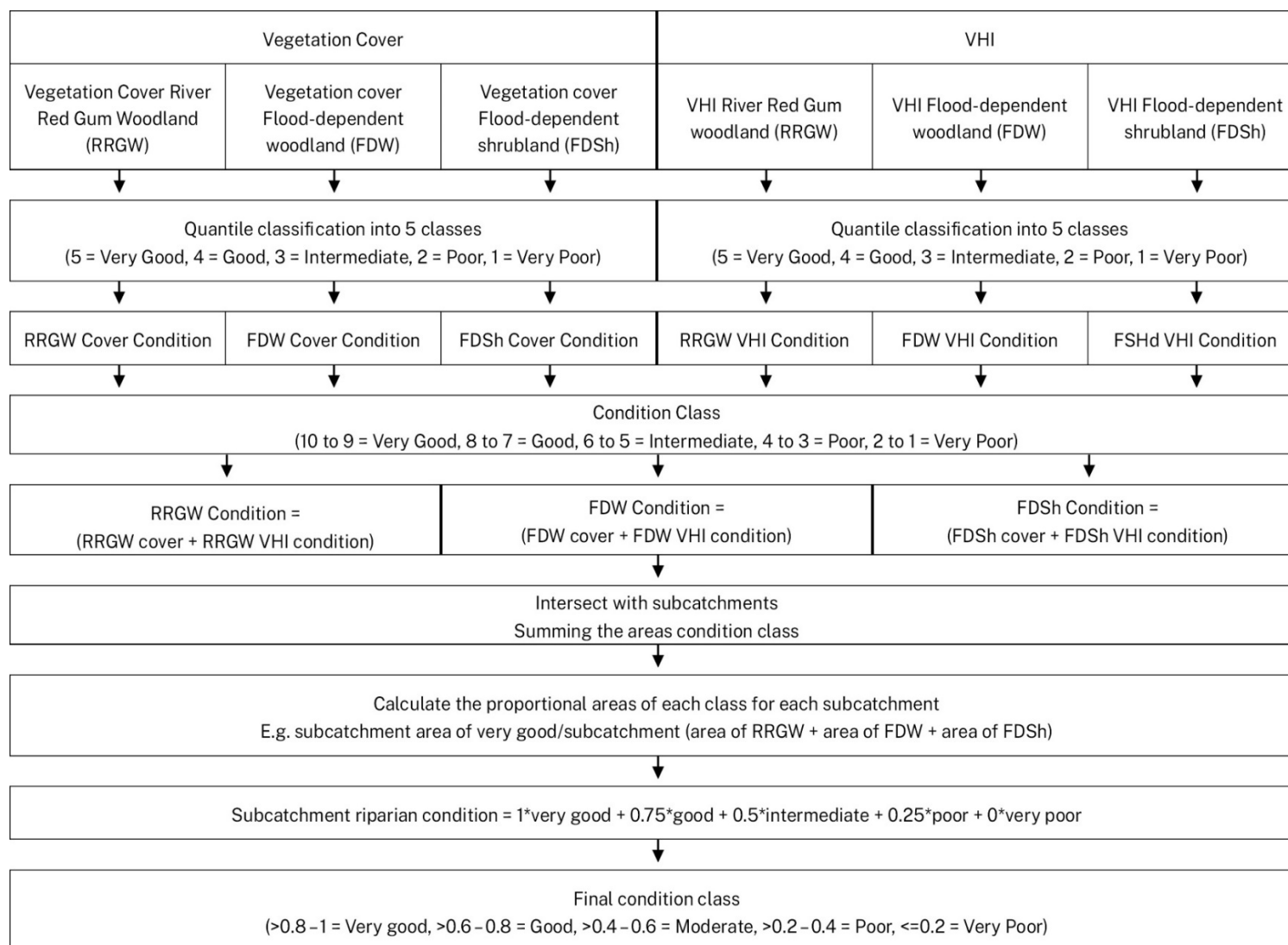


Figure 6 Flow chart showing the sequence of spatial analyses implemented to calculate riparian vegetation condition for each subcatchment.

To calculate the spatial vegetation condition indicator score, the remote sensing vegetation cover and vegetation health sub-indicator datasets were clipped to the area for each vegetation type (river red gum woodland, flood-dependent woodland and flood-dependent shrubland). This provided a set of rasters representing the 2 sub-indicators for each of the 3 vegetation types.

The vegetation health and vegetation cover raster datasets for each vegetation type were then classified using a quantile classification to allocate cell values into 5 classes. The quantile classification with 5 classes divides the raster dataset into 5 ranked condition categories by percentile:

1. raster cells with values in the highest 20% of the data, that is >80th percentile, were allocated to the very good category
2. raster cells with values in the 60th to 80th percentile were allocated to the good category
3. raster cells with values in the 40th to 60th percentile were allocated to the moderate category
4. raster cells with values between the 20th and 40th percentile were allocated to the poor category
5. raster cells with values <20th percentile were allocated to the very poor category.

The quantile classification approach applied to individual vegetation type categories ensured that the condition assessment took into account the different ranges in vegetation cover and vegetation health expected for each vegetation functional group. For example, healthy river red gum woodland is known to have a higher vegetation cover than healthy flood-dependent woodland and healthy flood-dependent shrubland.

The vegetation cover and the vegetation health raster datasets were then averaged, to provide a condition score out of 5 for each vegetation class. Note that in using this approach the vegetation cover and vegetation health sub-indicators contributed equally to the condition scores.

The combined areas of each vegetation condition class – very good, good, moderate, poor and very poor – were then calculated for each subcatchment. The area of each condition class was divided by the total area of surface water-dependent vegetation in the subcatchment to provide the proportional area of each vegetation class of surface water-dependent vegetation for each subcatchment.

The overall spatial vegetation condition score for each subcatchment was then calculated using the weightings applied to proportional areas for each condition class using Equation 3:

Equation 3:

$$\text{Spatial vegetation condition indicator} = \frac{((\%Very\ good \times 1) + (\%good \times 0.75) + (\%moderate \times 0.5) + (\%poor \times 0.25) + (\%Very\ poor \times 0))}{100}$$

The final step was to classify the weighted subcatchment spatial vegetation condition values using the classes outlined in Table 8.

Table 8 **Spatial vegetation condition indicator scores and associated condition grades**

Indicator score	RCI condition grade
0.0 to <0.2	Very poor
0.2 to <0.4	Poor
0.4 to <0.6	Moderate
0.6 to <0.8	Good
0.8 to 1.0	Very good

5.4.4 Final Riparian Vegetation Condition Index

The final Riparian Vegetation Condition Index score for each site was formed using the 3 indicators within this index. Before this could be completed, correlations between the desktop (spatial) method of calculating riparian condition and the field condition assessments were investigated.

Correlation of field-assessed condition with spatial indicators

Field data were used to assess the suitability of using spatial remote sensing techniques and modelling in assessing riparian vegetation condition. The tree stand condition and community condition sub-indicator scores calculated from the field data (see section 5.5) were compared to the spatially modelled vegetation health and vegetation cover sub-indicator scores. The values of spatial data pixels were matched to the location of the centre of each field-assessed floristic plot (see section 5.5). Pearson correlation coefficient (R statistic) was used to evaluate and report on correlation. A coefficient value correlation of 1 or -1 indicate a strong relationship, with correlations of 0.5 or -0.5 indicating weak relationships.

This analysis adopted community condition and tree stand condition values calculated for individual plots, rather than for sites. The use of plot data rather than site-level data (which was generated from pooled data from replicate plots spaced up to 500 m apart) enabled pairing of plot centre locations with the nearest 30 × 30 m pixel in the raster datasets.

Table 9 shows the results investigating relationships between community condition and tree stand condition scores for plots, and the vegetation health and vegetation cover spatially modelled values at the same location.

All of the available plot data were collected within PCTs 10, 11 and 13, with 34 river red gum woodland plots, and 4 flood-dependent wetland plots. The plots used were from data collected for the full floristic assessment (see section 5.4.1). No plot data were available for assessing relationship between ground-assessed condition and spatially modelled condition within flood-dependent shrublands.

Table 9 Results of correlation analysis to compare ground-assessed vegetation with spatially modelled values at the same point locations

Field condition sub-indicators	Spatial vegetation sub-indicators	R value	Interpretation
Community condition score	Vegetation health	0.291	Very weak positive/no correlation
Community condition score	Vegetation cover	-0.256	Very weak negative/ no correlation
Tree stand condition score	Vegetation health	0.029	No correlation
Tree stand condition score	Vegetation cover	0.453	Weak positive correlation

There was little to no correlation between community condition score and the vegetation health or vegetation cover remote sensing scores. Remote sensing rasters provide a measure of reflectance, and while it is assumed that the vegetation health measures photosynthesising vegetation, the colour of the trees' leaves and understorey groundcover reflectance can influence the overall scores. In addition, there was no correlation between tree stand condition score and vegetation health. However, tree stand condition score was weakly correlated with vegetation cover, presumably because the vegetation condition remote sensing indicator measures vegetation foliage cover, which is a very similar measurement to canopy cover in the tree stand condition scores.

Higher vegetation health sub-indicator values may indicate increased productivity, and vegetation cover measures foliage extent. Neither of these remote sensing sub-indicators would differentiate between weed infestations in the region, nor the condition of understorey or groundcover vegetation communities or debris and leaf litter. The lack of correlation between on-ground vegetation condition scores and the remote sensing data indicates a need for further investigation on the suitability of remote sensing to accurately describe on-ground riparian vegetation condition.

Overall, relationships between ground-assessed and spatial vegetation condition indicate that the remote sensing indicators and spatial modelling approach developed for this study are likely to only partially explain the structural variation in condition within vegetation communities. However, remote sensing is less able to describe the vegetation condition related to compositional variation (such as the presence or absence of weeds or species identification) or the overall health of the riparian community.

Combination of indicators into a final riparian vegetation condition score

There are strengths and weaknesses to each of the remote sensing and field assessment techniques, and they assess different components of vegetation condition. Field and remote survey techniques are likely to describe different components of the vegetation community. Whereas remote sensing describes the photosynthetic activity, which cannot be readily assessed using field assessment techniques. Similarly, it is

difficult to measure the total amount of vegetation cover in a unit area using visual estimates from the ground, as visual field estimates can be prone to observer bias. However, the lack of significant correlation between field and spatial data resulted in an increased weighting for field-derived indicators in the calculation of the Riparian Vegetation Condition Index being used in the RCI framework.

It is acknowledged that the 3 datasets used for this analysis were not uniformly collected at every site or at every subcatchment in the study area. This was due to time constraints and access issues, brought about due to wet-weather conditions. Remote sensing was performed for the entire study area, however due to the lack of correlation with on-ground data at the sites where field surveys were conducted, it is believed this method should not be used as a sole indicator for riparian vegetation condition.

The field-derived indicators (floristic condition and RARC condition) were both weighted at 45% of the final score, whereas the spatially derived indicator was assigned a weight of 10%. These were then averaged to achieve a single score per subcatchment as per Equation 4. Available data for all 3 sub-indicators were used for each subcatchment. If there were no floristic plot data, the RARC and spatial vegetation weights were altered to 60% and 40%, respectively. If there were no field data within a subcatchment (7 of the 28 subcatchments), the spatial vegetation condition was used as a sole indicator, acknowledging the limitations that this presents.

Equation 4:

$$\text{Riparian Vegetation Condition Index} = (\text{Floristic condition} * 0.45) + (\text{RARC} * 0.45) + (\text{Spatial vegetation condition} * 0.10)$$

The final Riparian Vegetation Condition Index scores and associated RCI condition grades are shown in Table 10.

Table 10 **Riparian Vegetation Condition Index scores and associated River Condition Index (RCI) grades**

Index score	RCI grade
0.0 to <0.2	Very poor
0.2 to <0.4	Poor
0.4 to <0.6	Moderate
0.6 to <0.8	Good
0.8 to 1.0	Very good

5.5 Results and discussion

5.5.1 General riparian vegetation

Tree demographics

Due to the low number of sites surveyed (34), diameter at breast height (DBH) data were pooled for all adult trees (DBH ≥10 cm) for all sites for each PCT, regardless of

subcatchment. Demographics at the site and plot scale are found in Appendix D and Appendix E.

River red gum in PCT 11 approximated the 'reverse-J' shape when data were pooled across sites (Figure 7), indicating a healthy demographic distribution. The reverse-J distribution is also evident in the black box population in PCT 13 (Figure 8) and the black box and river red gum populations in PCT 10 (Figure 9). However, due to the small number of sites surveyed these distributions cannot be fully relied upon to assess the health of the demographic distribution.

In all PCTs most dead trees were in the smallest size class (10 to 20 cm) indicating that these trees may have died during the Tinderbox Drought of 2017 to 2019.

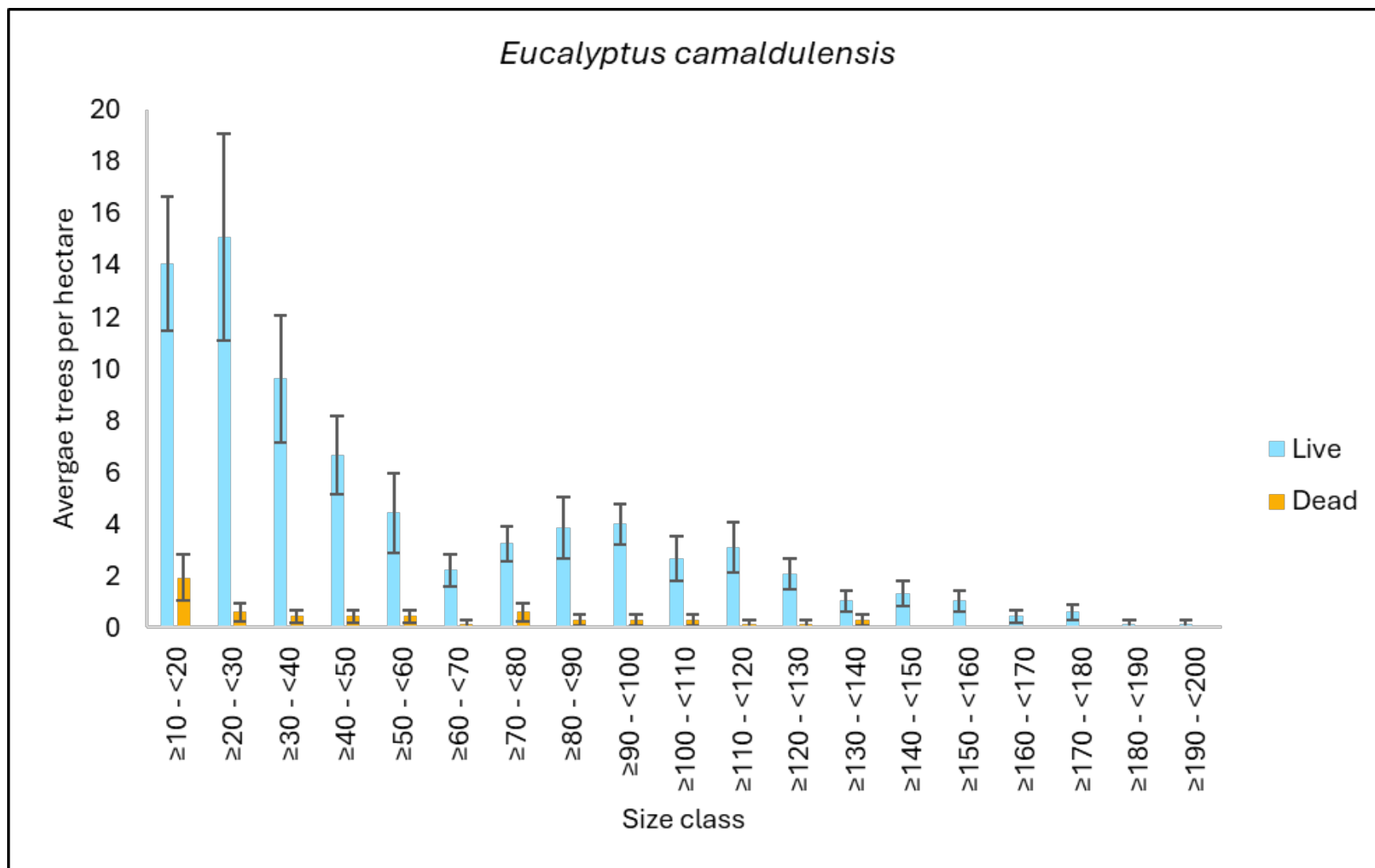


Figure 7 The mean ($\pm$ SE) river red gum (*Eucalyptus camaldulensis*) trees per hectare in PCT 11 in the study area

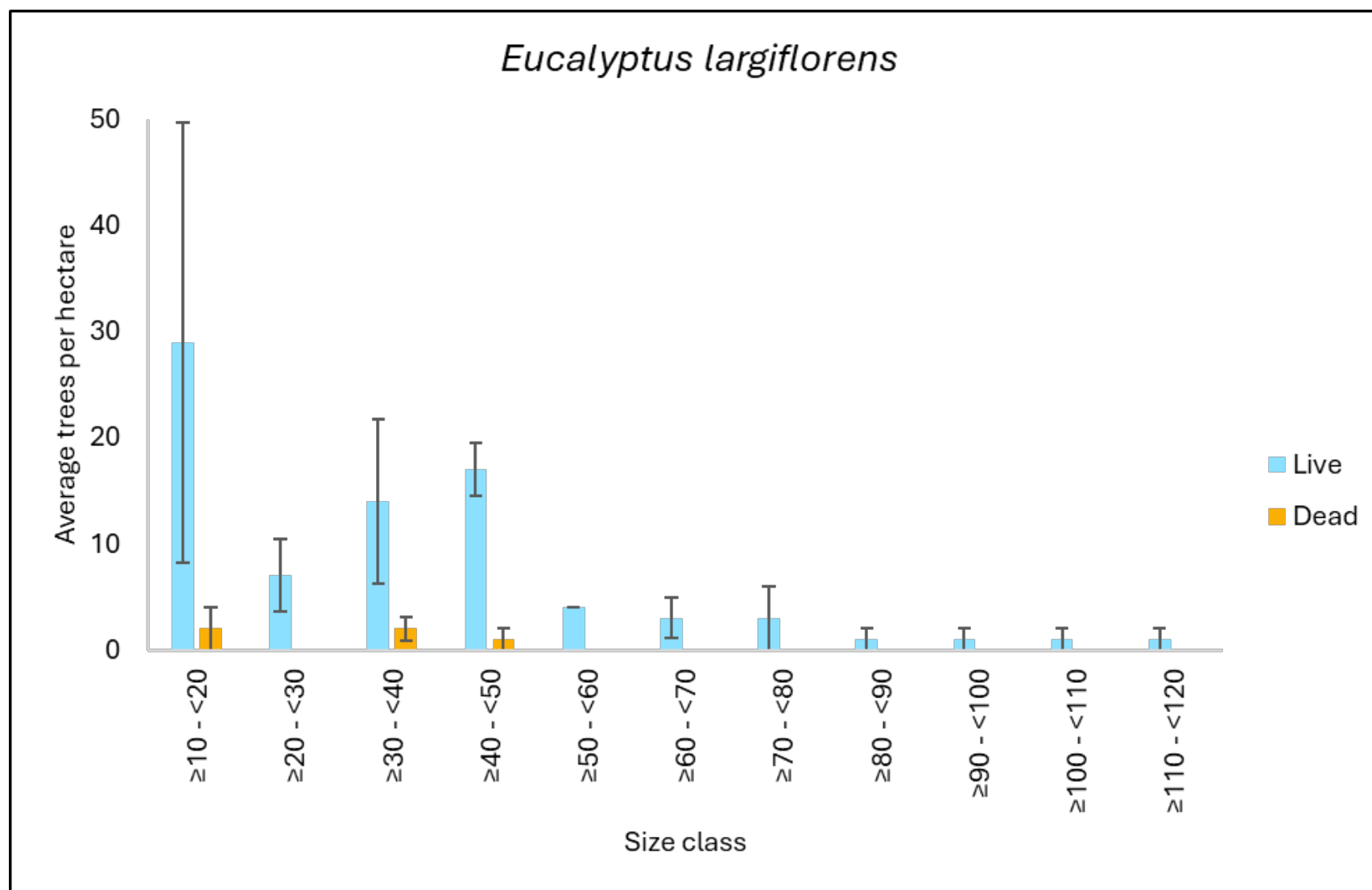


Figure 8 The mean ($\pm$ SE) black box (*Eucalyptus largiflorens*) trees per hectare in PCT 13 in the study area

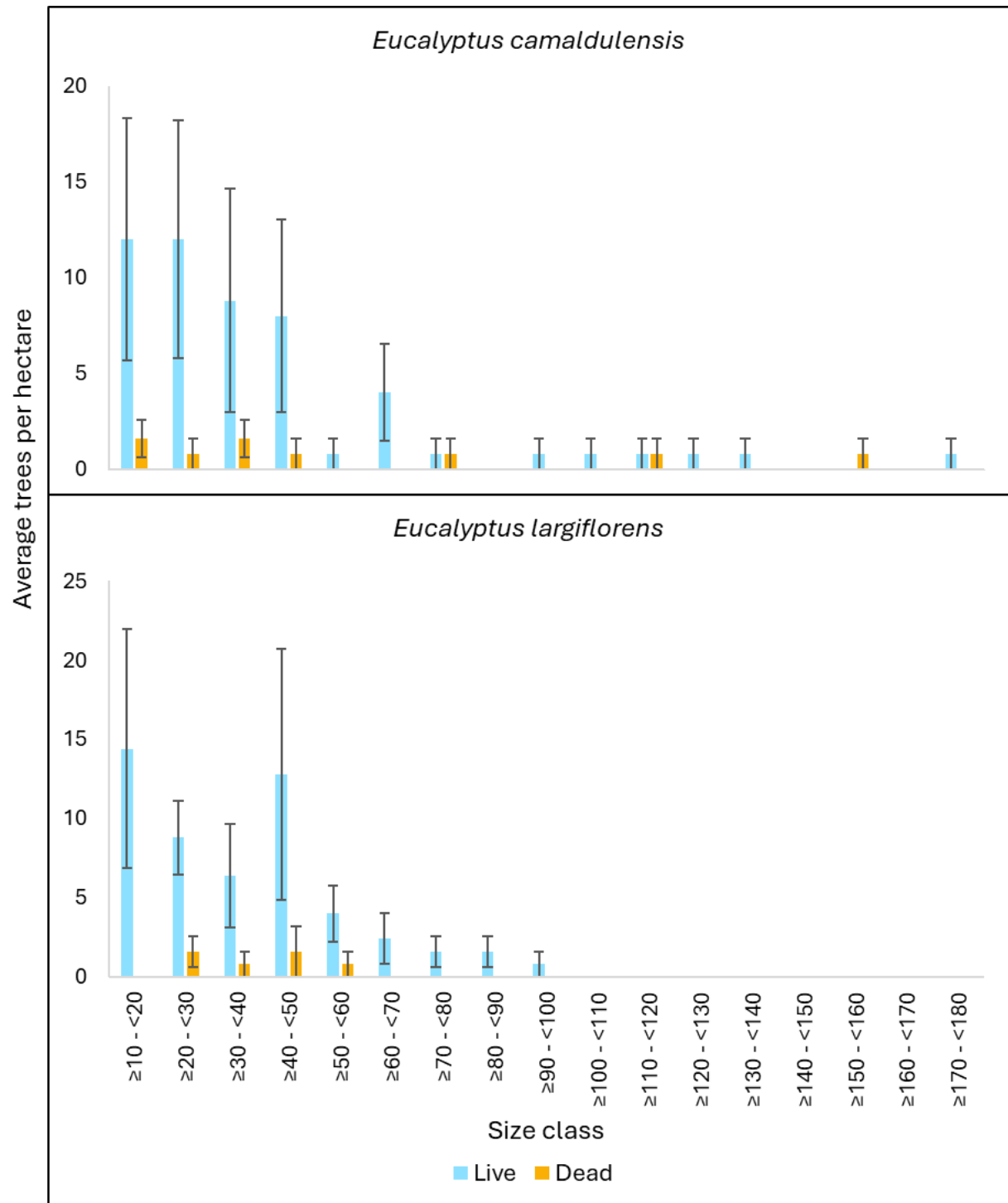


Figure 9 The mean (±SE) river red gum (*Eucalyptus camaldulensis*) (top) and black box (*Eucalyptus largiflorens*) (bottom) trees per hectare in PCT 10 in the study area

Population viability

Data suggest that several of the PCTs may not be viable into the future. The viability of river red gum and black box populations in all 3 PCTs needs to be further assessed. The modelled intercept value for the models presented were calculated to assess the average number of trees per hectare that would be expected in the juvenile size class (0 to 10 cm DBH) required for the population to be considered viable into the future. Recruit data at the plot level is in Appendix F.

The river red gum – lignum woodland population (PCT 11) closely adhered to the log-normal model ($R^2 = 0.89$, $p < 0.001$) indicating that the current population structure is viable (Figure 10). Since this analysis has been conducted with a sample size of 27 sites, this conclusion can be made with moderate-high confidence. However, the modelled number of juvenile river red gum trees in PCT 11 was 30 trees per hectare, with only an average of 5.6 river red gum recruits per hectare in PCT 11 sites (Table 11). Therefore, this population is likely to not be viable in the future.

The black box woodland population (PCT 13) appears to adhere to the log-normal model ($R^2 = 0.74$, $p < 0.001$) (Figure 11). The modelled intercept value for black box in PCT 13 was 56 trees per hectare. However, there was an average of 7 black box recruits per hectare recorded (Table 11). Therefore, this population cannot be considered viable in the future. As this analysis is only based on 4 sites, further sites and survey effort are required to fully assess the future viability of this population.

The river red gum – black box woodland population (PCT 10) appears to adhere to the log-normal model suggesting a level of viability for the current population structure (river red gum: $R^2 = 0.82$, $p < 0.001$; black box: $R^2 = 0.75$, $p = 0.002$) (Figure 12). In PCT 10, the modelled intercept value was 27 trees per hectare for river red gum and was 34 trees per hectare for black box, however, there was an average of 3.2 river red gum recruits and 0 (zero) black box recruits per hectare across all PCT 10 sites (Table 11). Therefore, this population is currently unlikely to remain viable in the future. However, this analysis is only based on 5 sites, therefore, further sites and survey effort are required to fully assess the future viability of this population.

Based on the available data, the future viability of these populations appears uncertain. Low numbers of river red gum and black box recruits across each PCT indicate these populations may not be viable into the future. As there were only 4 sites of PCT 13 and 5 sites of PCT 10, the number of sites may be insufficient to confidently assess future population viability. This finding reflects the lower community condition results which show that most sites have few juvenile trees in the mid or lower strata leading to lower community condition scores.

Table 11 **The average number of juvenile river red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) trees <10 cm DBH per hectare (PCTs 10, 11 and 13) in the lower Darling Baaka study area**

Species	PCT	Trees/ha modelled	Average trees/ha recorded
River red gum	10	27	3.2
Black box	10	34	0
River red gum	11	30	5.6
Black box	13	56	7.0

Table note: PCT 10 = River red gum (*Eucalyptus camaldulensis*) – black box (*E. largiflorens*) woodland.

PCT 11 = River red gum (*E. camaldulensis*) – lignum (*Duma florulenta*) forest/woodland.

PCT 13 = Black box (*E. largiflorens*) – lignum (*D. florulenta*) woodland wetland.

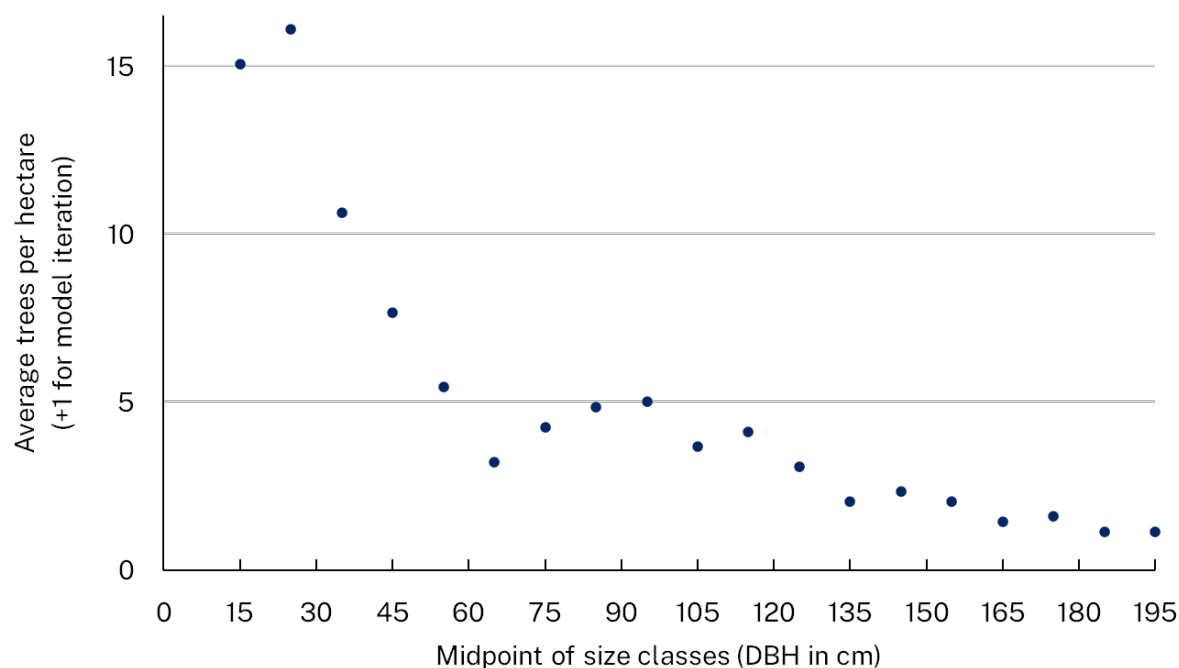


Figure 10 Extant population structure and viability of river red gum (*Eucalyptus camaldulensis*) populations in PCT 11 (27 sites) in the lower Darling Baaka. Confidence is moderate-high, where extant population appears viable

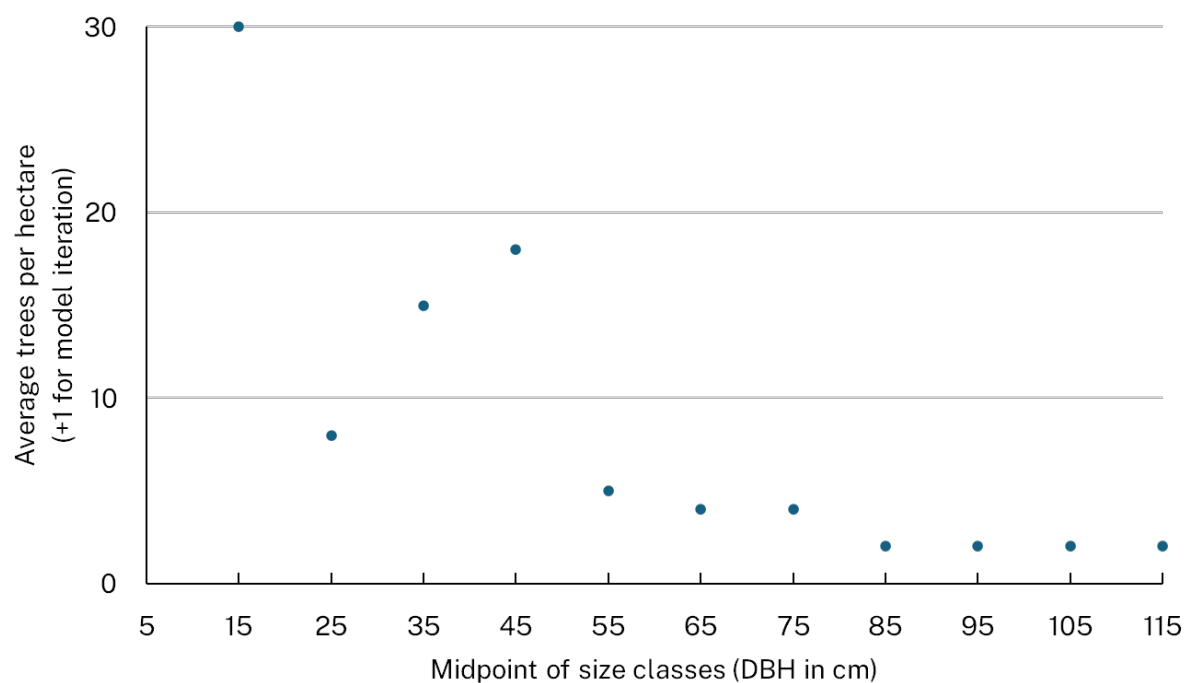


Figure 11 Extant population structure and viability of black box (*Eucalyptus largiflorens*) populations in PCT 13 (4 sites) in the lower Darling Baaka. Confidence is low, where extant population may be viable, but there is a low number of sites

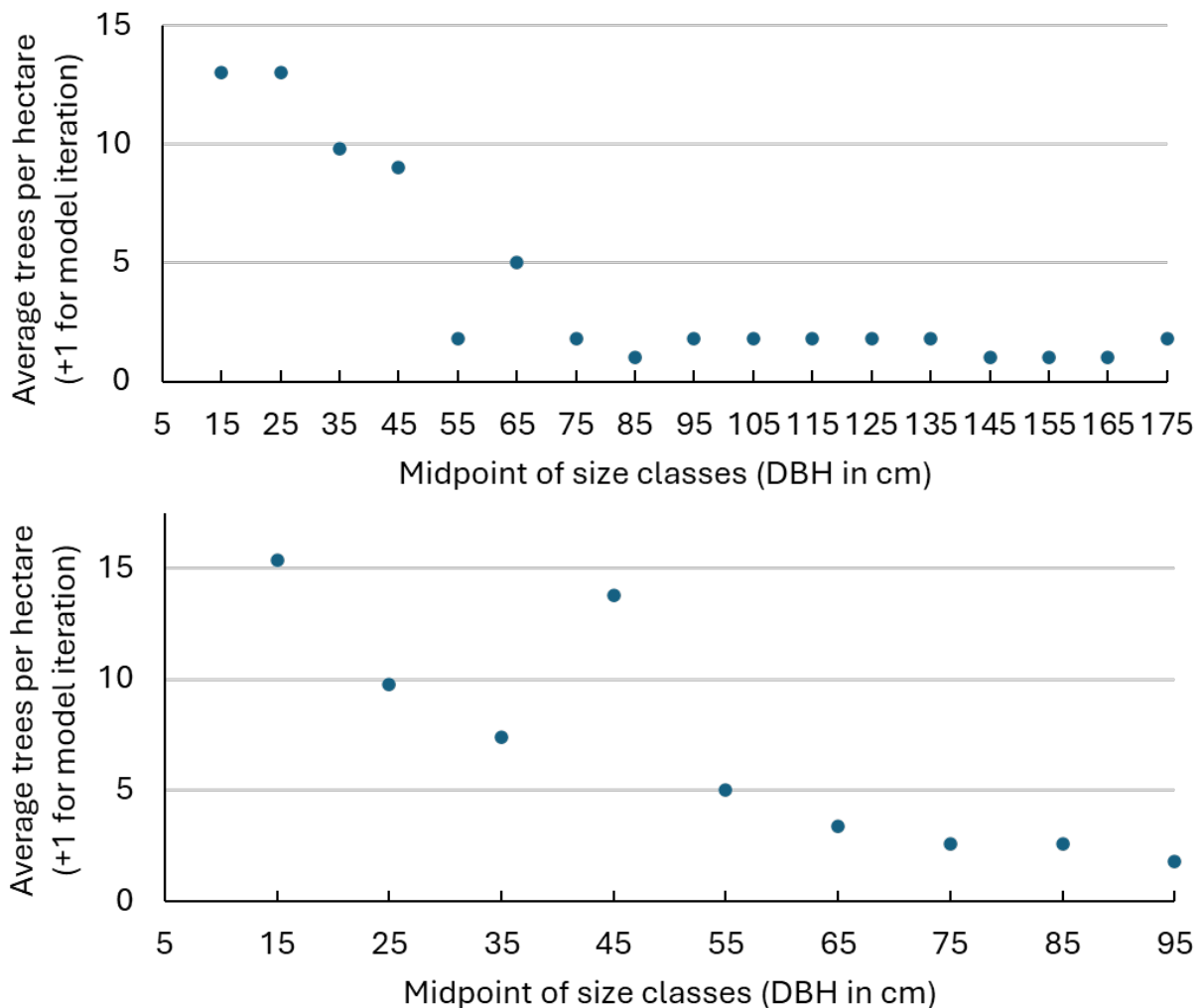


Figure 12 Extant population structure and viability of river red gum (*Eucalyptus camaldulensis*, top panel) and black box (*Eucalyptus largiflorens*, bottom panel) populations in PCT 10 (5 sites) in the lower Darling Baaka. Confidence for both species is low, where extant population may be viable, but there is a low number of sites

5.5.2 Floristic condition indicator

Community condition sub-indicator

On average, across the study region river red gum – black box woodland sites (PCT 10) and river red gum – lignum woodland sites (PCT 11) were in moderate condition. Black box wetland woodland sites (PCT 13) were in intermediate or good condition (Table 12). No subcatchment or individual site was assessed as having vegetative community condition in an excellent state. Rather most subcatchments (7/11 assessed catchments) recorded a ‘moderate’ community condition classification, indicating that water requirements of the dominant species are not often being met and the community may contain exotic species, dead trees and canopy and/or the percent foliage cover is less than expected for that plant community type. The highest condition classes recorded in

the entire study region was from site S31, Black box-lignum woodland wetland community (PCT 13), in Cawndilla subcatchment.

In the sites that were in poor community condition, there was a low percentage foliage cover of wetland plant species, a high percentage cover of bare ground and litter (up to 99%), an absence of the indicator species in mid or lower stratum, and high percentage foliage cover of exotic species (Table 12). The regions of concern for low community condition were the subcatchments of Lower Redbank Creek (site S29) on the Great Darling Anabranch and the subcatchments of Downstream Poongcarie and Cuthero Creek on the Darling Baaka River.

Within the study area, all sites recorded low to very low scores for mid and lower strata indicator species, indicating an absence of strata layers in the overall community (Table 12). There were also several sites which had low or absent indicator canopy species (i.e. river red gum and black box in PCT 10 sites, river red gum in PCT 11 sites, or black box in PCT 13 sites). Combined, this data implies that the long-term viability of the communities across the study area is poor, as there is little recruitment of new individuals into the adult population over time.

Table 12 Results of community condition analysis for plant community types (PCT) by subcatchment

Note: the bare ground/litter and lower stratum percent foliage cover metrics were adjusted at every site, duplicate samples were taken at some sites.

Subcatchment	PCT	RCI site numbers	Indicator species: tall stratum	Indicator species: mid stratum	Indicator species: lower stratum	Bare ground and litter	Invasive woody chenopods	Exotics	Average of native wetland functional species	Mean community condition score	Community condition grade
Darling Baaka River subcatchments											
Lake Woytchugga	11	S2, S3	27.50	0.00	0.00	66.00	0.00	1.20	51.18	15.67	Intermediate
Lake Wetherell	10	B2	26.50	0.00	0.00	97.50	0.00	0.35	34.25	13.50	Moderate
Lake Wetherell	11	S10, S14	25.83	0.33	0.00	65.50	0.52	8.38	33.77	14.50	Moderate
Downstream Weir 32	11	S16	29.17	0.00	0.02	75.00	3.03	6.07	25.33	14.50	Moderate
Cuthero Creek	11	S18	21.50	0.00	0.00	93.00	0.00	8.20	2.55	10.50	Poor
Upstream Pooncarie	11	S19	10.00	0.00	0.00	83.50	0.00	2.05	12.35	13.00	Moderate
Downstream Pooncarie	11	S21, S22	30.00	0.00	0.00	81.75	0.53	1.50	16.90	12.75	Intermediate
Great Darling Anabranh subcatchments											
Cawndilla	11	S15	37.50	0.00	0.00	95.00	0.05	12.60	6.75	10.00	Poor
Cawndilla	13	S31	30.00	0.00	7.50	26.00	1.50	1.15	67.10	18.50	Good
Lower Redbank Creek	11	S29	15.00	0.00	0.00	20.00	0.00	42.85	0.90	11.50	Poor
Anabranh North	10	S27	20.00	0.00	0.00	74.50	0.00	43.80	32.25	13.50	Moderate
Warrawenia Lake	10	S26	15.00	0.00	0.00	99.00	0.00	4.30	16.20	13.50	Moderate
Lower Anabranh	13	S25	20.00	0.00	0.00	72.00	0.00	0.30	55.00	15.50	Intermediate

Subcatchment	PCT	RCI site numbers	Indicator species: tall stratum	Indicator species: mid stratum	Indicator species: lower stratum	Bare ground and litter	Invasive woody chenopods	Exotics	Average of native wetland functional species	Mean community condition score	Community condition grade
Talyawalka Creek subcatchments											
All subcatchments			n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

Table note: n.d.= no data available for these metrics.

Tree stand condition sub-indicator

Tree condition surveys were completed at 34 sites, representing 17 subcatchments across the study area. Data from each PCT was analysed by subcatchment, although some subcatchments only contained one site (Table 13). Data are also presented at the site scale in Appendix I.

Sites ranged from intermediate to excellent tree stand condition (Table 13). S29 and S31, located on the Anabranck, were the only sites in the study area to receive an excellent tree stand condition classification. However, due to wet weather events and logistical constraints, the percent dead canopy scores were estimated at 0% in sites which may have resulted in over estimation of tree stand condition at these sites (see Appendix J). Several sites upstream of Poongcarie were classified as having good tree stand condition.

Overall, the dead canopy percent was low across all sites, and the percentage live basal area was high indicating that most of the larger trees were alive. Together, these 2 attributes were the primary drivers of the high tree stand condition scores achieved for this survey. The percentage foliage cover and percentage dead limbs were the attributes with the highest variance between sites (Table 13).

Several subcatchments had sites with moderate tree condition, indicating the water requirements of the dominant species are not often being met. These were mainly on the floodplains of Talyawalka Creek, where there were a high number of dead limbs and dead canopy within trees. These areas were also noted as having several mature trees, and high numbers of saplings. However, trees in the middle age range were absent. This may indicate that saplings are not maturing into larger trees at these sites.

Groundwater levels average around 9 m (Figure 13) at all gauged bores. Adult trees are likely accessing groundwater and river base flows, and this is likely to explain the higher scores for tree stand condition than community condition. However, as mentioned above, it appears saplings are dying before they can access this vital groundwater due to lack of water in between major floods indicating issues with the long-term viability of tree communities in the study area.

The very important metric for condition analysis, percent dead canopy, was not assessed at 5 sites in the field due to time constraints and weather conditions (see Appendix J). Some sites were also excluded as the percent foliage cover that was recorded was incorrectly recorded (see Appendix J).

Table 13 Results of tree stand condition analysis for 3 plant community types (PCT) by subcatchment. For site locations see Figure 2

Subcatchment	RCI subcatchment	PCT	Site number	%FC	%DL	%DC	%LBA	Tree stand condition score	Tree stand condition grade
Lower Paroo	3411	11	S1 ^Λ , a ^Λ	33.00	1.00	60.00	–	18.0	Good
Lake Woytchugga	3254	11	S2 S3	16.20	1.90	12.41*	99.85	18.0	Good
Wilcannia Downstream	3249	11	S4 ^Λ , S5 ^Λ , S7 ^Λ , j ^Λ , l ^Λ	60.00	17.00	34.00	–	16.6	Intermediate
Lake Wetherell	1483	10	B2	4.24	0.00	0.78*	100.00	19.0	Good
Lake Wetherell	1483	11	S9 ^Λ , S10, S14, S14.1, n ^Λ , q ^Λ	31.89	2.50	10.97*	94.68	19.3	Good
Downstream Weir 32	1518	11	S16, S16.1, S16.2	72.06	8.70	18.70	92.22	18.3	Good
Cuthero Creek	1514	11	S18	67.52	7.91	10.36	99.99	19.0	Good
Upstream Pooncarie	1484	11	S19	36.15	10.73	29.38	95.79	17.0	Intermediate
Downstream Pooncarie	1475	11	S21, S22	45.59	14.00	14.96	92.82	17.0	Intermediate
Cawndilla	1477	11	S15	37.61	0.00	0.00*	100.00	20.0	Excellent
Cawndilla	1477	13	S31	13.96	17.00	5.56	99.51	18.0	Good
Lower Redbank Creek	1476	11	S29	46.21	1.40	0.00*	100.00	20.0	Excellent
Anabranh North	1473	10	S27	31.84	14.84	20.05	76.58	16.0	Intermediate
Warrawenia Lake	1467	10	S26	27.91	17.18	28.79	91.63	16.0	Intermediate
Lower Anabranh	1521	13	S25	12.59	19.98	21.67	95.18	17.0	Intermediate
Upper Talyawalka Creek	3251	39	i ^Λ	19.00	4.00	80.00	n.a.	14.17	Moderate
Lower Three Mile Creek	1531	10	k ^Λ	28.10	11.30	72.00	n.a.	14.3	Moderate
Lower Talyawalka Creek	1530	13	m ^Λ , o ^Λ	20.05	23.91	73.44	n.a.	13.1	Moderate

Subcatchment	RCI subcatchment	PCT	Site number	%FC	%DL	%DC	%LBA	Tree stand condition score	Tree stand condition grade
Charlie Stones Creek	1482	10	p^	37.73	16.19	62.10	n.a.	15.5	Intermediate

Table notes:

FC = foliage cover; DL = dead limbs; DC = dead canopy; LBA = live basal area; n.a. = data not available for these sites.

* Percent dead canopy (%DC) has been estimated for some sites within these subcatchments (see Appendix J). ^ Tree condition only recorded, no full floristic plots conducted.

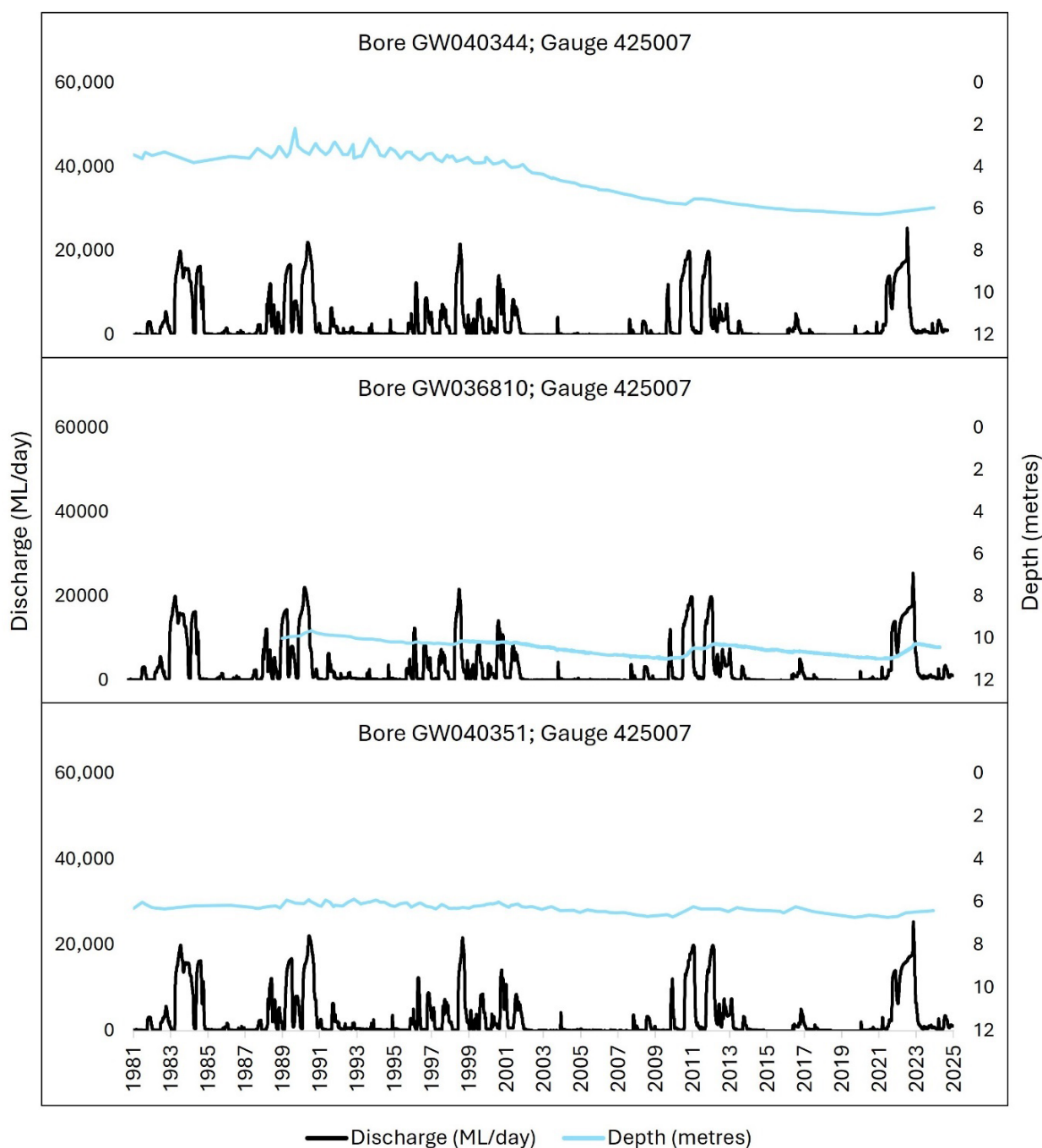


Figure 13 Groundwater levels and river discharges at selected groundwater bores in the lower Darling Baaka

Combined floristic condition sub-indicator scores

The results of combining the community condition and tree stand condition sub-indicator scores are presented in Table 14. Of the 17 subcatchments that were assessed for floristic condition, the vast majority displayed a moderate condition, which indicates impairment in the overall riparian vegetation condition in these sites. Sites commonly recorded dead trees, low percent foliage cover and lower stratum cover than would be expected for their respective PCTs. However, four subcatchments recorded good

overall floristic condition indicating good community health. These included the catchments of Lower Paroo, Lake Wetherell and Downstream weir 32 on the Darling Baaka River, and Cawndilla catchment on the Anabranch (Table 14).

Several sites displayed poor health in community condition but good health in tree stand condition. The averaging of these indices into the combine floristic condition indicators may mask the true health and riparian condition at several sites. Adult trees in the Great Darling Anabranch and the Darling Baaka River subcatchments have been assessed as in intermediate to excellent condition (Table 14). This is potentially linked to adult trees accessing groundwater and base flows during dry times. However, this was not the case in the Talyawalka subcatchments, where tree condition was assessed as moderate indicating the requirements of trees are not being met. The lack of young trees and the high percentage cover of bare ground and litter at many sites in this region indicates that the water needs of the immature trees and other species in the lower strata of the community have not been met and/or other stressors are impacting the overall community condition.

The comparatively high scores for tree stand condition when compared to community condition may indicate that the full floristic plot method used to calculate community condition is a better method for assessing overall vegetation (Figure 14). Community condition assesses all layers of the community as well as the recruitment of species and the number of invasive species. It is recommended that future assessments of condition complete a full floristic assessment as a field method for assessing riparian vegetation condition.

In the calculations of overall floristic condition, community condition scores were given 60% weighting and tree condition scores were given 40% weighting because of the importance of measuring understorey and groundcover growth in the assessment process. Where community condition scores were not available (due mainly to wet weather events), tree stand scores were used, however as this does not assess detailed floristics and invasive species, the limitations with this method must be acknowledged.

Table 14 Combined floristic condition indicator scores for each subcatchment

Subcatchment	RCI subcatchment	PCT	Tree stand condition score	Community condition score	Floristic condition score (RCI adjusted)	Riparian Vegetation Condition Index grade
Darling Baaka River subcatchments						
Lower Paroo	3254	11	14.8	n.a.	0.58#	Good
Lake Woytchugga	3411	11	18.0	14.2	0.65	Moderate
Wilcannia Downstream	32419	11	16.6	n.a.	0.71#	Moderate
Lake Wetherell	1483	10/11	19.0	14.0	0.67	Good
Downstream Weir 32	1518	11	18.3	14.5	0.67	Good
Cuthero Creek	1514	11	19.0	10.5	0.52	Moderate
Upstream Pooncarie	1484	11	17.0	13.0	0.57	Moderate
Downstream Pooncarie	1475	11	17.0	12.75	0.56	Moderate
Great Darling Anabranh subcatchments						
Cawndilla	1477	11/13	20.0	14.25	0.68	Good
Lower Redbank Creek	1476	11	20.0	11.5	0.59	Moderate
Anabranh North	1473	10	16.0	13.5	0.56	Moderate
Warrawenia Lake	1476	10	16.0	13.5	0.56	Moderate
Lower Anabranh	1521	13	17.0	15.5	0.68	Moderate
Talyawalka Creek subcatchments						
Upper Talyawalka Creek	3251	39	14.2	n.a.	0.54#	Moderate

Subcatchment	RCI subcatchment	PCT	Tree stand condition score	Community condition score	Floristic condition score (RCI adjusted)	Riparian Vegetation Condition Index grade
Lower Three Mile Creek	1531	10	14.3	n.a.	0.54#	Moderate
Lower Talyawalka Creek	1530	13	13.1	n.a.	0.47#	Moderate
Charlie Stones Creek	1482	10	15.5	n.a.	0.63#	Moderate

indicates only tree stand condition data were used; n.a. = no data available for these sites.

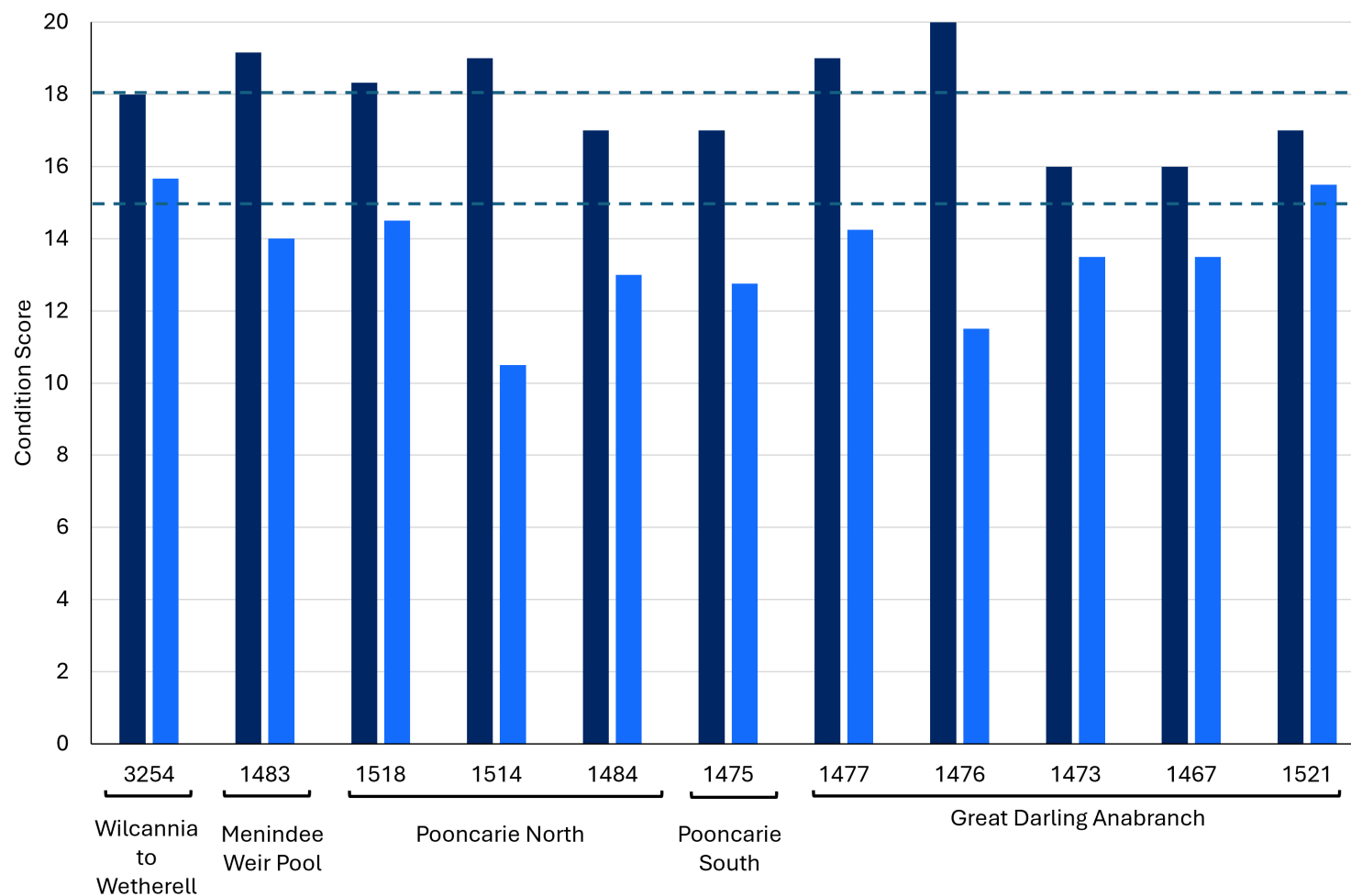


Figure 14 Comparison of tree stand condition (dark blue) and community condition (light blue) within the study area

Numbers represent subcatchment number. Dotted lines represent good or very good condition (upper line >18) and poor or very poor condition (lower line <15)

5.5.3 Rapid riparian condition assessments indicator

General characteristics

Rapid appraisal of riparian condition (RARC; Jansen et al. 2005) surveys were conducted at 53 sites, in 21 subcatchments (Table 15). Results ranged from very poor to very good riparian condition.

The subcatchments of Cawndilla (1477), Anabran North Lakes (1474) and Downstream Weir 32 (1518) indicated very good scores using the RARC methodology (Figure 15; Figure 16). These sites displayed recruitment and included both understorey and groundcover vegetation layers, although only one site was surveyed in catchment 1518.

The subcatchments around Talyawalka Creek indicated poor to very poor riparian condition. The primary reasons for this were lower abundances of hollow-bearing trees, low percentage of native understorey groundcover and low percentages of native leaf litter. These factors indicate that the overall condition of the sites are dissimilar to the reference condition. These sites were located on the floodplains of Talyawalka Creek, and the creek was dry at the time of sampling. It was also noted that at these sites there were numerous saplings and larger trees, however the mid-age ranged trees were absent. This indicates threats to the long-term viability of native river red gum and black box communities in these regions and aligns with the findings from the floristic condition indicators.

The other subcatchments observed to be in poor condition were: Wilcannia Downstream (3249), Cuthero Creek (1514), Warrawenia Lake (1476) and Lower Yampool Creek (1515). In several of these subcatchments sites were located on very steep banks which are not conducive to the growth of understorey or groundcover. These banks tended to be unvegetated, and there were limited to no signs of native regeneration occurring within these sites. All these factors lead to the evaluation that these subcatchments are displaying poor riparian condition.

Table 15 Standardised rapid appraisal of riparian condition (RARC) scores by subcatchment. For site numbers see Figure 3

Subcatchment	Subcatchment number	No. of sites sampled	Site numbers	PCT	RARC standardised score	RARC condition grade
Darling Baaka River subcatchments						
Lower Paroo	3254	2	S1, a	11	0.72	Good
Lake Woytchugga	3411	2	S2, S3	11	0.47	Intermediate
Wilcannia Downstream	3249	5	S4-8	11	0.34	Poor
Lake Wetherell	1483	8	S9-S14, S14.1, B2	10	0.44	Intermediate
Downstream Weir 32	1518	3	S16, S16.1, S16.2	11	0.81	Very good

Subcatchment	Subcatchment number	No. of sites sampled	Site numbers	PCT	RARC standardised score	RARC condition grade
Lower Yampoola Creek	1515	2	S17, b	11	0.37	Poor
Cuthero Creek	1514	3	S18, c, d	11	0.23	Poor
Upstream Pooncarie	1484	2	S19, S20	11	0.58	Intermediate
Downstream Pooncarie	1475	2	S21, s22	11	0.54	Intermediate
Palinyewah	1504	1	S32	10/11	0.58	Intermediate
Lower Darling	1512	3	S23, e, f	11	0.53	Intermediate
Great Darling Anabranh subcatchments						
Cawndilla	1477	3	S15, s30, s31	11	0.51	Very good
Lower Redbank Creek	1476	1	S29	11	0.79	Good
Anabranh North Lakes	1474	1	S28	10	1	Very good
Anabranh North	1473	1	S27	10	0.45	Intermediate
Warrawenia Lake	1467	2	S26, h	10	0.35	Poor
Lower Anabranh	1521	3	S25, S24, g	13	0.65	Intermediate
Talyawalka Creek subcatchments						
Upper Talyawalka Creek	3251	2	i, j	39	0.16	Very Poor
Lower Three Mile Creek	1531	2	k, l	10	0.36	Poor
Lower Talyawalka Creek	1530	3	m, n, o	13	0.34	Poor
Charlie Stones Creek	1482	2	p, q	10	0.73	Good



Figure 15 **A:** Black box plot near Cawndilla Channel (subcatchment 1474) indicating 3 vegetation layers **B:** River red gum open forest adjacent to the Darling Baaka at Kincheha National Park (subcatchment 1518)

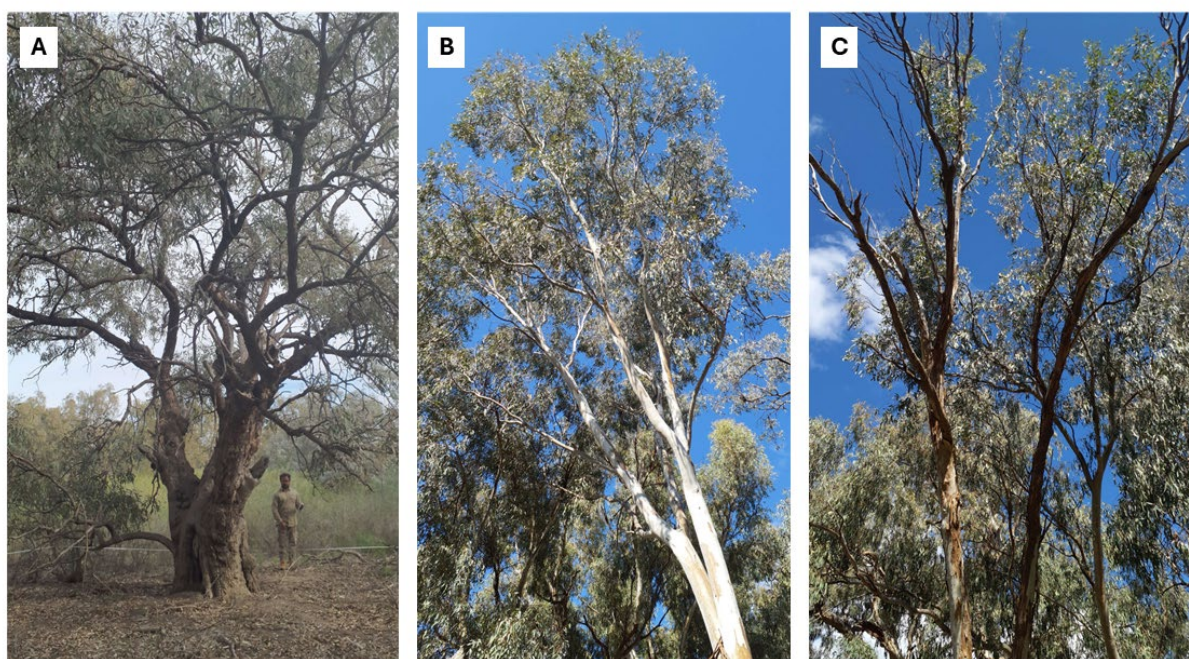


Figure 16 **Plant communities in the study area. A:** A larger (and older) black box (*Eucalyptus largiflorens*), with good foliage cover at the crown. **B:** A younger river red gum (*Eucalyptus camaldulensis*) tree with good foliage cover at the crown (subcatchment 1518). **C:** A younger river red gum tree with less foliage cover at the crown, indicating poorer tree health (subcatchment 1484)

5.5.4 Spatial vegetation condition indicator

Results for the remote sensing derived riparian vegetation condition indicator scores for each subcatchment are provided in Table 16. Condition of riparian and floodplain vegetation was found to be good at 12 subcatchments, moderate at 13 subcatchments and poor at 3 subcatchments.

Subcatchments located in northern areas of study area, around Wilcannia, were found to be mostly in good condition. There was a decline in riparian condition as the Darling Baaka River flowed downstream, with the sites downstream of Pooncarie displaying poorer riparian condition. The explanation for this trend requires further investigation. However, as riparian and floodplain vegetation is dependent on intermittent surface water inundation, and the remote sensing datasets are sensitive to vegetation greenness and biomass, the observed trend may be related to the history of rainfall, river flows and availability (frequency, timing and duration) of surface water to floodplain vegetation communities over recent years and decades.

Interestingly, spatial modelling indicated that the vegetation condition in 4 of the 6 subcatchments along Talyawalka Creek were in good condition. This conflicts with both the floristic plot and rapid riparian condition assessments, which indicated very poor to moderate condition in these subcatchments. It is possible that the spatial data analysis was recording high productivity from the existing trees in these subcatchments, However, the on-ground assessment indicated few hollow-bearing trees, and limited understorey and groundcover vegetation, and indicated that there were few medium-sized trees in the region. These results could also indicate low sampling effort in the region. Nonetheless, this highlights the importance of using spatial analysis and field verification together to assess vegetation condition.

Table 16 Proportion of riparian and floodplain vegetation in different condition classes and overall condition grades

Subcatchment name	Subcatchment number	% very poor	% poor	% moderate	% good	% very good	Spatial vegetation condition score	Condition grade
Darling Baaka River subcatchments								
Lower Paroo	3411	0.11	6.75	24.22	39.24	29.69	0.73	Good
Lake Woytchugga	3254	0.07	2.93	25.58	43.98	27.44	0.74	Good
Wilcannia downstream	3249	0.29	5.84	30.27	47.33	16.28	0.68	Good
Lake Wetherell	1483	1.48	9.89	27.25	37.69	23.69	0.68	Good
Downstream Weir 32	1518	0.38	5.99	31.78	46.09	15.77	0.68	Good
Lower Yampoola Creek	1515	1.17	12.72	36.46	39.13	10.51	0.61	Good
Cuthero Creek	1514	4.29	35.97	43.87	14.67	1.20	0.43	Moderate
Upstream Pooncarie	1484	2.73	25.41	47.67	22.68	1.52	0.49	Moderate
Downstream Pooncarie	1475	17.31	36.57	34.31	10.80	1.01	0.35	Poor
Palinyewah	1504	14.80	37.82	37.03	9.74	0.61	0.36	Poor
Lower Darling	1512	3.72	31.51	41.62	21.16	1.98	0.47	Moderate
Murray–Darling Confluence	1507	2.94	19.32	42.67	30.61	4.47	0.54	Moderate

Subcatchment name	Subcatchment number	% very poor	% poor	% moderate	% good	% very good	Spatial vegetation condition score	Condition grade
Great Darling Anabranh subcatchments								
Cawndilla	1477	0.44	5.83	27.91	43.84	21.99	0.70	Good
Lower Redbank Creek	1476	0.70	11.94	39.80	36.63	10.94	0.61	Good
Anabranh North Lakes	1474	2.02	26.84	45.86	23.00	2.28	0.49	Moderate
Coonalhugga Creek	1481	2.14	21.84	42.43	29.77	3.82	0.53	Moderate
Popio	1522	2.40	20.69	47.70	25.23	3.97	0.52	Moderate
Anabranh offtake	1516	1.22	25.49	49.43	21.81	2.05	0.49	Moderate
Anabranh North	1473	2.63	26.71	48.95	19.11	2.60	0.48	Moderate
Lake Milkengay	1495	4.62	38.45	45.13	10.21	1.59	0.41	Moderate
Warrawenia Lake	1467	5.40	33.45	44.47	15.07	1.61	0.44	Moderate
Lower Anabranh	1521	11.36	42.44	35.48	9.99	0.72	0.37	Poor
Talyawalka Creek subcatchments								
Upper Talyawalka	3251	0.63	8.42	39.48	40.50	10.97	0.63	Good
Middle Talyawalka	3248	1.56	17.81	48.42	27.41	4.79	0.54	Moderate
Lower 3 mile Creek	1531	0.27	9.27	31.80	38.10	20.57	0.67	Good

Subcatchment name	Subcatchment number	% very poor	% poor	% moderate	% good	% very good	Spatial vegetation condition score	Condition grade
Lower Talyawalka	1530	1.10	14.89	35.53	32.22	16.27	0.62	Good
Yampoola Creek	1480	1.32	15.75	37.38	36.13	9.41	0.59	Moderate
Charlie Stone Creek	1482	0.53	9.12	32.63	40.42	17.29	0.66	Good

5.6 Overall Riparian Vegetation Condition Index

The 3 indicators described in section 5.5 were combined to give an overall riparian vegetation condition score which correlated to the riparian vegetation indicator grade (Table 17). All 28 subcatchments were assessed in this indicator, with the majority being classified in moderate condition, indicating that there are deviations away from the natural condition (Figure 17).

Three subcatchments had an overall grade of poor, indicating that river health is being impacted by riparian vegetation condition in these areas. The subcatchments Lower Yampoola Creek (site S17) and Cuthero Creek (site S18) are situated on the Darling Baaka River. Both of these subcatchments have been assessed with poor hydrological condition (see Chapter 7). The subcatchment of Upper Talyawalka Creek has also been assessed as having poor riparian vegetation condition. This subcatchment also has very poor hydrological condition (Chapter 7).

Six subcatchments have been assessed as having good riparian condition. Two of these subcatchments displayed good hydrological condition (Lower Paroo and Downstream Weir 32), with the other 4 subcatchments displaying a variety of hydrological stress (Cawndilla, Lower Redbank Creek, Lower Anabranck and Charlie Stones Creek) (Figure 17). All of the subcatchments with good riparian condition had several vegetation strata and showed some signs of recruitment of canopy trees.

The site in Anabranck North Lakes (site S28) was recorded as having very good riparian condition. This site was one of the few with biodiversity condition recorded in a good state and hydrological stress recorded as moderate.

It should be noted that more work needs to be completed in assessing riparian vegetation and the methods used to devise overall scores. There was little correlation between on-ground and spatially derived indicator scores, which is of concern as 7 sites rely on spatial analysis alone to derive riparian vegetation condition scores. This may result in an unreliable riparian vegetation health assessment in these subcatchments.

Table 17 **Riparian Vegetation Condition Index (RvCI) indicators scores and associated River Condition Index (RCI) scores and grades for subcatchments of the lower Darling Baaka study area**

Subcatchment number	Subcatchment name	Floristic condition score (45%)	RARC score (45%)	Spatial vegetation condition score (10%)	RvCI score	RCI grade
Darling Baaka River subcatchments						
3411	Lower Paroo	0.58	0.72	0.73	0.66	Good
3254	Lake Woytchugga	0.65	0.47	0.74	0.58	Moderate
3249	Wilcannia Downstream	0.71	0.34	0.68	0.54	Moderate
1483	Lake Wetherell	0.67	0.44	0.68	0.57	Moderate
1518	Downstream Weir 32	0.67	0.81	0.68	0.73	Good
1515	Lower Yampoola Creek	n.a.	0.37	0.61	0.39	Poor
1514	Cuthero Creek	0.52	0.23	0.43	0.38	Poor
1484	Upstream Pooncarie	0.57	0.58	0.49	0.56	Moderate
1475	Downstream Pooncarie	0.56	0.54	0.35	0.53	Moderate
1504	Palinyewah	n.a.	0.58	0.36	0.50	Moderate
1512	Lower Darling	n.a.	0.53	0.47	0.52	Moderate
1507	Murray–Darling Confluence	n.a.	n.a.	0.54	0.54#	Moderate
Great Darling Anabranh subcatchments						
1477	Cawndilla	0.68	0.51	0.70	0.61	Good
1476	Lower Redbank Creek	0.59	0.79	0.61	0.68	Good
1474	Anabranh North Lakes	n.a.	1.0	0.49	0.95	Very good
1481	Coonalhugga Creek	n.a.	n.a.	0.53	0.53#	Moderate
1522	Popio	n.a.	n.a.	0.52	0.52#	Moderate
1516	Anabranh Offtake	n.a.	n.a.	0.49	0.49#	Moderate
1473	Anabranh North	0.56	0.45	0.48	0.50	Moderate
1495	Lake Milkengay	n.a.	n.a.	0.41	0.41#	Moderate
1467	Warrawenia Lake	0.56	0.35	0.44	0.45	Moderate

Subcatchment number	Subcatchment name	Floristic condition score (45%)	RARC score (45%)	Spatial vegetation condition score (10%)	RvCI score	RCI grade
1521	Lower Anabranh	0.68	0.63	0.37	0.62	Good
Talyawalka Creek subcatchments						
3251	Upper Talyawalka Creek	0.54	0.16	0.63	0.38	Poor
3248	Middle Talyawalka Creek	n.a.	n.a.	0.54	0.54#	Moderate
1531	Lower 3 Mile Creek	0.54	0.36	0.67	0.47	Moderate
1530	Lower Talyawalka Creek	0.47	0.34	0.62	0.42	Moderate
1480	Yampoola Creek	n.a.	n.a.	0.59	0.59#	Moderate
1482	Charlie Stones Creek	0.63	0.73	0.66	0.68	Good

Table notes: Percentages relate to the weightings given to the 3 indicator condition scores. n.a. = no data available; # = score relies on spatial dataset only.

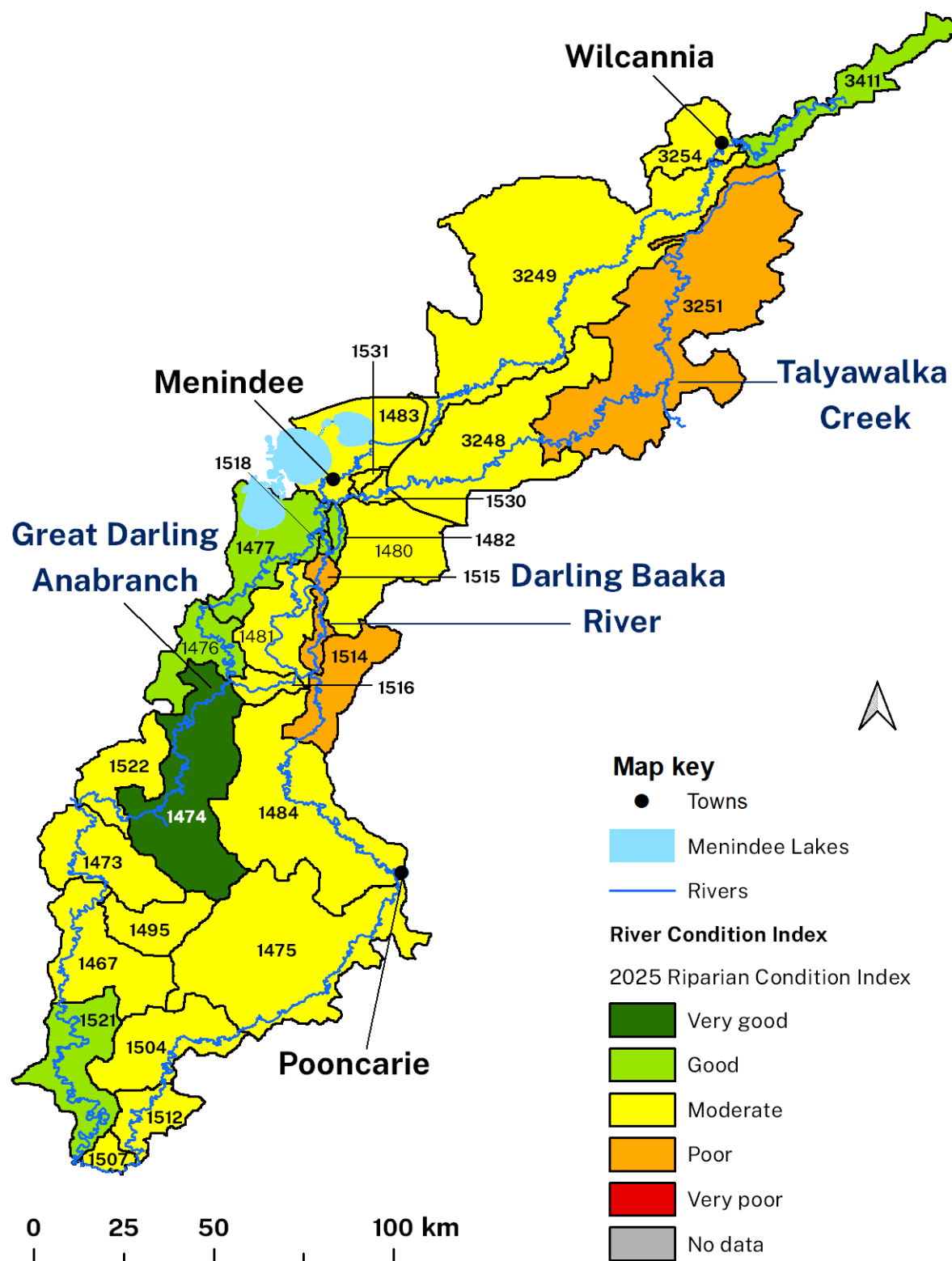


Figure 17 The 2025 Riparian Vegetation Condition Index grades for the lower Darling Baaka. Numbers refer to subcatchments (see Table 18)

5.7 Conclusion

There were 3 vegetation condition methods used to develop a condition score to be included in the overall 2025 Darling Baaka RCI. There were 2 field methods (floristic condition and a rapid assessment of riparian condition), and a desktop/remote sensing method. Overall, the Riparian Vegetation Condition Index indicated the study area was in moderate condition (19 subcatchments) with 7 subcatchments in good to very good condition and 3 subcatchments with poor riparian condition.

While the riparian vegetation within the lower Darling Baaka River system could be considered to be of moderate health, low numbers of river red gum and black box recruits across each of the 3 assessed plant community types (PCTs) indicate these populations may not be viable into the future. Despite the prevalence of mature river red gums throughout the area, many subcatchments have a lack of moderate-aged trees. The well-established mature trees have extensive root systems and are presumably accessing groundwater. Recent wet years have seen the establishment of saplings at several sites throughout the study area. However, it is of concern that these saplings do not seem to survive long enough for roots to access groundwaters, as there are very few trees between 5 and 20 years old. The recruitment of trees in the region appears limited, impacting the long-term sustainability of the tree populations. Factors such as this are not well accounted for in remote sensing or the rapid assessment of riparian condition methodology for assessing vegetation health.

As the ecotone between aquatic and terrestrial ecosystems, riparian vegetation is susceptible to long-term changes in hydrology and land uses. Changes in flood patterns and permanent inundation of floodplains due to river regulation, such as in Lake Wetherell, impact riparian vegetation by changing water levels. Hydrological shifts can also alter sediment deposits, nutrients and erosion. These patterns can be seen in various river segments between Wilcannia and Menindee Main Weir, where riparian areas have become devoid of groundcover and understorey vegetation, and the recruitment of canopy trees is limited. Other impacts on riparian condition in the region include vegetation clearing and grazing.

The results from this study have demonstrated that no single method should be used to assess riparian vegetation condition. There was a lack of correlation between remotely sensed data and on-ground vegetation surveys. However, this is not unexpected and indicates that complementary assessments of various components of vegetation condition were used. By integrating multiple new methods for assessing vegetation condition, these methods build on the 2023 Riparian Vegetation Condition Index (DPE 2023a) assessment.

Appendices

Appendix A: Community condition analysis schemas

Table 18 Community condition analysis schemas. Individual metrics (7) are allocated a category based on the benchmarks for individual PCTs. This is then converted into a community score value, all metrics are the added for each PCT to give a total score out of 20

PCT code	Attribute	Logic statement	Individual metric benchmark category* (%)				Community Score value (max score 20)			
			Excellent-Good	Intermediate-moderate	Poor	Very poor	Excellent-Good	Intermediate-moderate	Poor	Very poor
10	Bare ground and litter	%FC if growth form = bare ground or litter	≤40	>40 – ≤60	>60 – ≤80	>80	2	1.5	1	0
10	Invasive native terrestrial chenopods	%FC if growth form = CW	≤10	>10 – ≤40	>40 – ≤80	>80	4	3	2	0
10	Exotics	%FC if exotic = Y	≤10	>10 – ≤50	>50 – ≤80	>80	4	3	2	0
10	Indicator species in lower stratum	%FC if strata type = L and scientific name = <i>Eucalyptus camaldulensis</i> or <i>Eucalyptus largiflorens</i>	≥1	< 1 – ≥0.5	< 0.5 – >0	0	1.5	1	0.5	0

PCT code	Attribute	Logic statement	Individual metric benchmark category* (%)				Community Score value (max score 20)			
			Excellent-Good	Intermediate-moderate	Poor	Very poor	Excellent-Good	Intermediate-moderate	Poor	Very poor
10	Indicator species in mid stratum	%FC if strata type = M and scientific name = <i>Eucalyptus camaldulensis</i> or <i>Eucalyptus largiflorens</i>	≥5	<5 – ≥0.5	< 0.5 – >0	0	1.5	1	0.5	0
10	Indicator species in tallest stratum	%FC if strata type = T and scientific name = <i>Eucalyptus camaldulensis</i> or <i>Eucalyptus largiflorens</i>	≥30	<30 – ≥10	<10 – ≥1	<1	3	2.5	1.5	0
10	Native wetland functional species	Sum of %FC if functional group = Atw or Ate or Atl or Arp or Arf or Se or Sk and Exotic = N and scientific name does not = <i>Eucalyptus camaldulensis</i>	≥40	<40 – ≤15	<15 – ≥10	<10	4	3	2.5	0

PCT code	Attribute	Logic statement	Individual metric benchmark category* (%)				Community Score value (max score 20)			
			Excellent-Good	Intermediate-moderate	Poor	Very poor	Excellent-Good	Intermediate-moderate	Poor	Very poor
11	Bare ground and litter	%FC if growth form = bare ground or litter	≤30	>30 – ≤50	>50 – ≤80	>80	2	1.5	1	0
11	Invasive native terrestrial chenopods	%FC if growth form = CW	≤10	>10 – ≤40	>40 – ≤80	>80	4	3	2	0
11	Exotics	%FC if exotic = Y	≤10	>10 – ≤50	>50 – ≤80	>80	4	3	2	0
11	Indicator species in lower stratum	%FC if strata type = L and scientific name = <i>Eucalyptus camaldulensis</i>	≥1	<1 – ≥0.5	<0.5 – >0	0	1.5	1	0.5	0
11	Indicator species in mid stratum	%FC if strata type = M and scientific name = <i>Eucalyptus camaldulensis</i>	≥5	<5 – ≥0.5	<0.5 – >0	0	1.5	1	0.5	0
11	Indicator species in tallest stratum	%FC if strata type = T and scientific name = <i>Eucalyptus camaldulensis</i>	≥30	<30 – ≥10	<10 – ≥1	<1	3	2.5	1.5	0

PCT code	Attribute	Logic statement	Individual metric benchmark category* (%)				Community Score value (max score 20)			
			Excellent-Good	Intermediate-moderate	Poor	Very poor	Excellent-Good	Intermediate-moderate	Poor	Very poor
11	Native wetland functional species	Sum of %FC if functional group = Atw or Ate or Atl or Arp or Arf or Se or Sk and exotic = N and scientific name does not = <i>Eucalyptus camaldulensis</i>	≥40	<40 – ≤15	<15 – ≥10	<10	4	3	2.5	0
13	Bare ground and litter	%FC if growth form = bare ground or litter	≤30	>30 – ≤50	>50 – ≤80	>80	2	1.5	1	0
13	Invasive native terrestrial chenopods	%FC if growth form = CW	≤10	>10 – ≤40	>40 – ≤80	>80	4	3	2	0
13	Exotics	%FC if exotic = Y	≤10	>10 – ≤50	>50 – ≤80	>80	4	3	2	0
13	Indicator species in lower stratum	%FC if strata type = L and scientific name = <i>Eucalyptus largiflorens</i>	≥1	< 1 – ≥0.5	< 0.5 – >0	0	1.5	1	0.5	0

PCT code	Attribute	Logic statement	Individual metric benchmark category* (%)				Community Score value (max score 20)			
			Excellent-Good	Intermediate-moderate	Poor	Very poor	Excellent-Good	Intermediate-moderate	Poor	Very poor
13	Indicator species in mid stratum	%FC if strata type = M and scientific name = <i>Eucalyptus largiflorens</i>	≥5	<5 – ≥0.5	< 0.5 – >0	0	1.5	1	0.5	0
13	Indicator species in tallest stratum	%FC if strata type = T and scientific name = <i>Eucalyptus largiflorens</i>	≥30	<30 – ≥10	<10 – ≥1	<1	3	2.5	1.5	0
13	Native wetland functional species	Sum of %FC if functional group = Atw or Ate or Atl or Arp or Arf or Se or Sk and exotic = N and scientific name does not = <i>Eucalyptus largiflorens</i>	≥40	<40 – ≤15	<15 – ≥10	<10	4	3	2.5	0

Table notes: %FC = Foliage Cover; CW = Chenopod Woody; Y = Yes; N = No; L = Low; M = Medium; T = Tall; Atw = Amphibious Tolerators – Woody; Ate = Amphibious Tolerators – Emergent; Atl = Amphibious Tolerators - Low growing; Arp = Amphibious Responders – Plastic; Arf = Amphibious Responders – Floating; Se/Sk = Aquatic Obligates. * see table 4 for category descriptions.

Appendix B: Tree stand condition analysis schema

Table 19 Tree stand condition analysis schema for all plant community types. Individual metrics (4) are allocated a category based on the benchmarks. This is then converted into a community score value, all metrics are the added to give a total score out of 20.

		Individual metrics benchmark categories* (%)				Final Tree stand condition score (max 20)			
Attribute	PCT specific attributes	Excellent	Intermediate	Moderate - poor	Very poor	Excellent-Good	Intermediate	Moderate -poor	Very poor
%DeadCanopy	n.a	≤10	>10 – ≤40	>40 – ≤80	>80	8	6	4	0
%LiveBasalArea	n.a	≥80	<80 – ≥60	<60 – ≥40	<40	4	3	2	0
%DeadLimbs	n.a	≤10	>10 – ≤40	>40 – ≤80	>80	4	3	2	0
% foliage cover	%FC Forest (Tallest stratum 0.1/0.25 ha plot)	≥70	<70 – ≥50	<50 – ≥30	<30	4	3	2	0
	%FC Woodland (Tallest stratum 0.1/0.25ha plot)	≥30	<30 – ≥10	<10 – ≥5	<5				
	%FC Open Woodland (Tallest stratum 0.1/0.25ha plot)	≥10	< 10 – ≥5	<5 – ≥1	<1				

Table notes: %FC = Percentage Foliage Cover. * see table 4 for category descriptions

Appendix C: Recalibrated RARC benchmarks for individual sites

Details of assessment methodologies are provided in Jansen et al. (2005). Briefly, each of the metrics have expected vegetation conditions. These conditions established in Jansen et al. 2005, are based on statewide averages. The recalibration of the 7 metrics below was completed using plant community types (PCT) for each site. The scoring system for each metric, detailed in Jansen et al. (2005) was used.

Table 20 Recalibrated benchmarks for individual sites using the rapid appraisal of riparian condition (RARC) methodology

Site	PCT	Species*	IBRA region	Subcatchment name	Tree cover	Shrub cover	Total ground cover	Total length of fallen logs	Litter cover	Large tree threshold size (hollows)	Regen of under-storey (seedlings)	Total of 7 metrics
1	11	RRG-lignum	Darling Riverine Plains	Lower Paroo	3	0	1	2	2	1	1	10
2	11	RRG-lignum	Darling Riverine Plains	Lake Woytchugga	3	0	1	2	2	1	1	10
3	11	RRG-lignum	Darling Riverine Plains	Lake Woytchugga	3	0	1	2	2	1	1	10
4	11	RRG-lignum	Darling Riverine Plains	Wilcannia downstream	3	0	1	2	2	1	1	10
5	13	BB-lignum	Darling Riverine Plains	Wilcannia downstream	2	2	1	1	2	1	1	10
6	13	BB-lignum	Darling Riverine Plains	Wilcannia downstream	2	2	1	1	2	1	1	10
7	10	RRG-BB	Darling Riverine Plains	Wilcannia downstream	3	0	1	2	3	1	1	11

Site	PCT	Species*	IBRA region	Subcatchment name	Tree cover	Shrub cover	Total ground cover	Total length of fallen logs	Litter cover	Large tree threshold size (hollows)	Regen of under-storey (seedlings)	Total of 7 metrics
8	11	RRG-lignum	Darling Riverine Plains	Wilcannia downstream	3	0	1	2	2	1	1	10
9	11	RRG-lignum	Darling Riverine Plains	Lake Wetherell	3	0	1	2	2	1	1	10
10	11	RRG-lignum	Darling Riverine Plains	Lake Wetherell	3	0	1	2	2	1	1	10
11	11	RRG-lignum	Darling Riverine Plains	Lake Wetherell	3	0	1	2	2	1	1	10
12	11	RRG-lignum	Darling Riverine Plains	Lake Wetherell	3	0	1	2	2	1	1	10
13	10	RRG-BB	Darling Riverine Plains	Lake Wetherell	3	0	1	2	3	1	1	11
14	11	RRG-lignum	Darling Riverine Plains	Lake Wetherell	3	0	1	2	2	1	1	10
15	11	RRG-lignum	Darling Riverine Plains	Cawndilla	3	0	1	2	2	1	1	10
16	11	RRG-lignum	Darling Riverine Plains	Downstream Weir 32	3	0	1	2	2	1	1	10
17	10	RRG-BB	Darling Riverine Plains	Lower Yampoola Creek	3	0	1	2	3	1	1	11

Site	PCT	Species*	IBRA region	Subcatchment name	Tree cover	Shrub cover	Total ground cover	Total length of fallen logs	Litter cover	Large tree threshold size (hollows)	Regen of under-storey (seedlings)	Total of 7 metrics
18	11	RRG-lignum	Darling Riverine Plains	Cuthero Creek	3	0	1	2	2	1	1	10
19	10	RRG-BB	Darling Riverine Plains	Upstream Pooncarie	3	0	1	2	3	1	1	11
20	11	RRG-lignum	Darling Riverine Plains	Upstream Pooncarie	3	0	1	2	2	1	1	10
21	11	RRG-lignum	Darling Riverine Plains	Downstream Pooncarie	3	0	1	2	2	1	1	10
22	11	RRG-lignum	Darling Riverine Plains	Downstream Pooncarie	3	0	1	2	2	1	1	10
23	11	RRG-lignum	Darling Riverine Plains	Lower Murray-Darling	3	0	1	2	2	1	1	10
24	10	RRG-BB	Darling Riverine Plains	Lower Anabranche	1	0	2	2	3	1	1	10
25	11	RRG-lignum	Darling Riverine Plains	Lower Anabranche	3	0	1	2	2	1	1	10
26	11	RRG-lignum	Darling Riverine Plains	Warrawenia Lake	3	0	1	2	2	1	1	10
27	11	RRG-lignum	Darling Riverine Plains	Anabranche North	3	0	1	2	2	1	1	10

Site	PCT	Species*	IBRA region	Subcatchment name	Tree cover	Shrub cover	Total ground cover	Total length of fallen logs	Litter cover	Large tree threshold size (hollows)	Regen of under-storey (seedlings)	Total of 7 metrics
28	13	BB-lignum	Darling Riverine Plains	Anabranck North Lakes	2	2	1	1	2	1	1	10
29	13	BB-lignum	Murray Darling Depression	Lower Redbank Creek	3	3	1	1	2	1	1	12
30	13	BB-lignum	Darling Riverine Plains	Cawndilla	2	2	1	1	2	1	1	10
31	13	BB-lignum	Darling Riverine Plains	Cawndilla	2	2	1	1	2	1	1	10
32	11	RRG-lignum	Darling Riverine Plains	Ellerslie	3	0	1	2	2	1	1	10
33	39	Coolabah	Darling Riverine Plains	Upper Talyawalka Creek	2	2	1	1	2	0	1	9
34	11	RRG-lignum	Darling Riverine Plains	Lower Three Mile Creek	3	0	1	2	2	1	1	10
35	13	BB-lignum	Darling Riverine Plains	Lower Talyawalka Creek	2	2	1	1	2	1	1	10
36	13	BB-lignum	Darling Riverine Plains	Charlie Stones Creek	2	2	1	1	2	1	1	10

Table notes:

* RRG = river red gum; BB = black box

Appendix D: Demographic results at each plot – river red gum

Table 21 Distribution of river red gum (*Eucalyptus camaldulensis*) by size class at each plot where the species was recorded (32 from 36 plots, at 17 sites)

Site	Size class	≥10 to <20	≥20 to <30	≥30 to <40	≥40 to <50	≥50 to <60	≥60 to <70	≥70 to <80	≥80 to <90	≥90 to <100	≥100 to <110	≥110 to <120	≥120 to <130	≥130 to <140	≥140 to <150	≥150 to <160	≥160 to <170	≥170 to <180	≥180 to <190	≥190 to <200	Outside defined range
B2_A	Live	3	3	1																	
B2_A	Dead																				
B2_B	Live	1	1	1	1			1					1								
B2_B	Dead																				
S10_A	Live	2	1	3	2	9	2	2	1			1	1								
S10_A	Dead				1			1		1											
S10_B	Live	5	5	6	2				1				1		1						
S10_B	Dead																				
S14_1_A	Live				1	1	1			1											
S14_1_A	Dead																				
S14_1_B	Live	7	1	1		1		2	1		1		1		1						
S14_1_B	Dead	1												1							
S14_A	Live	3	2	1	1									1				1			
S14_A	Dead																				
S14_B	Live				3																
S14_B	Dead																				
S15_A	Live	2	2	2				1				1				1					
S15_A	Dead																				
S15_B	Live		1	2			2	1		1	1										

Site	Size class	≥10 to <20	≥20 to <30	≥30 to <40	≥40 to <50	≥50 to <60	≥60 to <70	≥70 to <80	≥80 to <90	≥90 to <100	≥100 to <110	≥110 to <120	≥120 to <130	≥130 to <140	≥140 to <150	≥150 to <160	≥160 to <170	≥170 to <180	≥180 to <190	≥190 to <200	Outside defined range
S15_B	Dead																				
S16_1_A	Live	1	2	1	1		1	3	3	3	1	4	2		2						
S16_1_A	Dead					1															
S16_1_B	Live	5	9	2	3	3		2	1	2		1			1	1					
S16_1_B	Dead	2			1			2													
S16_2_A	Live	3	4	1	3	2	3	1	7	3	3	1	2								
S16_2_A	Dead			1																	
S16_2_B	Live	2		3	5	2	1		1	2	1		2				1				
S16_2_B	Dead		1																		
S16_A	Live	6					1		1	1		4									
S16_A	Dead			1					1			1									
S16_B	Live	4	6	2	1			2	1	1		1									
S16_B	Dead	5									1			2							
S18_A	Live		1		1			1	2	3	1	2		1	1						
S18_A	Dead						1	1													
S18_B	Live	9	4	10	8	1		2	1	1	1	1						1			1
S18_B	Dead																				
S19_A	Live	3	7		2		1	1			1		1			2					
S19_A	Dead								1												
S19_B	Live	13	22	9	1	1	1			1								1			
S19_B	Dead	1	2																		
S2_A	Live	2	7	2	1			1	3	1											4
S2_A	Dead																				

Site	Size class	≥10 to <20	≥20 to <30	≥30 to <40	≥40 to <50	≥50 to <60	≥60 to <70	≥70 to <80	≥80 to <90	≥90 to <100	≥100 to <110	≥110 to <120	≥120 to <130	≥130 to <140	≥140 to <150	≥150 to <160	≥160 to <170	≥170 to <180	≥180 to <190	≥190 to <200	Outside defined range
S2_B	Live	3		1	1	2	1	1					1					1			
S2_B	Dead	1																			
S21_A	Live	2		2	1					1	1	4		1	1	1			1		1
S21_A	Dead			1										1							
S21_B	Live	1					1	1		1	1			1	2	1					1
S21_B	Dead												1								
S22_A	Live									1	5		2	1			1			1	
S22_A	Dead					1				1											
S22_B	Live		1	2					3	3	1	1	1								
S22_B	Dead				1						1										
S26_A	Live		1		1					1	1	1						1			
S26_A	Dead	1	1	1				1													
S27_A	Live	2	1	1	1		2							1							
S27_A	Dead											1									
S27_B	Live	9	9	8	7	1	3														1
S27_B	Dead	1		1	1											1					1
S29_A	Live	7	12	12	6	4				1											
S29_A	Dead																				
S29_B	Live	9	13	3	2	4		1													
S29_B	Dead	3				1															
S3_A	Live	6	2													1	1				
S3_A	Dead		1																		

Appendix E: Demographic results at each plot – black box

Table 22 Distribution of black box (*Eucalyptus largiflorens*) by size class at each plot where the species was recorded (16 from 32 plots)

Site	Size Class	≥10 to <20	≥20 to <30	≥30 to <40	≥40 to <50	≥50 to <60	≥60 to <70	≥70 to <80	≥80 to <90	≥90 to <100	≥100 to <110	≥110 to <120	Outside defined range
B2_A	Live	11	2			1							2
B2_A	Dead												
B2_B	Live	1	3										
B2_B	Dead												
S10_B	Live	2		3					1				
S10_B	Dead												
S14_1_B	Live	1	2			1			1				
S14_1_B	Dead												
S14_B	Live	2	2										
S14_B	Dead												
S16_A	Live	3	1										
S16_A	Dead												
S18_A	Live	2											
S18_A	Dead												
S19_B	Live			1									
S19_B	Dead												
S25_A	Live				4	1	2					1	
S25_A	Dead			1									
S25_B	Live		1	3	4	1		3	1	1			
S25_B	Dead			1	1								
S26_A	Live	1	3	3	9	2				1			

Site	Size Class	≥10 to <20	≥20 to <30	≥30 to <40	≥40 to <50	≥50 to <60	≥60 to <70	≥70 to <80	≥80 to <90	≥90 to <100	≥100 to <110	≥110 to <120	Outside defined range
S26_A	Dead		1	1		1							

Appendix F: Number of juvenile river red gum and black box trees

Table 23 Trees <10 cm diameter at breast height (DBH) present in survey sites (PCTs 10, 11 and 13) in the Darling Baaka

Plot	PCT	Species	Non-established seedlings in 0.25 ha	Established seedlings in 0.25 ha	Saplings in 0.25 ha	Total established seedlings/ saplings in 0.25ha	Seedlings/ saplings per ha	Grazing pressure (H/M/L)
B2 A	10	<i>Eucalyptus largiflorens</i>	0	0	0	0	0	L
B2 A	10	<i>Eucalyptus camaldulensis</i>	4	3	0	3	12	L
B2 B	10	<i>Eucalyptus largiflorens</i>	0	0	0	0	0	L
B2 B	10	<i>Eucalyptus camaldulensis</i>	2	1	0	1	4	L
S26 A	10	<i>Eucalyptus largiflorens</i>	0	0	0	0	0	H
S26 A	10	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	H
S27 A	10	<i>Eucalyptus largiflorens</i>	1	0	0	0	0	L
S27 A	10	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	L
S27 B	10	<i>Eucalyptus largiflorens</i>	2	0	0	0	0	M
S27 B	10	<i>Eucalyptus camaldulensis</i>	2	0	0	0	0	M
S10 A	11	<i>Eucalyptus camaldulensis</i>	1	0	0	0	0	L
S10 B	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	L
S14 A	11	<i>Eucalyptus camaldulensis</i>	1	0	0	0	0	L
S14 B	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	L
S14.1 A	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	L
S14.1 B	11	<i>Eucalyptus camaldulensis</i>	8	10	0	10	40	L
S15 A	11	<i>Eucalyptus camaldulensis</i>	2	0	0	0	0	L

Plot	PCT	Species	Non-established seedlings in 0.25 ha	Established seedlings in 0.25 ha	Saplings in 0.25 ha	Total established seedlings/ saplings in 0.25ha	Seedlings/ saplings per ha	Grazing pressure (H/M/L)
S15 B	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	L
S16 A	11	<i>Eucalyptus camaldulensis</i>	1	1	1	2	8	L
S16 B	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	L
S16.1 A	11	<i>Eucalyptus camaldulensis</i>	1	1	1	2	8	H
S16.1 B	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	M
S16.2 A	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	M
S16.2 B	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	L
S18 A	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	H
S18 B	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	H
S19 A	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	M
S19 B	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	M
S2 A	11	<i>Eucalyptus camaldulensis</i>	0	0	2	2	8	L
S2 B	11	<i>Eucalyptus camaldulensis</i>	55	17	5	22	88	L
S21 A	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	M
S21 B	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	L
S22 A	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	L
S22 B	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	M
S29 A	11	<i>Eucalyptus camaldulensis</i>	2	0	0	0	0	M
S29 B	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	H
S3 A	11	<i>Eucalyptus camaldulensis</i>	0	0	0	0	0	L

Plot	PCT	Species	Non-established seedlings in 0.25 ha	Established seedlings in 0.25 ha	Saplings in 0.25 ha	Total established seedlings/saplings in 0.25ha	Seedlings/saplings per ha	Grazing pressure (H/M/L)
S25 A	13	<i>Eucalyptus largiflorens</i>	232	7	0	7	28	M
S25 B	13	<i>Eucalyptus largiflorens</i>	0	0	0	0	0	M
S31 A	13	<i>Eucalyptus largiflorens</i>	13	0	0	0	0	L
S31 B	13	<i>Eucalyptus largiflorens</i>	620	0	0	0	0	L

Table notes: H = high; M = medium; L = low.

PCT 10 = River red gum (*Eucalyptus camaldulensis*) – black box (*E. largiflorens*) woodland.

PCT 11 = River red gum (*E. camaldulensis*) – lignum (*Duma florulenta*) forest/woodland.

PCT 13 = Black box (*E. largiflorens*) – lignum (*D. florulenta*) woodland wetland.

Table 24 Average number of established seedlings/saplings per hectare in PCTs 10, 11 and 13

Species	No. seedlings/saplings per ha
<i>E. camaldulensis</i> in PCT 10	3.2
<i>E. largiflorens</i> in PCT 10	0
<i>E. camaldulensis</i> in PCT 11	5.6
<i>E. largiflorens</i> in PCT 13	7

Appendix G: Community condition results at each site

Table 25 Site-scale results and score for each metric comprising the community condition sub-indicator

Site	PCT	Ind. spp. lower stratum	Ind. spp. mid stratum	Ind. spp. tall stratum	Bare ground and litter	Invasive woody chenopods	Exotics	Native wetland functional species
B2	10	0	0	26.5	97.5	0	0.35	34.25
S10	11	0	0	20	51	1	9.2	31.55
S14	11	0	0	35	80	0.05	0.25	35.5
S14.1	11	0	1	22.5	65.5	0.5	15.7	34.25
S15	11	0	0	37.5	95	0.05	12.6	6.75
S16	11	0.05	0	20	73.5	5.05	5.45	21.7
S16.1	11	0	0	45	86	1.5	7.45	21.5
S16.2	11	0	0	22.5	65.5	2.55	5.3	32.8
S18	11	0	0	21.5	93	0	8.2	2.55
S19	11	0	0	10	83.5	0	2.05	12.35
S2	11	0	0	30	56	0	0.6	54.55
S21	11	0	0	27.5	65	1.05	1.95	32.65
S22	11	0	0	32.5	98.5	0	1.05	1.15
S25	13	0	0	20	72	0	0.3	55
S26	10	0	0	15	99	0	4.3	16.2
S27	10	0	0	20	74.5	0	43.8	32.25
S29	11	0	0	15	20	0	42.85	0.9
S3	11	0	0	25	76	0	1.8	47.8

Site	PCT	Ind. spp. lower stratum	Ind. spp. mid stratum	Ind. spp. tall stratum	Bare ground and litter	Invasive woody chenopods	Exotics	Native wetland functional species
S31	13	7.5	0	30	26	1.5	1.15	67.1

Table notes: The bare ground and litter and lower stratum %FC (foliage cover) metrics were estimated or adjusted at every site Ind. spp. = indicator species.

Table 26 Site-scale results and score for each metric comprising the community condition sub-indicator continued

Site	Plot	Ind. spp. lower stratum score	Ind. spp. mid stratum score	Ind. spp. tall stratum score	Bare ground and litter score	Invasive woody chenopods score	Exo-tics score	Native wetland functional species score	Score	Class
B2	B2 A	0	0	2.5	0	4	4	3	13.5	Intermediate/Poor
S10	B2 B	0	0	2.5	1	4	4	3	14.5	Intermediate/Poor
S14	S10 A	0	0	3	1	4	4	3	15	Intermediate
S14.1	S10 B	0	0.5	2.5	1	4	3	3	14	Intermediate/Poor
S15	S14 A	0	0	3	0	4	3	0	10	Poor
S16	S14 B	0.5	0	2.5	1	4	4	3	15	Intermediate
S16.1	S14.1 A	0	0	3	0	4	4	3	14	Intermediate/Poor
S16.2	S14.1 B	0	0	2.5	1	4	4	3	14.5	Intermediate/Poor
S18	S15 A	0	0	2.5	0	4	4	0	10.5	Poor
S19	S15 B	0	0	2.5	0	4	4	2.5	13	Intermediate/Poor
S2	S16 A	0	0	3	1	4	4	4	16	Intermediate

Site	Plot	Ind. spp. lower stratum score	Ind. spp. mid stratum score	Ind. spp. tall stratum score	Bare ground and litter score	Invasive woody chenopods score	Exo-tics score	Native wetland functional species score	Score	Class
S21	S16 B	0	0	2.5	1	4	4	3	14.5	Intermediate/Poor
S22	S16.1 A	0	0	3	0	4	4	0	11	Poor
S25	S16.1 B	0	0	2.5	1	4	4	4	15.5	Intermediate
S26	S16.2 A	0	0	2.5	0	4	4	3	13.5	Intermediate/Poor
S27	S16.2 B	0	0	2.5	1	4	3	3	13.5	Intermediate/Poor
S29	S18 A	0	0	2.5	2	4	3	0	11.5	Poor
S3	S18 B	0	0	2.5	1	4	4	4	15.5	Intermediate
S31	S19 A	1.5	0	3	2	4	4	4	18.5	Good

Table notes: The bare ground and litter and lower stratum %FC (foliage cover) metrics were estimated or adjusted at every site.
Ind. spp. = indicator species.

Appendix H: Community stand condition results at each plot

Table 27 Plot-scale results and score for each metric comprising the community condition sub-indicator

The bare ground and litter and lower stratum %FC metrics were estimated or adjusted at every site

Plot	PCT	Ind. spp. lower stratum	Ind. spp. mid stratum	Ind. spp. tall stratum	Bare ground and litter	Invasive woody chenopods	Exotics	Native wetland functional species
B2 A	10	0	0	28	99	0	0.2	42.7
B2 B	10	0	0	25	96	0	0.5	25.8
S10 A	11	0	0	30	48	0	15.6	35.9
S10 B	11	0	0	10	54	2	2.8	27.2
S14 A	11	0	0	45	84	0	0.2	16.4
S14 B	11	0	0	25	76	0.1	0.3	54.6
S14.1 A	11	0	0	25	98	0	31.2	16.3
S14.1 B	11	0	2	20	33	1	0.2	52.2
S15 A	11	0	0	60	98	0	0.2	1.1
S15 B	11	0	0	15	92	0.1	25	12.4
S16 A	11	0.1	0	15	58	10	4.3	34.4
S16 B	11	0	0	25	89	0.1	6.6	9
S16.1 A	11	0	0	50	82	3	1.5	33.6
S16.1 B	11	0	0	40	90	0	13.4	9.4
S16.2 A	11	0	0	30	58	0.1	9.3	35.9
S16.2 B	11	0	0	15	73	5	1.3	29.7
S18 A	11	0	0	35	98	0	10.5	3

Plot	PCT	Ind. spp. lower stratum	Ind. spp. mid stratum	Ind. spp. tall stratum	Bare ground and litter	Invasive woody chenopods	Exotics	Native wetland functional species
S18 B	11	0	0	8	88	0	5.9	2.1
S19 A	11	0	0	5	91	0	2.9	3.3
S19 B	11	0	0	15	76	0	1.2	21.4
S2 A	11	0	0	35	30	0	0.5	72.4
S2 B	11	0	0	25	82	0	0.7	36.7
S21 A	11	0	0	45	58	0.1	3.6	41
S21 B	11	0	0	10	72	2	0.3	24.3
S22 A	11	0	0	30	99	0	0.8	0.8
S22 B	11	0	0	35	98	0	1.3	1.5
S25 A	13	0	0	25	67	0	0.5	66.3
S25 B	13	0	0	15	77	0	0.1	43.7
S26 A	10	0	0	15	99	0	4.3	16.2
S27 A	10	0	0	10	67	0	0.6	35.4
S27 B	10	0	0	30	82	0	87	29.1
S29 A	11	0	0	15	12	0	70	0.8
S29 B	11	0	0	15	28	0	15.7	1
S3 A	11	0	0	25	76	0	1.8	47.8
S31 A	13	0	0	40	22	2	2.3	79.9
S31 B	13	15	0	20	30	1	0	54.3

Table notes: Ind. spp. = indicator species.

Table 28 Plot-scale results and score for each metric comprising the community condition sub-indicator continued

Plot	Ind. spp. lower stratum score	Ind. spp. mid stratum score	Ind. spp. tall stratum score	Bare ground and litter score	Invasive woody chenopods score	Exotics score	Native wetland functional species score	Score	Class
B2 A	0	0	2.5	0	4	4	4	14.5	Intermediate/Poor
B2 B	0	0	2.5	0	4	4	3	13.5	Intermediate/Poor
S10 A	0	0	3	1.5	4	3	3	14.5	Intermediate/Poor
S10 B	0	0	2.5	1	4	4	3	14.5	Intermediate/Poor
S14 A	0	0	3	0	4	4	3	14	Intermediate/Poor
S14 B	0	0	2.5	1	4	4	4	15.5	Intermediate
S14.1 A	0	0	2.5	0	4	3	3	12.5	Intermediate/Poor
S14.1 B	0	1	2.5	1.5	4	4	4	17	Intermediate
S15 A	0	0	3	0	4	4	0	11	Poor
S15 B	0	0	2.5	0	4	3	2.5	12	Intermediate/Poor
S16 A	0.5	0	2.5	1	4	4	3	15	Intermediate
S16 B	0	0	2.5	0	4	4	0	10.5	Poor
S16.1 A	0	0	3	0	4	4	3	14	Intermediate/Poor
S16.1 B	0	0	3	0	4	3	0	10	Poor
S16.2 A	0	0	3	1	4	4	3	15	Intermediate
S16.2 B	0	0	2.5	1	4	4	3	14.5	Intermediate/Poor

Plot	Ind. spp. lower stratum score	Ind. spp. mid stratum score	Ind. spp. tall stratum score	Bare ground and litter score	Invasive woody chenopods score	Exotics score	Native wetland functional species score	Score	Class
S18 A	0	0	3	0	4	3	0	10	Poor
S18 B	0	0	1.5	0	4	4	0	9.5	Poor
S19 A	0	0	1.5	0	4	4	0	9.5	Poor
S19 B	0	0	2.5	1	4	4	3	14.5	Intermediate/Poor
S2 A	0	0	3	2	4	4	4	17	Intermediate
S2 B	0	0	2.5	0	4	4	3	13.5	Intermediate/Poor
S21 A	0	0	3	1	4	4	4	16	Intermediate
S21 B	0	0	2.5	1	4	4	3	14.5	Intermediate/Poor
S22 A	0	0	3	0	4	4	0	11	Poor
S22 B	0	0	3	0	4	4	0	11	Poor
S25 A	0	0	2.5	1	4	4	4	15.5	Intermediate
S25 B	0	0	2.5	1	4	4	4	15.5	Intermediate
S26 A	0	0	2.5	0	4	4	3	13.5	Intermediate/Poor
S27 A	0	0	2.5	1	4	4	3	14.5	Intermediate/Poor
S27 B	0	0	3	0	4	0	3	10	Poor
S29 A	0	0	2.5	2	4	2	0	10.5	Poor
S29 B	0	0	2.5	2	4	3	0	11.5	Poor
S3 A	0	0	2.5	1	4	4	4	15.5	Intermediate
S31 A	0	0	3	2	4	4	4	17	Intermediate

Plot	Ind. spp. lower stratum score	Ind. spp. mid stratum score	Ind. spp. tall stratum score	Bare ground and litter score	Invasive woody chenopods score	Exotics score	Native wetland functional species score	Score	Class
S31 B	1.5	0	2.5	2	4	4	4	18	Good

Table notes: The bare ground and litter and lower stratum %FC metrics were estimated or adjusted at every site. Ind. spp. = indicator species.

Appendix I: Tree stand condition results at each site

Table 29 Site-scale results and score for each metric comprising the tree stand condition sub-indicator

Site	PCT	%FC	%DL	%DC	%LBA	%FC score	%DL score	%DC score	%LBA score	Score	Class
B2*	10	4	1	0	100	0	4	8	4	16	Intermediate
S10*	11	20	15	0	92	3	3	8	4	18	Good
S14*	11	7	2	0	100	3	4	8	4	19	Good
S14.1	11	50	6	7	99	4	4	8	4	20	Excellent/Benchmark
S15*	11	21	17	0	100	3	3	8	4	18	Good
S16	11	47	38	14	82	4	3	6	4	17	Intermediate
S16.1	11	142	11	6	94	4	3	8	4	19	Good
S16.2	11	27	7	6	100	3	4	8	4	19	Good
S18	11	68	10	8	100	4	4	8	4	20	Excellent/Benchmark
S19	11	36	29	11	96	4	3	6	4	17	Intermediate
S2	11	16	12	2	100	3	3	8	4	18	Good
S21	11	59	17	11	95	4	3	6	4	17	Intermediate
S22	11	32	19	17	90	4	3	6	4	17	Intermediate
S25	13	13	22	20	94	3	3	6	4	16	Intermediate
S26	10	28	29	17	92	3	3	6	4	16	Intermediate
S27	10	32	20	15	73	4	3	6	3	16	Intermediate
S29	11	28	35	13	100	3	3	6	4	16	Intermediate

Site	PCT	%FC	%DL	%DC	%LBA	%FC score	%DL score	%DC score	%LBA score	Score	Class
S3*	11	5	0	0	99	2	4	8	4	18	Good
S31	13	22	5	13	99	3	4	6	4	17	Intermediate

Table notes: The % canopy density, % dead canopy and % live basal area metrics were estimated at sites shaded grey or '*'. %FC = Percentage Foliage Cover, %DL = Percentage Dead Limbs, %DC = Percentage Dead Canopy, %LBA = Percentage Live Basal Area.

Appendix J: Survey sites

Table 30 **Survey sites**

Site	Plot name	Sub-catchment no.	Subcatchment	Longitude	Latitude	NSW PCT ID no.	PCT name
S27	S27 A	1473	Anabranh North	141.79592	-33.26806	10	River Red Gum - Black Box woodland wetland
S27	S27 B	1473	Anabranh North	141.79453	-33.26808	10	River Red Gum - Black Box woodland wetland
S15	S15 A*	1477	Cawndilla	142.3787	-32.46769	11	River Red Gum - Lignum very tall open forest or woodland wetland
S15	S15 B*Δ	1477	Cawndilla	142.38357	-32.46566	11	River Red Gum - Lignum very tall open forest or woodland wetland
S31	S31 A	1477	Cawndilla	142.22188	-32.59736	13	Black Box - Lignum woodland wetland
S31	S31 B	1477	Cawndilla	142.22119	-32.59496	13	Black Box - Lignum woodland wetland
S18	S18 A	1514	Cuthero Creek	142.37687	-32.93195	11	River Red Gum - Lignum very tall open forest or woodland wetland
S18	S18 B	1514	Cuthero Creek	142.37698	-32.93003	11	River Red Gum - Lignum very tall open forest or woodland wetland
S21	S21 A	1475	Downstream Pooncarie	142.45025	-33.57745	11	River Red Gum - Lignum very tall open forest or woodland wetland
S21	S21 B	1475	Downstream Pooncarie	142.44988	-33.57578	11	River Red Gum - Lignum very tall open forest or woodland wetland
S22	S22 A	1475	Downstream Pooncarie	142.32144	-33.70791	11	River Red Gum - Lignum very tall open forest or woodland wetland
S22	S22 B	1475	Downstream Pooncarie	142.32272	-33.70855	11	River Red Gum - Lignum very tall open forest or woodland wetland

Site	Plot name	Sub-catchment no.	Subcatchment	Longitude	Latitude	NSW PCT ID no.	PCT name
S16	S16 A	1518	Downstream Weir 32	142.3857	-32.5517	11	River Red Gum - Lignum very tall open forest or woodland wetland
S16	S16 B	1518	Downstream Weir 32	142.38758	-32.55244	11	River Red Gum - Lignum very tall open forest or woodland wetland
S16.1	S16.1 A	1518	Downstream Weir 32	142.37659	-32.62379	11	River Red Gum - Lignum very tall open forest or woodland wetland
S16.1	S16.1 B	1518	Downstream Weir 32	142.37919	-32.62369	11	River Red Gum - Lignum very tall open forest or woodland wetland
S16.2	S16.2 A	1518	Downstream Weir 32	142.38016	-32.61858	11	River Red Gum - Lignum very tall open forest or woodland wetland
S16.2	S16.2 B	1518	Downstream Weir 32	142.38161	-32.61714	11	River Red Gum - Lignum very tall open forest or woodland wetland
B2	B2 A*	1483	Lake Wetherall	142.50368	-32.31293	10	River Red Gum - Black Box woodland wetland
B2	B2 B*	1483	Lake Wetherall	142.49987	-32.31106	10	River Red Gum - Black Box woodland wetland
S10	S10 A*	1483	Lake Wetherall	142.49966	-32.32483	11	River Red Gum - Lignum very tall open forest or woodland wetland
S10	S10 B*Δ	1483	Lake Wetherall	142.50111	-32.32357	11	River Red Gum - Lignum very tall open forest or woodland wetland
S14	S14 A*	1483	Lake Wetherall	142.38215	-32.41791	11	River Red Gum - Lignum very tall open forest or woodland wetland
S14	S14 B*Δ	1483	Lake Wetherall	142.3776	-32.41847	11	River Red Gum - Lignum very tall open forest or woodland wetland
S14.1	S14.1 A	1483	Lake Wetherall	142.37345	-32.43117	11	River Red Gum - Lignum very tall open forest or woodland wetland

Site	Plot name	Sub-catchment no.	Subcatchment	Longitude	Latitude	NSW PCT ID no.	PCT name
S14.1	S14.1 B	1483	Lake Wetherall	142.37322	-32.42976	11	River Red Gum - Lignum very tall open forest or woodland wetland
S2	S2 A	3254	Lake Woytchugga	143.40622	-31.55916	11	River Red Gum - Lignum very tall open forest or woodland wetland
S2	S2 B	3254	Lake Woytchugga	143.40335	-31.55511	11	River Red Gum - Lignum very tall open forest or woodland wetland
S3	S3 A*Δ	3254	Lake Woytchugga	143.37294	-31.57817	11	River Red Gum - Lignum very tall open forest or woodland wetland
S25	S25 A	1521	Lower Anabranh	141.71063	-33.85363	13	Black Box - Lignum woodland wetland
S25	S25 B	1521	Lower Anabranh	141.71214	-33.85503	13	Black Box - Lignum woodland wetland
S29	S29 A	1476	Lower Redbank Creek	142.09105	-32.71643	11	River Red Gum - Lignum very tall open forest or woodland wetland
S29	S29 BΔ	1476	Lower Redbank Creek	142.09372	-32.71502	11	River Red Gum - Lignum very tall open forest or woodland wetland
S19	S19 A	1484	Upstream Pooncarie	142.47965	-33.33075	11	River Red Gum - Lignum very tall open forest or woodland wetland
S19	S19 B	1484	Upstream Pooncarie	142.48025	-33.33163	11	River Red Gum - Lignum very tall open forest or woodland wetland
S26	S26 A	1467	Warrawenia Lake	141.7535	-33.57677	10	River Red Gum - Black Box woodland wetland
a	-	3411	Lower Paroo	143.61065	-31.4564	11	River Red Gum - Lignum very tall open forest or woodland wetland
b	-	1515	Lower Yampool Creek	142.347402	-32.82355	10	River Red Gum - Black Box woodland wetland

Site	Plot name	Sub-catchment no.	Subcatchment	Longitude	Latitude	NSW PCT ID no.	PCT name
c	–	1514	Cuthero Creek	142.3463469	–32.8922662	11	River Red Gum – Lignum very tall open forest or woodland wetland
d	–	1514	Cuthero Creek	142.31216	–33.050775	11	River Red Gum – Lignum very tall open forest or woodland wetland
e	–	1512	Lower Darling	141.950419	–33.974387	11	River Red Gum – Lignum very tall open forest or woodland wetland
f	–	1512	Lower Darling	141.949957	–33.965912	11	River Red Gum – Lignum very tall open forest or woodland wetland
g	–	1521	Lower Anabranh	141.8363134	–33.9747341	13	Black Box – Lignum woodland wetland
h	–	1467	Warrawenia Lake	141.8054808	–33.4478693	10	River Red Gum – Black Box woodland wetland
i	–	3251	Upper Talyawalka Creek	143.4275	–31.65355	39	Coolabah – river coobah – lignum woodland
j	–	3251	Upper Talyawalka Creek	143.28122	–31.77202	39	Coolabah – river coobah – lignum woodland
k	–	1531	Lower Three Mile Creek	142.47438	–32.41858	10	River Red Gum – Black Box woodland wetland
l	–	1531	Lower Three Mile Creek	143.61425	–32.31301	10	River Red Gum – Black Box woodland wetland
m	–	1530	Lower Talyawalka Creek	142.51567	–32.43439	13	Black Box – Lignum woodland wetland

Site	Plot name	Sub-catchment no.	Subcatchment	Longitude	Latitude	NSW PCT ID no.	PCT name
n	–	1530	Lower Talyawalka Creek	142.41207	–32.439256	13	Black Box – Lignum woodland wetland
o	–	1530	Lower Talyawalka Creek	142.50792	–32.44465	13	Black Box – Lignum woodland wetland
p	–	1482	Charlie Stones Creek	142.42579	–32.48927	10	River Red Gum – Black Box woodland wetland
q	–	1482	Charlie Stones Creek	142.41771	–32.457889	10	River Red Gum – Black Box woodland wetland

Tables notes: Grey shading or ‘*’ denotes sites where %dead canopy was not assessed in the field and therefore was given the value of 0. ‘Δ’ denotes sites excluded as the percent foliage cover that was recorded seemed to be incorrect.