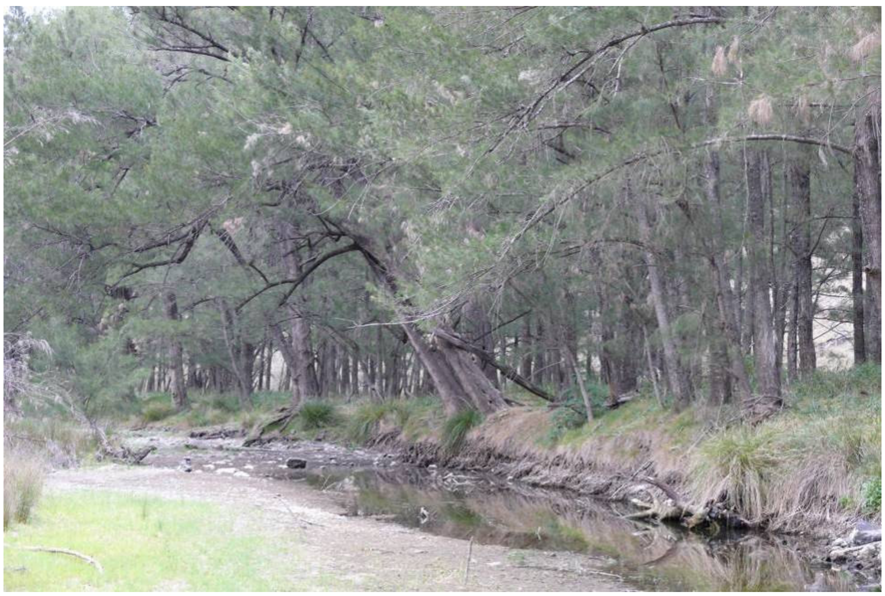
Riverine Vegetation in the Namoi Catchment
An Assessment of Type and Condition



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Final Report prepared for:

Cotton Catchment Communities CRC
Namoi Catchment Management Authority

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Disclaimer

Executive Summary

Riverine vegetation includes riparian vegetation associated with the stream or river channel and bank, and floodplain vegetation associated with alluvial flats adjacent of the bank. Riverine vegetation provides multiple benefits within rural landscapes. It influences in-bed physical form and prevents erosion and incision, provides terrestrial and aquatic habitat, and facilitates movement of fauna across the landscape. Floodplain vegetation is unique in the landscape, commonly comprising extensive native grasslands and grassy open woodlands which are not represented elsewhere. The riverine vegetation of most NSW catchments, particularly the floodplain component, has been cleared extensively over the past 150 years for cropping and pastoralism, so that only fragments of the original extent remain. It is important that those who manage remaining areas of riverine vegetation are aware of their inherent condition, so that informed decisions can be made about prioritisation for conservation and management.

The total area of the riverine zone in the Namoi catchment in north-western NSW exceeds 10,000 km^2, about 25% of the catchment area. It includes over 8,000 km of major streams and rivers within 40 sub-catchments, dominated by either river oak (*Casuarina cunninghamiana*) or river red gum (*Eucalyptus camaldulensis*) types, with various other riparian types less common. The floodplain represents about 90% of the riverine zone, and includes major cotton and other cropping areas of the Namoi valley, such as the Liverpool Plains and Walgett Plains. Native vegetation of the floodplain includes open grassy woodlands dominated by Poplar Box (*Eucalyptus populnea*), Black Box (*Eucalyptus largiflorens*) and Coolibah (*Eucalyptus coolabah*), and also true native grasslands dominated by Plains Grass (*Austrostipa aristiglumis*). A total of 30 regional vegetation communities (RVCs) occur in the riverine zone.

An estimated 35% of the riparian zone and 7% of the floodplain zone comprises woody cover in the Namoi, indicating substantial loss of native tree cover in the past. About half the original native vegetation of the Namoi floodplain has been displaced by cropland – most other treeless areas support native grasslands derived from former grassy open woodlands (although areas of true native grassland also remain). The majority of the cleared riparian zone also constitutes derived grassland.

This study was commissioned by Cotton Catchment Community CRC and Namoi CMA to develop and apply a framework for evaluating and mapping the condition of native riverine vegetation (riparian and floodplain) in the Namoi catchment. A framework was developed that measured condition using:

i. a combination of landscape metrics derived from remotely sensed data, and

ii. a plot-based sampling program designed to capture ecological data and score them against established benchmarks.

The landscape condition assessment used metrics such as %-woody cover, %-non-native, continuity of vegetation along rivers, and connectivity. Through the combined influence of all landscape metrics, the assessment established that the best 'condition' sub-catchments were associated with large contiguous blocks of vegetation such as in the Pilliga. Conversely, the worst 'condition' sub-catchments were associated with extensively cleared lowlands, such as the Liverpool Plains.

The plot-based assessment of vegetation condition sampled a total of 329 plots across the Namoi riverine zone, including 91 on the floodplain and 238 along major channels. A number of ecological attributes, including %-cover and species richness in the canopy, midstorey and understorey, number of large trees, and length of dead fallen timber were measured consistently in each plot. A set of 'benchmarks' was established for each RVC (one benchmark for each ecological attribute) from which plot data could be compared and scored to a maximum value of 100. Vegetation was scored for all 329 sampled plots, providing a final vegetation condition score at each plot.

Vegetation condition varied from 98/100 (best condition) to 2/100 (poorest condition), with an overall mean score of 55/100 across all plots sampled in the Namoi catchment. Absence of large and recruiting trees and low shrub diversity and cover appeared to influence condition the most. Three major patterns were observed from the plot data:

1. Remnant floodplain vegetation appeared to be in better condition than riparian vegetation;
2. Riparian vegetation of upland areas associated with pastoral activities was in poorer condition than that in lowland channels associated with cropping; and
3. Condition of native remnant vegetation within cotton growing areas was almost identical to that outside cotton growing areas.

These observations indicate that the cotton and other cropping industries do not adversely affect the inherent condition of remnant native vegetation relative to other agricultural land-uses in the Namoi (in fact the converse might be true), although the extent to which native floodplain vegetation has been removed and displaced by cropping is likely to be compromising landscape functionality, in terms of provision of effective habitat and facilitation of species movement via corridors of native vegetation.

The results are encouraging for the cotton industry because they provide evidence that an effective network of habitats and corridors might be secured and managed to support and improve the conservation of native vegetation, and local fauna and flora species within the Namoi floodplain, while maintaining and developing the cotton industry. It is important that Namoi CMA now commit to better mapping and sampling intact areas of floodplain vegetation, working with landholders and the Cotton CRC to protect the larger areas, and developing a revegetation strategy which aims to link strongholds of good condition native vegetation across the riverine landscape.

While some regional priorities for conservation works are proposed - these target good condition floodplain and riparian vegetation – a broader strategy of targeted river reach revegetation is also proposed which aims to improve vegetation condition along significant river reaches in the short term. The strategy requires direct tree (and some shrub) planting over sections of major streams and rivers in which recruitment is lacking and canopy cover is poor, with hands-on protection through the first years of establishment. The Namoi River itself is suggested as a starting point, as a long term goal might be achievement of a continuous east-west riparian corridor through the valley. The program would be focus on working with multiple rather than single landholders.

Comparison of landscape-derived and plot-based condition scores provides evidence of a positive correlation, with inherent condition generally greater than surrounding landscape condition. However the relationship is weak, suggesting that local condition of riverine vegetation cannot be confidently predicted from landscape-generated estimates of condition, and that field assessment is ideally required to evaluate vegetation condition on the ground.

Outcomes of plot-based sampling demonstrate that a robust estimate of average vegetation condition can be established for any geographic region or entity, such as sub-catchment or stream order, if an adequate number of plots are sampled therein. It follows that estimation of change in vegetation condition is also achievable from year to year, or at regular intervals, if a minimum number of plots are sampled and average condition re-derived. Plot-based condition sampling could readily be employed to monitor, evaluate and report changes in riverine vegetation condition (riparian and floodplain), thus addressing key responsibilities of the Namoi Catchment Action Plan (CAP). The sampling protocol has been designed to undertake sampling rapidly and repeatedly, and is consistent with vegetation condition assessment protocols used in New South Wales, Queensland and Victoria.

In summary, a total of seven key recommendations are put forward following outcomes of this project:

1. Protect remaining areas of intact native vegetation in cotton (and other cropping) areas;
2. Identify key links, potential links and important habitats across the floodplain;
3. Prioritise protection and conservation of least degraded streams and rivers in the Namoi catchment, as opposed to rehabilitation of the more degraded streams and rivers;
4. Target identified priority areas for protection and restoration;
5. Institute a catchment-wide riparian planting scheme along major channels;
6. Develop a Riverine Vegetation Condition Monitoring Strategy based on field plots; and
7. Complete and maintain the Vegetation Condition and Benchmarks Database to accommodate new data and report condition trends in the Namoi catchment.

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List of Acronyms

API	Aerial Photograph Interpretation
BBS	Brigalow Belt South
CAP	Catchment Action Plan
CMA	Catchment Management Authority
CRC	Cooperative Research Centre
CWD	Coarse Woody Debris
DBH	Diameter at Breast Height
DECC	NSW Department of Environment and Climate Change (formerly NPWS)
DEM	Digital Elevation Model
DRP	Darling Riverine Plains
DSE	VIC Department of Sustainability and Environment
DSE	Dry Sheep Equivalent
ELA	Eco Logical Australia
EPA	Environmental Protection Agency (QLD)
FAU	Floodplain Assessment Unit
GIS	Geographic Information System
Ha	Hectare
LiDAR	Light Detection and Ranging
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority (formerly MDBC)
MDBC	Murray-Darling Basin Commission (now MDBA)
NAN	Nandewar
NET	New England Tablelands
NPWS	NSW National Parks and Wildlife Service (now DECC)
NSW	New South Wales
PVP	Property Vegetation Plan
QLD	Queensland
RAU	River Assessment Unit
RCL	Reserved Crown Land
RVC	Regional Vegetation Community
SLT	Spatial Links Tool
SRA	Sustainable Rivers Audit
TSR	Travelling Stock Reserve (Route)
VIC	Victoria

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1. Introduction

Healthy vegetation within riverine systems provides a suite of ecological services including a diversity of habitat for terrestrial and instream species, food for terrestrial and aquatic fauna, corridors for movement and migration of fauna species, shading and water temperature regulation, and streambank stability. Maintenance and improvement of the condition of riverine vegetation within catchments is thus critical.

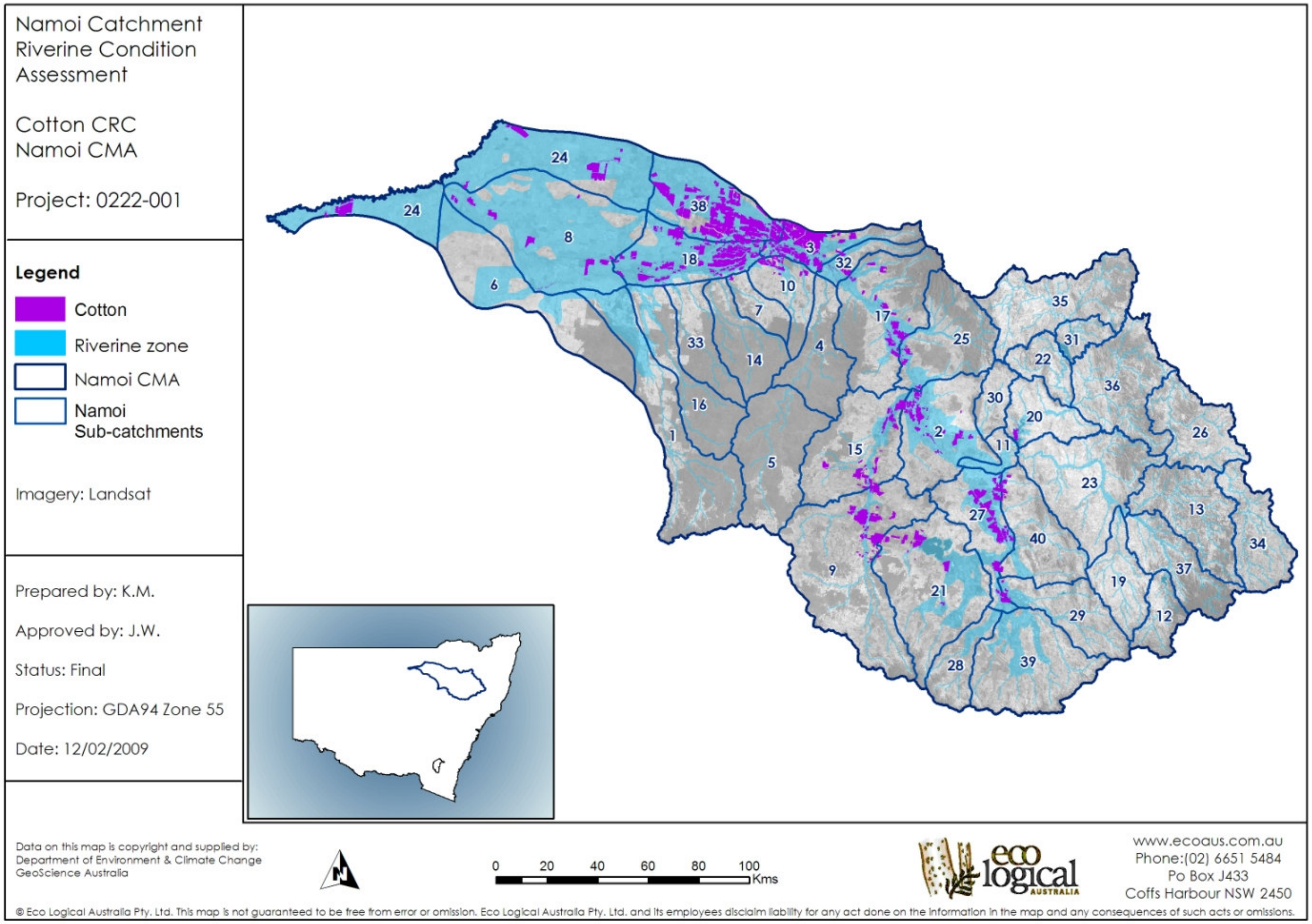
The broad condition of riverine vegetation along most of the major watercourses in the Namoi catchment has declined over the past 150 years through a combination of factors such as vegetation removal, application of fertiliser and other chemicals, overgrazing, dryland salinity, and regulated water flows (e.g. Gehrke *et al*. 2003; Norris *et al*. 2001). Vegetation removal has been most extensive on the undulating slopes of the Northern Tablelands, which supports a pastoral industry established in the mid-1800s, and on the alluvial soils of the lower floodplain, where cotton and other broadscale cropping industries were established a century later.

Cotton is grown extensively throughout the lower elevation parts of the Namoi floodplain, with a concentration of activity in the Ginudgera and Upper Pian sub-catchments in the north and the Mooki sub-catchment in the east (Figure 1). The total area of cotton cropland and associated infrastructure in the Namoi is about 1,450 km^2, which is about 3% of the areas of the Namoi catchment and 15% of the area of the Namoi floodplain. Other extensive crop types include chickpeas, sorghum, lucerne, maize, sunflowers and wheat.

In the cotton growing areas in particular, there is a tendency for people to associate the landscape with poor vegetation condition. While the cotton fields themselves retain little native habitat value, there may be reaches of the main channels, or uncropped areas of the floodplain, where native vegetation is in reasonable condition.

Eco Logical Australia (ELA) was engaged in April 2008 by the Cotton Catchment Communities Cooperative Research Centre (Cotton CRC), in partnership with the Namoi Catchment Management Authority (Namoi CMA), to develop a framework for mapping the extent and condition of native vegetation in the riverine zone of the Namoi catchment. This document provides a detailed review of the major findings, and suggests ways in which the cotton industry (and other extensive cropping enterprises) might adapt to maintain and improve native vegetation condition within the main cropland areas of the Namoi.

Figure 1. Cotton footprint of the Namoi catchment (from DECC land-use data)



1 Baradine
2 Bluevale
3 Bobbiwaa
4 Bohena
5 Borah
6 Box Creek
7 Brigalow
8 Bugilbone
9 Bundella Creek
10 Bundock
11 Carroll
12 Chaffey
13 Cockburn River
14 Coghill
15 Cox's Creek
16 Etoo
17 Eulah Creek
18 Ginudgera
19 Goonoo Goonoo
20 Keepit
21 Lake Goran
22 Lower Manilla
23 Lower Peel
24 Lower Pian
25 Maules
26 Mid MacDonald
27 Mooki
28 Phillips
29 Quirindi
30 Rangira
31 Split Rock
32 Spring Creek
33 Tallaba
34 Upper MacDonald
35 Upper Manilla
36 Upper Namoi
37 Upper Peel
38 Upper Pian
39 Warrah
40 Werris Creek

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2. Vegetation Condition Assessment

2.1 Background

The current condition of native vegetation within riverine areas of the Namoi catchment varies in response to factors including current and past land use, vegetation type and climate. Agricultural land uses which require clearing of native vegetation or employ cultivation and/or irrigation are known to have reduced the condition of vegetation within the riverine landscape, particularly within extensive floodplains where grasslands and grassy woodlands were previously dominant. However, some patches or reaches of native vegetation may exhibit good condition in landscapes where land use impact has been considerable, such as the Walgett floodplain and Liverpool Plains.

The Sustainable Rivers Audit (SRA) is an initiative of the Murray Darling Basin Authority (MDBA) which aims to report on the condition of major valleys in the Murray Darling Basin (MDB), including the Namoi, against several 'themes' including vegetation (SRA 2008). The draft SRA vegetation theme recognises three major aspects of riverine vegetation condition, namely 'state' (current state of vegetation), 'persistence' (capacity of vegetation to persist), and 'functioning' (capacity of vegetation to contribute to ecological functioning of the river system). These three aspects are represented by various landscape attributes and field attributes. Landscape attributes include vegetation cover, patchiness, and connectivity, and can be estimated remotely using Geographic Information System (GIS) analysis. Field attributes include species richness, groundcover and regeneration which are sampled on the ground and compared with condition 'benchmarks', providing the opportunity to quantify condition or health of individual stands.

2.2 Landscape assessment

There is a large quantity of literature which explores the use of landscape metrics for estimating vegetation condition, and a considerable variation in the models employed and the relationships identified. Zerger *et al*. (2006) identified vegetation connectivity, topographic position and neighbourhood terrain roughness as indicators of vegetation condition in the Little River Sub-Catchment in Central West NSW. Other landscape metrics in that study, such as vegetation cover, patch size and vegetation type, were found to be poor surrogates for site condition. Arthur Rylah Institute *et al*. (2003) modelled vegetation condition in Victoria using various metrics generated from remote sensing data and mapped GIS variables, and found a positive relationship between on-ground condition and predicted condition based on several landscape metrics including climatic variables (mean annual rainfall, temperature and evaporation), tree density, elevation, vegetation type, and patch perimeter. Jansen *et al*. (2003) found a strong relationship between livestock density, measured in dry stock equivalents (DSEs)/ha/year, and riparian condition.

Most of the literature recognises the 'noise' inherent in the landscape-site interface, and thus the danger of applying regional condition models at the local scale, where on-ground condition may be misrepresented. It is also widely recognised that remote sensing will not eliminate the requirement for ground-based assessments (e.g. Stone and Haywood 2006) partly because of technical

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and seasonal problems with satellite imagery (e.g. Zerger *et al.* 2007 in-press; Wallace and Furby 1994). Higher resolution imagery such as Quickbird satellite imagery or Light Detection and Ranging (LiDAR) photography may well provide a tool for consistently mapping site-based metrics such as %cover in the canopy, midstratum and groundcover. However, attributes such as species richness, weediness, regeneration and logs and litter will always require field verification. As such, both levels of assessment will continue to be used to evaluate and monitor condition across large areas such as the Namoi catchment, and any derived relationship between landscape and site condition should include confidence limits.

2.3 On-ground condition assessment

2.3.1 Application of benchmarks

'Benchmark' or 'reference' vegetation condition is a term which commonly refers to the condition of an undisturbed or minimally disturbed patch of vegetation (Roberts and Bickford 2006). It is usually derived for individual vegetation types by sampling a set of ecological parameters in vegetation exhibiting no apparent or minimum disturbance. Attributes sampled relate to state, persistence and functioning of vegetation communities, and normally include species diversity, %cover, recruitment of canopy species and groundcover variables. Once established, the condition of any other stand of vegetation of that type can be 'referenced' against the benchmark by sampling and comparing the same set of ecological parameters.

The local condition of native vegetation is referenced against benchmarks established for broad vegetation class in NSW (classes described by Keith 2004) using the 'Biometric' tool of the Property Vegetation Plan (PVP) – Developer (Gibbons *et al*. 2005). To reference condition within a particular area or property, Biometric requires that vegetation first be mapped into spatial 'zones, which are broadly defined in terms of vegetation type and broad condition-state, based largely on %cover and 'nativeness'. The number and size of zones depends on factors such as property size, patch size distribution and vegetation heterogeneity.

An example of zone delineation is drawn from similar work in Queensland which used regional ecosystems rather than vegetation classes (Figure 2). Vegetation classes are generally regarded as being too broad for benchmarking, so the NSW Department of Environment and Climate Change (DECC) is exploring other classifications which might support an alternative set of benchmarks. Recent work completed by ELA (2008a) on behalf of DECC establishes a set of regional vegetation communities (RVCs) in northern NSW which are roughly compatible with regional ecosystems in Queensland, and might provide a more suitable basis for benchmarking. The distribution of these RVCs has recently been mapped across the Namoi catchment (ELA 2008b).

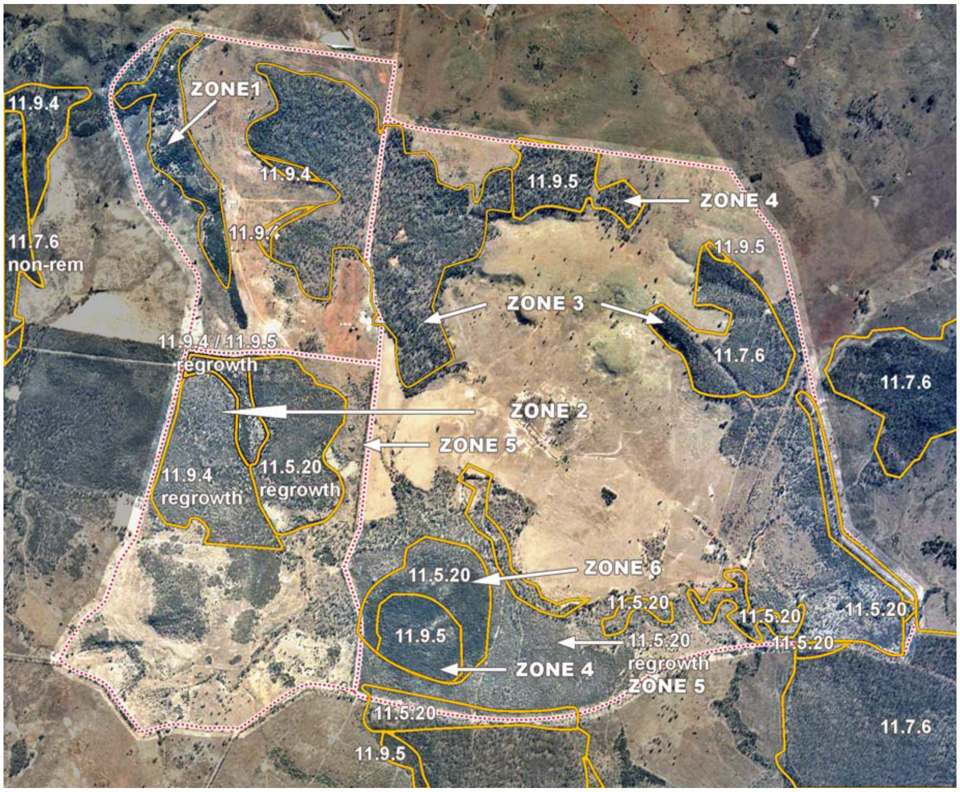

Figure 2. Example of stratification of zones into regional ecosystems and broad condition (from Eyre *et al.* 2006).

2.3.2 Ecological attributes and sampling techniques

Field attributes selected for benchmarking and condition assessment, and the way in which they are measured, differ between the three major jurisdictions in the MDB (i.e. NSW, Queensland and Victoria), although there is much common ground. This section reviews the field sampling strategy employed by each jurisdiction and the SRA. Table 1 lists the field attributes for which benchmark data are available in each jurisdiction. All jurisdictions measure recruitment, weediness, fallen logs, and %cover for most growth forms. Large trees and litter are sampled by QLD and VIC but not NSW, while NSW counts trees with hollows. Total species richness is measured in NSW and QLD, but is limited to midstorey and understorey species in VIC. Tree height is only measured in QLD as a primary benchmark variable.

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Table 1. Attributes used for benchmarking and condition assessment in NSW, QLD and VIC [shown in terms of a score (/100) towards benchmark] (from ELA 2008d)

Attribute	NSW [A]	QLD [B]	VIC [C]
Total species richness	25	10	
Large trees		15	10
Number of trees with hollows	20		
Tree canopy height		5	
Tree canopy cover		5	5
Native overstorey cover	10		
Native midstorey cover	10		
Shrub layer cover		5	
Native ground cover (shrubs)	2.5		
Native ground cover (grasses)	2.5		
Native perennial grass cover		5	
Native ground cover (other)	2.5		
Native perennial forb and non-grass cover		5	
Native annual grass, forb and non-grass cover		5	
Understorey cover (all non-canopy growth forms)			25
Exotic plant cover, weediness	5	10	15
Recruitment/regeneration	12.5	5	10
Organic litter		5	5
Logs	10	5	5
Landscape context variables		*25*	*25*

A. Gibbons et al. (2005)
B. Eyre et al. (2006)
C. DSE (2004)

ELA (2008d) provides a detailed definition of each of attribute listed in Table 1, and the jurisdiction and SRA approaches to sampling them.

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3. A Condition Assessment Framework for Namoi Catchment

3.1 Background

A vegetation condition assessment undertaken recently for the MDBA (ELA 2008c,d) underpins development of a framework for assessing riverine vegetation condition in the Namoi catchment. There are eight main components to the framework:

- delineation of the riverine zone;
- separation of the riverine zone into assessment units;
- vegetation mapping of assessment units;
- landscape (Level 1) assessment of each assessment unit;
- site (Level 2) assessment of a sub-set of units;
- development and application of a condition scoring system;
- derivation of a set of 'benchmark' attributes for each riverine type;
- development of a database for data entry and scoring; and
- mapping native vegetation condition.

The broad structure of the framework is shown in Figure 3.

3.2 Application to the Namoi

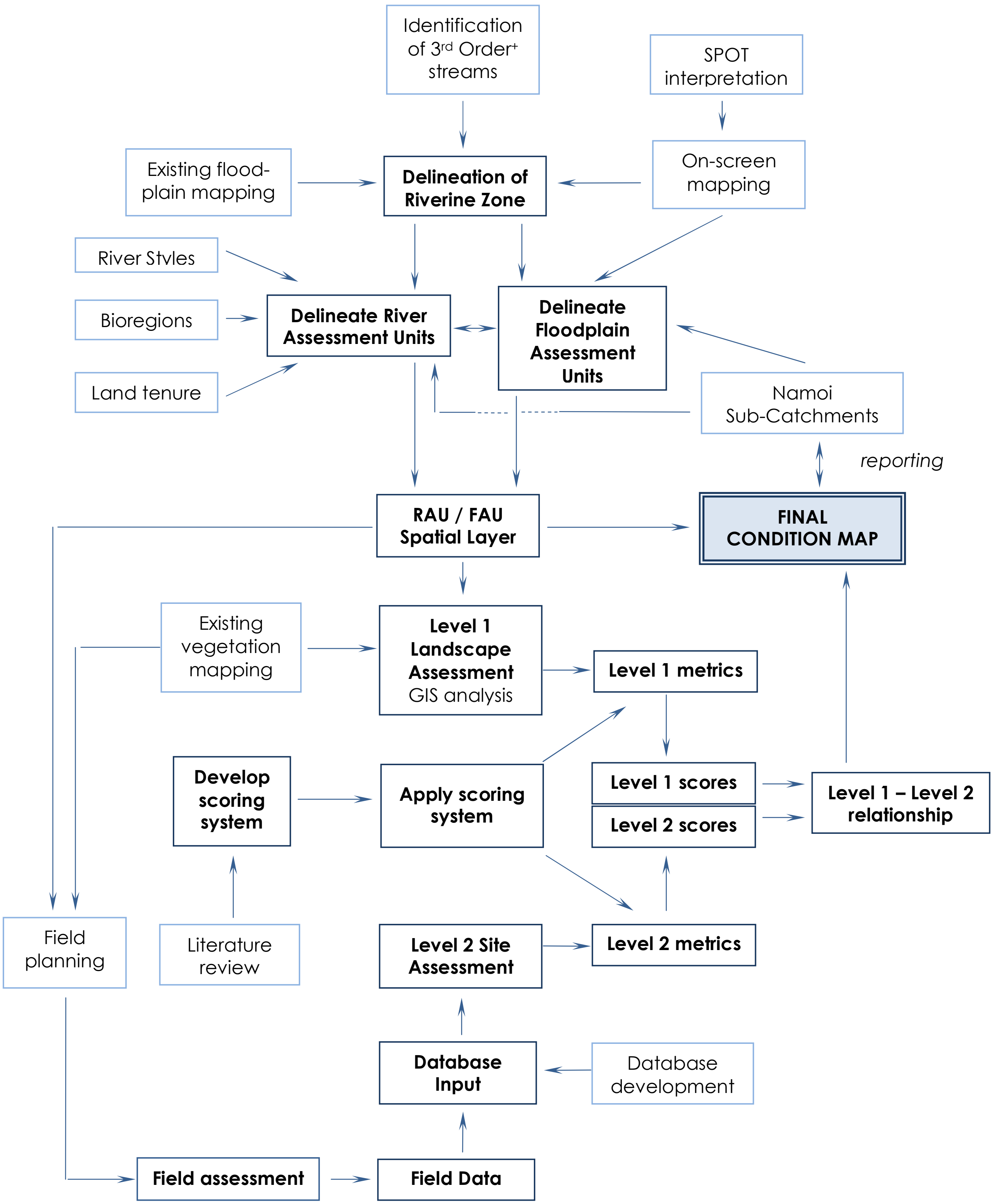
3.2.1 Delineation of the Riverine Zone

The Riverine Zone was defined for this project as all riparian and floodplain areas associated with third order streams or larger, where third order streams were defined as those originating from the confluence of two second order streams (after Strahler 1964). Third order streams more or less coincide with permanent watercourses in the Namoi, although some will cease flowing in drought conditions.

The Namoi floodplain was mapped in ArcGIS with the support of the Namoi Valley Floodplains Atlas, a hard-copy compendium of spatial flood data sourced from aerial photographs, interviews with landholders and Local Government Authorities, and from other Government records (Laurie, Montgomerie and Pettit P/L 1982). Atlas data were digitised on-screen using a similar satellite image backdrop as appears in the Atlas. Recent flood models completed for the MDB (Pickup *et al*. 2008) were used to verify Atlas data, and on-screen refinements were made accordingly. Expert observation of floodplain patterns against SPOT imagery also informed realignment or addition to the floodplain footprint. Digital Elevation Models (DEMs) were not of sufficient resolution to meaningly contribute to floodplain delineation.

Flood data are generally absent for minor rivers in the Namoi, so riparian areas were manually digitised on-screen with the assistance of SPOT satellite imagery and digital topographic maps. The NSW Mitchell Landscapes layer does separate the main channels, but channel definition was found to be too broad for this project.

Figure 3. Riverine condition assessment framework for Namoi catchment



3.2.2 Delineation of Assessment Units

The riparian zone was separated into river assessment units (RAUs), where each RAU represented a unique combination of bioregion, sub-catchment, river style data (Lampert and Short 2004; Brierley and Fryirs 2005) stream order and land tenure (public or private). River styles and sub-catchment data were provided by Namoi CMA. Each RAU was named according to the following protocol:

XXXXX-YYYYY##

where XXXXX represents the first 5 letters of the channel name;
YYYYY represents the first 5 letters of the sub-catchment; and
represent the RAU number of that sequence (upstream to downstream)

The floodplain zone was split into floodplain assessment units (FAUs) based on bioregions and sub-catchments alone. Each FAU was named according to the following protocol:

XXXXX-YYYYY

where XXXXX represents the first 5 letters of bioregion; and
YYYYY represents the first 5 letters of the sub-catchment

3.2.3 Vegetation mapping in RAUs and FAUs

A vegetation surface currently being developed by ELA (2008b) for the Namoi CMA was clipped to the riverine footprint so that all RAUs and FAUs exhibited a complete coverage of RVCs (ELA 2008a). The mapping was checked, and typing and delineation errors addressed as necessary (often following field assessment – see below). The RVC classification included native woody types, true native grasslands and wetlands, and derived native grasslands (derived from removal of woody canopy species). It also included naturalised pasture, cropping, urban, water storage and other artificial zones. The accuracy of RVC mapping (spatial and floristic) was largely dependent on the respective accuracy of the contributing mapping datasets which were sourced from various past projects, integrated into a single composite layer, then classified into RVCs to provide a composite layer for the Namoi (ELA 2008b).

3.2.4 Landscape Assessment in RAUs and FAUs

A vegetation cover model available for the whole catchment (DECC 2008) was also sourced for this project, and was used to derive 10 cover metrics for each RAU, and four cover metrics for each FAU (Table 2), each reported as a %-score between 0 and 100. The DECC surface was used in preference to the composite API layer as it was considered to be spatially superior.

A mean RAU score for each of the 10 metrics (± 95% confidence limits) was calculated for each sub-catchment in the Namoi, and *t*-tests were employed to test for significant differences between RAU means. Similarly, a mean FAU score for each of the four metrics was calculated for each sub-catchment in the Namoi, and *t*-tests were employed to test for significance. A final score was calculated for each sub-catchment in the Namoi by averaging all RAU and FAU scores across all metrics.

Table 2. Landscape metrics calculated for each RAU and FAU

Metric	Approach	Assessment Units FAU	Assessment Units RAU
Cover			
% native vegetation	Estimated the % of each RAU or FAU containing native woody vegetation.	yes	yes
% native vegetation within 200m	Derived a 200m buffer around each RAU and estimated the % of each buffer containing native woody vegetation.		yes
% native vegetation within 550m	Derived a 550m buffer around each RAU and estimated the % of each buffer containing native woody vegetation.		yes
% native vegetation within 1750m	Derived a 1750m buffer around each RAU and estimated the % of each buffer containing native woody vegetation.		yes
% non-native vegetation	Estimated the % of each FAU containing non-native vegetation, which included cropping, improved pasture, urban areas, major infrastructure and water storages.	yes	
% non-native vegetation within 200m	Estimated the % of each 200m RAU buffer containing non-native vegetation.		yes
% non native vegetation within 550m	Estimated the % of each 550m RAU buffer containing non-native vegetation.		yes
% non-native vegetation within 1750m	Estimated the % of each 1750m RAU buffer containing non-native vegetation.		yes
Connectivity & patchiness			
% habitat links	Generated a habitat links output from the Spatial Links Tool (Drielsma *et al.* 2007) and estimated the % of each RAU and FAU containing habitat links (also, see text).	yes	yes
% longitudinal woody vegetation connectivity	Estimated the % of the reach of each RAU that contained continuous native vegetation (from Jansen *et al.* 2004).		yes
% native vegetation patches ≥ 20ha	Generated a gridcell layer of all native woody vegetation patches ≥ 20ha and estimated the % of each RAU and FAU comprising this vegetation.	yes	yes

Note. derived native grassland was <u>not</u> including in any of the above metrics, other than '% habitat links'

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Buffer widths of 200, 550 and 1750m associated with cover metrics were drawn from Biometric, which applies the same buffers to the landscape component of site assessment in the PVP-Developer (Gibbons *et al.* 2005). A patch area of 20 ha was drawn from Oliver and Parkes (2003), and is considered to represent a size within which most species populations could persist in the long term.

The connectivity and patchiness metrics in Table 2 provide some indication of the landscape functionality of RAUs in terms of their capacity to facilitate movement of species across the landscape. These metrics recognise that organisms can disperse to varying degrees across spaces that include unsuitable habitat, and that smaller patches are not as effective in providing habitat as larger patches because they contain less core habitat and more 'edge' (e.g. Oliver and Parkes 2003).

The '% habitat links' metric requires prior derivation of a map of landscape connectivity using the spatial links tool (SLT) developed by Drielsma *et al*. (2007). A cost grid was first constructed from recent cover extent mapping (DECC 2008) in which each category represented by numerous gridcells, was assigned a relative 'cost' based on the assumed capacity of species to traverse it. Native woody vegetation provided the least cost to species dispersal and movement, while non-native non-woody (mainly croplands and urban environments) provided the highest cost.

To run the SLT, a large number of random points first need to be generated within the extent of existing vegetation. Each iteration of the SLT then identifies the least cost path (as a set of adjacent cells) between any randomly selected pair of points exhibiting a maximum separation distance threshold. Each cell in that path is assigned a 'link value' which is the contribution that cell makes to landscape connectivity. There can be many thousands of iterations, and each successive path tends to overlap at least partly to produce a range of link values. A relatively high link value suggests a more favourable corridor across which species are able to move and disperse.

3.2.5 Site Assessment in RAUs and FAUs

A field survey proforma for evaluating ecological attributes associated with vegetation condition was used for this project. The proforma evolved from previous work undertaken for the MDBA (ELA 2008d), and more recently from on-farm assessments carried out for the Namoi CMA. In summary, survey protocol required the following:

- Identification of a sub-set of all RAUs within which to undertake site assessment (all FAUs to be sampled);
- Selection of 50x20 plots within identified RAUs and FAUs, representative of the general condition of those units; and
- Application of the field sampling protocol.

The field sampling protocol required assessment of 16 ecological attributes (Table 3, Figure 4) each known to contribute to vegetation condition in terms of persistence and/or function. Six attributes were sampled within the 50x20m baseplot, two attributes were sampled within the nested 20x20m sub-plot, three

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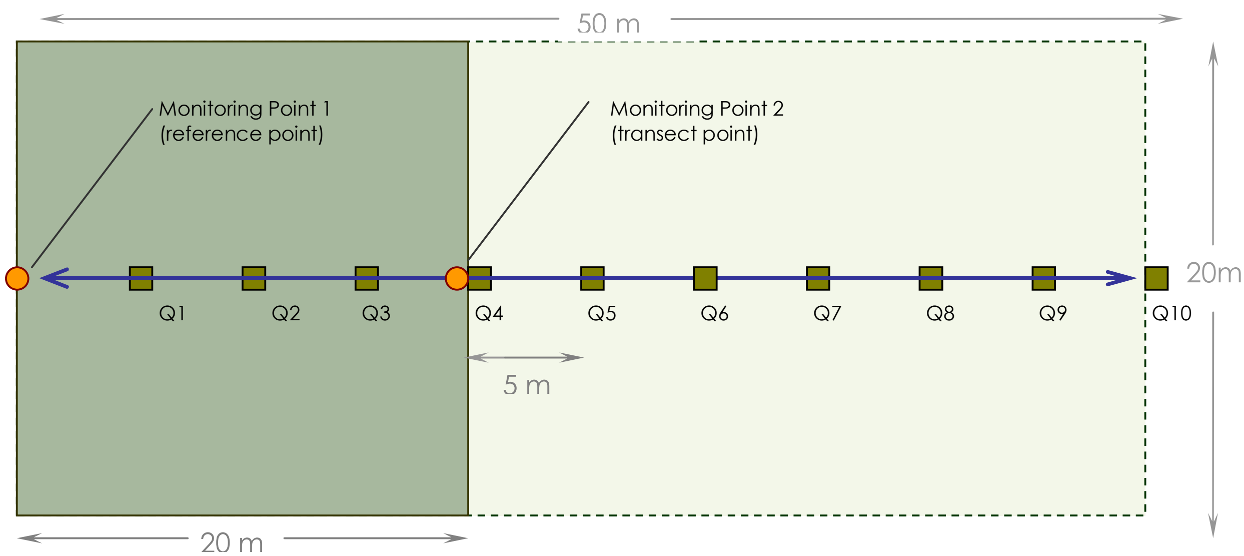
attributes were sampled at 10 points along a 50m transect (positioned in the centre of the baseplot), and five attributes were sampled within each of 10 1x1m quadrats along the same 50m transect (Figure 4). The sampling units and methodology used to sample each attribute are listed in Table 3. The field proforma is included in Appendix I.

Figure 4. Baseplot layout and dimensions for sampling vegetation condition



Baseplot	Species richness (canopy) Number of regenerating native canopy (tree) species Number of large trees Number of trees with hollows Canopy health (i.e. health of tree foliage) Coarse woody debris (length of dead fallen timber (logs))
20 x 20m subplot	Species richness (midstorey > 1m high) Species richness (groundcover)
50m transect	Native canopy (tree) cover Native midstorey cover (cover of native shrubs/small trees >1m) Weed canopy/midstorey cover (i.e. cover of weeds >1m)
1 x 1m quadrat	Native groundcover % cover (< 1m high) Mosses and lichens % cover Weeds % cover Organic litter % cover Rock/bare ground % cover

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Table 3. Method employed to sample each attribute in the field (adapted from Gibbons *et al*. 2005)

Attribute	Sampling Unit	Sampling Method
Species richness (canopy)	50 x 20m baseplot	Count of native species in the canopy. Canopy species are tree (including tall Acacias) and tree mallee species that form the tallest layer of the vegetation. This layer is usually taller than 6m.
Species richness (midstorey)	20 x 20m subplot	Count of native shrub and small tree species in the midstorey (≥ 1m height). This can include immature specimens of potential canopy species.
Species richness (groundcover)	20 x 20m subplot	Count of native species in the understorey (< 1m height, including grasses, forbs, herbs, sedges, rushes and small shrubs). If a species occurs in more than one layer it should only be counted once.
Native canopy cover	10 points along 50m	Measured as projected foliage cover (including trunks and branches) of native canopy species expressed as a %. Estimated visually, with or without assistance of reference cover images, by looking at the canopy within a 2.5m radius of the point.
Canopy health	50 x 20m baseplot	Estimated to the nearest 10% as the proportion of the expected healthy canopy cover that is present (i.e. not missing due to tree death or decline, or mistletoe infestation)
Native midstorey (shrub) cover	10 points along 50m	Measured as projected foliage cover (expressed as a %) of native midstorey shrub and small tree species. Estimated visually within a 2.5m radius of the point. This can include immature native canopy species.
Weed canopy and midstorey cover	10 points along 50m	Measured as projected foliage cover (expressed as a %) of weed shrub and tree species. Estimated visually within a 2.5m radius of the point.
Groundcover	1 x 1m plots	Measured as projected foliage cover (expressed as a %) of native understorey vegetation (< 1m height. Visually estimated as the proportion of each quadrat occupied by understorey plants. This includes grasses, forbs, herbs, sedges, rushes and small shrubs. Species can contribute to cover scores in more than one layer.
Bryophyte cover	1 x 1m plots	Estimated as cover of bryophytes (mosses and lichens) in the ground layer.
Weeds	1 x 1m plots	Estimated visually as total projected foliage cover (expressed as a %) of weeds in the ground layer.
Organic litter	1 x 1m plots	Estimated as %cover of all organic litter (including standing dead plant material and sticks <10cm diameter).
Rock/bare ground	1 x 1m plots	Estimated as % of rock and/or bare ground.

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Table 3. cont'd)

Attribute	Sampling Unit	Sampling Method
Number of large trees	50 x 20m baseplot	Count of the number of living trees greater or equal to the benchmark diameter at breast height (dbh) (see Appendix 1).
Number of trees with hollows	50 x 20m baseplot	Count of the number of living and dead trees which possess at least one hollow, where the hollow entrance clearly possesses depth into the tree, is estimated to be ≥5cm diameter, and occurs as part of the main trunk or limbs, at least 1m above the ground. (Note: the base of tree needs to be in the plot, but the hollow does not)
Number of canopy species regenerating	50 x 20m baseplot	Count of the number of canopy or potential canopy species observed to be regenerating (dbh ≤5cm). There can be more species in this category than the number of native canopy species.
Coarse woody debris	50 x 20 m baseplot	Measured as the total combined length of dead fallen timber (diameter ≥ 10 cm; length ≥ 50cm). Estimated to the nearest metre using a tape or by pacing.

3.2.6 Database development

A relational database was developed in Microsoft ACCESS to input, store, manage and analyse field data collected in riverine environments in the Namoi. Capacity to score site condition automatically by applying the scoring system in section 3.2.8 to incoming field data was built into the database via a 'derived condition' report. This required that all benchmark attributes for all riverine RVCs be built into a separate table embedded in the database.

3.2.7 Establishing benchmarks

For each riverine RVC, a 'benchmark' was derived for each of the 16 ecological field attributes listed in Table 3, using a combination of:

- Field data;
- NSW benchmarks (Gibbons et al. 2005);
- Queensland benchmarks (website); and
- Expert consideration

Benchmark data were input into a separate table in the vegetation condition database. The RVC field provided a common link to other tables, enabling calculation and reporting of the condition of any plot, based on its RVC and ecological attributes.

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3.2.8 *Vegetation condition scoring system*

3.2.8.1 Condition score

Condition scoring techniques employed by NSW, Queensland and Victoria vary in terms of site selection, sampling design and attributes measured (Roberts and Bickford 2006). However, the operational framework of each is broadly similar, and the ecological attributes that are scored largely overlap (Table 1). For any particular vegetation type, the scoring system requires comparison of the site score associated with a particular ecological attribute, to its equivalent 'benchmark' score, which represents the highest possible score. The field score for each attribute is derived using a set of scoring rules, and the sum of all field scores is summed to obtain an overall condition score for the site.

Table 4 lists the weightings assigned to each of the 16 ecological attributes (some of which are amalgamated for scoring). These weightings are informed by current approaches (Table 1) and add to a maximum of 100. Attributes associated with woody vegetation are ignored for native grassland types, so a simplified scoring system is used for grasslands.

Table 4. Attributes and weightings for deriving the final condition metric

	Weighting %	
Attribute	**Forest/Woodland**	**Grassland**
Native species richness (all strata)	15	30
Native canopy cover	10	-
Native shrub cover	5	-
Native groundcover (including mosses & lichens)	15	30
Organic litter cover	5	10
Weed cover (understorey + canopy/midstorey)	15	30
Number of large trees	15	-
Number of trees with hollows	5	-
Number of canopy species regenerating	10	-
Coarse woody debris	5	-
	100	**100**

3.2.8.2 Species richness (canopy, midstorey and groundcover)

The diversity of native species within a site is a key indicator of condition. The higher the diversity, the greater the range of habitat space for native fauna, and the greater the functioning in the system. Removal of flora species through land clearing or overgrazing can simplify ecosystems and reduce site condition. Three broad growth forms contribute to total native species richness at the site level: canopy; midstorey (>1m); and groundcover (<1m). The suggested ruleset for referencing species richness is broadly similar to the approach used in Queensland (Eyre *et al.* 2006), although the maximum score was increased from 10 to 15 as species richness can score as high as 25/100 in Biometric (Gibbons *et al*. 2005). Individual scores for canopy, midstorey and groundcover growth forms (each scoring a maximum of 5) are summed to provide a maximum score of 15 for species richness (Table 5).

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Table 5. Criteria and scores for species richness (from Eyre *et al*. 2006)

Criterion (applied separately to canopy, midstorey and groundcover)	Score
< 10% of benchmark number of species in the stratum	0
10% - 24% of benchmark number of species in the stratum	1
25% - 49% of benchmark number of species in the stratum	2
50% - 74% of benchmark number of species in the stratum	3
75% - 89% of benchmark number of species in the stratum	4
≥ 90% of benchmark number of species in the stratum	5

3.2.8.3 Canopy cover

Canopy cover assessment involves estimation of the projected foliage cover of the native tree canopy at 10 points along a plot transect, as practiced in NSW (Gibbons *et al.* 2005). A scoring system was adapted from that used by DSE (2004) and Eyre *et al.* (2006) which takes into account canopy health (Table 6). However, a maximum score of 10 rather than 5 was imposed on canopy cover (consistent with Biometric – Gibbons *et al.* 2005), as loss of tree cover though clearing or dieback can reduce structure and function of forest and woodland systems, and threaten their viability.

The scoring system in Table 6 includes assignment of a lower score for vegetation exhibiting a canopy cover in excess of 150% of the benchmark (consistent with DSE (2004) and Eyre et al. (2006)). Overly high cover may result from regenerative response to fire or other dense regrowth and generally results in changes to stand function and structure (e.g. through excessive shading).

Table 6. Criteria and scores for canopy cover (from DSE 2004; Eyre *et al.* 2006)

	% canopy health *		
Criterion	>70%	30-70%	<30%
< 10% of benchmark canopy cover	2	1	0
< 50% or >150% of benchmark canopy cover	6	4	3
50-150% of benchmark canopy cover	10	7	5

* Estimated proportion of an expected healthy canopy cover that is present (i.e. 100 - %missing due to tree death and/or decline, and/or mistletoe infestation)

3.2.8.4 Shrub cover

Shrub cover was scored using rules in Table 7 (from Eyre *et al*. 2006). As for canopy cover, excessive shrub cover may arise from response to fire or other disturbance, and may reduce grassy cover and impede natural regeneration. Hence a lower score for above-benchmark shrub cover.

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Table 7. Criteria and scores for shrub cover (adapted from Eyre *et al.* 2006)

Criterion	Score
No shrub cover	0
< 10% of benchmark shrub cover	1
< 30% of benchmark shrub cover	2
< 50% or >150% of benchmark shrub cover	3
< 75% or >125% of benchmark shrub cover	4
75-125% of benchmark shrub cover	5

3.2.8.5 Native groundcover

Native groundcover incorporates all native plants with a height to 1m, including graminoids, forbs, vines, juvenile trees and shrubs, and bryophytes. Native groundcover is often split into structural components such as perennial grasses, annual grasses and forbs, which are each scored separately (e.g. DSE 2004; Eyre et al. 2006; Oliver and Parkes 2003). However, this requires trained botanists rather than land managers, so a simplified system was used in which all native vascular plants and mosses/lichens were combined for scoring using a system adapted from Eyre *et al.* (2006) (Table 8).

Table 8. Criteria and scores for groundcover (adapted from Eyre *et al.* 2006)

Criterion	Score
< 10% of benchmark native ground cover	0
10% – 24% of benchmark native ground cover	3
25% – 49% of benchmark native ground cover	6
50% – 74% of benchmark native ground cover	9
75% - 89% of benchmark native ground cover	12
≥ 90% of benchmark native ground cover	15

3.2.8.6 Organic litter cover

Organic litter includes both fine and coarse material, such as fallen leaves, twigs, bark and small branches. It plays a key role in nutrient cycling and protection of soil biota. It can also be important to successful plant regeneration through influences on soil microclimate, structure and composition (Oliver and Parkes 2003). Organic litter cover was scored using a ruleset adapted from Eyre *et al*. (2006) (Table 9).

Table 9. Criteria and scores for organic litter cover (from Eyre *et al.* 2006)

Criterion	Score
No organic litter	0
< 10% of benchmark organic litter cover	1
< 30% of benchmark organic litter cover	2
< 50% or >150% of benchmark organic litter cover	3
< 75% or >125% of benchmark organic litter cover	4
75-125% of benchmark organic litter cover	5

3.2.8.7 Weediness

Exotic flora species can reduce the condition of vegetation communities by excluding natives and reducing viability and longevity of the system. Weeds such as Lippia (*Phyla canescens*) can completely dominate the understorey of floodplain areas in the Namoi, to the detriment of native understorey species and thus ecosystem function.

Weed cover refers to the percentage cover of non-native or exotic plant species, and was assessed within the 1x1m plots as a component of groundcover, and at 10 points along the transect as a component of canopy and midstorey cover. An overall weed %cover was first calculated by adding the understorey %cover to half the overstorey/midstorey %cover. This assumes that any weed cover above 1m height overlaps understorey cover by 50%.

Some scoring systems apply a negative weighting to 'high threat' weed species (e.g. Oliver and Parks 2003; DSE 2004) even though the degree of weed infestation and associated disturbance may be the same, irrespective of the weed species involved. A scoring system adapted from that developed by Eyre *et al*. (2006) was used as the basis of scoring weeds in this project (Table 10), although the maximum score was set to 15 instead of 10 because the impact of weeds on site biodiversity (and thus condition) can be high (Oliver and Parkes 2003).

Table 10. Criteria and scores for the cover and threat of exotic plant species (from Eyre *et al.* 2006)

Criterion	Score
>50% weed cover	0
26-50% weed cover	3
15-25% weed cover	6
6-15% weed cover	9
1-5% weed cover	12
< 1% weed cover	15

3.2.8.8 Large trees

The presence of large trees suggests that a forest or woodland exhibits mature and/or senescent characteristics. Large trees are usually well over 100 years old, so take many decades to replace once removed. They are a significant component of stand condition. Large trees (non-*Callitris*) were identified using a benchmark DBH, and were calculated as the total number per plot. The ruleset for scoring large trees was based on DSE (2004) and Oliver and Parkes (2003), each of which incorporates a measure of canopy health (Table 11).

Table 11. Criteria and scores for the number and health of large trees present

	% canopy health *		
Criterion	>70%	30-70%	<30%
No large trees present	0	0	0
1% to 19% of the benchmark number of large trees	3	2	1
20% to 39% of the benchmark number of large trees	7	5	3
40% to 69% of the benchmark number of large trees	10	8	5
70% to 89% of the benchmark number of large trees	13	10	7
≥ 90% the benchmark number of large trees	15	12	9

* Estimated proportion of an expected healthy canopy cover that is present
(i.e. 100 - %missing due to tree death and/or decline, and/or mistletoe infestation)

If a *Callitris spp*. was known to dominate or sub-dominate the canopy of a RVC, a benchmark was also established for the number of large *Callitris* trees per plot. If this benchmark was not achieved, an additional 2 points were deducted from the score calculated in Table 11.

3.2.8.9 Trees with hollows

This attribute is important for providing an index of arboreal fauna habitat and thus ecosystem function, and is measured by the Biometric tool in NSW (Gibbons *et al*. 2005). It is an important addition to the large tree metric because it includes hollows in dead trees and trees which might not have achieved the 'large tree' benchmark. It also recognises that not all large trees contain hollows. Table 12 outlines the scoring protocol used for trees with hollows (from Oliver and Parkes 2003). Similar to large trees, the density of hollow-bearing trees was calculated and benchmarked on a trees per plot basis.

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Table 12. Criteria and scores for hollow-bearing trees (from Oliver and Parkes 2003).

Criterion	Score
No hollows	0
< 20% of benchmark no. hollows	2
20% to 39% of benchmark no. hollows	3
40% to 69% of benchmark no. hollows	4
≥ 70% of benchmark no. hollows	5

3.2.8.10 Tree species regeneration

Natural regeneration of overstorey species is essential for persistence of forest and woodland communities. Regeneration is often suppressed through continuous grazing and associated soil structure decline, and is a key indicator of condition. The suggested ruleset for scoring tree recruitment is based on that used by Eyre *et al*. (2006) and is shown in Table 13. This does not take into account episodic versus continuous regeneration (e.g. DSE 2004; Oliver and Parkes 2003), and it does not discriminate between seedlings and saplings.

Table 13. Criteria and scores for recruitment of overstorey species (adapted from Eyre *et al*. 2006)

Criterion	Score
No overstorey recruitment	0
< 20% of overstorey species present as regeneration	2
20-39% of overstorey species present as regeneration	4
40-59% of overstorey species present as regeneration	6
60-79% of overstorey species present as regeneration	8
≥ 80 of overstorey species present as regeneration	10

3.2.8.11 Course woody debris (CWD)

Dead fallen timber plays a functional role in forest and woodland ecology, providing habitat for a suite of ground-dwelling mammals, reptiles and invertebrates, and cycling organic matter and nutrients. CWD was sampled by measuring the total length of dead logs within the 50x20m baseplot, where dead logs were ≥ 0.5m in length and ≥ 0.1m in (i.e. no part of any log with diameter < 0.1m was included), and occurred in various states of decomposition. The scoring system is shown in Table 14, and is based on that used by Eyre et al. (2006). However, it does not include a weighting for the state of decay of fallen logs (e.g. Eyre et al. 2006; Oliver and Parkes 2003) or the presence of 'large' logs (e.g. DSE 2004).

Table 14. Criteria and scores for CWD (adapted from Eyre *et al.* 2006)

Criterion	Score
No CWD	0
< 10% of benchmark CWD	1
< 30% of benchmark CWD	2
< 50% or >150% of benchmark CWD	3
< 75% or >125% of benchmark CWD	4
75-125% of benchmark CWD	5

3.2.9 Final condition map

Mapping riverine condition was undertaken using two approaches.

1. Results of landscape-scale condition scoring (section 3.2.4) provided a score from 0-100 for each RAU and FAU in the Namoi catchment. Given these scores were linked directly to the RAU/FAU spatial layer, they were able to be readily mapped as a landscape-scale condition surface, classified into five broad condition categories (0-20; 21-40; 41-60; 61-80; and 81-100).

2. For all RAUs and FAUs in which riverine condition was sampled within one or more plots (section 3.2.5), and a set of site condition scores calculated via the scoring system (section 3.2.7), a regression relationship between landscape and site condition was able to be established. This relationship was applied to all RAUs and FAUs to provide a model of site condition across the catchment.

3.2.10 Condition distribution

Results of the landscape-scale condition and plot based condition assessments were each reported against geographic features such as bioregion, tenure, stream order and sub-catchment to establish any patterns of condition variation across the Namoi. Results of the plot based condition assessment were also used to explore differences in condition of remnant native vegetation between cotton growing areas and other areas in the Namoi.

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4. Application of the Framework to Namoi Catchment

4.1 Sub-catchments

A total of 40 sub-catchments have been delineated and described for the Namoi catchment. These provide the spatial basis for analysing and mapping riverine vegetation condition across the Namoi. Figure 5 shows a distribution map of Namoi sub-catchments.

4.2 Delineation of the Riverine Zone

The riverine zone of the Namoi catchment was delineated into a total of 1395 RAUs, comprising a combined area of 1022 km^2 (2.4% of the total area of the Namoi catchment) and 40 FAUs (most comprising multiple parcels), with a combined area of 9260 km^2 (22.0% of the area of the Namoi catchment). The total area of the riverine zone is 10,282 km^2, representing almost 25% of the Namoi catchment. The floodplain occupies 90% of the riverine zone, while stream and river channels occupy 10% of the riverine zone.

The mapped distribution of RAUs and FAUs is shown in Figure 6. Most of the floodplain is associated with the Walgett plains in the west, although some occurs in the Liverpool Plains in the south and extends into central floodplains around Gunnedah. Riparian reaches originate from all parts of the catchment as 3rd order streams, flowing into larger rivers including the Manilla, McDonald and Peel, and eventually into the Namoi which flows through Gunnedah, Narrabri and Wee Waa and joins the Barwon River at Walgett. In general, RAUs associated with higher order streams and rivers in the lower parts of the catchment are both longer and wider (and thus exhibit larger areas) than those associated with lower order streams in the headwaters.

The distribution of RAUs and FAUs within each bioregion is shown in Figure 7. Nandewar contains most RAUs - 560 (or 40%) in total - which represent 26% of the total RAU area. Brigalow Belt South (BBS) contains 540 RAUs (39% of the total) or 45% of the total RAU area. The New England Tablelands (NET) Bioregion incorporates 187 RAUs (13% of the total), but represents only 5% of the total area given most RAUs in this region include lower order streams. Darling Riverine Plains (DRP) contains 108 RAUs (8% of the total). These are generally larger and represent 24% of the total RAU area in the Namoi. The Namoi floodplain is located in BBS, DRP and Nandewar Bioregions, but not NET. The DRP contributes a combined area of 66% of the Namoi floodplain, BBS contains 33% of the floodplain area, and Nandewar contains 1% of the floodplain area.

Figure 8 shows the distribution of RAUs according to land tenure. A total of 1202 RAUs (86%) are located on freehold land, representing 90% of the total area of RAUs. A further 193 RAUs (14%) comprise National Park, State Forest, Travelling Stock Reserve (TSR) or Reserved Crown Land (RCL), and represent a combined 10% of the RAU area.

Figure 9 shows the distribution of RAUs according to stream order. A total of 836 RAUs (60%) occur on 3rd order streams, mainly in the upper parts of the catchment. These contribute 32% of the total area. A further 428 RAUs (31%) constitute 4th and 5th order streams, and represents 32% of the total RAU area. The remaining 131 RAUs (9% of total) are 6th, 7th or 8th order major streams and rivers, and represent 36% of the total area of RAUs.

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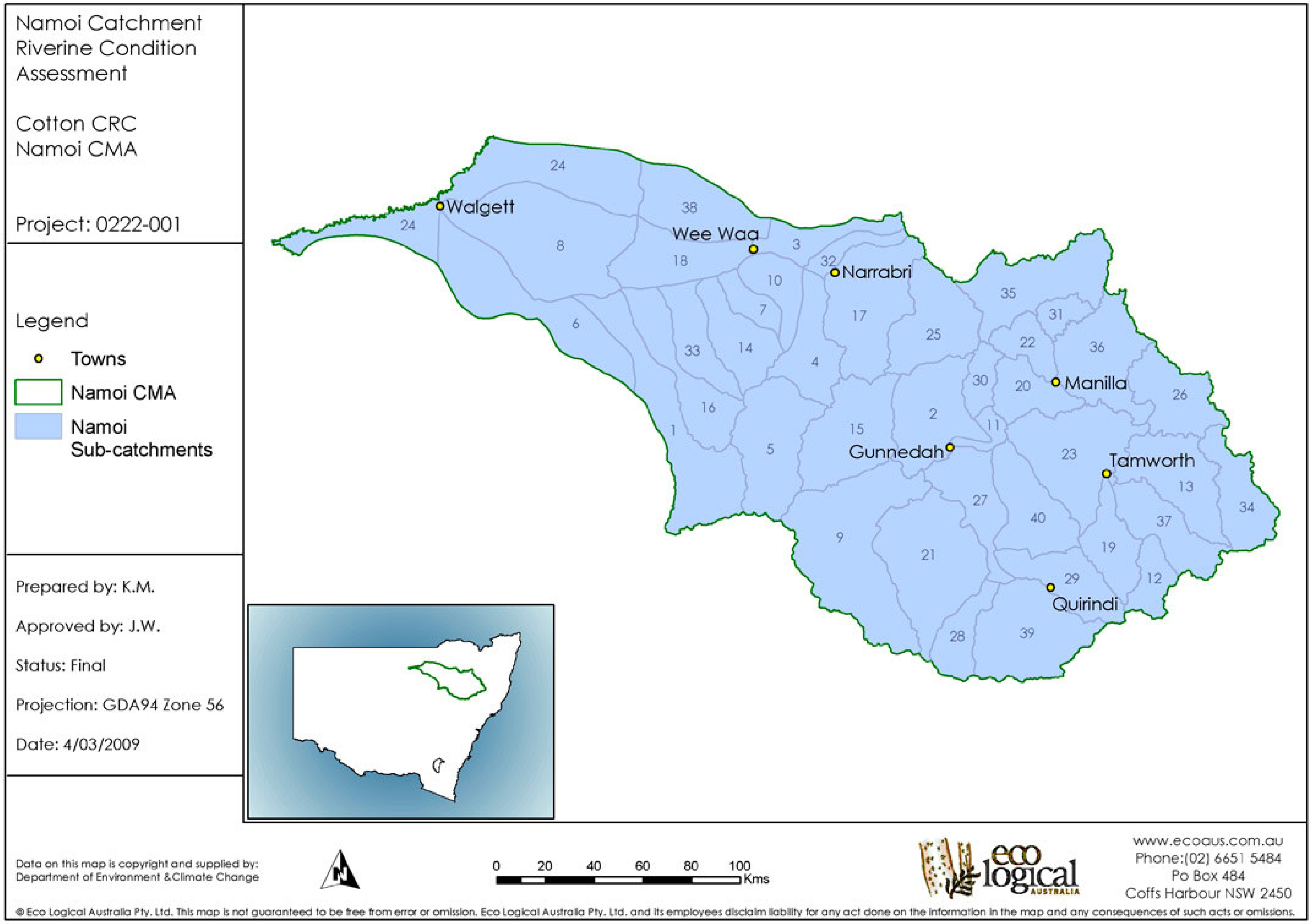
Figure 5. Namoi sub-catchments



1 Baradine
2 Bluevale
3 Bobbiwaa
4 Bohena
5 Borah
6 Box Creek
7 Brigalow
8 Bugilbone
9 Bundella Creek
10 Bundock
11 Carroll
12 Chaffey
13 Cockburn River
14 Coghill
15 Cox's Creek
16 Etoo
17 Eulah Creek
18 Ginudgera
19 Goonoo Goonoo
20 Keepit
21 Lake Goran
22 Lower Manilla
23 Lower Peel
24 Lower Pian
25 Maules
26 Mid MacDonald
27 Mooki
28 Phillips
29 Quirindi
30 Rangira
31 Split Rock
32 Spring Creek
33 Tallaba
34 Upper MacDonald
35 Upper Manilla
36 Upper Namoi
37 Upper Peel
38 Upper Pian
39 Warrah
40 Werris Creek

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Figure 6. Distribution of RAUs and FAUs within the riverine zone of the Namoi catchment

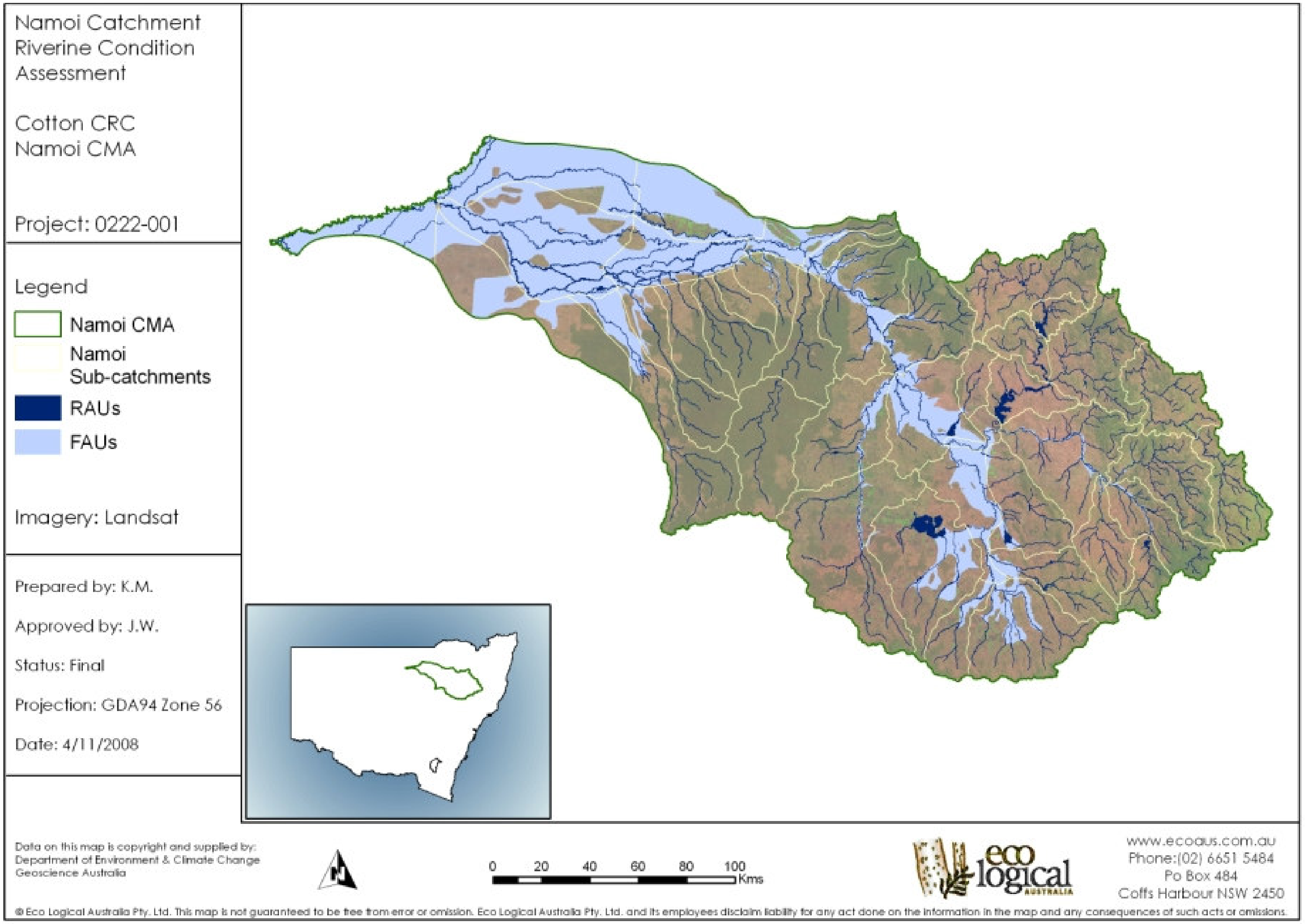

Figure 7. Distribution of RAUs and FAUs in the Namoi catchment, according to bioregion

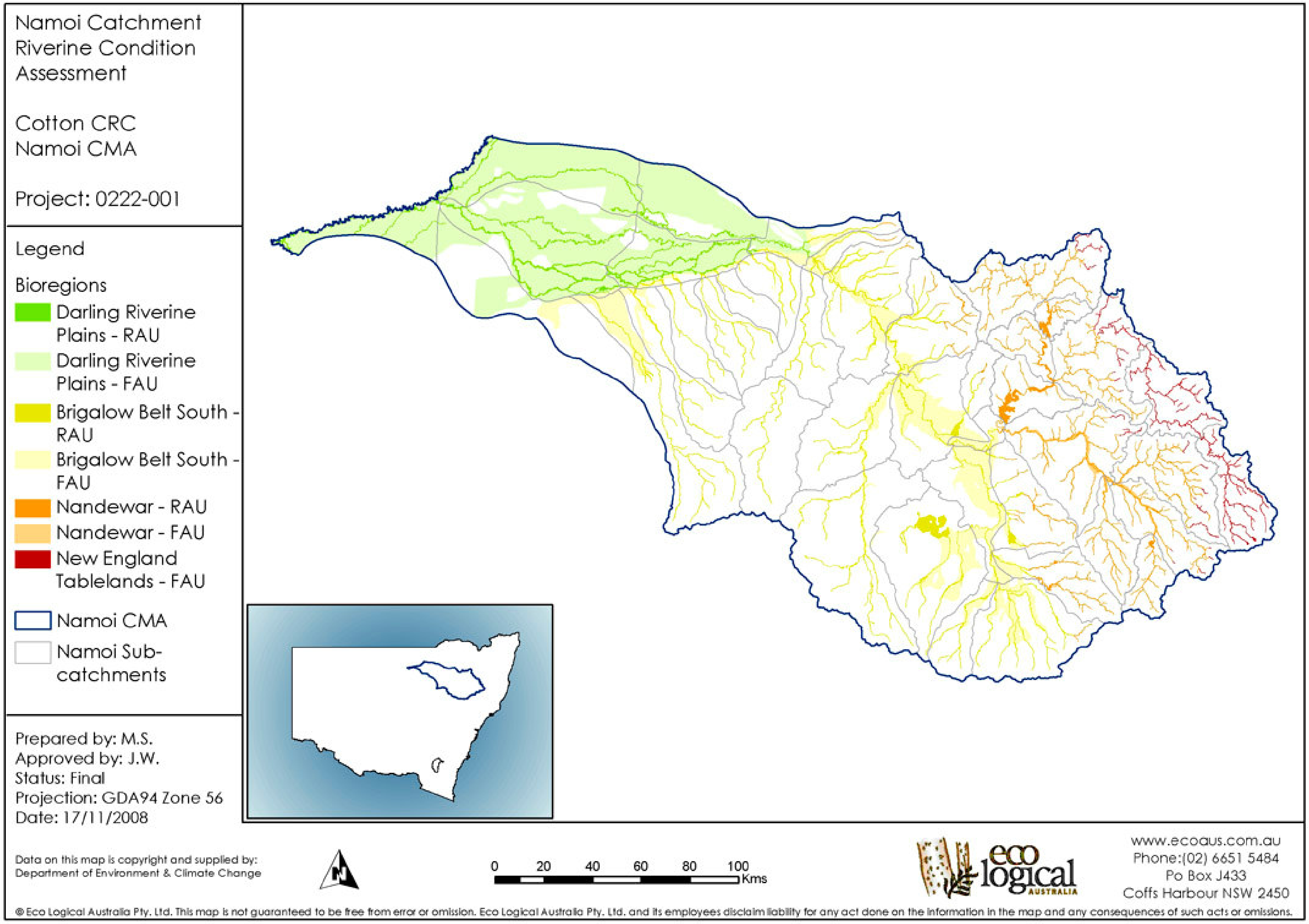

Figure 8. Distribution of RAUs in the Namoi catchment, classified by land tenure

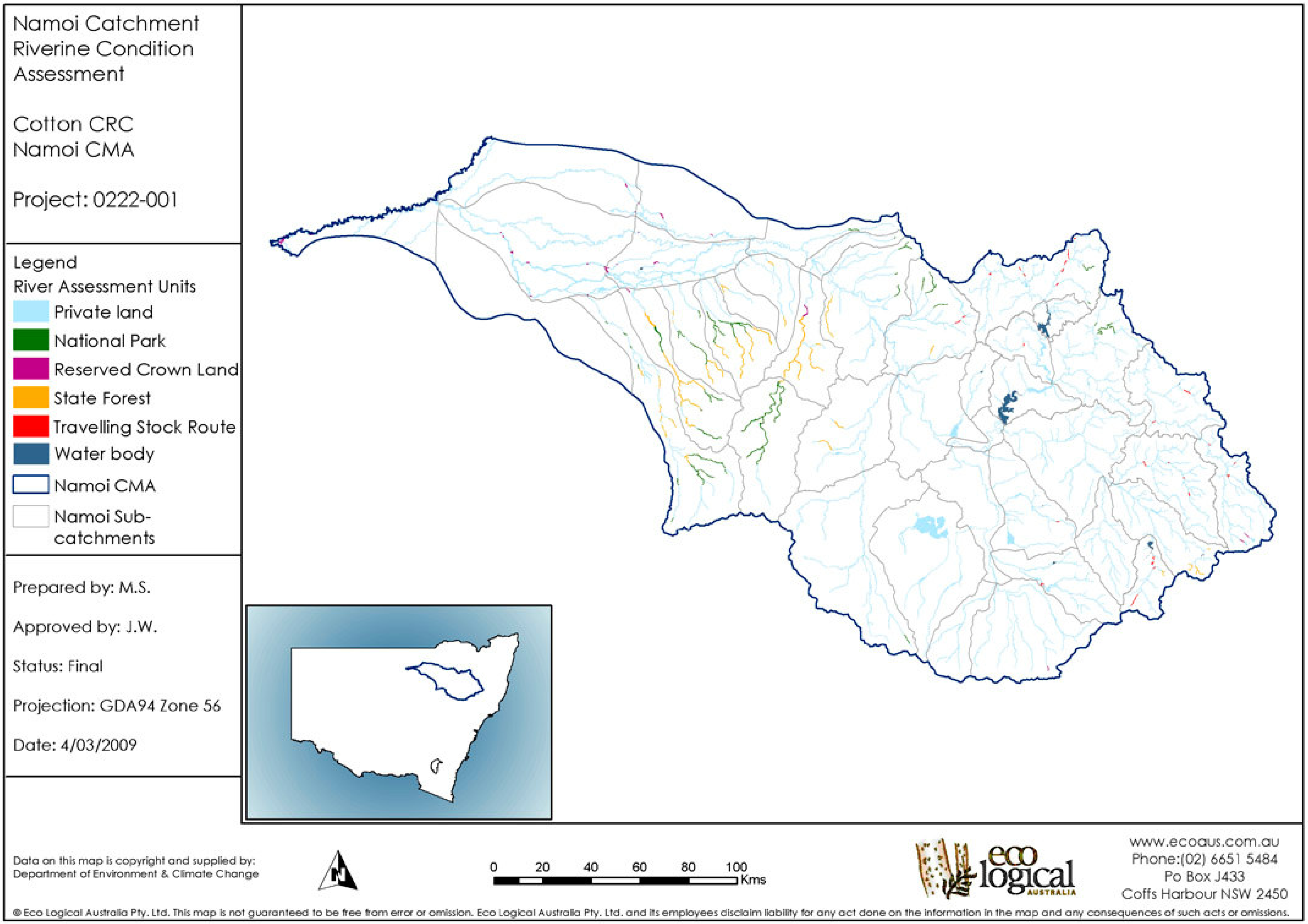

Figure 9. Distribution of RAUs in the Namoi catchment, classified by stream order

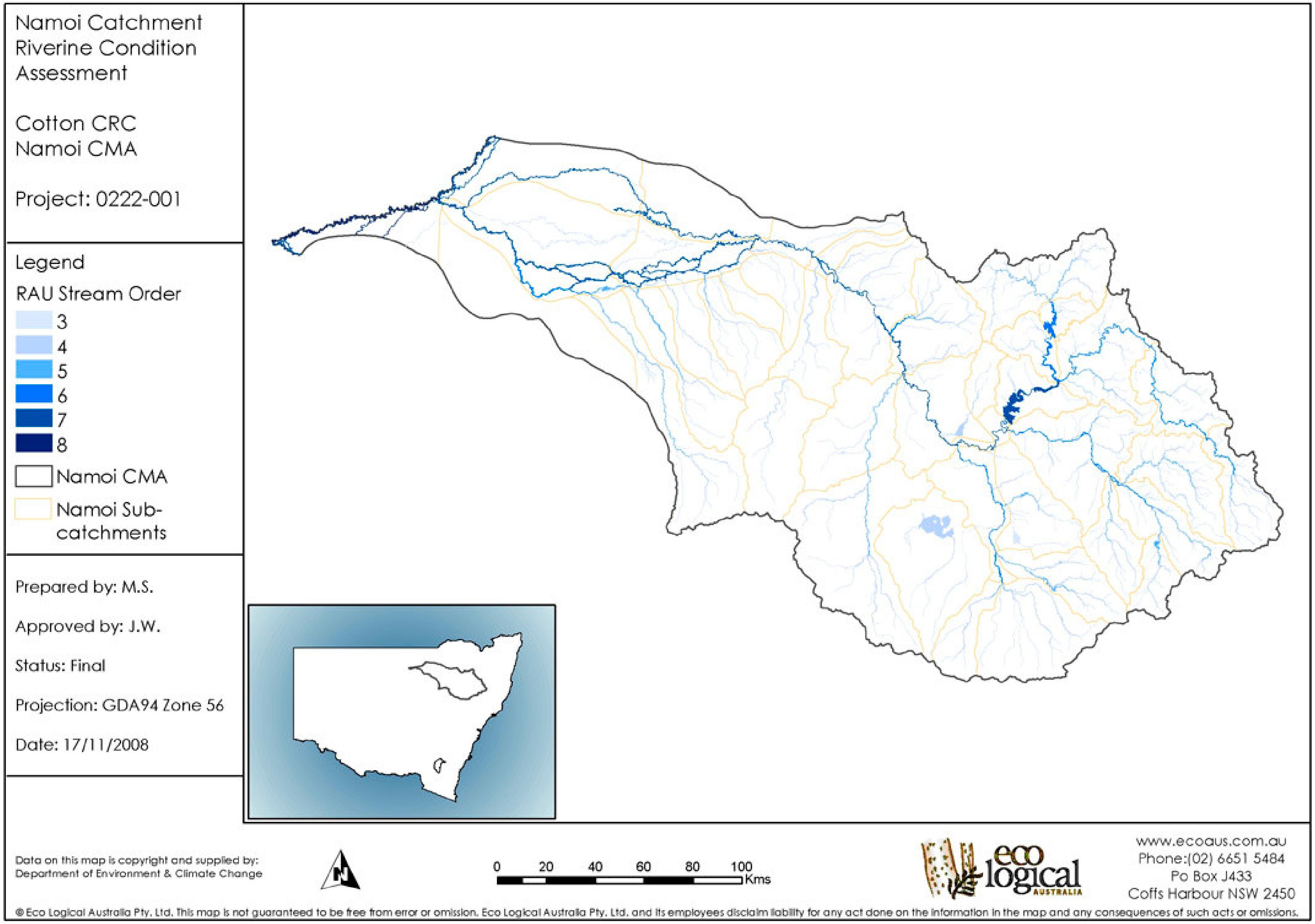

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Table 15 provides a summary of FAUs within each of the 40 Namoi sub-catchments. A total of 32 sub-catchments contain some part of the mapped floodplain zone, while eight sub-catchments do not contain any floodplain mapping. More than 75% of the total area of each of four sub-catchments (Bugilbone, Ginudgera, Lower Pian and Upper Pian) is occupied by floodplain - these four sub-catchments account for 61% of the entire Namoi floodplain.

Table 16 provides a summary of RAUs within each of the 40 Namoi sub-catchments. Baradine, Cockburn River, Eulah Creek, Lower Peel, Upper McDonald, Upper Manilla, Upper Namoi and Warrah sub-catchments each comprise at least 60 individual RAUs, whereas Box Creek, Brigalow and Carroll each contain fewer than 10 RAUs. The total length of RAUs in the Namoi is about 8,100 km. Bundella Creek, Cockburn River, Eulah Creek, Ginudgera, Lower Peel, Lower Pian, Upper Manilla, Upper Namoi and Warrah sub-catchments each comprise a combined length of RAUs of at least 300 km.

The average length of RAUs in the Namoi is 5.8 km. The average length of RAUs within sub-catchments varies from 2.1 km in Box Creek to 20.6 km in Carroll, and is generally greater within sub-catchments associated with floodplains. The shortest individual RAU is 0.2 km; the longest is 110 km. The average width of RAUs in the Namoi is 125 m. Average width of riparian areas generally increases with stream order, with wider channels associated with larger rivers meandering across the floodplain.

The total number of individual watercourses within the Namoi riverine zone is 379, including nine named rivers, 303 named streams and 67 unnamed tributaries. The Namoi River is over three times as long as any other watercourse in the catchment, with a total length of 659 km. An additional 10 rivers and streams exceed 100 km length, including Pian Creek (219 km), Barwon River (218 km), Baradine Creek (195 km), Coxs Creek (176 km), MacDonald River (174 km), Peel River (157 km), Manilla River (148 km), Cubbaroo Warrumbool (137 km), Mooki River (130 km) and Spring Creek (109 km). An additional 30 watercourses are between 50 and 100 km in length, 132 are between 10 and 50 km, and 206 are less than 10 km.

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Table 15. Details of Floodplain Assessment Units (FAUs) within each Namoi Sub-catchment

Sub Catchment	Sub Catchment Area (km^2)	No. floodplain parcels	FAU Area (km^2) * (% of sub-catchment)
1. Baradine	1785.1	10	312.4 (18)
2. Bluevale	1246.0	6	498.6 (40)
3. Bobbiwaa	560.2	14	264.4 (47)
4. Bohena	832.3	2	0.9 (0)
5. Borah	1397.1	none	0 (0)
6. Box Creek	1696.5	2	475.5 (28)
7. Brigalow	323.8	1	0.1 (0)
8. Bugilbone	2365.8	13	1864.9 (79)
9. Bundella Creek	2499.5	5	39.2 (2)
10. Bundock	549.2	9	47.3 (9)
11. Carroll	186.6	12	78.2 (42)
12. Chaffey	420.3	6	0.5 (0)
13. Cockburn River	1126.5	14	3.8 (0)
14. Coghill	793.9	2	0.3 (0)
15. Cox's Creek	1358.1	10	119.2 (9)
16. Etoo	1023.7	3	86.0 (8)
17. Eulah Creek	1581.4	20	236.7 (15)
18. Ginudgera	991.4	40	829.9 (84)
19. Goonoo Goonoo	663.4	4	6.7 (1)
20. Keepit	605.8	none	0 (0)
21. Lake Goran	1871.0	9	294.9 (16)
22. Lower Manilla	429.5	none	0 (0)
23. Lower Peel	1597.7	30	50.6 (3)
24. Lower Pian	1570.5	23	2042.4 (91)
25. Maules	684.3	10	102.0 (9)
26. Mid MacDonald	1155.4	none	0 (0)
27. Mooki	912.9	21	433.0 (51)
28. Phillips	848.8	9	62.6 (12)
29. Quirindi	529.3	7	61.7 (7)
30. Rangira	839.7	2	3.9 (1)
31. Split Rock	320.5	none	0 (0)
32. Spring Creek	253.9	6	88.6 (32)
33. Tallaba	274.1	2	5.6 (1)
34. Upper MacDonald	687.9	none	0 (0)
35. Upper Manilla	844.3	none	0 (0)
36. Upper Namoi	1385.9	none	0 (0)
37. Upper Peel River	1303.7	29	21.1 (2)
38. Upper Pian	856.8	4	943.1 (82)
39. Warrah	1150.9	13	235.7 (15)
40. Werris Creek	1531.2	13	50.8 (5)
ALL	42,061	351	9260.6 (22)

* not including area of RAUs

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Table 16. Details of River Assessment Units (RAUs) within each Namoi Sub-Catchment

			Total (average)	
Sub-catchment	**Total**	Rivers and Creeks (**no. RAUs** – stream order(s))	Area km^2	Length km
Baradine	**64**	Baradine Ck (**26** – 4,5); Baradine Ck trib. (**1** – 3); Baradine Ck trib. 2 (**1** – 3); Bugaldi Ck (**9** – 3); Coolangla Ck (**2** – 3); Dandry Ck (**5** – 3,4); Dandry Ck trib. (**1** – 3); Gwabegar Ck (**3** – 3,4); Gwabegar Ck trib. (**2** – 3); Merriwee Ck (**4** – 3); Wittenbra Ck (**3** – 3); Wittenbra Ck trib. (**1** – 3); Yearinan Ck (**5** – 3,4); Yearinan Ck trib. (**1** – 3).	31.4 (0.5)	296.4 (4.6)
Bluevale	**18**	Barbars Lagoon (**1** – 3); Collygra Ck (**2** – 3); Coocooboonah Ck (**1** – 3); Deadmans Gully (**2** – 3); Driggle Draggle Ck (**6** – 3); Namoi R (**1** – 7); Namoi R trib. (**1** – 4); Native Cat Ck (**1** – 3); Rangira Ck (**2** – 4); Rock Vale Ck (**1** – 3).	28.7 (1.6)	148.9 (8.3)
Bobbiwaa	**20**	Bobbiwaa Ck (**9** – 3); Bundock Ck (**3** – 3,4); Illaroo Ck (**1** – 3); Mollee Ck (**3** – 3); Namoi R (**2** – 7); Station Ck (**1** – 7); Wee Waa Gully (1 – 4).	16.3 (0.8)	132.3 (6.6)
Bohena	**18**	Bibblewindi Ck (**5** – 3,4); Bibblewindi Ck trib. (**1** – 3); Bohena Ck (**5** – 3,4); Cowallah Ck (**3** – 3); Spring Ck (**4** – 3).	18.2 (1)	95.6 (5.3)
Borah	**13**	Billy Ck (**1** – 3); Bohena Ck (**1** – 4); Borah Ck (**1** – 3); Timmallallie Ck (**1** – 3); Yaminda Ck (**9** – 3,4).	14.6 (1.1)	120.2 (9.2)
Box Creek	**2**	Cumberdoon Wrbl (**2** – 3).	0.3 (0.2)	4.2 (2.1)
Brigalow	**8**	Brigalow Ck (**6** – 3,4); Brigalow Ck trib. (**1** – 3); Janewindi Ck (**1** – 3).	3.1 (0.4)	29.9 (3.7)
Bugilbone	**29**	Baradine Ck (**5** – 5,6); Coolibag Wtcs (**3** – 3); Cubbaroo Wrbl (**3** – 3); Dead Bullock Wrbl (**1** – 3); Gil Gil Ck (**1** – 7); Keepit Ck (**1** – 5); Namoi R (**11** – 7); Pian Ck (**1** – 7); Quegobla Ck (**2** – 3,5); Turragulla Ck (**1** – 7).	85 (2.9)	487.8 (16.8)
Bundella Creek	**39**	Bomera Ck (**7** – 3,4,5); Bundella Ck (**8** – 3,4); Coxs Ck (**6** – 3,4,5); Coxs Ck trib. (**1** – 3); Deans Mountain Ck (**1** – 3); Garrawilla Ck (**7** – 3,4); Little Goragilla Ck (**1** – 3); Mitchells Ck (**3** – 3); Nombi Ck (**1** – 3); Saltwater Ck (**3** – 3); Tamatie Ck (**1** – 3).	28.8 (0.7)	319.1 (8.2)
Bundock	**14**	Bundock Ck (**7** – 3); Illaroo Ck (**1** – 3); Mollee Ck (**3** – 3); Womera Ck (**2** – 3); Womera Ck trib. (**1** – 3).	12.1 (0.9)	94.3 (6.7)

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Table 16. cont'd

Sub-catchment	No.	Rivers and Creeks (**no. RAUs** – stream order(s))	Total (average) Area km²	Total (average) Length km
Carroll	**3**	Namoi R (**3** – 7).	7.3 (2.4)	61.7 (20.6)
Chaffey	**35**	Back Ck (**2** – 3); Burrows Ck (**4** – 3,4); Cann Ck (**2** – 3); Hydes Ck (**1** – 3); Nundle Ck (**2** – 3); Nundle Ck trib. (**1** – 3); Peel R (**14** – 3,4,5); Peel R trib. (**1** – 3); Peel R trib. 2 (**1** – 3); Quackanacka Gully (**1** – 3); Wardens Brook (**1** – 3); Wombramurra Ck (**4** – 3); Woodleys Ck (**1** – 3).	10.5 (0.3)	106.8 (3.1)
Cockburn River	**70**	Boundary Ck (**1** – 3); Branch Ck (**1** – 3); Bungadore Ck (**2** – 3); Callaghans Ck (**2** – 3); Cauborn Ck (**4** – 3,4); Cockburn R (**5** – 5); Cockburn R trib. (**1** – 5); Coghlans Ck (**2** – 3); Fairy Ground Ck (**1** – 3); Goal Ck (**2** – 3); Gills Oaky Ck (**1** – 3); Jamiesons Ck (**5** – 3,4); Jamiesons Ck trib. (**1** – 3); Little Oakey Ck (**1** – 3); Little Oaky Ck (**1** – 3); Monkey Ck (**1** – 3); Moonbi Ck (**1** – 4); Moonbi Ck trib. (**1** – 3); Mulla Mulla Ck (**8** – 3,4); Mulla Mulla Ck trib. (**1** – 3); Mulla Mulla Ck trib. 2 (**1** – 3); Mulla Mulla Ck trib. 3 (**1** – 3); Oakey Ck (**2** – 3); Reedy Ck (**1** – 3); Sandy Ck (**1** – 3); Seven Mile Ck (**1** – 3); Shearins Ck (**3** – 3,4); Shearins Ck trib. (**1** – 3); Shingle Hut Ck (**1** – 3); Stockyard Ck (**1** – 3); Swamp Oak Ck (**13** – 3,4,5); Swamp Oak Ck trib. (**1** – 3); Swamp Oak Ck trib. 2 (**1** – 3).	20.7 (0.3)	371.7 (5.3)
Coghill	**27**	Coghill Ck (**7** – 3,4,5); Goona Ck (**3** – 3); Harriss Ck (**1** – 3); Mollieroi Ck (**5** – 3,4); Rock Ck (**8** – 3,4); Werah Ck (**3** – 3).	19.5 (0.7)	158.6 (5.9)
Cox's Creek	**18**	Bara Ck (**8** – 3); Coxs Ck (**3** – 5); Dunnadee Ck (**1** – 3); Sawpit Ck (**2** – 3); Washpen Ck (4 – 3).	18.4 (1)	147.4 (8.2)
Etoo	**23**	Coomore Ck (**3** – 3); Etoo Ck (**13** – 3,4,5); Etoo Ck trib. (**1** – 3); Oaky Ck (**2** – 5); Rocky Ck (**3** – 3,4); Wellyard Gully (**1** – 3).	23.2 (1)	134.5 (5.8)
Eulah Creek	**63**	Bibbla Ck (**8** – 3,4); Bullawa Ck (**9** – 3,4); Coolah Ck (**2** – 3); Deriah Ck (**1** – 3); Eulah Ck (**6** – 3); Horsearm Ck (**10** – 3); Jacks Ck (**5** – 3); Kurrajong Ck (**3** – 3); Mulgate Ck (**2** – 3,4); Namoi R (**2** – 7); Narrabri Ck (**1** – 7); Oaky Ck (**2** – 3); Sandy Ck (**3** – 3); Sandy Ck 2 (**1** – 3); Teatree Ck (**1** – 3); Tulla Mullen Ck (**7** – 3,4).	39 (0.6)	305.5 (4.8)
Ginudgera	**37**	Brigalow Ck (**1** – 4); Bullerawa Ck (**2** – 3); Coghill Ck (**1** – 5); Cubbaroo Wrbl (**3** – 3); Drildool Wrbl (**4** – 3); Duncan Wrbl (**1** – 3); Ginudgera Ck (**2** – 7); Myall Camp Wrbl (**6** – 7); Namoi R (**3** – 7); Namoi R trib. (**1** – 3); Namoi R trib. 2 (**1** – 7); Oaky Ck (**1** – 5); Pilliga Lagoon Ck (**1** – 5); Talluba Ck (**2** – 4); Turragulla Ck (**5** – 4,7); Werah Ck (**1** – 3); Womera Ck (**1** – 3); Womera Ck trib. (**1** – 3).	57.1 (1.5)	396.3 (10.7)

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Table 16. cont'd

Sub-catchment	No.	Rivers and Creeks (**no. RAUs** – stream order(s))	Total (average) Area km^2	Total (average) Length km
Goonoo Goonoo	**42**	Algona Ck (**1** – 3); Anembo Ck (**1** – 3); Benama Ck (**3** – 3); Boiling Down Ck (**2** – 3); Goonoo Goonoo Ck (**8** – 3,4,5); Middlebrook Ck (**7** – 3,4); Middlebrook Ck trib. (**1** – 3); Sandy Ck (**2** – 3,4); Spring Ck (**4** – 3); Spring Ck 2 (**3** – 3,4); Sugarloaf Ck (**4** – 3); Swamp Ck (**5** – 3,4); Warrimoo Ck (**1** – 3).	12 (0.3)	189.2 (4.5)
Keepit	**18**	Dam Gully (**1** – 3); Greenhatch Ck (**6** – 3); Hallalinga Ck (**1** – 3); Namoi R (**2** – 7); Namoi R trib. (**1** – 3); Spring Ck (**4** – 3); Wongo Ck (**3** – 3,4).	60.1 (3.3)	126.8 (7)
Lake Goran	**26**	Campbells Ck (**1** – 3); Coomoo Coomoo Ck (**4** – 3,4); Gananny Ck (**5** – 3); Goran Swamp (**1** – 3); Kickerbell Ck (**2** – 3); Lake Goran (**1** – 4); Lever Gully (**1** – 3); Native Dog Gully trib. (**1** – 3); Red Bobs Ck (**2** – 3); Yarraman Ck (**8** – 3).	94.1 (3.6)	208.0 (8.0)
Lower Manilla	**25**	Black Springs Ck (**1** – 3); Borah Ck (**8** – 3,4); Borah Ck trib. (**1** – 3); Manilla R (**1** – 6); Manilla R trib. (1 – 3); Oaky Ck (**9** – 3,4); Tarpoly Ck (**4** – 3).	18.6 (0.7)	112.6 (4.5)
Lower Peel	**63**	Attunga Ck (**11** – 3,4,5); Back Ck (**1** – 3); Boller Gully (**1** – 3); Bradys Plain (**1** – 4); Brown Springs Ck (**2** – 3); Catong Gully (**2** – 3); Cattle Ck (**1** – 3); Clay Ck (**3** – 3); Clay Water Hole Gully (**2** – 3); Donnellys Springs Ck (**1** – 3); Dry Ck (**2** – 3,4); Heifer Ck (**2** – 3); Limestone Gully (**1** – 3); Manilla R (**1** – 6); Menedebri Ck (**1** – 3); Moore Ck (**9** – 3,4); Mountain Ck (**1** – 3); Peel R (**2** – 6); Peel R trib. (**1** – 6); Peel R trib. 2 (**1** – 6); Peel R trib. 3 (**1** – 6); Peel R trib. 4 (**1** – 6); Sandy Ck (**2** – 3,4); Spring Ck (**1** – 3); Tangaratta Ck (**4** – 3,4); The Horsearm Ck (**2** – 3); Timbumburi Ck (**3** – 3); Willow Tree Ck (**1** – 3); Yellow Gully (2 – 3).	48.8 (0.8)	387.8 (6.2)
Lower Pian	**28**	Barwon R (**9** – 7,8); Burren Ck (**1** – 3); Cumberdoon Wrbl (**1** – 3); Macquarie R (**6** – 7); Namoi R (**2** – 7); Pagan Ck (**1** – 7); Pian Ck (**5** – 7); Two Mile Wrbl (**1** – 7); Wanourie Ck (**1** – 8); Yarra Ck (**1** – 8).	81.3 (2.9)	523.6 (18.7)
Maules	**70**	Back Ck (**5** – 3); Barbars Lagoon (**2** – 3,4); Black Mountain Ck (**3** – 3); Boggabri Ck (**1** – 3); Bollol Ck (**8** – 3,4); Connors Ck (**2** – 3); Coxs Ck (**1** – 3); Deep Ck (**1** – 3); Gap Ck (**1** – 3); Goonbri Ck (**2** – 3); Horsearm Ck (**7** – 3,4,5); Maules Ck (**15** – 3,4,5,6); Middle Ck (**6** – 3,4); Mihi Ck (**5** – 3); Namoi R (**1** – 7); Oaky Ck (**2** – 3); Pinnacle Ck (**4** – 3,4); Pinnacle Ck trib. (**1** – 3); Stony Ck (**3** – 3).	32.2 (0.5)	287.5 (4.1)
Mid Macdonald	**44**	Caslisle Gully (**7** – 3,4,5); Caslisle Gully trib. (**1** – 3); Congi Ck (**3** – 3,4); Congi Ck trib. (**1** – 3); Corys Camp Ck (**1** – 3); Duck Gully (**1** – 3); Dunduckely Ck (**1** – 3); Gibsons Rocky Gully (**1** – 3); Looanga Ck (**1** – 3); McDonald R (**9** – 6); Pine Ck (**3** – 3); Pringles Rock Ck (**4** – 3); Rocky Gully (**2** – 3,4); Rocky Gully trib. (**1** – 3); Rose Valley Ck (**3** – 3,4); Spring Ck (**1** – 3); Spring Ck 2 (**1** – 3); Watsons Ck (**3** – 3).	17.2 (0.4)	216.7 (4.9)

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Table 16. cont'd

Sub-catchment	No.	Rivers and Creeks (**no. RAUs** – stream order(s))	Total (average) Area km²	Total (average) Length km
Mooki	**18**	Mooki R (**7** – 5); Native Dog Gully (**2** – 3,4); Native Dog Gully trib. (**1** – 3); Oaky Ck (**1** – 4); Peach Tree Gully (**4** – 3); Swains Ck (**1** – 3); Werris Ck (**2** – 4,5).	10.6 (0.6)	132.1 (7.3)
Phillips	**21**	Black Ridge Gully (**1** – 3); Cattle Ck (**3** – 3); Clarkes Ck (**1** – 3); Larrys Ck (**1** – 3); Mooki R (**3** – 4,5); Mooki R trib. (**2** – 3,4); Mooki R trib. 2 (**1** – 3); Omaleah Ck (**5** – 3); Phillips Ck (**4** – 3,4).	9.8 (0.5)	97.4 (4.6)
Quirindi	**54**	Back 2 Ck (**1** – 1); Back Ck (**3** – 3); Basin Ck (**2** – 3); Dry Gully (**1** – 3); Gospard Ck (**1** – 3); Jacob and Joseph Ck (**5** – 4); Jacob and Joseph Ck trib. (**1** – 3); Kangaroo Ck (**5** – 3,4); Quipolly Ck (**13** – 3,4); Quipolly Ck trib. (**1** – 3); Quirindi Ck (**15** – 3,4,5); Sheep Station Ck (**1** – 3); Spring Ck (**1** – 3); Spring Ck 3 (**1** – 3); Wiles Gully (**2** – 3); Yellow Woman Ck (**1** – 3).	19.8 (0.4)	212.6 (3.9)
Rangira	**15**	Orphants Well Ck (**3** – 3); Rangira Ck (**12** – 3,4).	4.1 (0.3)	44.3 (3)
Split Rock	**18**	Back Ck (**3** – 3); Crow Mountain Ck (**6** – 3,4); Eumur Ck (**5** – 3,4); Middle Ck (**1** – 3); Teatree Ck (**3** – 3).	2.8 (0.2)	56.8 (3.2)
Spring Creek	**17**	Bohena Ck (**2** – 4); Namoi R (**2** – 7); Narrabri Ck (**1** – 7); Spring Ck (**12** – 3).	9.6 (0.6)	74.1 (4.4)
Tallaba	**21**	Bullerawa Ck (**4** – 3); Talluba Ck (**15** – 3,4); Talluba Ck trib. (**1** – 3); Tinebie Ck (**1** – 3).	11.7 (0.6)	88.7 (4.2)
Upper Macdonald	**70**	Alicks Swamp Ck (**1** – 3); Back Ck (**1** – 3); Bald Ck (**2** – 3,4); Branga Swamp (**1** – 3); Brick Wall Ck (**1** – 3); Chimney Swamp Ck (**1** – 3); Cobrabald R (**9** – 3,4,5); Cobrabald R trib. (**1** – 3); Halls Ck (**2** – 3); Inglebra Ck (**7** – 3,4); Inglebra Ck trib. (**1** – 3); Inglebra Ck trib. 2 (**1** – 3); McDonald R (**14** – 3,4,5,6); McDonald R trib. (**1** – 3); Mount McDonald R trib. 2 (**1** – 3); McDonald R trib. 3 (**1** – 3); Pipeclay Gully (**1** – 3); Reedy Ck (**3** – 3); Running Ck (**1** – 3); Shingle Hut Ck (**1** – 3); Smiths Ck (**5** – 3); Spitzbergen Ck (**2** – 3,4); Spitzbergen Ck trib. (**3** – 3); Surveyors Ck (**6** – 3); Three Mile Ck (**3** – 3).	15.6 (0.2)	281.4 (4)
Upper Manilla	**89**	Barraba Ck (**3** – 3,4); Boiling Swamp Ck (**1** – 3); Chain of Ponds Ck (**2** – 4); Chain of Ponds Ck trib. (**1** – 3); Chain of Ponds Ck trib. 2 (**1** – 3); Connors Ck (**5** – 3,4); Connors Ck trib. (**1** – 3); Five Mile Ck (**1** – 3); Goat Island Ck (**1** – 3); Hawkins Ck (**2** – 3,4); Hawkins Ck trib. (**1** – 3); Ironbark Ck (**16** – 3,4,5); Jericho Ck (**1** – 3); Little Ck (**5** – 3,4); Long Swamp Ck (**5** – 3,4); Long Swamp Ck trib. (**1** – 3); Manilla R (**9** – 3,4,5); Mille Ck (**5** – 3,4); Nangahrah Ck (**7** – 3,4); Oaky Ck (**2** – 3); Oaky Ck 2 (**1** – 3); Paling Yard Ck (**2** – 3); Saveall Ck (**7** – 3,4); Sawyers Ck (**1** – 3); Sheep Station Ck (**1** – 3); Spring Ck (**1** – 3); Station Ck (**1** – 3); Tareela Ck (**2** – 3); Teatree Ck (**1** – 3); Welshs Ck (**2** – 3).	25.6 (0.3)	363.5 (4.1)

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Table 16. cont'd

			Total (average)	
Sub-catchment	**No.**	Rivers and Creeks (**no. RAUs** – stream order(s))	Area km^2	Length km
Upper Namoi	**84**	Black Gully (**2** – 3,4); Black Gully trib. (**3** – 3); Boundary Ck (**1** – 3); Bungadore Ck (**4** – 3); Burnt Yard Ck (**1** – 3); Calchemboy Ck (**1** – 3); Cold Rock Ck (**2** – 3); Giant Den Ck (**2** – 3,4); Halls Ck (**10** – 3,4,5); Halls Ck trib. (**1** – 3); Halls Ck trib. 2 (**1** – 3); Helloo Ck (**2** – 3,4); Helloo Ck trib. (**1** – 3); Ireland Ck (**1** – 3); McDonald R (**2** – 6); McDonald R trib. (**1** – 3); Mount Lowry Ck (**2** – 3); Namoi R (**5** – 6); Namoi R trib. (**1** – 3); Namoi R trib. 2 (**1** – 3); New England Ck (**6** – 3,4); New England Ck trib. (**2** – 3); New England Ck trib. 2 (**1** – 3); Oaky Ck (**3** – 3,4); Oaky Ck 3 (**1** – 3); Oaky Ck 4 (**1** – 3); Old Man Gully (**1** – 3); Spring Ck (**4** – 3,4); Spring Ck 2 (**1** – 3); Spring Gully (**1** – 3); Warrabah Ck (**11** – 3,4); Wisemans Arm Ck (**1** – 3); Yarramanbully Ck (**3** – 3); Yarramanbully Ck trib. (**1** – 3); Yellow Rock Ck (**3** – 3).	26 (0.3)	357.6 (4.3)
Upper Peel River	**54**	Brandy Spring (**1** – 3); Copes Ck (**2** – 3); Duncans Ck (**7** – 3,4); Dungowan Ck (**10** – 3,4,5); Dungowan Ck trib. (**1** – 3); Dungowan Ck trib. 2 (**1** – 3); Dungowan Ck trib. 3 (**1** – 3); Georges Gully (**2** – 3,4); Ironbark Ck (**2** – 3,4); Ironbark Ck trib. (**1** – 3); Johnston Oak Ck (**2** – 3,4); Johnston Oak Ck trib. (**1** – 3); Junction Ck (**2** – 3); Lever Ck (**2** – 3); Oaky Ck (**1** – 3); Peel R (**3** – 5,6); Piallamore Ck (**1** – 3); Reedy Ck (**2** – 3); Sandy Ck (**4** – 3); Shortells Ck (**1** – 3); South Head Ck (**2** – 3,4); South Head Ck trib. (**1** – 3); Spring Ck (**1** – 3); Terrible Billy Ck (**2** – 3); Trough Ck (**1** – 3).	16.3 (0.3)	247.5 (4.6)
Upper Pian	**16**	Burren Ck (**1** – 3); Pian Ck (**14** – 7); Womat Ck (**1** – 8).	20.1 (1.3)	151 (9.4)
Warrah	**60**	Back Ck (**1** – 3); Big Jacks Ck (**10** – 3,4); Borambil Ck (**7** – 3,4); Chilcotts Ck (**8** – 4); Dry Ck (**1** – 3); McDonald Ck (**5** – 3); Millers Ck (**7** – 3); Pump Station Ck (**1** – 3); Warrah Ck (**14** – 3,4,5); Warrah Ck trib. (**1** – 3); Yarramanbah Ck (**5** – 3).	21.1 (0.4)	317.3 (5.3)
Werris Creek	**41**	Bald Hill Gully (**2** – 3); Campbells Gully (**3** – 3); Chinamans Ck (**5** – 3); Currububula Ck (**10** – 3,4,5); Oaky Ck (**3** – 3,4); Spring Ck (**3** – 3,4); Swains Ck (**3** – 3); Washpool Ck (**1** – 3); Werris Ck (**6** – 3); Werris Ck trib. (**2** – 3); Whites Ck (**2** – 3); Yorran Ck (**1** – 3).	29.9 (0.7)	187 (4.6)
ALL	**1395**	**ALL**	**1022 (0.7)**	**8096 (5.8)**

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4.3 Vegetation in the riverine zone

A total of 60 RVCs were mapped into the riverine zone by overlaying the composite vegetation map (ELA 2008b) with the riverine footprint. A subset of 26 of these RVCs were considered not to constitute riverine RVCs, their spatial extent either an artifact of the limitations of the composite layer, or an artifact of the scale at which RAUs were delineated, particularly for lower order streams. The total area of non-riverine RVCs mapped into the riverine zone was 23,300 ha, or 2.3% of the riverine zone. Of this, Ironbark shrubby woodlands of the Pilliga area (RVC 33) contributed 15,000 ha (1.46% of the riverine zone) in total.

The combined area of a total of 34 riverine RVCs in the riverine zone was 1,400,900 ha area, or 97.7% of the riverine zone. The area and proportion of each of these RVCs occupying the RAU and FAU footprints of the riverine zone is shown in Table 17. The %area of the major RVCs occupying FAUs and RAUs is illustrated in Figure 10, and their spatial distribution in the riverine zone is mapped in Figure 11. It is evident from these Figures that almost half the floodplain zone is occupied by cropland and other non-vegetation (RVC 0), while less than 20% of the riparian zone is occupied by RVC 0. This suggests that native vegetation on the floodplain is more fragmented than that immediately adjacent to and within the stream channels.

The proportion of major riverine RVCs varies appreciably between the floodplain and riparian zones. For example, a large proportion of the floodplain is occupied by dry alluvial grasslands of the DRP and BBS (RVC 26), Coolibah – Poplar Box – Belah floodplain woodlands (RVC 76) and Black Box floodplain woodlands RVC 77), in total covering 36.5% of the floodplain compared with 13.1% of the riparian zone. In contrast, Box-gum grassy woodland (RVC 17), Derived grasslands of BBS and Nandewar (RVC 28), River Oak riparian woodland (RVC 71), River Red Gum riverine forests and woodlands (RVC 73) and Blakely's Red Gum riparian woodland, Pilliga (RVC 96) each cover a larger proportion of the riparian zone (47.3% in total) than the floodplain zone (10.8% in total).

Comparison of relative RVC areas across different stream orders is also shown in Figure 10. The smaller order streams (3 and 4) have a larger proportion of Box-gum grassy woodland (RVC 17), Rough-barked Apple – Blakely's Red Gum riparian grassy woodlands (RVC 20) and Wetlands and marshes (RVC 70). In contrast, the riparian zone of larger streams and rivers (stream order 7 and 8) contains a greater proportion of River Red Gum riverine forests and woodlands (RVC 73), Coolibah – Poplar Box – Belah floodplain woodlands (RVC 76) and Black Box floodplain woodlands (RVC 77), compared to that of smaller streams. Pilliga Box – Poplar Box – Cypress alluvial grassy woodlands (RVC 32) and River Oak riparian woodlands (RVC 71) are the only RVCs that are more representative of the mid-order streams (stream order 5 and 6) than the lower or higher order streams. River Oak in particularly does not tend to occupy smaller streams (where box-gum types are more prevalent), and is replaced by River Red Gum in the larger streams and rivers.

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Table 17. Riverine RVCs in the Namoi catchment

RVC	RVC Name	FAU Area (km^2)	%FAU Area	RAU Area (km^2)	%RAU Area
0	*Non-native vegetation (mainly cropping)*	*4225.3*	*45.27*	*141.9*	*14.97*
4	Wilga - Western Rosewood shrubland, Darling Riverine Plains and Brigalow Belt South	22.3	0.24	0.1	0.02
16	Box - gum grassy woodlands, New England Tablelands	0.0	0	3.2	0.34
17	Box - gum grassy woodlands, Brigalow Belt South and Nandewar	69.8	0.75	34.5	3.64
20	Rough-barked Apple - Blakely's Red Gum riparian grassy woodlands, Brigalow Belt South and Nandewar	0.5	0.01	25.1	2.65
21	Inland Grey Box tall grassy woodland on clay soils, Brigalow Belt South and Nandewar	7.3	0.08	1.0	0.1
22	Poplar Box - Belah woodlands, mainly Darling Riverine Plains and Brigalow Belt South	8.9	0.09	0.5	0.05
26	Dry grasslands of alluvial plains, Darling Riverine Plains and Brigalow Belt South	1570.0	16.82	29.3	3.09
27	Derived grasslands, New England Tablelands	0.0	0	23.6	2.49
28	Derived grasslands, Brigalow Belt South and Nandewar	793.1	8.5	185.9	19.61
29	Plains Grass - Blue Grass grasslands, Brigalow Belt South and Nandewar	8.0	0.09	4.4	0.46
32	Pilliga Box - Poplar Box- White Cypress Pine grassy open woodland on alluvial loams, Darling Riverine Plains and Brigalow Belt South	193.3	2.07	8.7	0.92
50	Stringybark - Blakely's Red Gum - Rough-barked Apple open forests, Nandewar and western New England Tablelands	0.0	0	3.6	0.38
63	Tea-tree shrubland in drainage lines, Nandewar and New England Tablelands	0.0	0	0.5	0.05
64	Fens and wet heaths, Nandewar and New England Tablelands	0.0	0	3.6	0.38
67	Eurah shrubland of inland floodplains, Darling Riverine Plains	1.9	0.02	0.0	0
68	Lignum - River Coobah shrublands on floodplains, Darling Riverine Plains and Brigalow Belt South	6.5	0.07	0.1	0.01
70	Wetlands and marshes, inland NSW	172.0	1.84	41.1	4.34
71	River Oak riparian woodland, eastern NSW	0.0	0	36.3	3.83
72	Bracteate Honey Myrtle riparian shrubland, Brigalow Belt South	0.0	0	0.9	0.1
73	River Red Gum riverine woodlands and forests, Darling Riverine Plains, Brigalow Belt South and Nandewar	132.4	1.42	155.8	16.43

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Table 17. cont'd

RVC	RVC Name	FAU Area (km^2)	%FAU Area	RAU Area (km^2)	%RAU Area
75	Weeping Myall open woodland, Darling Riverine Plains, Brigalow Belt South and Nandewar	21.8	0.23	0.0	0
76	Coolibah - Poplar Box - Belah woodlands on floodplains, mainly Darling Riverine Plains and Brigalow Belt South	1025.1	10.98	59.5	6.27
77	Black Box woodland on floodplains, mainly Darling Riverine Plains	815.0	8.73	35.7	3.76
78	Coolibah - River Coobah - Lignum woodland of frequently flooded channels, mainly Darling Riverine Plains.	21.8	0.23	7.2	0.76
79	Brigalow - Belah woodland on alluvial clay soil, mainly Brigalow Belt South	6.5	0.07	0.3	0.04
80	Poplar Box grassy woodland on alluvial clay soils, Brigalow Belt South and Nandewar	50.9	0.55	4.6	0.48
81	Leopardwood woodland of alluvial plains, Darling Riverine Plains and Brigalow Belt South	0.7	0.01	0.0	0
82	Poplar Box low woodlands, western NSW	29.8	0.32	1.0	0.11
84	Whitewood open woodland, mainly eastern Darling Riverine Plains	1.7	0.02	0.0	0
85	Carbeen woodland on alluvial soils, Darling Riverine Plains and Brigalow Belt South	8.3	0.09	0.0	0
87	Silver-leaved Ironbark - White Cypress Pine on alluvial sandy loam, Darling Riverine Plains	0.9	0.01	0.0	0
89	Copperburr chenopod shrubland, Darling Riverine Plains and Brigalow Belt South	1.0	0.01	0.0	0
96	Blakely's Red Gum riparian woodland of the Pilliga	10.4	0.11	35.5	3.74
	Non-riverine RVCs	*128.5*	*1.38*	*104.2*	*10.99*
	TOTAL	9333.9	100.00	948.1	100.00

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Figure 10. Proportion of different parts of the riverine zone occupied by RVCs

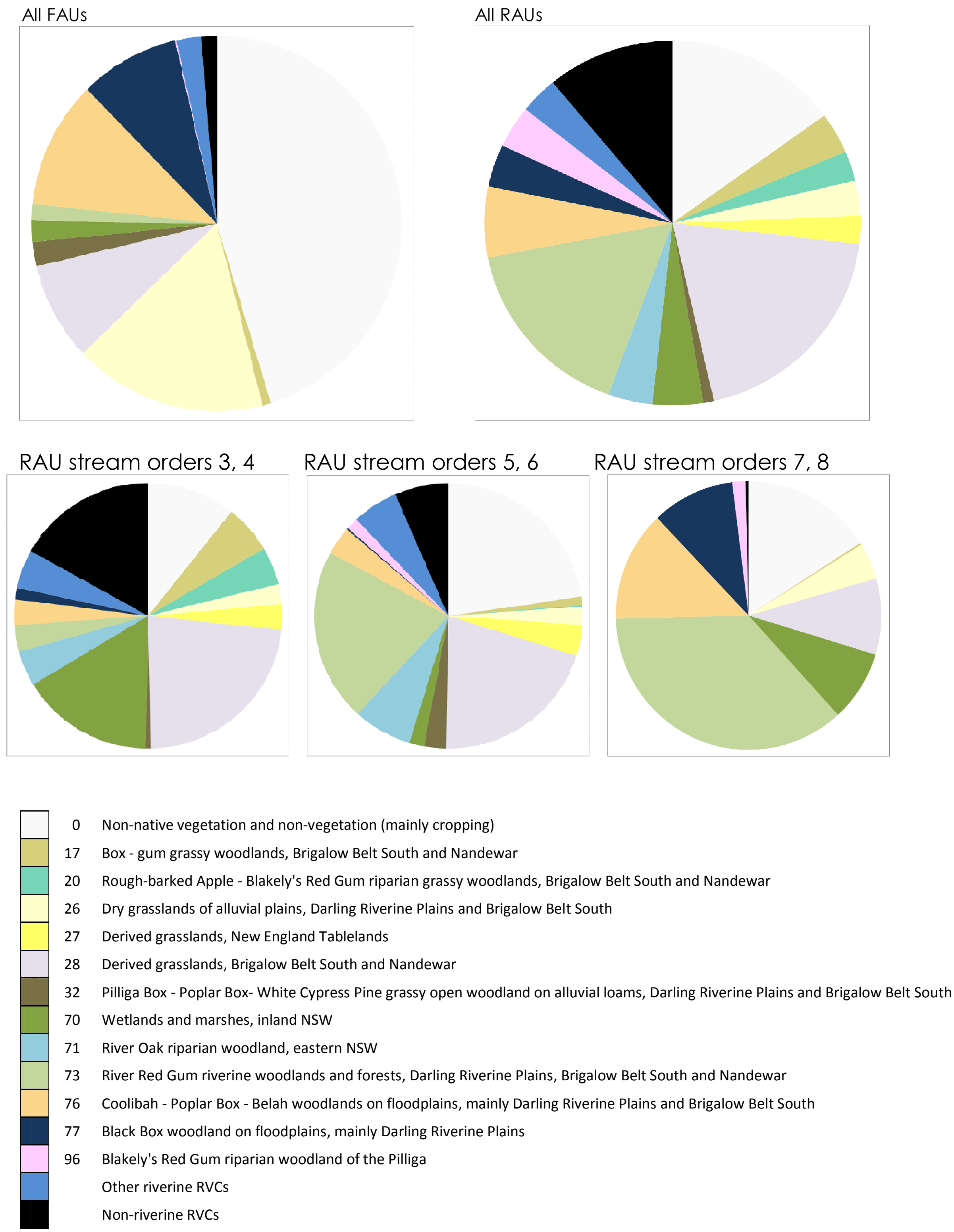
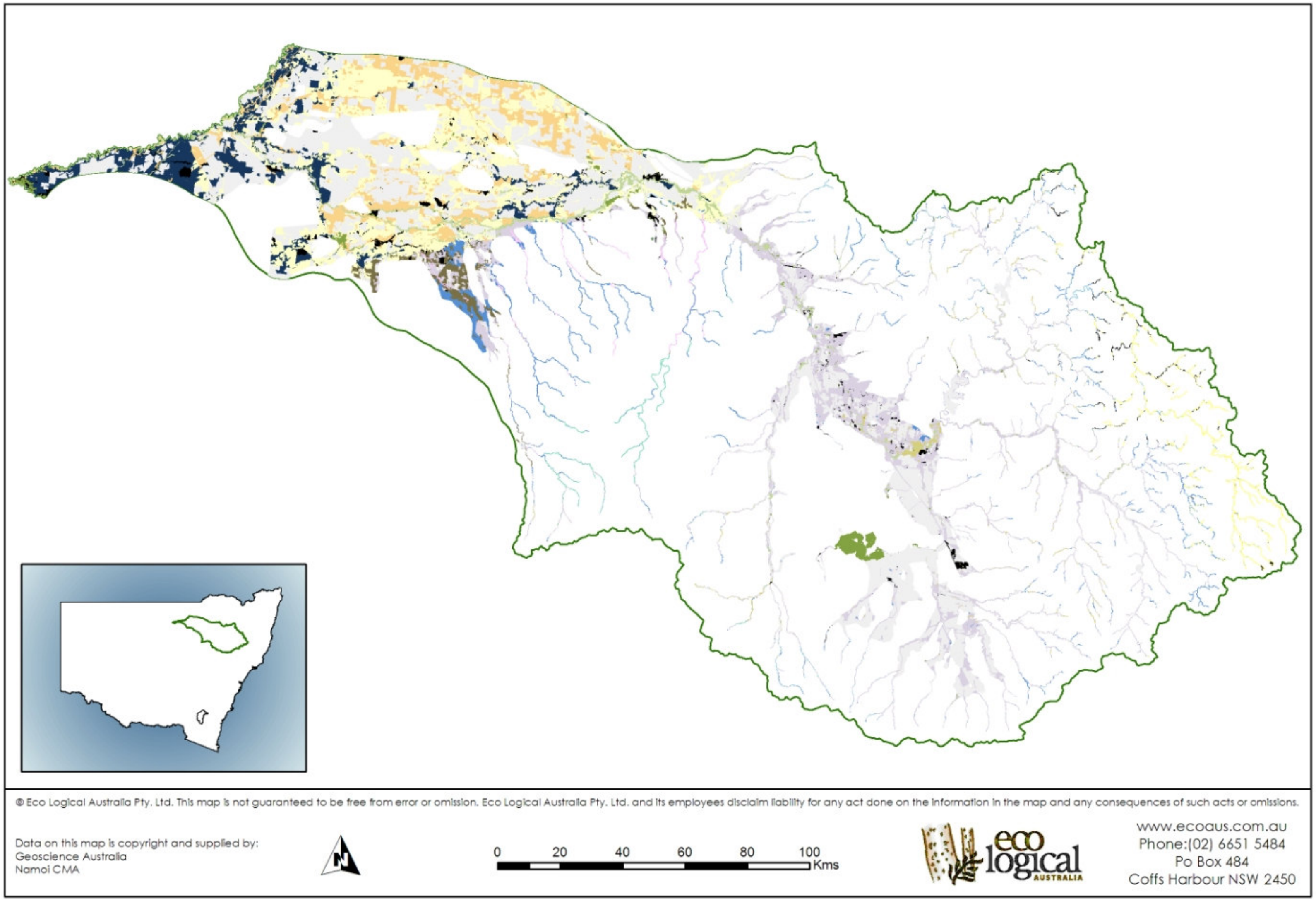


Figure 11. Distribution of RVCs in the riverine zone of the Namoi catchment (refer to Figure 10 on previous page for colour legend)



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4.4 Landscape metrics

4.4.1 RAU woody cover

Clearing of riparian vegetation immediately adjacent to and within major and minor river channels is known to impact river channel health and function, through streambank erosion, loss of woody instream habitat, and water temperature change as a result of increased solar radiation. Extensive clearing is also known to reduce population viability of fauna species reliant on large intact stands of native vegetation. Thus calculation of cover metrics provides a useful surrogate of vegetation condition. The distribution of native woody vegetation and non-native vegetation in the riverine zone of the Namoi catchment is shown in Figure 12.

The average RAU in the Namoi catchment comprises 35% native woody cover. However, this varies considerably with bioregion, tenure, stream order, and sub-catchment. For example, the effect of bioregion on RAU vegetation cover is shown in Table 18. Two-tailed *t*-tests demonstrate that RAUs within the New England Tablelands and Nandewar Bioregions possess comparatively less cover than those associated with the Brigalow Belt South and Darling-Riverine Plains.

Table 18. Effect of bioregion on woody cover of RAUs

			Significant Difference?			
Bioregion	**No RAUs**	**% Woody Cover**	**BBS**	**DRP**	**NAN**	**NET**
BBS	540	49.3 ± 3.1				
DRP	108	43.8 ± 5.4	*no*			
NAN	560	39.5 ± 2.6	yes	*no*		
NET	187	36.1 ± 4.7	yes	yes	*no*	

The effect of land tenure on woody vegetation cover is shown in Table 19. Two-tailed *t*-tests demonstrate that RAUs within national park and state forest contain significantly greater %-native cover than other classes of tenure, and that freehold land and reserved crown land each contain significantly less %-native cover than other classes of tenure. Woody cover associated RAUs in national park averages more than 90%, while woody cover in freehold RAUs averages less than 40%.

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Table 19. Effect of land tenure on woody cover of RAUs

			Significant difference?				
Tenure	**No RAUs**	**% Woody Cover**	**NP**	**SF**	**TSR**	**RCL**	**FH**
NP	71	92.4 ± 2.5					
SF	66	88.7 ± 3.8	*no*				
TSR	28	54.9 ± 9.5	yes	yes			
RCL	28	39.6 ± 9.2	yes	yes	yes		
FH	1202	37.8 ± 1.8	yes	yes	yes	*no*	

NP = NPWS-managed land SF = state forest TSR = travelling stock reserve RCL = reserves crown land
FH = freehold land

The effect of stream order on woody vegetation cover is shown in Table 20. RAUs exhibiting a stream order of 3, 4, 5 and 8 have a mean %-cover of about 40%, and do not differ significantly. In contrast, RAUs on 6th order streams possess a relatively low %-cover, which differs significantly from all but 8th order streams, while RAUs on 7th order streams possess a relatively high %-cover which differs significantly from all but RAUs in 5th order streams. A possible explanation for the relative cover difference between 6th and 7th order RAUs is land tenure. Only 2 of the 43 RAUs on 6th order streams occur on public land, while 14 of the 78 RAUs on 7th order streams occur on public land.

Table 20. Effect of stream order on woody cover of RAUs

			Significant difference?					
Stream Order	**No RAUs**	**% Woody Cover**	**3**	**4**	**5**	**6**	**7**	**8**
3	836	43.1 ± 2.4						
4	312	42.6 ± 3.8	*no*					
5	116	45.5 ± 5.8	*no*	*no*				
6	43	28.4 ± 7.5	yes	yes	yes			
7	78	51.6 ± 6.1	yes	yes	*no*	yes		
8	10	38.5 ± 9.2	*no*	*no*	*no*	*no*	yes	

Mean % woody cover of RAUs varies significantly between Namoi sub-catchments, from 92% in Coghill sub-catchment, to 0% in Box Creek sub-catchment (Figure 13). A total of five sub-catchments contain RAUs which exhibit a mean woody cover of >80%; a total of 10 sub-catchments contain RAUs which exhibit a mean cover of <10% woody vegetation.

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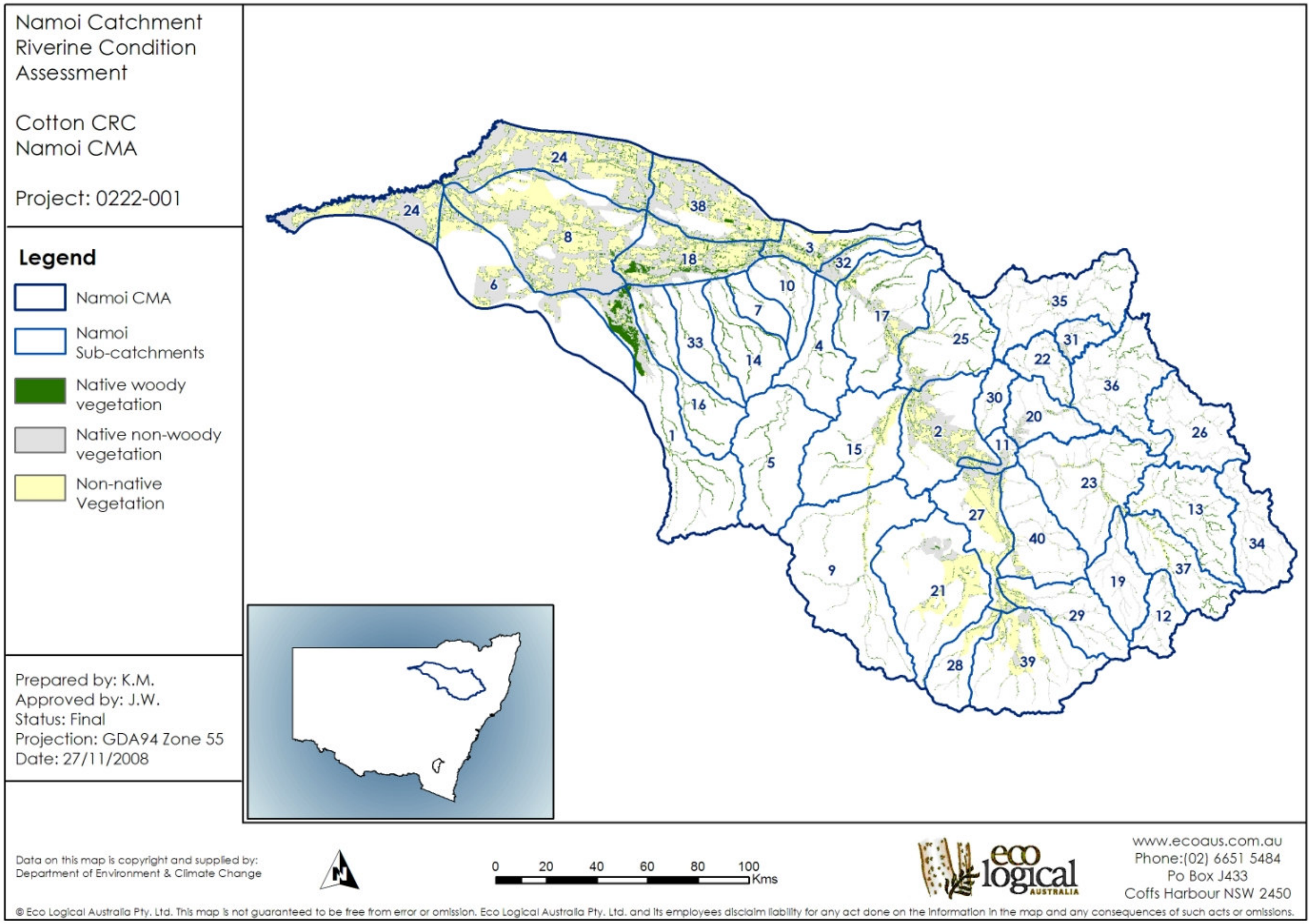
Figure 12. Distribution of three classes of vegetation cover in the riverine zone of the Namoi catchment



1 Baradine
2 Bluevale
3 Bobbiwaa
4 Bohena
5 Borah
6 Box Creek
7 Brigalow
8 Bugilbone
9 Bundella Creek
10 Bundock
11 Carroll
12 Chaffey
13 Cockburn River
14 Coghill
15 Cox's Creek
16 Etoo
17 Eulah Creek
18 Ginudgera
19 Goonoo Goonoo
20 Keepit
21 Lake Goran
22 Lower Manilla
23 Lower Peel
24 Lower Pian
25 Maules
26 Mid MacDonald
27 Mooki
28 Phillips
29 Quirindi
30 Rangira
31 Split Rock
32 Spring Creek
33 Tallaba
34 Upper MacDonald
35 Upper Manilla
36 Upper Namoi
37 Upper Peel
38 Upper Pian
39 Warrah
40 Werris Creek

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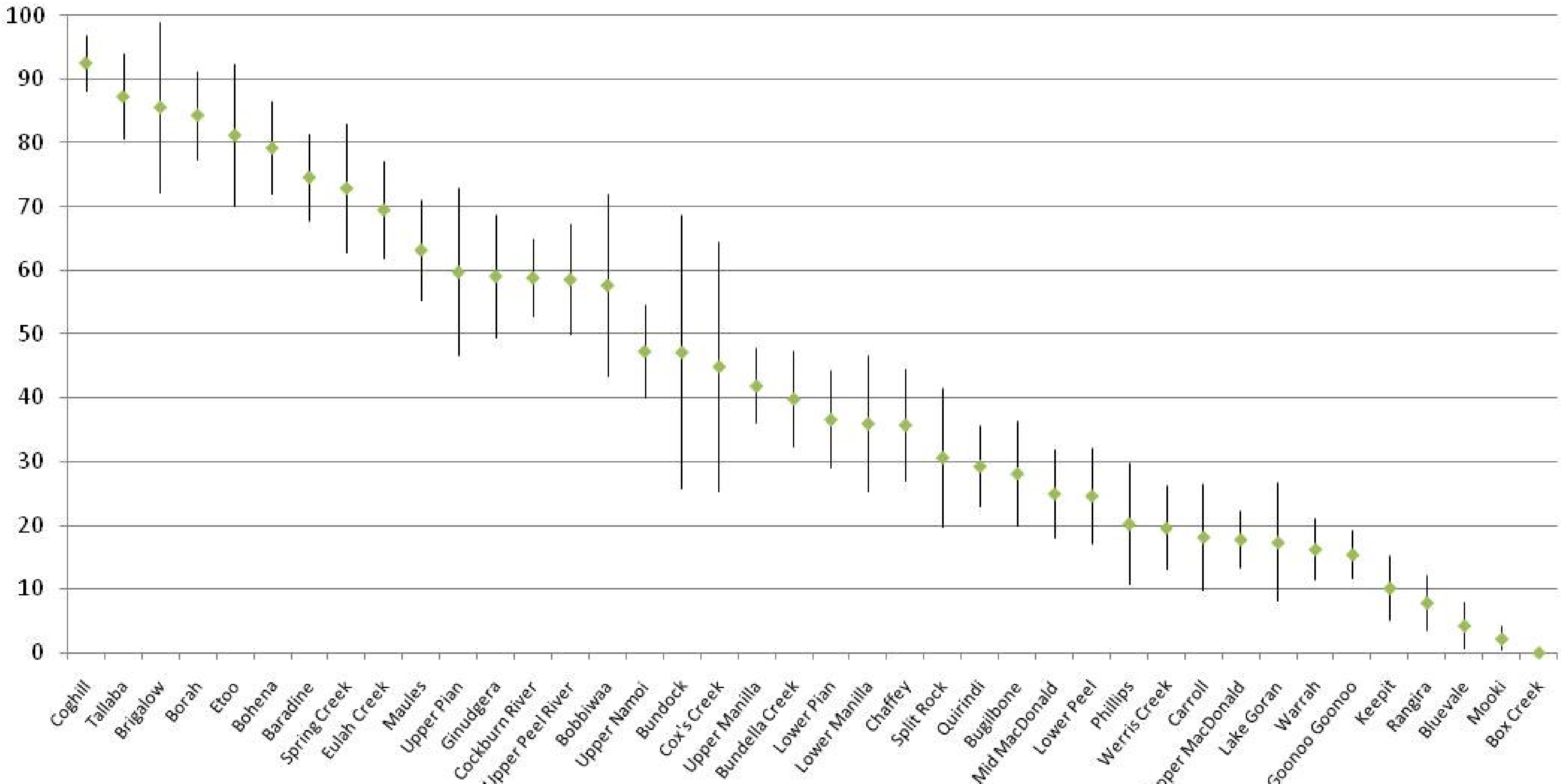
Figure 13. Mean %cover of RAUs in each sub-catchment of the Namoi



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4.4.2 FAU woody cover

A total of 672 km^2 or 7% of the combined areas of all FAUs in the Namoi catchment comprises native woody vegetation, while 4,085 km^2 or 44% comprises native non-woody vegetation, most of which is likely to constitute derived native grassland (although some areas of true native grasslands persist as remnants in the Namoi). A total of 20 of the 32 sub-catchments comprise FAUs which exhibit less than 10% native woody vegetation (Table 21; Figure 14). The floodplain of Baradine sub-catchment contains by far the greatest proportion of native woody vegetation of all of the FAUs in the Namoi.

4.4.3 FAU non-native cover

The gross proportion of cropping in the riverine zone is a useful indicator of vegetation condition at the catchment level, particularly in relation to weediness. The intensive nature of cropping usually results in removal of native vegetation and replacement with one or more target and numerous non-target exotic species. These are readily dispersed downstream as periodic floodwaters carrying exotic plant material flow from cropped to uncropped floodplains and into major river channels. Notwithstanding, it is possible to integrate cropping and native vegetation management to achieve robust biodiversity outcomes, particularly if adequate corridors and patches of core native habitat are retained and managed for nature conservation.

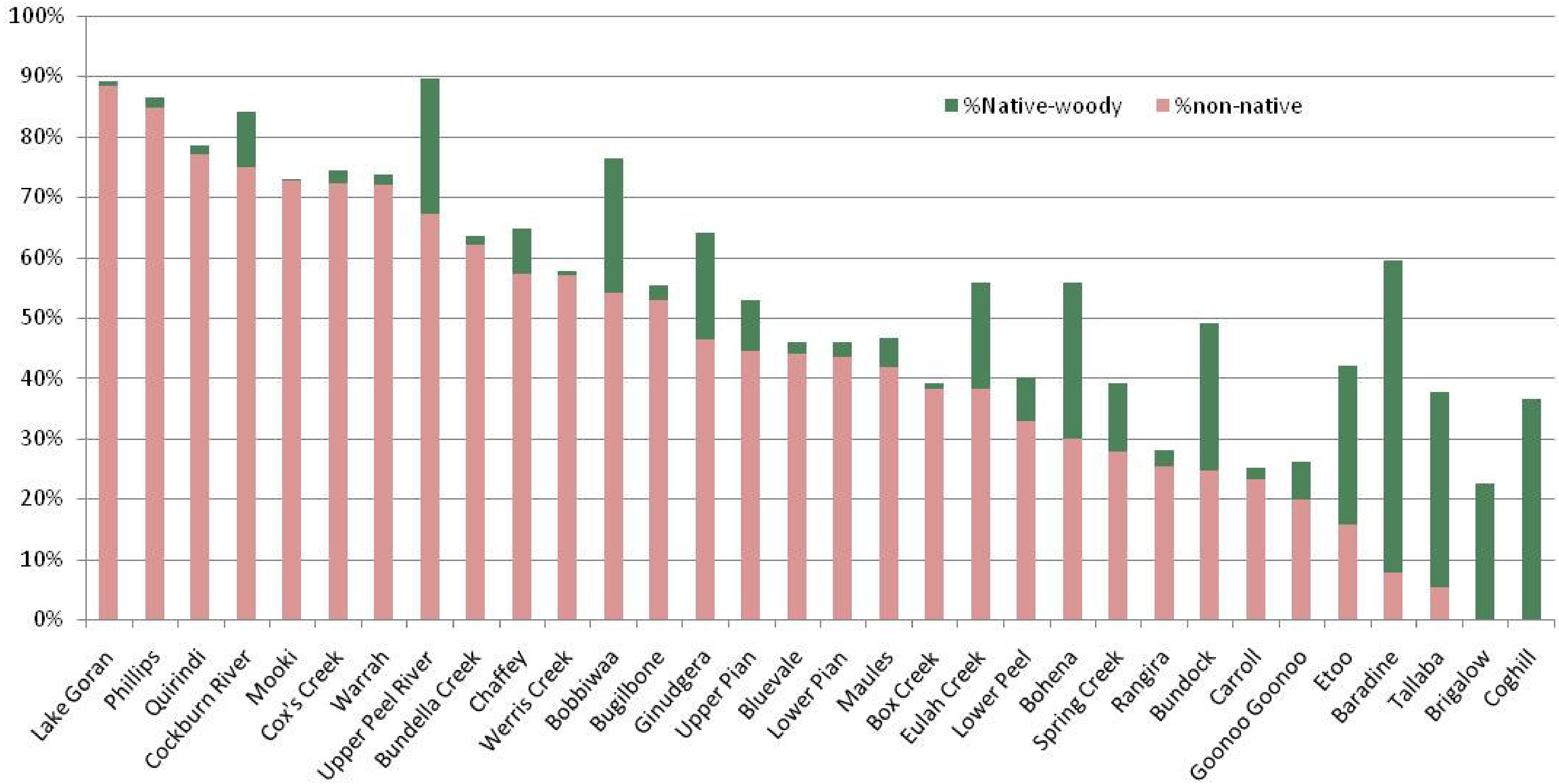
A total of 4,503 km^2 or 49% of the combined areas of all FAUs in the Namoi catchment comprises non-native vegetation (mainly cropping land, but also water storages, urban land and quarries). The larger FAUs appear to contain a greater proportion of non-native vegetation than the smaller FAUs. The percentage of non-native cover in FAUs in each sub-catchment varies from 0 in Brigalow and Coghill, (which each possess very minor areas of floodplain in the BBS Bioregion) to in excess of 80% in Lake Goran (when dry) and Phillips sub-catchments in BBS (Table 21).

Table 21. Proportion of FAUs containing native woody and non-native vegetation, by Namoi Sub-catchment.

			Native Woody		Non-Native	
Sub-Catchment	Bioregion(s)	Area	Area	%Area	Area	%Area
Baradine	BBS, DRP	312.4	161.4	51.7	24.2	7.7
Bluevale	BBS	498.6	8.9	1.8	221.3	44.4
Bobbiwaa	BBS, DRP	264.4	58.6	22.2	145.6	55.1
Bohena	BBS	0.9	0.2	26.0	0.3	30
Box Creek	BBS, DRP	475.5	4.7	1.0	181.1	38.1
Brigalow	BBS	0.1	0	21.9	0	0
Bugilbone	BBS, DRP	1864.9	48.4	2.6	986.2	52.9
Bundella Creek	BBS	39.2	0.6	1.6	24.4	62.2
Bundock	BBS	47.3	11.6	24.5	12.6	26.6
Carroll	BBS, NAN	78.2	1.5	1.9	18.2	23.3
Chaffey	NAN	0.5	0	7.5	0.3	57.3
Cockburn River	NAN	3.8	0.3	9.0	2.8	75
Coghill	BBS	0.3	0.1	36.8	0	0
Cox's Creek	BBS	119.2	2.7	2.2	87.6	73.5
Etoo	BBS	86	22.7	26.4	13.6	15.8
Eulah Creek	BBS	236.7	41.9	17.7	91.2	38.5
Ginudgera	BBS, DRP	829.9	147.7	17.8	392.4	47.3
Goonoo Goonoo	NAN	6.7	0.4	6.3	1.3	20
Lake Goran	BBS	294.9	2	0.7	261.2	88.6
Lower Peel	NAN	50.6	3.7	7.3	16.7	33
Lower Pian	DRP	2042.4	46.3	2.3	893.9	43.8
Maules	BBS	102.0	5	4.9	42.6	41.8
Mooki	BBS	433	1.1	0.3	318.3	73.5
Phillips	BBS	62.6	0.9	1.5	53.2	84.9
Quirindi	BBS	61.7	1	1.6	47.6	77.1
Rangira	BBS	3.9	0.1	2.7	1.0	25.4
Spring Creek	BBS, DRP	88.6	10.2	11.5	24.6	27.8
Tallaba	BBS, NAN	5.6	1.8	32.3	0.3	5.4
Upper Peel River	NAN	21.1	4.8	22.5	14.2	67.1
Upper Pian	DRP	943.1	79	8.4	427.5	45.3
Warrah	BBS	235.7	4.2	1.8	169.4	71.9
Werris Creek	BBS, NAN	50.8	0.4	0.8	29.3	57.5
ALL		9260.4	672.3	7.3	4502.9	48.6

Note. All areas in km^2.

Figure 14. Proportion of non-native vegetation and native woody vegetation within FAUs in each Namoi sub-catchment



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4.4.4 RAU adjacent woody cover

The average RAU in the Namoi catchment comprises 35% native woody cover. In contrast, the average 200m, 550m and 1750m buffer that surrounds each RAU in the Namoi contains slightly less native woody cover; 28%, 28% and 30%, respectively. The %-cover in each RAU buffer varies between bioregions, stream order, and sub-catchment.

The effect of bioregion on RAU-buffer vegetation cover is shown in Table 22. Two-tailed *t*-tests demonstrate that % woody cover in 200m, 550m and 1750m RAU buffers in the DRP Bioregion is significantly lower to that of respective RAU buffers in other bioregions. There is no significant difference in the proportion of native woody vegetation surrounding RAUs in BBS, Nandewar and NET Bioregions, for 550m and 1750m buffers, although woody cover in 200m RAU buffers is significantly higher in BBS than in Nandewar or NET.

Table 22. Effect of bioregion on woody cover of RAU buffers

200m buffer			**Significant Difference?**			
Bioregion	**No RAUs**	**% Woody Cover**	**BBS**	**DRP**	**NAN**	**NET**
BBS	540	35.2 ± 3.0				
DRP	108	21.4 ± 3.4	yes			
NAN	560	29.9 ± 2.4	yes	yes		
NET	187	31.7 ± 4.2	yes	yes	*no*	
550m buffer						
BBS	540	33.4 ± 2.9				
DRP	108	17.7 ± 3.1	yes			
NAN	560	30.6 ± 2.3	*no*	yes		
NET	187	31.9 ± 4.0	*no*	yes	*no*	
1750m buffer						
BBS	540	35.2 ± 2.8				
DRP	108	14.7 ± 2.4	yes			
NAN	560	34.4 ± 2.4	*no*	yes		
NET	187	34.0 ± 3.7	*no*	yes	*no*	

The effect of stream order on woody vegetation cover surrounding RAUs is shown in Table 23. In general there is no significant difference between 3rd, 4th and 5th order streams in terms of %-native woody cover within surrounding buffers, which averages 32 to 35%. However, the %- native woody vegetation within RAU buffers is significantly less in the higher order streams and rivers, not surprisingly as they are often surrounded by floodplains within which native vegetation clearance has been historically high. Over 80% of the woody vegetation has been removed from the majority of 200m, 550m and 1750m buffers surrounding RAUs on the floodplain.

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Table 23. Effect of stream order on woody cover of RAU buffers

200m buffer

Stream Order	No RAUs	% Woody Cover	Significant difference? 3	4	5	6	7	8
3	836	32.9 ± 2.2						
4	312	31.8 ± 3.5	no					
5	116	32.1 ± 5.1	no	no				
6	43	16.2 ± 6.2	yes	yes	yes			
7	78	24.2 ± 4.2	yes	yes	yes	yes		
8	10	22.2 ± 9.1	no	no	no	no	no	

550m buffer

Stream Order	No RAUs	% Woody Cover	3	4	5	6	7	8
3	836	32.7 ± 2.2						
4	312	31.5 ± 3.4	no					
5	116	32.4 ± 4.8	no	no				
6	43	15.7 ± 6.0	yes	yes	yes			
7	78	20.8 ± 3.8	yes	yes	yes	yes		
8	10	13.9 ± 5.1	no	no	yes	no	no	

1750m buffer

Stream Order	No RAUs	% Woody Cover	3	4	5	6	7	8
3	836	35.2 ± 2.1						
4	312	33.6 ± 3.2	no					
5	116	34.8 ± 4.4	no	no				
6	43	17.1 ± 5.9	yes	yes	yes			
7	78	17.2 ± 2.7	yes	yes	yes	no		
8	10	9.1 ± 2.3	yes	yes	yes	no	yes	

There is no significant difference between mean %-native woody cover in 200m RAU and 550m RAU buffers within any of the 40 sub-catchments in the Namoi. However, there is a significant difference between mean %-native woody cover in the 1750m RAU and mean %-native woody cover in the 200m and/or 550m RAU buffer within four of the 40 sub-catchments in the Namoi (Table 24). Averaging %-native woody cover across all sub-catchments reveals a non-significant difference between the three buffer sizes, thus for the purpose of illustrating the variation in buffer cover across sub-catchments (Figure 15), all buffer values (220, 550 and 1750) are combined.

Mean %-cover of RAU buffers varies significantly between Namoi sub-catchments, from 91% in Coghill sub-catchment, to 0% in Box Creek sub-catchment (Figure 15). The proportion of %-native woody vegetation within the RAU is always greater than that surrounding the RAU. This is most evident for sub-catchments in the DRP Bioregion including Baradine, Bugilbone, Ginudgera, Lower Pian, Spring Creek and Upper Pian (Figure 15).

Table 24. Mean percent woody vegetation of three RAU buffers in each sub-catchment

	Buffer width (m)			
Sub Catchment	200	550	1750	Signif. 0.05 [A]
1. Baradine	55.3 ± 7.8	54.8 ± 7.7	58.3 ± 6.6	no
2. Bluevale	2.2 ± 1.0	2.6 ± 1.2	3.9 ± 1.4	yes (1750m)
3. Bobbiwaa	35.7 ± 8.3	32.4 ± 7.6	31.8 ± 7.9	no
4. Bohena	79.5 ± 9.1	78.2 ± 9.7	77.2 ± 10.1	no
5. Borah	73.2 ± 11.3	71.0 ± 12.0	72.3 ± 11.0	no
6. Box Creek	0	0	0	no
7. Brigalow	48.9 ± 25.2	41.2 ± 24.6	40.2 ± 20.4	no
8. Bugilbone	11.1 ± 4.1	8.5 ± 2.9	6.3 ± 1.7	yes (1750m)
9. Bundella Creek	19.6 ± 4.4	19.4 ± 4.9	23.3 ± 6.1	no
10. Bundock	29.2 ± 16.9	27.0 ± 15.1	27.1 ± 12.5	no
11. Carroll	11.5 ± 8.2	9.8 ± 18.3	10.0 ± 14.1	no
12. Chaffey	26.0 ± 7.2	28.1 ± 6.7	34.9 ± 5.9	no
13. Cockburn River	44.5 ± 5.8	45.7 ± 5.1	51.2 ± 3.9	no
14. Coghill	92.6 ± 4.6	91.5 ± 5.3	89.3 ± 5.2	no
15. Cox's Creek	37.2 ± 18.7	36.2 ± 17.4	34.2 ± 14.4	no
16. Etoo	77.7 ± 14.2	77.5 ± 13.7	76.8 ± 13.3	no
17. Eulah Creek	49.8 ± 7.8	48.4 ± 7.8	49.9 ± 7.6	no
18. Ginudgera	32.0 ± 7.0	29.2 ± 6.8	26.1 ± 5.4	no
19. Goonoo Goonoo	6.1 ± 1.8	5.3 ± 1.6	6.0 ± 1.9	no
20. Keepit	5.0 ± 2.7	5.8 ± 3.2	6.9 ± 3.6	no
21. Lake Goran	9.2 ± 7.5	9.8 ± 7.8	13.4 ± 8.4	no
22. Lower Manilla	27.9 ± 8.4	25.3 ± 7.0	26.1 ± 5.6	no
23. Lower Peel	19.8 ± 7.0	21.1 ± 7.1	24.4 ± 7.1	no
24. Lower Pian	20.2 ± 5.6	15.7 ± 4.2	12.7 ± 3.6	yes (1750m)
25. Maules	41.4 ± 8.9	41.5 ± 9.0	44.1 ± 8.7	no
26. Mid MacDonald	19.3 ± 5.2	18.8 ± 4.6	21.1 ± 4.1	no
27. Mooki	2.1 ± 2.7	1.9 ± 2.0	1.9 ± 1.0	no
28. Phillips	10.0 ± 7.1	9.6 ± 6.7	13.8 ± 7.8	no
29. Quirindi	22.2 ± 6.0	23.3 ± 5.8	26.4 ± 4.6	no
30. Rangira	3.0 ± 1.0	2.7 ± 1.0	4.0 ± 2.2	no
31. Split Rock	19.1 ± 7.8	20.3 ± 7.5	22.7 ± 6.4	no
32. Spring Creek	37.0 ± 11.4	31.9 ± 11.8	32.5 ± 13.0	no
33. Tallaba	75.1 ± 12.8	69.4 ± 13.1	61.9 ± 11.9	no
34. Upper MacDonald	15.3 ± 3.0	14.8 ± 2.4	16.3 ± 1.8	no
35. Upper Manilla	31.5 ± 5.3	30.7 ± 5.1	31.7 ± 4.5	no
36. Upper Namoi	39.1 ± 6.7	40.2 ± 6.3	45.3 ± 5.5	no
37. Upper Peel River	50.0 ± 9.8	52.6 ± 9.4	57.8 ± 8.0	no
38. Upper Pian	17.0 ± 4.5	13.2 ± 3.9	11.5 ± 3.1	yes (1750m)
39. Warrah	8.8 ± 3.6	8.6 ± 3.1	10.8 ± 3.0	no
40. Werris Creek	12.9 ± 6.0	13.5 ± 5.3	19.4 ± 5.8	no
ALL	31.5 ± 1.6	31.1 ± 1.6	33.1 ± 1.5	no

A. significant at the 5% level (using 2-tailed t statistic)

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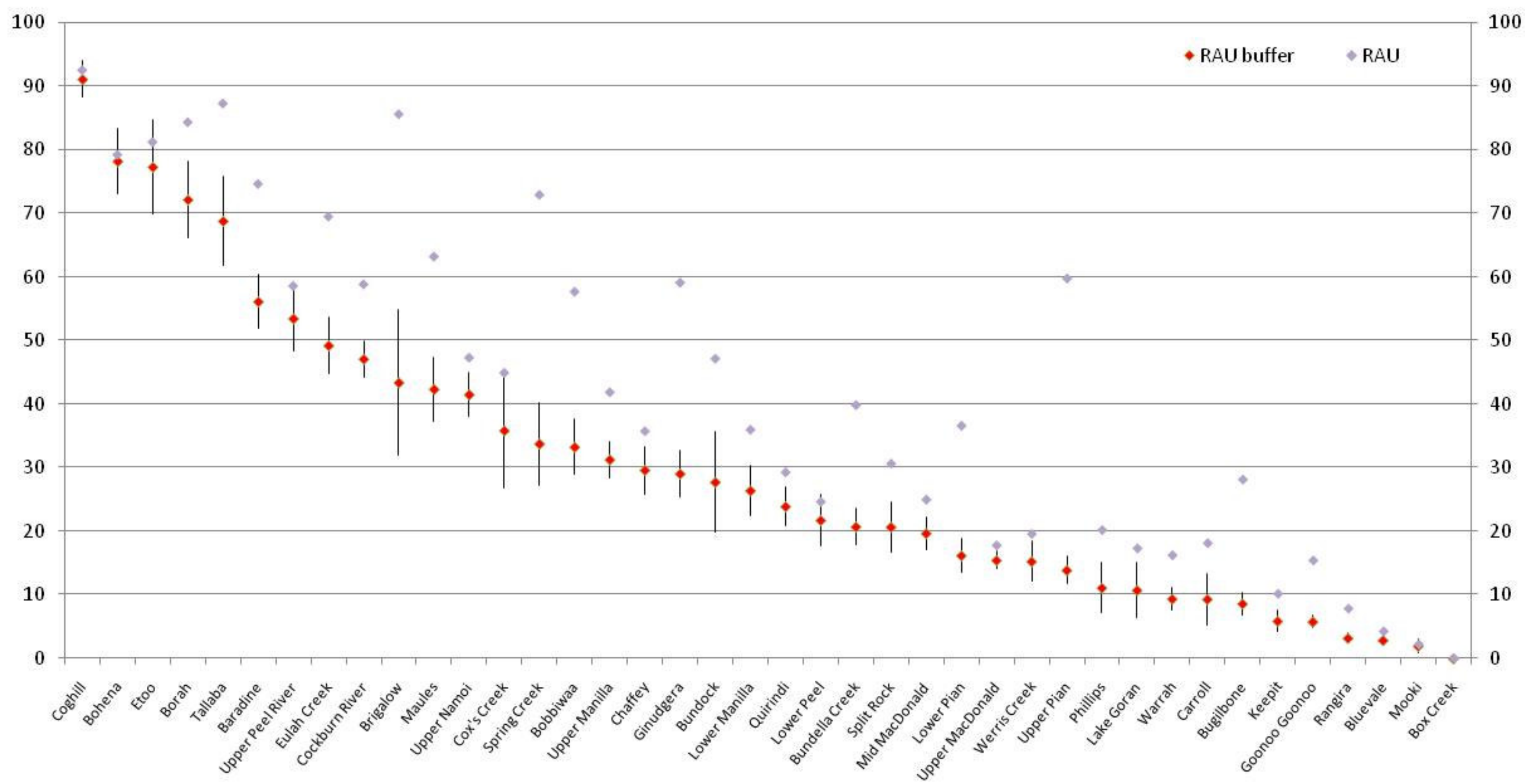
Figure 15. Mean %cover of combined RAU buffers in each sub-catchment of the Namoi
(mean %cover of respective RAU also shown)



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4.4.5 RAU adjacent non-native cover

The 200m, 550m and 1750m buffers that surround each RAU in the Namoi each contains an average 17%, 20% and 19% non-native vegetation cover, respectively (principally crops). However, this varies between bioregions, stream order, and sub-catchment.

The effect of bioregion on RAU-buffer non native cover is shown in Table 25. Two-tailed *t*-tests demonstrate that % non-native cover in 200m, 550m and 1750m RAU buffers in the NET Bioregion is significantly less than that of respective RAU buffers in other bioregions, and that % non-native cover in 200m, 550m and 1750m RAU buffers in the Nandewar Bioregion is significantly lower to that of respective RAU buffers in BBS and DRP Bioregions. There is no significant difference between BBS and DRP in terms of mean % non-native cover within 200m and 550m buffers, however DRP possesses significantly greater non-native vegetation in 1750m buffers than BBS. These results confirm the prevalence of cropping in the BBS and DRP compared with Nandewar and New England.

Table 25. Effect of bioregion on non-native cover of RAU buffers

200m buffer			**Significant Difference?**			
Bioregion	**No RAUs**	**% Woody Cover**	**BBS**	**DRP**	**NAN**	**NET**
BBS	540	22.0 ± 2.1				
DRP	108	19.5 ± 3.9	*no*			
NAN	560	9.1 ± 1.3	yes	yes		
NET	187	1.1 ± 0.7	yes	yes	yes	
550m buffer						
BBS	540	24.2 ± 2.2				
DRP	108	24.6 ± 4.0	*no*			
NAN	560	9.7 ± 1.3	yes	yes		
NET	187	1.0 ± 0.6	yes	yes	yes	
1750m buffer						
BBS	540	23.8 ± 2.0				
DRP	108	31.3 ± 4.0	yes			
NAN	560	8.8 ± 1.2	yes	yes		
NET	187	1.0 ± 0.4	yes	yes	yes	

The effect of stream order on non-native vegetation cover surrounding RAUs is shown in Table 26. There is no significant difference between 3rd, 4th and 5th order streams in terms of % non-native cover within surrounding buffers, which averages between 13 and 17%. There is no significant difference between these and 8th order streams, although the latter varies between 6 and 22% depending on buffer size (and exhibits large variance about the mean). Percent non-native cover within RAU buffers is significantly higher in 6th and 7th order streams and rivers (averaging 20 - 30%), not surprisingly as they are often surrounded by floodplains within which native vegetation clearance has been historically high.

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Table 26. Effect of stream order on non-native cover of RAU buffers

200m buffer

Stream Order	No RAUs	% Non-native Cover	Significant difference? 3	4	5	6	7	8
3	836	12.5 ± 1.4						
4	312	14.0 ± 2.3	no					
5	116	16.3 ± 3.8	no	no				
6	43	28.1 ± 7.0	yes	yes	no			
7	78	20.1 ± 4.5	yes	yes	no	no		
8	10	6.0 ± 7.3	no	no	no	yes	yes	

550m buffer

Stream Order	No RAUs	% Non-native Cover	3	4	5	6	7	8
3	836	13.9 ± 1.5						
4	312	14.9 ± 2.4	no					
5	116	17.2 ± 3.8	no	no				
6	43	23.4 ± 7.3	yes	yes	no			
7	78	25.0 ± 4.6	yes	yes	yes	no		
8	10	9.4 ± 8.1	no	no	no	no	yes	

1750m buffer

Stream Order	No RAUs	% Non-native Cover	3	4	5	6	7	8
3	836	13.8 ± 1.4						
4	312	14.1 ± 2.2	no					
5	116	15.7 ± 3.6	no	no				
6	43	23.9 ± 7.8	yes	yes	yes			
7	78	30.0 ± 4.1	yes	yes	yes	no		
8	10	21.5 ± 7.1	no	no	no	no	no	

There is no significant difference between mean % non-native cover in 200m RAU and that in the 550m RAU buffer, for any of the 40 sub-catchments in the Namoi. However, there is a significant difference between mean % non-native cover in the 1750m RAU and that in the 200m and/or 550m RAU buffer within three of the 40 sub-catchments in the Namoi (Table 27). Averaging %-native woody cover across all sub-catchments reveals a non-significant difference between the three buffer sizes, thus for the purpose of illustrating the sub-catchment variation in non-native cover surrounding RAUs (Figure 16), all buffer values (220, 550 and 1750) are combined.

Mean %cover of non-native vegetation within RAU buffers varies significantly between Namoi sub-catchments, from about 50% in Lake Goran and Mooki sub-catchments, to 0% in Coghill and Split Rock sub-catchments (Figure 16). Buffers containing a relatively high percentage of non-native cover are associated with the BBS and DRP Bioregions, while those exhibiting very little non-native vegetation are in the Nandewar and NET Bioregions where opportunities for cropping are limited. Native non-woody vegetation (mainly derived native grasslands) is prevalent around RAUs in Nandewar and NET which have been subject to past clearing, such as Goonoo Goonoo, Keepit, Mid MacDonald and Upper MacDonald,

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Table 27. Mean percent non-native vegetation of three RAU buffers in each sub-catchment

	Buffer width (m)			
Sub Catchment	200	550	1750	Signif. 0.05 [A]
1. Baradine	8.1 ± 3.1	8.4 ± 2.8	6.1 ± 1.7	no
2. Bluevale	24.7 ± 11.1	29.2 ± 10.7	32.2 ± 9.1	no
3. Bobbiwaa	26.4 ± 7.6	31.7 ± 7.4	36.6 ± 7.6	no
4. Bohena	0.2 ± 0.2	0.4 ± 0.4	1.3 ± 1.6	no
5. Borah	0.1 ± 0.3	0.6 ± 0.9	0.8 ± 1.3	no
6. Box Creek [B]	13.7	16.8	42.2	no
7. Brigalow	5.6 ± 6.8	9.3 ± 9.2	10.6 ± 8.1	no
8. Bugilbone	20.4 ± 6.9	27.4 ± 7.6	33.7 ± 8.1	yes (1750m)
9. Bundella Creek	26.1 ± 7.6	28.5 ± 7.8	25.9 ± 7.6	no
10. Bundock	17.2 ± 9.2	21.1 ± 8.9	24.8 ± 7.8	no
11. Carroll	12.1 ± 8.1	14.1 ± 16.6	19.1 ± 17.7	no
12. Chaffey	9.9 ± 8.5	9.2 ± 8.4	7.4 ± 6.6	no
13. Cockburn River	5.0 ± 3.2	4.7 ± 3.0	3.4 ± 1.9	no
14. Coghill	0.1 ± 0.1	0.2 ± 0.2	0.1 ± 0.2	no
15. Cox's Creek	23.7 ± 11.5	27.1 ± 11.9	28.4 ± 11.0	no
16. Etoo	6.1 ± 7.5	5.6 ± 6.2	5.0 ± 4.4	no
17. Eulah Creek	15.5 ± 4.6	16.4 ± 4.6	17.5 ± 4.4	no
18. Ginudgera	22.6 ± 8.1	26.5 ± 8.0	29.8 ± 5.5	no
19. Goonoo Goonoo	4.0 ± 2.3	5.2 ± 2.8	6.5 ± 3.2	no
20. Keepit	13.1 ± 5.7	14.0 ± 6.3	11.0 ± 4.5	no
21. Lake Goran	44.4 ± 14.0	46.6 ± 13.9	44.0 ± 12.3	no
22. Lower Manilla	4.9 ± 3.1	5.5 ± 2.2	4.8 ± 1.5	no
23. Lower Peel	21.9 ± 5.4	25.1 ± 6.0	24.5 ± 6.1	no
24. Lower Pian	8.8 ± 5.9	10.6 ± 5.7	17.6 ± 5.1	yes (1750m)
25. Maules	22.8 ± 5.9	24.6 ± 6.1	23.0 ± 5.4	no
26. Mid MacDonald	2.8 ± 2.6	2.4 ± 2.0	3.0 ± 2.0	no
27. Mooki	45.9 ± 11.0	49.1 ± 11.0	53.6 ± 9.0	no
28. Phillips	27.3 ± 14.0	31.2 ± 13.2	33.8 ± 13.3	no
29. Quirindi	11.5 ± 4.0	13.4 ± 4.7	13.5 ± 4.3	no
30. Rangira	23.3 ± 7.6	22.8 ± 8.0	23.3 ± 7.3	no
31. Split Rock	0	0	0.2 ± 0.3	no
32. Spring Creek	20.9 ± 11.4	26.0 ± 12.4	26.0 ± 10.5	no
33. Tallaba	1.8 ± 1.6	2.4 ± 2.1	3.1 ± 1.8	no
34. Upper MacDonald	1.1 ± 1.0	0.9 ± 0.7	0.7 ± 0.6	no
35. Upper Manilla	5.3 ± 2.0	5.8 ± 2.0	4.8 ± 1.3	no
36. Upper Namoi	3.4 ± 2.0	2.9 ± 1.3	1.5 ± 0.6	no
37. Upper Peel River	13.1 ± 5.6	11.2 ± 4.5	9.4 ± 3.5	no
38. Upper Pian	20.1 ± 11.1	28.9 ± 12.1	37.5 ± 11.7	yes (1750m)
39. Warrah	36.5 ± 7.9	39.7 ± 7.7	36.0 ± 6.7	no
40. Werris Creek	22.1 ± 7.3	26.2 ± 7.3	27.8 ± 6.6	no
ALL	13.8 ± 1.1	15.3 ± 1.1	15.3 ± 1.1	no

A. *significant at the 5% level (using 2-tailed t statistic)*

B. *no error reported as sample size = 2*

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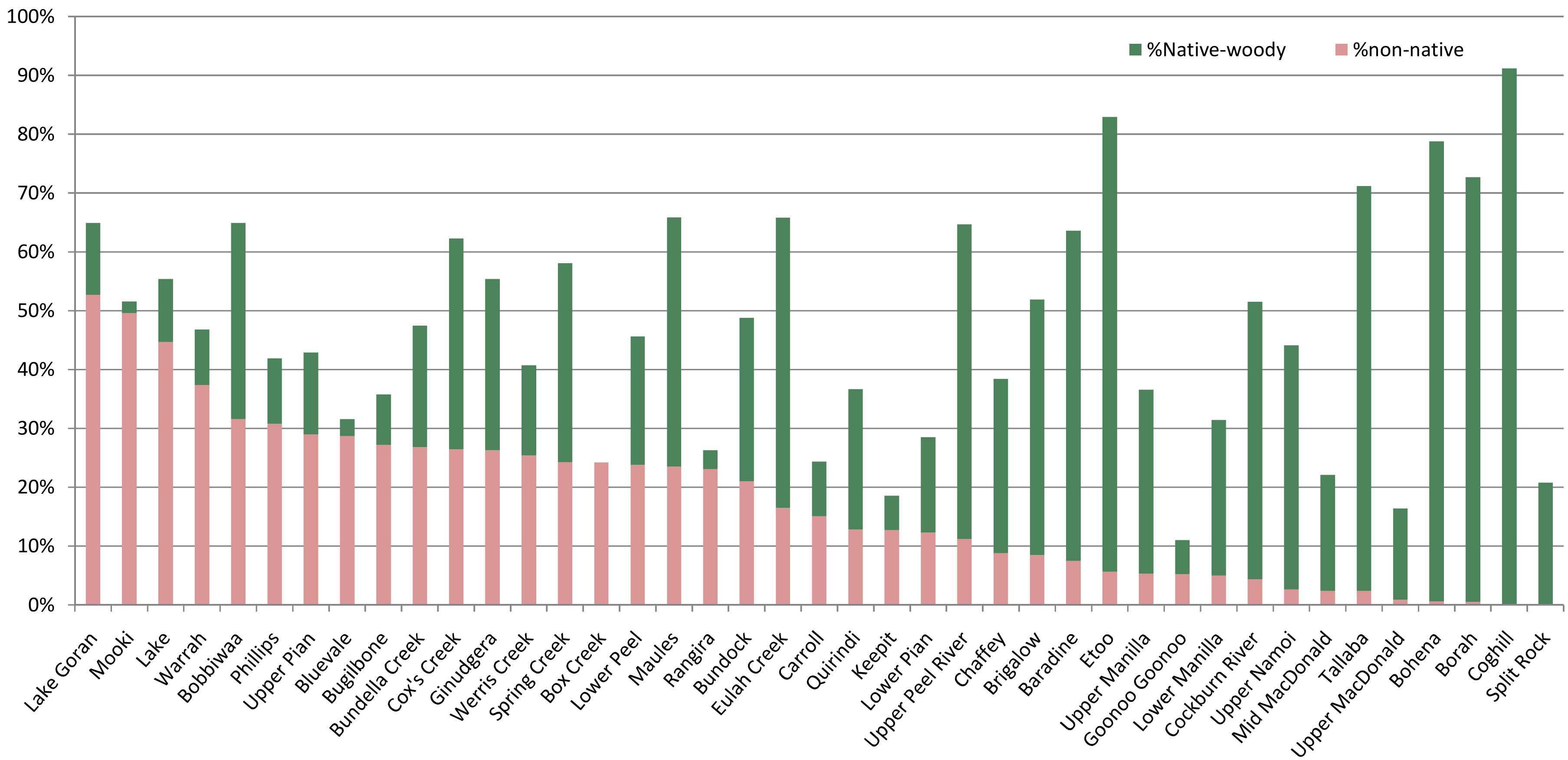
Figure 16. Proportion of non-native and native woody vegetation within combined RAU buffers in each Namoi sub-catchment



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4.4.6 Habitat links

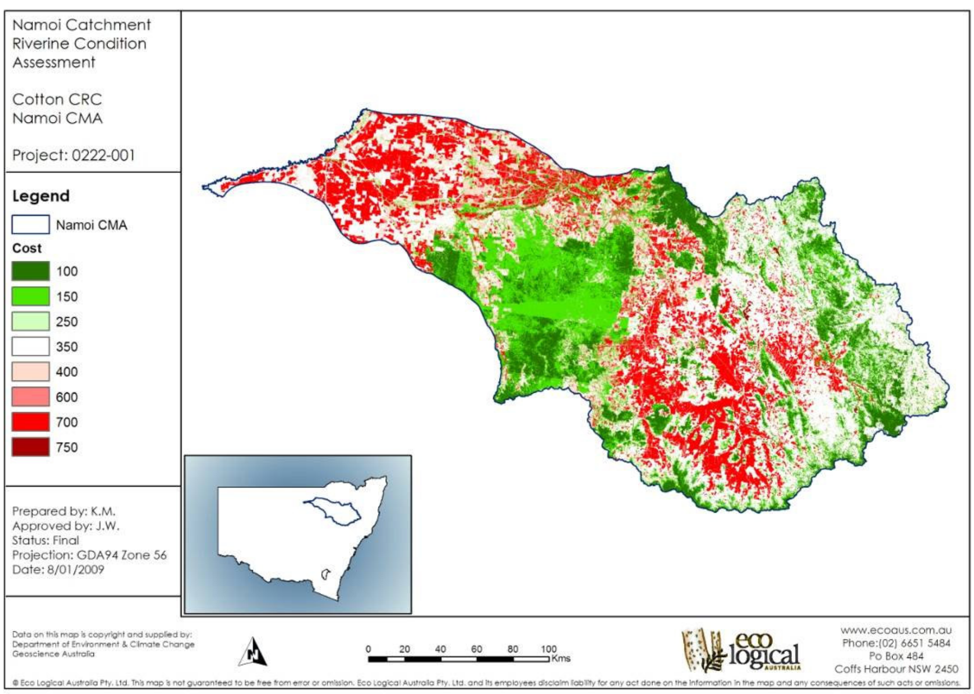
The spatial links tool was successfully run across the whole extent of the Namoi CMA using a cost grid derived from DECC vegetation extent data. The cost grid is shown in Table 28 and Figure 17. A total of 10,000 random points was generated within existing vegetation (coded '1' under habitat grid - Table 28) and 100,000 iterations of the SLT were run. A common gridcell size of 100m and a maximum travel distance of 15km were employed. Standard values of $1/\alpha$ = 5000 and i = 0.0004 were also employed. These indices are embedded in the SLT program as part of a decay function which underpins calculation of link value of each cell, based on distance from starting point (Drielsma *et al.* 2007).

Table 28. Values used to construct the cost grid

LABEL	Cost grid	Habitat grid
woody - (most likely) native	100	1
woody - (K&S) native	100	1
woody - (likely) native	150	1
woody - (likely) non-native	250	0
woody - (most likely) non-native	350	0
non-woody - (most likely) native	350	0
non-woody (K&S) - native	350	0
non-woody - (likely) native	400	0
non-woody - (likely) non-native	600	0
non-woody - (most likely) non-native	700	0
Other (mainly water storages)	750	0

K & S =

Figure 17. Cost grid for Namoi catchment (based on cover data provided by DECC)



The final SLT output was converted to an integer-grid expressed as values from 0 to 100, and clipped to the extent of the riverine zone. Figure 18 shows the distribution of links within the Namoi riverine footprint, while Table 29 shows the proportion of each RAU and FAU occupied by links, averaged across each sub-catchment. Values in Table 29 take into account the gross area of links in each sub-catchment, and the relative values of those links as derived by the SLT.

Table 29. Mean weighted habitat links value for each sub-catchment in the Namoi catchment

Sub Catchment	RAUs	FAUs	Sub Catchment	RAUs	FAUs
1. Baradine	18.7 ± 3.2	66.8	21. Lake Goran	6.0 ± 2.2	2.3
2. Bluevale	4.0 ± 11.1	1.9	22. Lower Manilla	10.2 ± 2.6	na
3. Bobbiwaa	25.3 ± 7.7	22.4	23. Lower Peel	6.4 ± 2.1	4.0
4. Bohena	18.3 ± 2.8	13.1	24. Lower Pian	9.7 ± 2.8	2.3
5. Borah	15.9 ± 5.0	na	25. Maules	15.8 ± 2.6	6.6
6. Box Creek	0.0	0.7	26. Mid MacDonald	4.7 ± 1.7	na
7. Brigalow	33.0 ± 11.7	na	27. Mooki	2.3 ± 1.4	1.2
8. Bugilbone	10.7 ± 3.5	1.7	28. Phillips	6.2 ± 2.8	3.3
9. Bundella Creek	9.4 ± 2.2	4.6	29. Quirindi	9.7 ± 2.7	3.8
10. Bundock	23.6 ± 11.7	29.6	30. Rangira	2.7 ± 1.6	3.7
11. Carroll	11.7 ± 13.6	3.6	31. Split Rock	6.3 ± 3.6	na
12. Chaffey	9.0 ± 2.5	21.6	32. Spring Creek	26.7 ± 4.9	18.1
13. Cockburn River	6.9 ± 1.4	7.6	33. Tallaba	25.2 ± 5.1	31.0
14. Coghill	19.1 ± 2.1	3.0	34. Upper MacDonald	4.6 ± 1.1	na
15. Cox's Creek	13.6 ± 5.0	4.8	35. Upper Manilla	12.1 ± 1.9	na
16. Etoo	18.7 ± 3.5	30.8	36. Upper Namoi	13.9 ± 3.1	na
17. Eulah Creek	21.5 ± 3.4	20.4	37. Upper Peel River	13.4 ± 2.5	26.4
18. Ginudgera	30.1 ± 7.7	24.9	38. Upper Pian	24.7 ± 6.4	8.5
19. Goonoo Goonoo	3.7 ± 1.3	7.2	39. Warrah	9.1 ± 2.4	3.5
20. Keepit	3.3 ± 1.2	na	40. Werris Creek	4.8 ± 1.8	2.5

Values in Table 29 are also represented in Figure 19. The coverage of habitat links within FAUs appears to be strongly associated with the proportion of native vegetation cover. For example, Baradine, Bundock, Etoo, Tallaba and Upper Manilla floodplains, which score highest for habitat links, contain a relatively high proportion of native woody cover (see Table 21 and Figure 14). The coverage of habitat links within RAUs is likewise associated with percent native cover, as illustrated in Figure 20. There is also evidence that RAU links tend to be more prevalent in larger order streams, with 5th to 8th order steams exhibiting a mean value of 16.1, compared to 3rd and 4th order streams' value of 11.3. Larger streams are often associated with the floodplain in which native woody vegetation has been largely removed; as such they provide a least cost opportunity for native fauna to move across the landscape.

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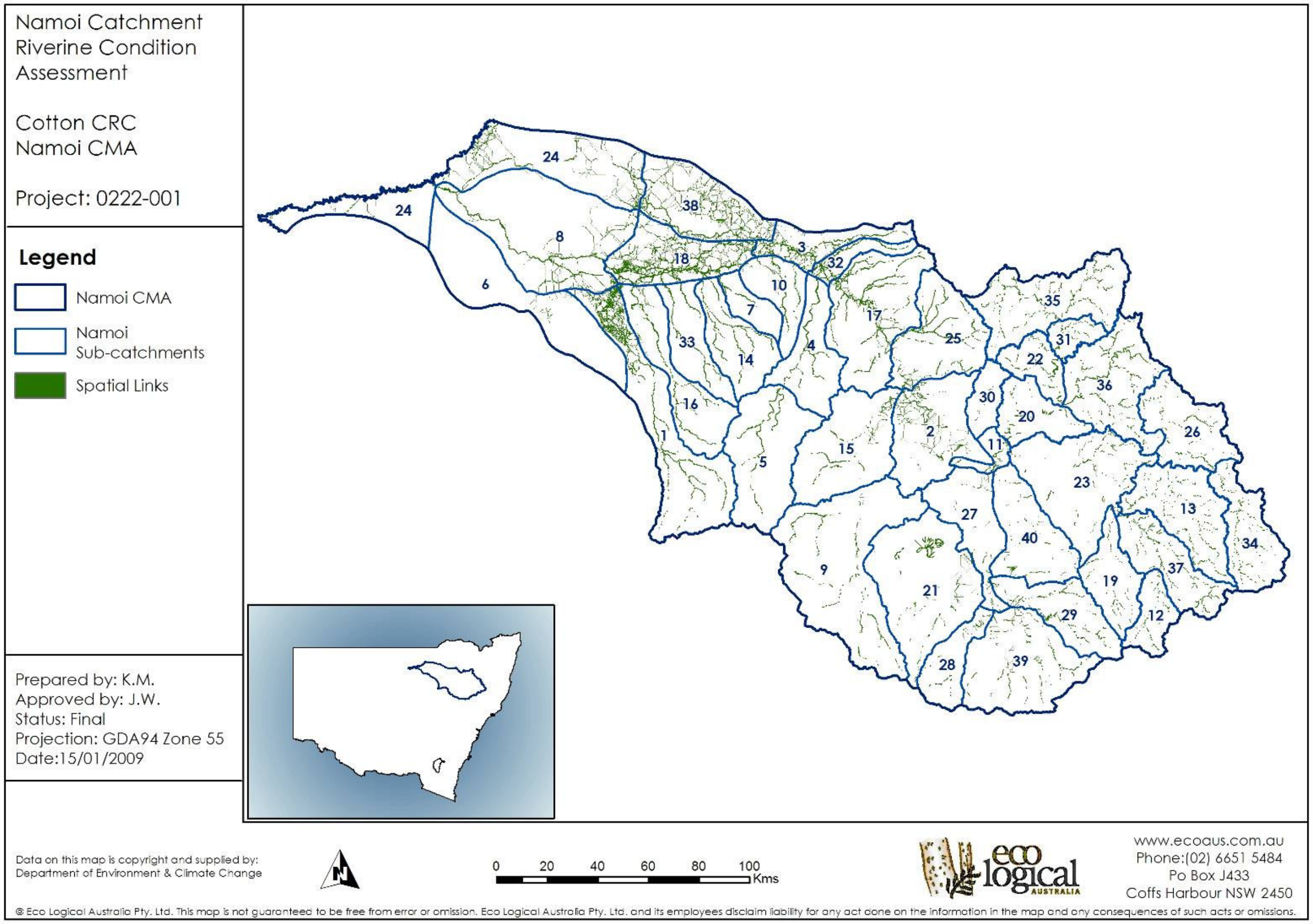
Figure 18. Distribution of habitat links in the riverine zone of the Namoi catchment



1 Baradine
2 Bluevale
3 Bobbiwaa
4 Bohena
5 Borah
6 Box Creek
7 Brigalow
8 Bugilbone
9 Bundella Creek
10 Bundock
11 Carroll
12 Chaffey
13 Cockburn River
14 Coghill
15 Cox's Creek
16 Etoo
17 Eulah Creek
18 Ginudgera
19 Goonoo Goonoo
20 Keepit
21 Lake Goran
22 Lower Manilla
23 Lower Peel
24 Lower Pian
25 Maules
26 Mid MacDonald
27 Mooki
28 Phillips
29 Quirindi
30 Rangira
31 Split Rock
32 Spring Creek
33 Tallaba
34 Upper MacDonald
35 Upper Manilla
36 Upper Namoi
37 Upper Peel
38 Upper Pian
39 Warrah
40 Werris Creek

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Figure 19. Mean RAU and FAU habitat links cover within each Namoi sub-catchment

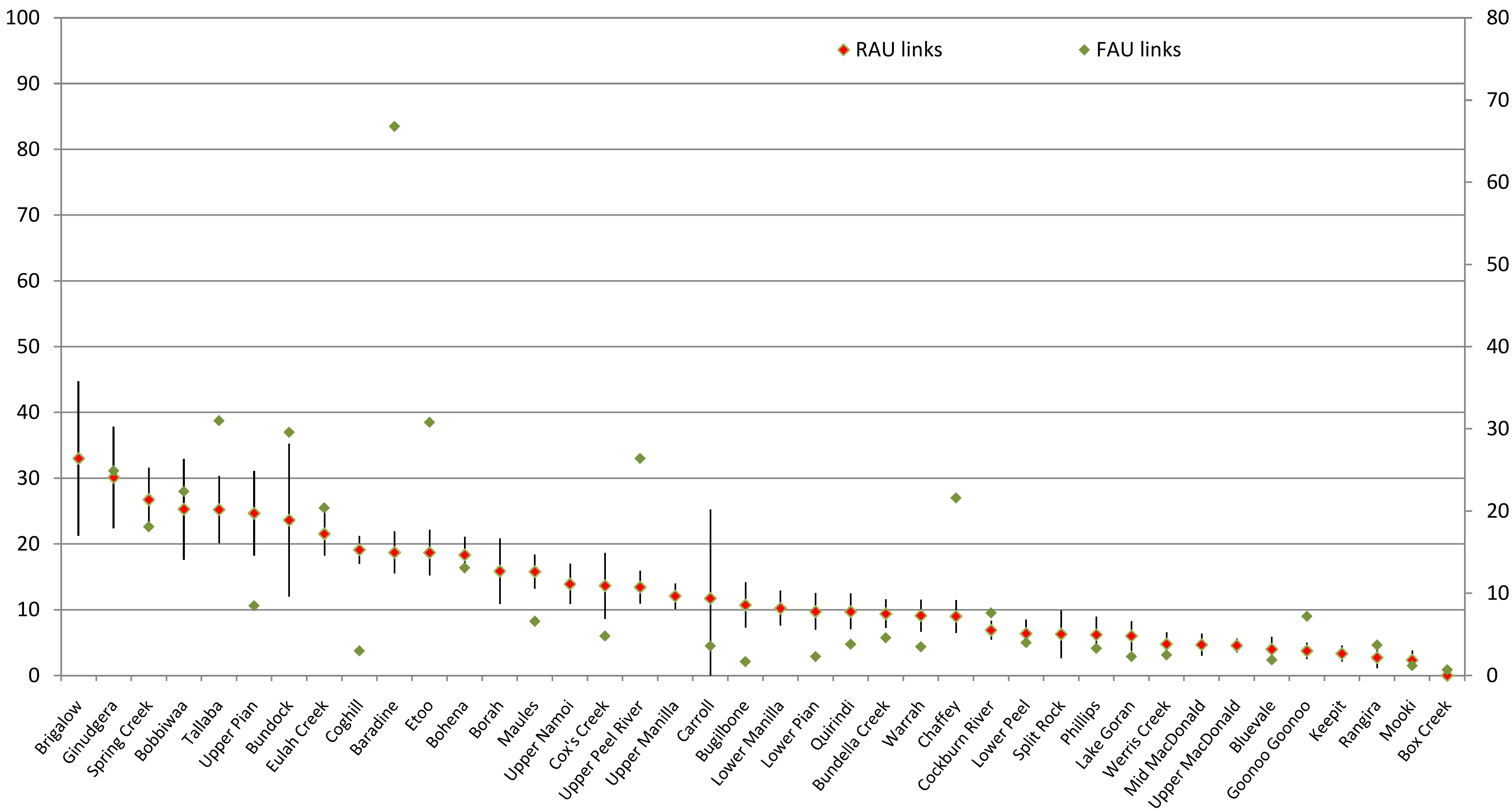

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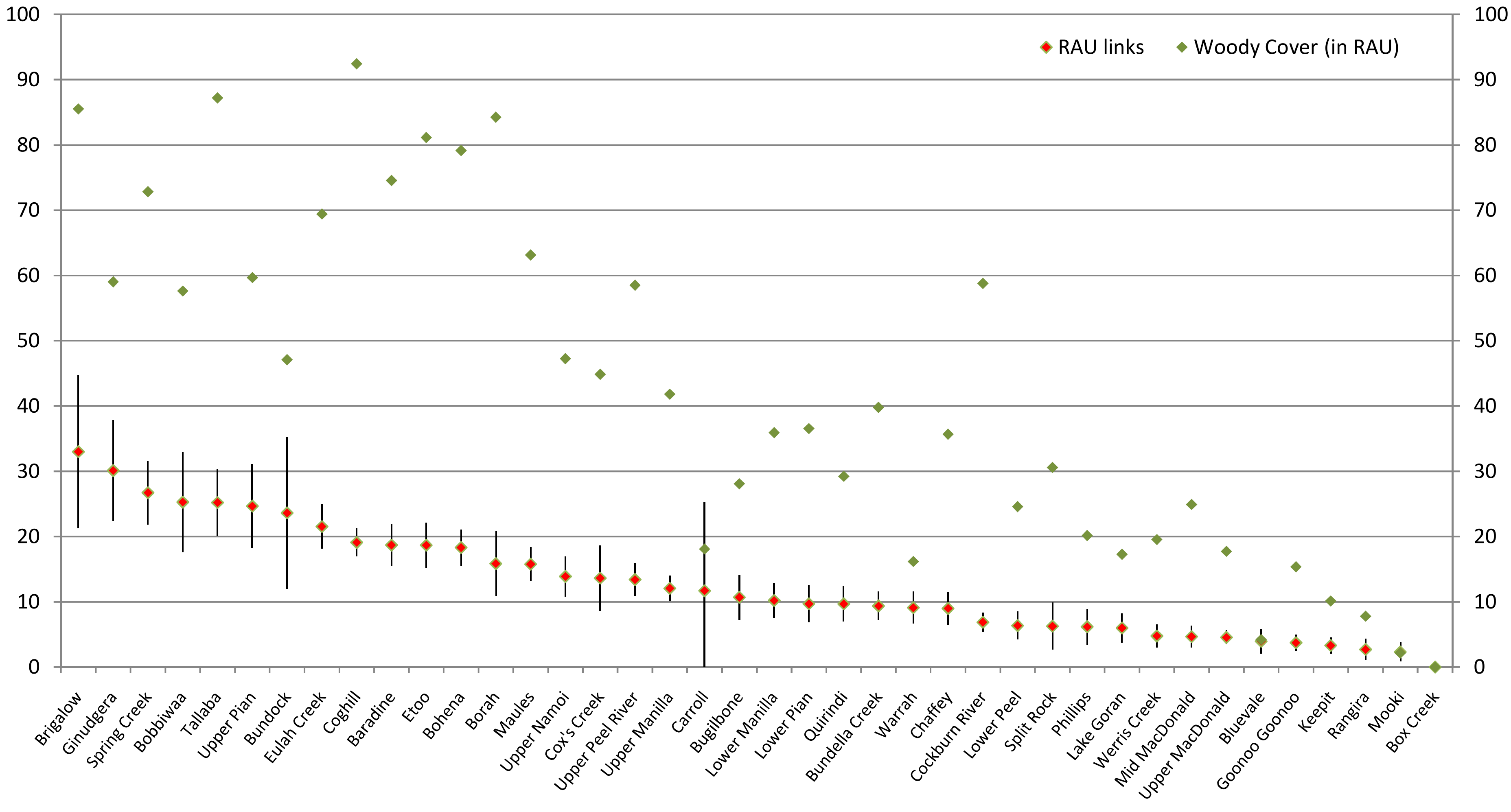
Figure 20. Mean habitat link value and woody vegetation cover within RAUs in each Namoi sub-catchment



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4.4.7 Longitudinal continuity

Longitudinal continuity of vegetation along the stream channel provides an alternative means of expressing habitat effectiveness from the point of potential fauna migration, and has been used in previous scoring algorithms (e.g. Jansen *et al*. 2003). To undertake continuity analysis, a 'centreline' command was applied in Arc9 to the RAU layer to derive a representative channel line. This line was then intersected with the extant RVC map (ELA 2008b) to provide a multi-part line, where each part was coded with its relevant RVC. All lines coded with non-vegetation RVCs (i.e. including non vegetation and derived grasslands) were removed from the multi-part line layer to leave a discontinuous series of lines representing native RVCs. A continuity index was simply calculated for each sub-catchment as the total length of centreline codes with native vegetation (not including derived grassland), as a proportion of the total length of stream channel. Figure 21 shows the distribution of native and derived riparian vegetation (or cropping) within the major channels, as derived by intersection with mapped vegetation polygons. Table 30 lists the proportion of native riparian vegetation in each sub-catchment, as a mean of all individual RAU values.

Continuity values are relatively high given that RVC mapping (ELA 2008b) was used instead of native cover modelling (DECC 2008) to derive the index. RVC mapping delineates whole vegetation communities, including grassy woodlands which exhibit a mosaic of native woody and grassy vegetation. Conversely, cover modelling separates the woody and non-woody components across the whole landscape, thus does not represent vegetation as communities. The general observation is that vegetation continuity tends to be significantly less in 3rd and 4th order streams, an average of 61.5 ± 2.2, compared to the larger 5th, 6th, 7th and 8th order streams, which average 78.0 ± 4.2. Clearing riparian vegetation appears to have been more intensive in the upland areas associated with pastoralism, than in the lowland floodplain where cropping predominates.

Table 30. Mean vegetation continuity value for each sub-catchment in the Namoi catchment

Sub Catchment	RAUs	Sub Catchment	RAUs	Sub Catchment	RAUs
1. Baradine	74.6 ± 8.5	15. Cox's Creek	48.0 ± 20.4	29. Quirindi	50.0 ± 10.2
2. Bluevale	42.4 ± 17.5	16. Etoo	96.2 ± 4.4	30. Rangira	59.2 ± 21.7
3. Bobbiwaa	85.4 ± 10.0	17. Eulah Creek	60.8 ± 10.1	31. Split Rock	54.7 ± 19.8
4. Bohena	97.6 ± 2.4	18. Ginudgera	90.5 ± 7.4	32. Spring Creek	70.0 ± 20.7
5. Borah	87.1 ± 14.3	19. Goonoo Goonoo	59.8 ± 10.5	33. Tallaba	98.9 ± 1.2
6. Box Creek	100	20. Keepit	53.6 ± 16.4	34. Upper MacDonald	13.1 ± 5.1
7. Brigalow	96.5 ± 4.6	21. Lake Goran	46.9 ± 16.7	35. Upper Manilla	75.2 ± 6.6
8. Bugilbone	98.4 ± 2.4	22. Lower Manilla	83.6 ± 11.0	36. Upper Namoi	81.2 ± 5.8
9. Bundella Creek	70.3 ± 10.0	23. Lower Peel	52.1 ± 8.9	37. Upper Peel	54.9 ± 10.7
10. Bundock	84.1 ± 10.5	24. Lower Pian	99.0 ± 1.5	38. Upper Pian	91.6 ± 12.9
11. Carroll	93.9 ± 15.4	25. Maules	86.4 ± 5.6	39. Warrah	26.7 ± 8.7
12. Chaffey	21.6 ± 11.2	26. Mid MacDonald	51.1 ± 11.6	40. Werris Creek	42.9 ± 10.3
13. Cockburn River	70.2 ± 6.7	27. Mooki	48.4 ± 19.5		
14. Coghill	98.6 ± 2.3	28. Phillips	51.3 ± 18.9		

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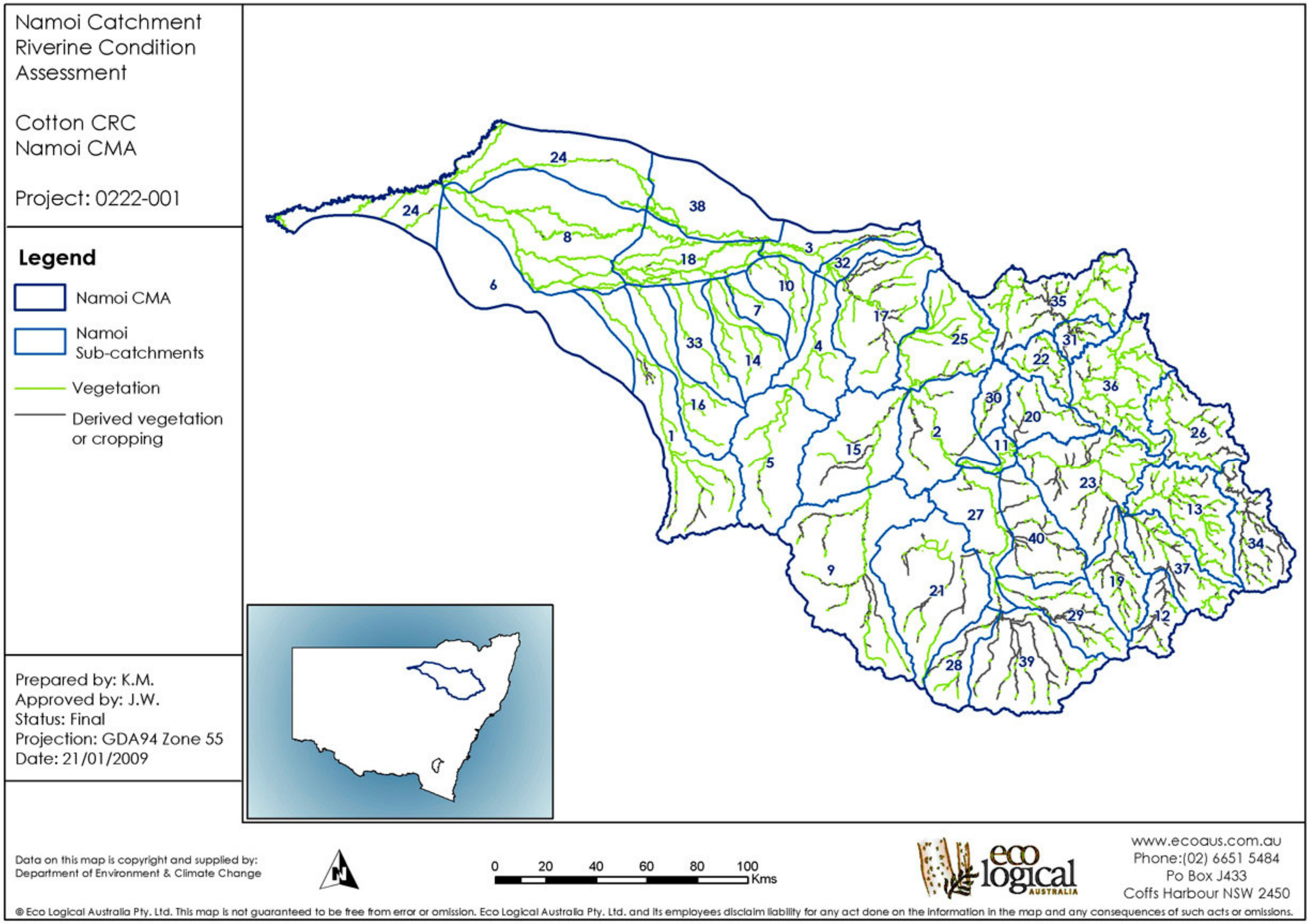
Figure 21. Distribution of native riparian vegetation along major watercourses in the Namoi catchment



1 Baradine
2 Bluevale
3 Bobbiwaa
4 Bohena
5 Borah
6 Box Creek
7 Brigalow
8 Bugilbone
9 Bundella Creek
10 Bundock
11 Carroll
12 Chaffey
13 Cockburn River
14 Coghill
15 Cox's Creek
16 Etoo
17 Eulah Creek
18 Ginudgera
19 Goonoo Goonoo
20 Keepit
21 Lake Goran
22 Lower Manilla
23 Lower Peel
24 Lower Pian
25 Maules
26 Mid MacDonald
27 Mooki
28 Phillips
29 Quirindi
30 Rangira
31 Split Rock
32 Spring Creek
33 Tallaba
34 Upper MacDonald
35 Upper Manilla
36 Upper Namoi
37 Upper Peel
38 Upper Pian
39 Warrah
40 Werris Creek

4.4.8 Patch size

A patch can be defined as a contiguous area of vegetation in the landscape, and patch size distribution provides a useful indicator of the 'patchiness' or 'fragmentation' of native vegetation in the riverine zone. It relates to landscape function in terms of provision of core habitat for native fauna assemblages. A minimum patch area of 20ha was used in this analysis to separate 'core' habitat from smaller, fragmented and less effective habitat.

The average RAU in the Namoi catchment comprises 27% native woody cover associated with patches ≥ 20ha, compared with 35% for all native woody vegetation. In contrast, the average FAU in the Namoi comprises 5% native woody cover associated with patches ≥ 20ha, compared with 7% for all native woody vegetation.

Figure 22 shows the distribution of woody vegetation associated with large and small patches within the riverine footprint in the Namoi. It is evident that much of the native vegetation within the riverine zone occurs in patches less than 20ha in area, particularly in the major floodplains where native vegetation has been relatively highly fragmented.

Figure 23 shows the proportion of woody cover associated with large patches in the RAUs of each sub-catchment, and compares it with total woody cover. In general, almost all vegetation within RAUs exhibiting the highest percentage of native woody cover is associated with large patches. Conversely, much of the woody cover associated with RAUs that contain a modest percentage of cover occurs in smaller patches <20 ha. A total of 14 sub-catchments contain RAUs within which remaining native woody vegetation is dominated by patches less than 20ha in size.

Figure 24 shows the proportion of woody cover associated with large patches in FAUs of each sub-catchment, and compares it with total woody cover. Most vegetation within relatively highly cleared floodplains (i.e. less than 10% woody vegetation cover) occurs in smaller patches.

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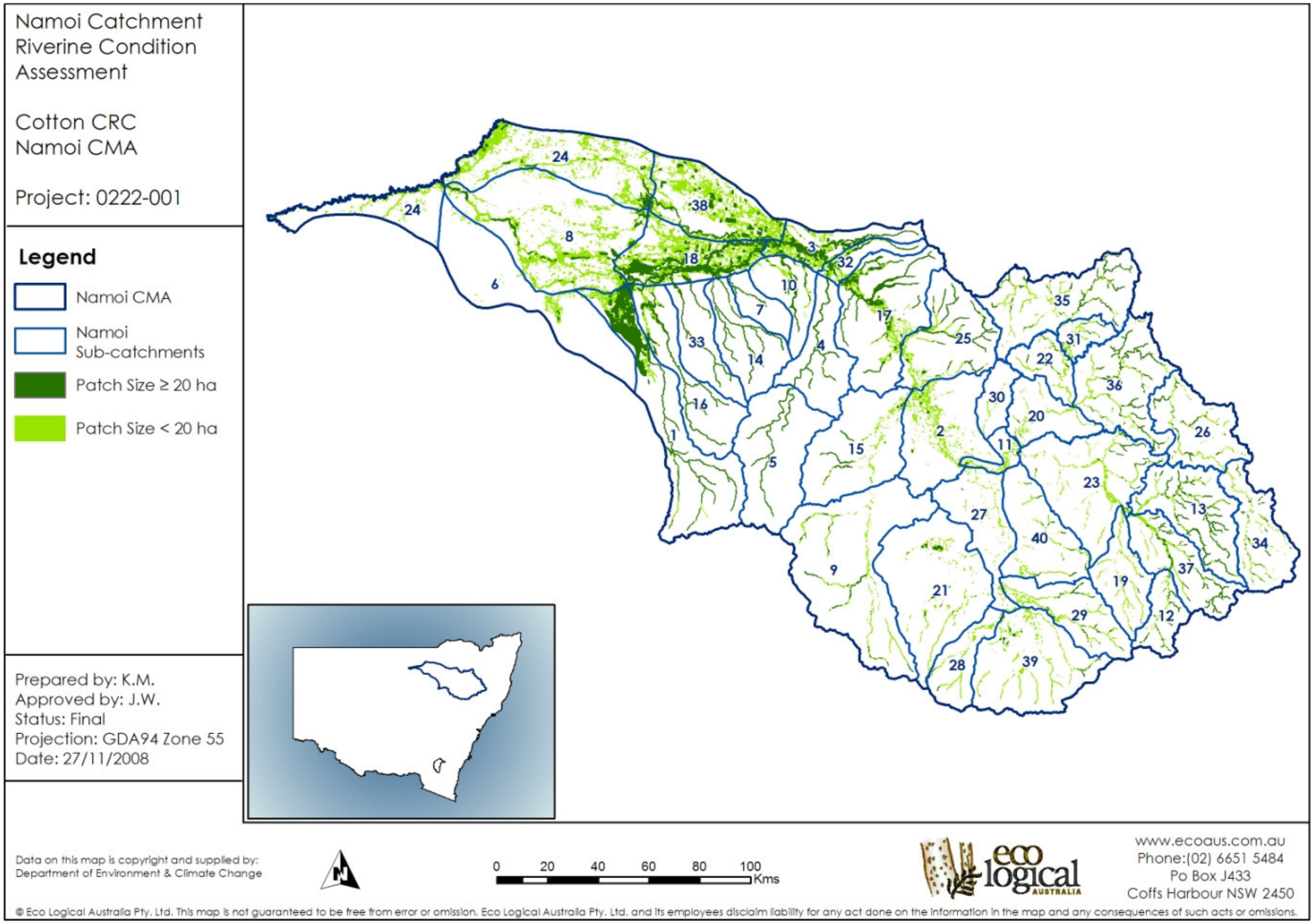
Figure 22. Distribution of two patch size classes of woody native vegetation in the riverine zone of the Namoi catchment



1 Baradine
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11 Carroll
12 Chaffey
13 Cockburn River
14 Coghill
15 Cox's Creek
16 Etoo
17 Eulah Creek
18 Ginudgera
19 Goonoo Goonoo
20 Keepit
21 Lake Goran
22 Lower Manilla
23 Lower Peel
24 Lower Pian
25 Maules
26 Mid MacDonald
27 Mooki
28 Phillips
29 Quirindi
30 Rangira
31 Split Rock
32 Spring Creek
33 Tallaba
34 Upper MacDonald
35 Upper Manilla
36 Upper Namoi
37 Upper Peel
38 Upper Pian
39 Warrah
40 Werris Creek

Figure 23. Mean RAU native woody cover (large patches) within each Namoi sub-catchment
(mean %cover (all patches) also shown)

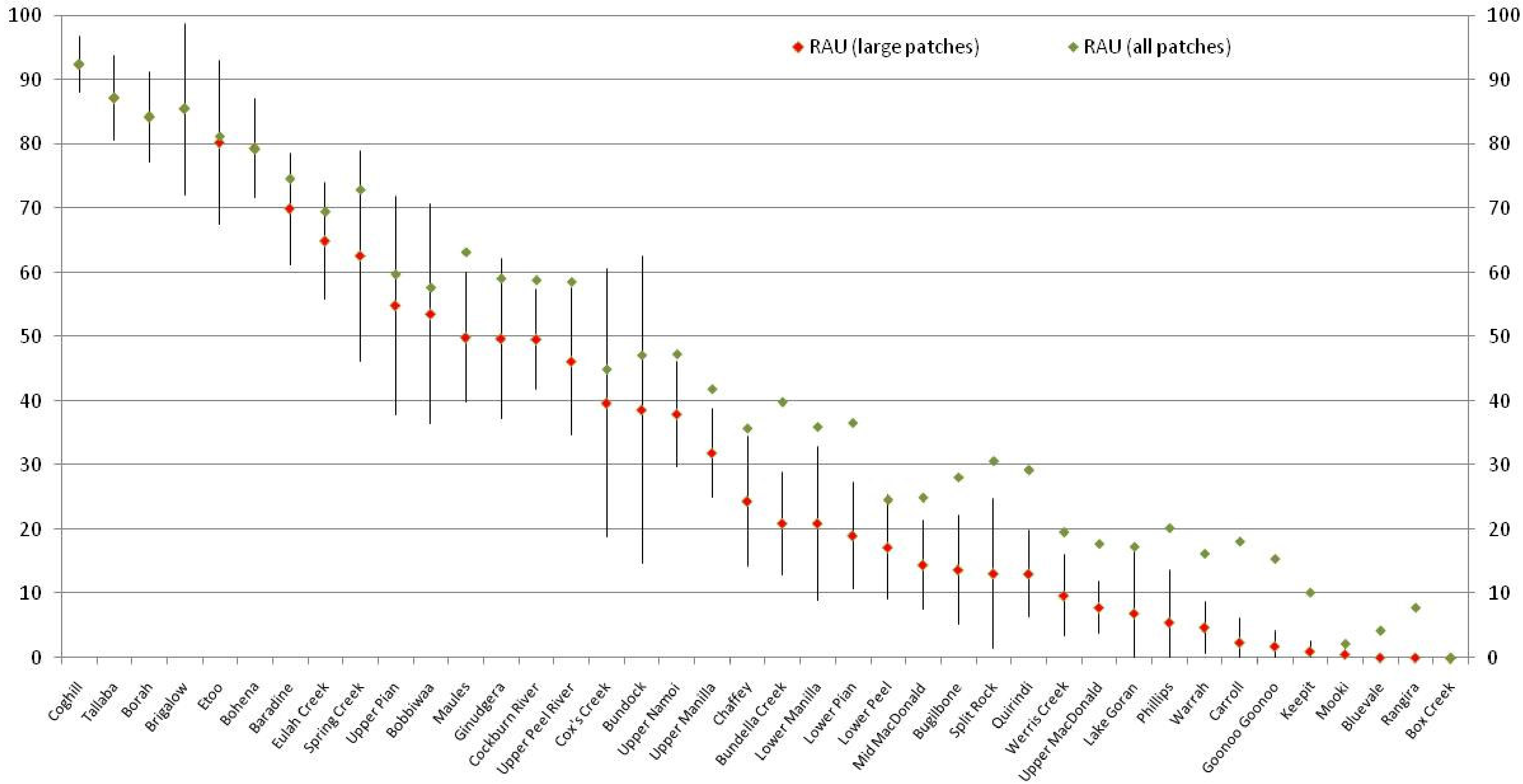

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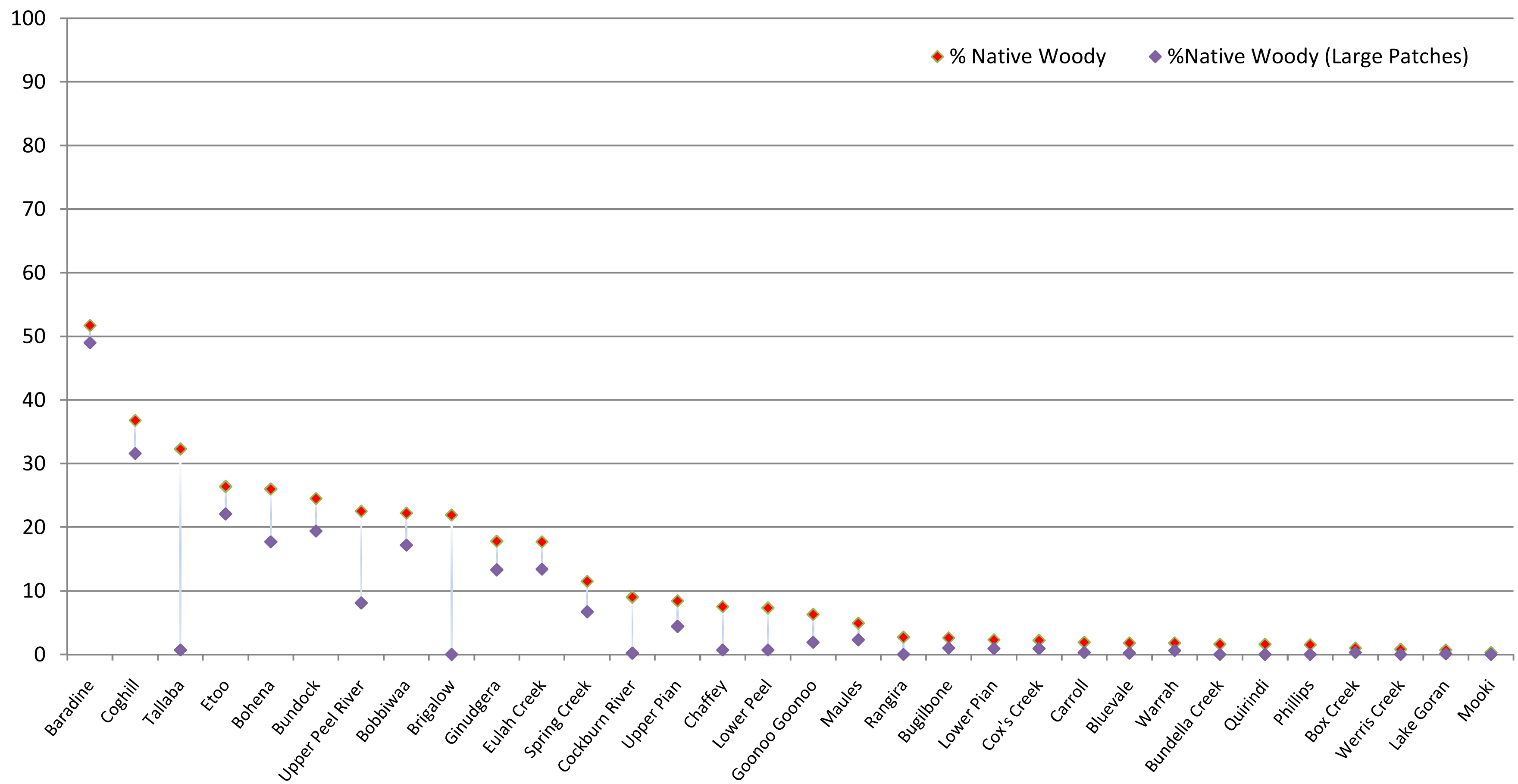
Figure 24. Mean FAU native woody cover (large patches) within each Namoi sub-catchment
(mean %cover (all patches) also shown)



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4.4.9 *Final Landscape Scores*

Final scores were calculated for each sub-catchment as the average of the following landscape metrics:

- RAU native woody cover
- RAU native woody cover (large patches)
- FAU native woody cover
- FAU native woody cover (large patches)
- 100-(FAU non-native cover)
- RAU woody cover in buffer
- 100-(RAU non-native cover in buffer)
- RAU links
- FAU links
- RAU continuity

Final scores are provided in Table 31, and illustrated in Figures 25 and 26. Scores range from 75.4 for Borah sub-catchment to 16.3 for Lake Goran sub-catchment. A total of four of the 40 sub-catchments score greater than 60%, while 25 of the 40 sub-catchments score less than 40%.

It is evident from Figure 26 that the best condition sub-catchments (as measured by landscape metrics) are associated with the Pilliga region, where vegetation stands remain relatively intact within both the riverine zone and its surrounds. The poorest condition sub-catchments (as measured by landscape metrics) occur in the Liverpool Plains, which have been extensively cleared for crops such as sorghum, sunflowers and wheat. The condition of riverine vegetation in the central part of the catchment, extending north-west, appears to be in better condition to that of the eastern upland part of the catchment, and the far west of the catchment.

Table 31. Mean score for riverine vegetation condition for each sub-catchment in the Namoi (derived from landscape metrics)

Sub Catchment	Score	Sub Catchment	Score	Sub Catchment	Score
1. Baradine	64.6	15. Cox's Creek	30.4	29. Quirindi	22.8
2. Bluevale	18.5	16. Etoo	60.6	30. Rangira	25.2
3. Bobbiwaa	43.3	17. Eulah Creek	46.2	31. Split Rock	41.1
4. Bohena	58.1	18. Ginudgera	40.5	32. Spring Creek	41.8
5. Borah	75.4	19. Goonoo Goonoo	26.4	33. Tallaba	57.8
6. Box Creek	23.8	20. Keepit	31.9	34. Upper MacDonald	37.4
7. Brigalow	53.2	21. Lake Goran	16.3	35. Upper Manilla	40.5
8. Bugilbone	27.1	22. Lower Manilla	40.0	36. Upper Namoi	53.5
9. Bundella Creek	30.2	23. Lower Peel	31.2	37. Upper Peel	38.3
10. Bundock	38.7	24. Lower Pian	28.2	38. Upper Pian	37.0
11. Carroll	27.9	25. Maules	38.7	39. Warrah	25.8
12. Chaffey	36.1	26. Mid MacDonald	31.9	40. Werris Creek	25.6
13. Cockburn River	34.8	27. Mooki	18.3		
14. Coghill	66.2	28. Phillips	17.3		

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Figure 25. Riverine vegetation condition of sub-catchments in the Namoi, calculated as the average of several landscape metrics

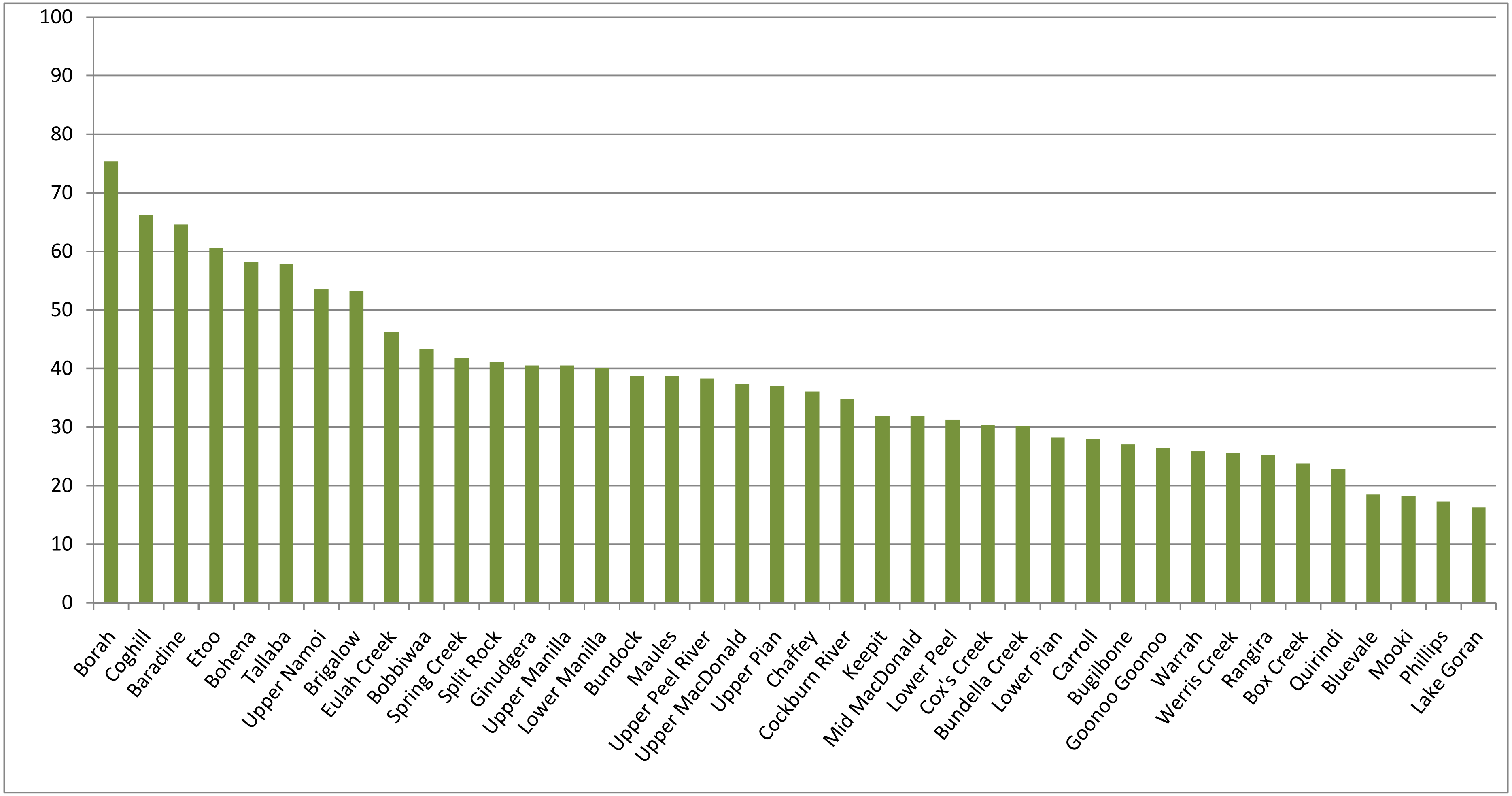

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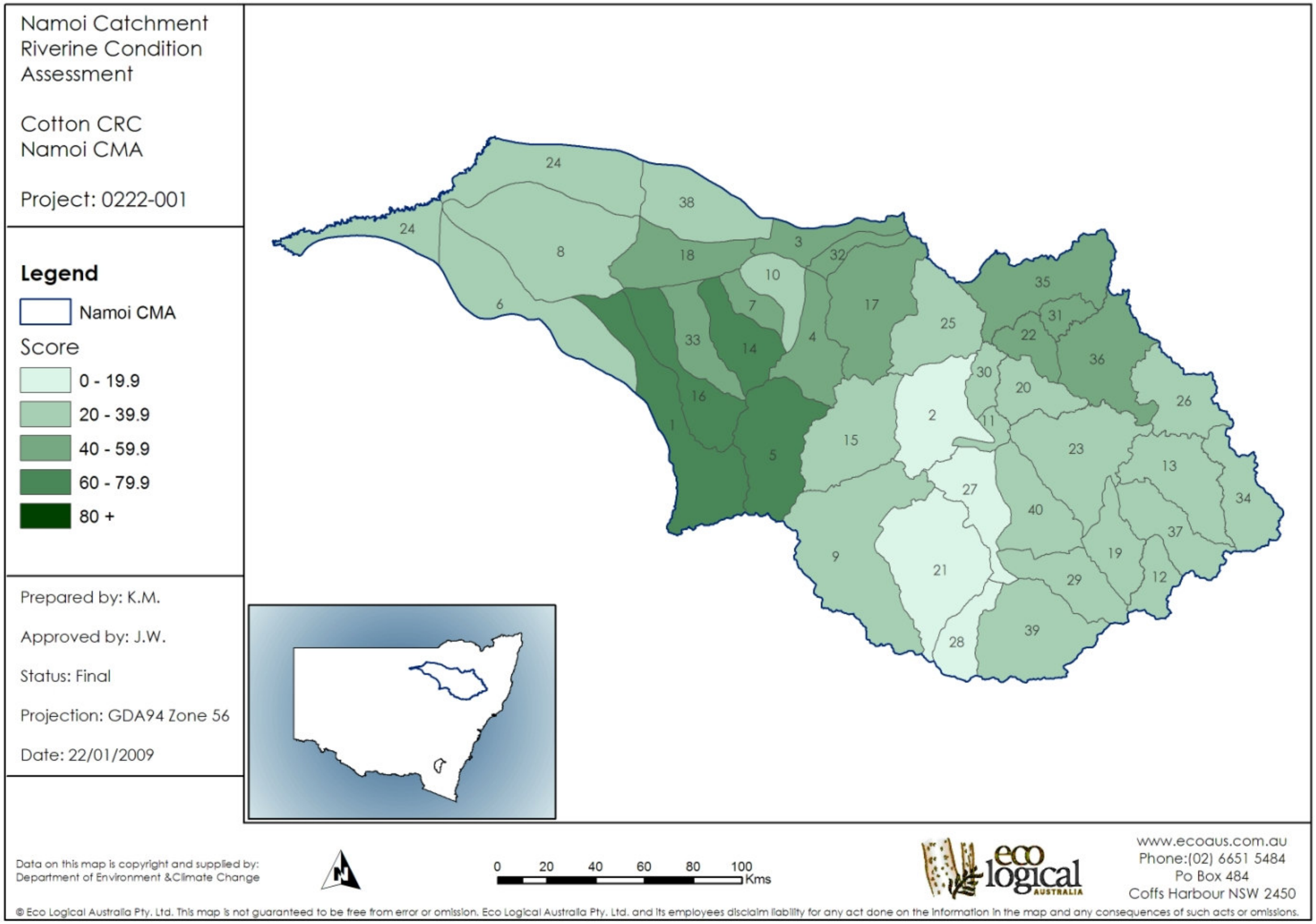
Figure 26. Distribution of riverine vegetation condition scores, derived from landscape metrics, across the Namoi catchment



1 Baradine
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37 Upper Peel
38 Upper Pian
39 Warrah
40 Werris Creek

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4.4.10 Individual channel scores

The six condition metrics calculated for each RAU, namely %cover, %cover of large (20 ha) patches, %cover within buffers, %native vegetation within buffers, habitat links and spatial continuity, were averaged to obtain a final landscape score for each RAU. These scores were grouped according to channel name to obtain an average landscape score for each channel mapped in the Namoi. The full list of scores is included in Appendix II, while a summary of results is shown in Table 32.

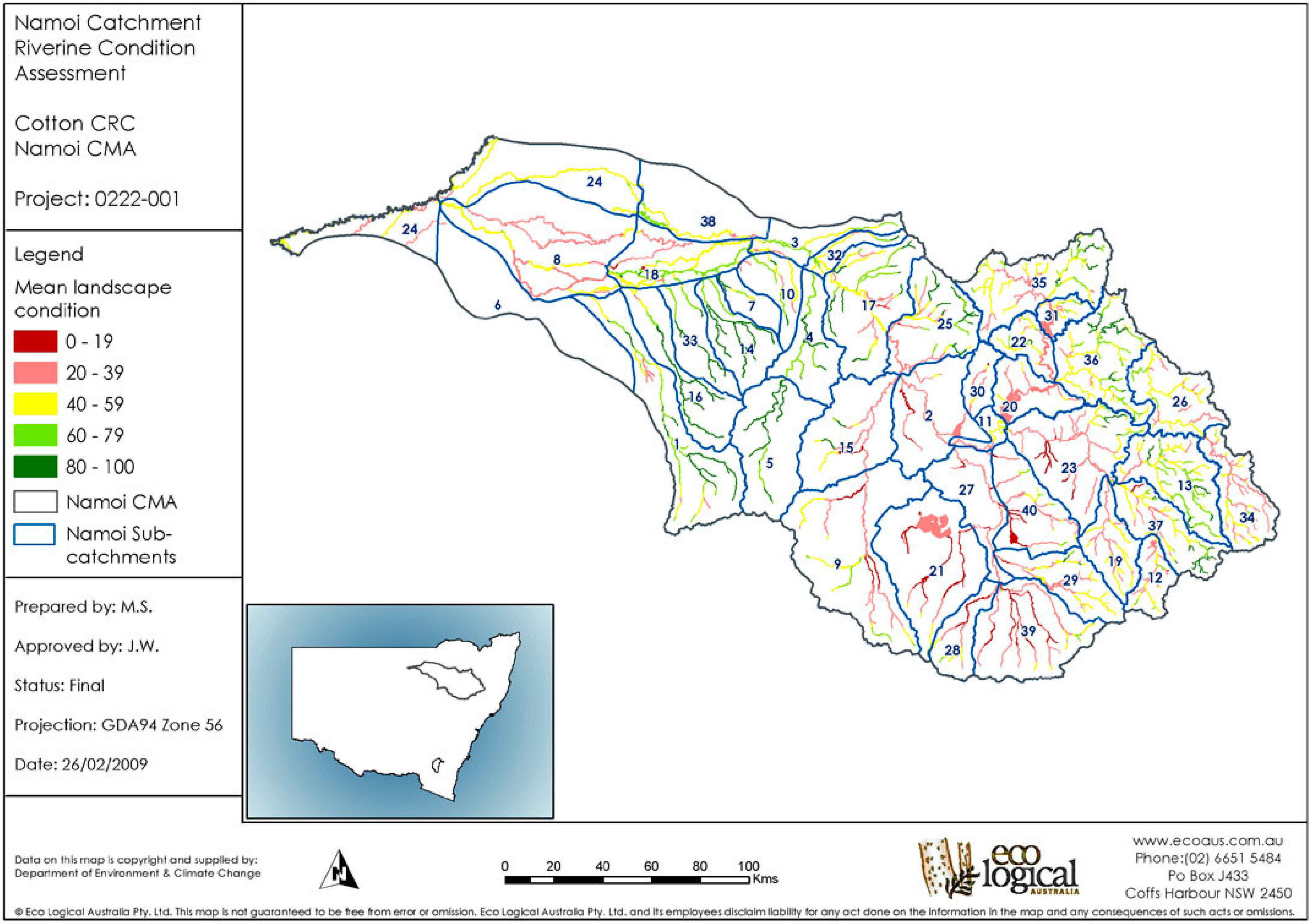
All the major rivers in the Namoi catchment, including the Namoi itself, and 72% of all major streams exhibit either average or poor condition according to landscape metrics. About 23% of the total length of major watercourses is in above-average condition, while 30% are in below-average condition.

The geographic distribution of vegetation condition, according to landscape metrics, is shown in Figure 27. RAUs within sub-catchments associated with the Pilliga block of forests (e.g. Bohena, Borah, Coghill, Etoo and Tallaba) are in relatively good condition, while those associated with the Liverpool Plains to the east (e.g. Lake Goran, Mooki, Phillips and Warrah) are in relatively poor condition. A number of sub-catchments along the Nandewar Range (e.g. Cockburn River and Upper Namoi) possess RAUs in reasonable condition, according to landscape metrics.

Table 32. Number of watercourses in each landscape condition class in the Namoi catchment

Condition Class	Total Streams	Total Rivers	Combined length (km)	Examples
Excellent	40	0	427 *(5.3%)*	Bullawa Creek; Dandry Creek; Coghill Creek; Rocky Creek.
Good	65	0	1419 (*17.6%)*	Baradine Creek; Bohena Creek; Borah Creek; Dungowan Creek; Etoo Creek; Ironbark Creek; Maules Creek; Mulla Mulla Creek; Talluba Creek; Warrabah Creek; Yaminbah Creek.
Average	127	6	3763 *(46.7%)*	Barraba Creek; Barwon River; Bobbiwaa Creek; Bundella Creek; Bundock Creek; Cockburn River; Ginudgera Creek; Ingleba Creek; MacDonald River; Namoi River; Peel River; Pian Creek; Quipolly Creek; Spring Creek.
Poor	120	3	2277 *(28.2%)*	Borambil Creek; Cobrabald River, Coxs Creek; Currububula Creek; Goonoo Goonoo Creek; Manilla River; Mooki River; Quirindi Creek; Rangira Creek; Warrah Creek; Werris Creek; Yarraman Creek.
Very poor	18	0	177 *(2.2%)*	Big Jacks Creek; MacDonalds Creek.
	370	9	*8063*	

Figure 27. Distribution of landscape-derive condition classes across all mapped RAUs in the Namoi catchment



1 Baradine
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25 Maules
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27 Mooki
28 Phillips
29 Quirindi
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31 Split Rock
32 Spring Creek
33 Tallaba
34 Upper MacDonald
35 Upper Manilla
36 Upper Namoi
37 Upper Peel
38 Upper Pian
39 Warrah
40 Werris Creek

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4.5 Plot-based Metrics

4.5.1 Overview

A total of 271 riverine condition plots were sampled for this project. A further 219 vegetation condition plots were completed (using the same sampling protocols) as part of a concurrent monitoring project for the Namoi CMA, on properties subject to funding for conservation works. Of the total 490 plots completed for both projects, a sub-set of 329 were used for plot-based riverine condition assessment. All plots were sampled in native vegetation (i.e. no plots were sampled in croplands or other non-native vegetation land-uses).

Of the final 329 plots, 294 were located inside the riverine zone delineated for this project, while 35 occurred in unmapped parts of the zone, but exhibited RVC types consistent with active floodplain or riparian channels (Table 33).

Table 33. Plots used for the field-based condition assessment

Project	No. plots	Riverine Zone	Comments
Riverine (this project)	250	yes	
	21	no	Usually in close proximity to RAUs, or within unmapped part of floodplain
Properties	44	yes	
	14	no	Plots sampled in RVCs 68, 71, 72, 73, 77 or 78, which are true riverine vegetation types. Usually in close proximity to RAUs, in a 2nd order stream, or within unmapped part of floodplain.
	329		

Of the 35 plots that occurred outside the mapped extent of the riverine zone, 12 were allocated their respective RAU or FAU, based on its allocated RVC and location in the landscape. The remaining 23 plots were not assigned an RAU, as they occurred in 2nd order streams in the top end of sub-catchments. However, they were included in some analyses.

Figure 28 shows the distribution of the 329 riverine plots across the Namoi. A total of 238 plots were completed in the riparian zone, while 91 plots were completed on the floodplain. At least one plot was completed in 36 of the 40 Namoi sub-catchments (Goonoo Goonoo, Keepit, Split Rock and Werris Creek were not sampled), at least five plots were completed in 26 of the 40 sub-catchment, and at least 10 plots were completed in 12 of the 40 sub-catchments. Most plots were completed in Bugilbone and Warrah sub-catchments, 52 and 23 respectively.

Vegetation plot in Bugilbone sub-catchment

Blakelys Red Gum riparian woodland of the Pilliga (RVC 96) in moderate condition (score = 54)

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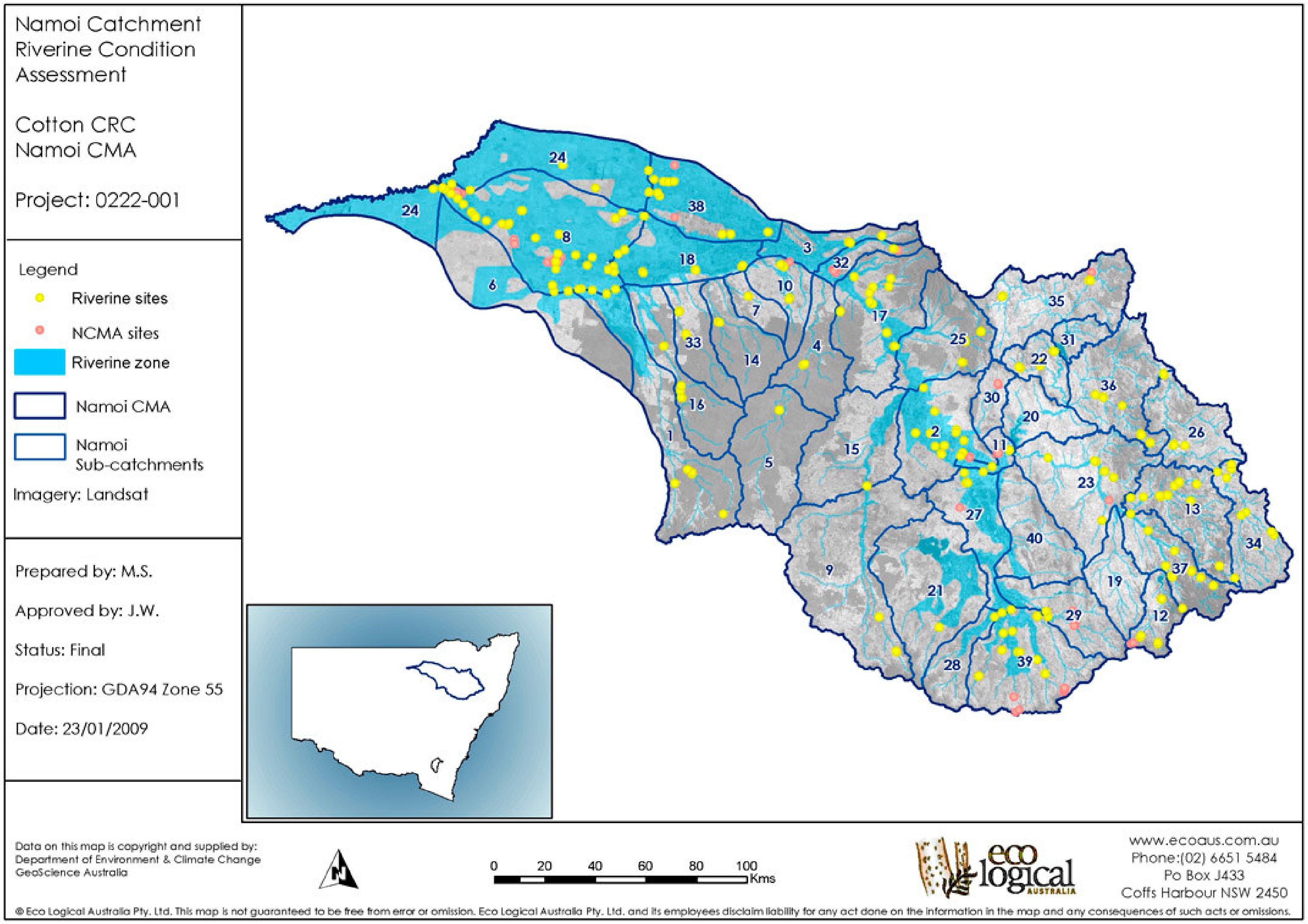
Figure 28. Distribution of riverine sites in the Namoi catchment



1 Baradine
2 Bluevale
3 Bobbiwaa
4 Bohena
5 Borah
6 Box Creek
7 Brigalow
8 Bugilbone
9 Bundella Creek
10 Bundock
11 Carroll
12 Chaffey
13 Cockburn River
14 Coghill
15 Cox's Creek
16 Etoo
17 Eulah Creek
18 Ginudgera
19 Goonoo Goonoo
20 Keepit
21 Lake Goran
22 Lower Manilla
23 Lower Peel
24 Lower Pian
25 Maules
26 Mid MacDonald
27 Mooki
28 Phillips
29 Quirindi
30 Rangira
31 Split Rock
32 Spring Creek
33 Tallaba
34 Upper MacDonald
35 Upper Manilla
36 Upper Namoi
37 Upper Peel
38 Upper Pian
39 Warrah
40 Werris Creek

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4.5.2 Benchmark scores

Benchmark scores for each of the 17 ecological attributes were derived using a combination of field data collected during survey, benchmark data from the NSW Biometric and the Queensland BioCondition databases, and expert input from field ecologists who undertook the sampling. Table 34 lists the range of benchmarks for each of the attributes sampled during the project. Appendix III lists the benchmark score for each attribute, for all RVCs sampled in the riverine zone.

Table 34. Benchmark scores for ecological attributes

Ecological Attribute	Mean	High	Low
25 forest and woodland RVCs			
Native species richness (canopy)	1.9	3	1
Native species richness (midstorey)	3.0	8	0
Native species richness (groundcover)	22.0	35	0
Native canopy cover (%)	23.4	50	15
Canopy health (%)	100	100	100
Native midstorey (shrub) cover (%)	9.8	30	5
Weed canopy and midstorey cover (%)	0	0	0
Native groundcover (%)	42.2	60	20
Mosses/lichen cover (%)	4.0	20	0
Weed groundcover (%)	0	0	0
Organic litter cover (%)	26.2	35	20
Rock/bare ground cover (%)	27.6	40	10
Number of large canopy trees (0.1ha)	3.8	6	2
Number of large *Callitris* trees (0.1ha)	0.3	3	0
Number of trees with hollows (0.1ha)	3.2	7	0
Number of canopy species regenerating	1.8	3	1
Coarse woody debris (m/0.1ha)	30.6	70	0
5 non-forest and non-woodland RVCs			
Native species richness (canopy)	0	0	0
Native species richness (midstorey)	0.2	1	0
Native species richness (groundcover)	18.0	20	15
Native canopy cover (%)	0	0	0
Canopy health (%)	100	100	100
Native midstorey (shrub) cover (%)	1.0	5	0
Weed canopy and midstorey cover (%)	0	0	0
Native groundcover (%)	52.0	60	50
Mosses/lichen cover (%)	6.0	15	0
Weed groundcover (%)	0	0	0
Organic litter cover (%)	23.0	30	10
Rock/bare ground cover (%)	19.0	25	15
Number of large trees	0	0	0
Number of large *Callitris* trees	0	0	0
Number of trees with hollows	0	0	0
Number of canopy species regenerating	0	0	0
Coarse woody debris	0	0	0

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4.5.3 Plot scores

4.5.3.1 Overview

Each plot sampled in the Namoi riverine zone was referenced against its RVC-dependent set of benchmark data to derive a unique condition score between 0 and 100. Final scores varied from poor condition (2/100) to excellent condition (98/100). The median score was 57 and the mean score was 55.

Figure 29 shows the distribution of plots across the total range of native vegetation condition sampled in the Namoi. A total of 11 plots (3%) contained vegetation which exhibited very poor condition (score 0 to 19), 50 plots (15%) contained vegetation in poor condition (score 20 to 39), 121 plots (37%) comprised native vegetation in moderate condition (score 40 to 59), 126 plots (38%) comprised vegetation in good condition (score 60 to 79), and 23 (7%) plots supported native vegetation in excellent condition (score 80 - 100).

Figure 29. Distribution of condition scores for the 329 riverine plots in the Namoi

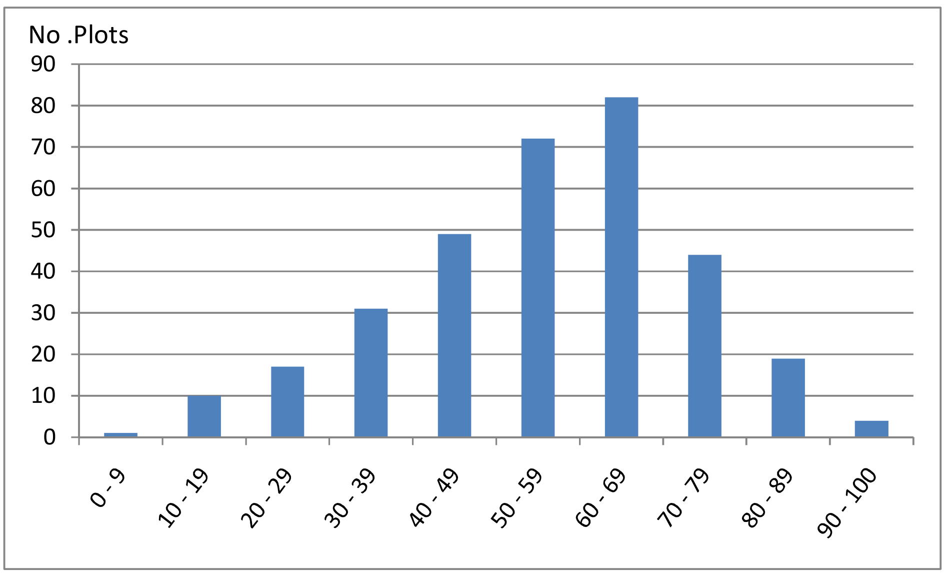
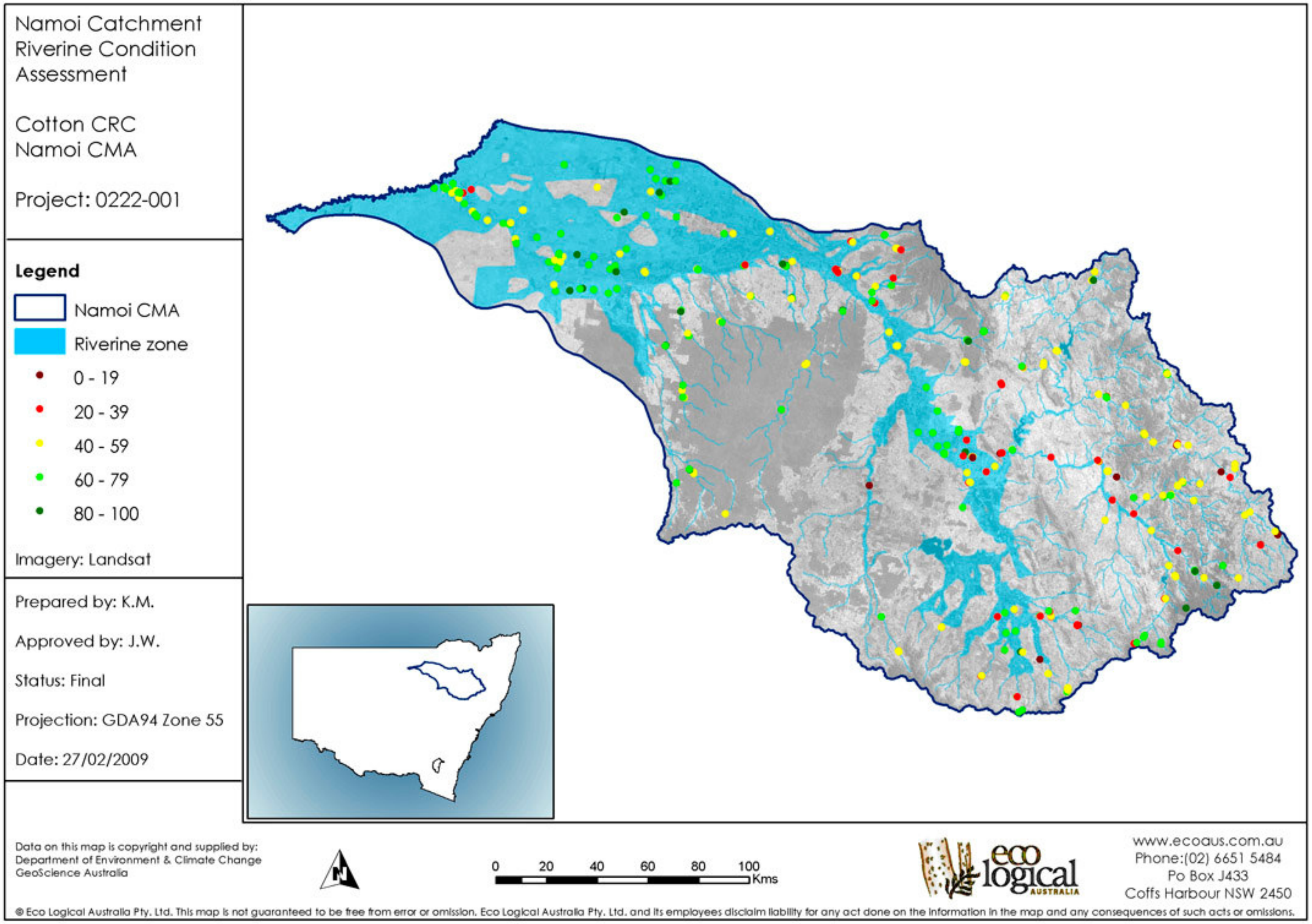


Figure 30 shows the geographical distribution of plots across the Namoi, classified into five classes of vegetation condition (very poor 0-19; poor 20-39; moderate 40-59; good 60-79; and excellent 80-100). The majority of plots exhibiting good and excellent condition occurred within remnant grassland and grassy woodland of the floodplain, particularly in the west, while those exhibiting average and poor condition were associated with channel vegetation, particularly within eastern parts of the catchment. This suggests that remnant floodplain vegetation not impacted by cropping directly, is in better condition than native vegetation of the slopes and tablelands where pastoralism represents the main land-use. This observation is discussed further in following sections.

Figure 30. Geographic distribution of plots in the Namoi, classified into broad classes of vegetation condition



4.5.3.2 Plot condition by tenure

A total of 55 of the 329 condition plots were sampled on public land (Table 35), all within channel rather than floodplain environments. Plots sampled in national park, state forest and reserved crown land were found to exhibit a significantly better state of condition than those sampled in freehold, leasehold and travelling stock reserve, presumably as a result of lighter grazing and clearing impacts, and fewer weeds.

Excellent condition plot in state forest; Score = 81
Pilliga-Poplar Box Woodland (RVC 32)

Table 35. Effect of tenure on plot condition scores

Tenure	No. plots	Mean condition
National Park	10	65 ± 9
Reserved Crown Land	6	71 ± 6
State Forest	20	72 ± 5
Travelling Stock Reserve	19	57 ± 6
Freehold/Leasehold	274	53 ± 2

4.5.3.3 Plot condition in channels and on the floodplain

The condition of remnant native vegetation on the floodplain was found to be significantly greater than that along the main channels, even when better condition public land plots within channels were included (Table 36). This suggests that, where they have not been replaced by cropland, the native grasslands and grassy woodlands remaining on the floodplain of the Brigalow Belt South and Darling Riverine Plains have been subject to a lower degree of structural and floristic disturbance than native vegetation situated along the channels. Of course the majority of native vegetation on the floodplain has been converted to cropland which, if sampled, would commonly generate condition scores <5.

A mean score of 60 for remnant floodplain vegetation is encouraging given the extensiveness of the cropping industry in the Namoi. It indicates that appropriate management and protection of remaining vegetation might enable retention of a long term matrix of good condition native vegetation within adjacent croplands.

Native Grassland (RVC 26) on the Box Creek floodplain
Excellent condition plot: Score = 98

Table 36. Condition scores in the channels and on the floodplain

Position in Landscape	No. plots	Mean condition
Floodplain	91	60 ± 3
Channels	238	53 ± 2
Channels A	202	50 ± 2

A.Excluding national park, state forest and reserved crown land

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4.5.3.4 Plot condition by bioregion

The variation in mean condition score between the four bioregions in the Namoi catchment is shown in Table 37. The broad condition of riverine vegetation appears to increase from east to west within the catchment. For analyses including all plots and channel plots only, the mean condition of vegetation in the New England Tablelands Bioregion is significantly lower than that of other bioregions, and the mean condition of vegetation in the Darling Riverine Plains Bioregion is significantly higher than that of other bioregions. This may have implications for how Namoi CMA might prioritise funding for conservation works, and for what purposes (Section 5).

River Oak community (RVC 71) infested with weeds
Ingleba Creek, New England (Score = 13)

Table 37. Condition scores for each bioregion in the Namoi

	Channels + Floodplain [A]		Channels only [A]	
Position in Landscape	No. plots	Mean condition	No. plots	Mean condition
New England Tablelands	23	42 ± 8	23	42 ± 8
Nandewar	98	51 ± 3	98	51 ± 3
Brigalow Belt South	94	51 ± 4	55	49 ± 5
Darling Riverine Plains	78	62 ± 3	26	57 ± 5

A. Excluding national park, state forest and reserved crown land

4.5.3.5 Plot condition by stream order

In broad terms, the vegetation in smaller streams (1-3) was found to be in better condition than that along the larger channels (4-7) (Table 38). This observation reflects the fact that 7% of plots in larger streams were found to be in very poor condition (i.e. score < 20), while no plots in smaller streams were in very poor condition. An additional 22% of plots in large streams were in poor condition (score 20-39), compared to 13% in smaller streams. Furthermore, a total of 38% of plots in small streams exhibited good condition (score = 60+), while 31% of plots in larger streams exhibited good condition.

River Red Gum community (RVC 73) in very poor condition
Stream order 5, Coxs Creek, Brigalow Belt South (Score = 11)

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Table 38. Condition scores for different order streams in the Namoi

Stream Order	No. plots	Mean condition A	
1	3	63 ± 34	53 ± 3
2	17	48 ± 8	
3	44	55 ± 4	
4	50	50 ± 5	49 ± 3
5	34	52 ± 7	
6	15	39 ± 9	
7	39	50 ± 6	

A. Excluding national park, state forest and reserved crown land

Given the relatively poor condition of riverine vegetation on the New England Tablelands compared to the Darling Riverine Plains (section 4.5.3.4), yet the relatively good condition of smaller streams which might be expected to be more prevalent on the Tablelands, and the relatively poor condition of larger channels which are more prevalent in the plains, the condition of streams of different order is better addressed in the context of bioregions.

Table 39 shows that vegetation condition in the larger order streams of the Northern Tablelands is relatively low in contrast to equivalent streams in the three other bioregions, and that vegetation condition in the smaller order streams of the Northern Tablelands and Nandewar is relatively low in contrast to equivalent streams in the Brigalow Belt South. It can be inferred from these data that activities associated with pastoralism on the Tablelands (mainly clearing adjacent to and within the channel, and some application of super-phosphate) may have had a more severe impact on the condition of riverine native vegetation than activities associated with cropping, which appear not to have impacted on the adjacent channel (or floodplain) vegetation to the same extent. In other words, remnant stands of riverine woodland and grassland persisting in the cropped landscape to the west (i.e. not physically impacted by cropping activities) appear to be in better condition than native vegetation within the pastoral landscape to the east.

Table 39. Condition scores for small and large streams in bioregions of the Namoi

	Stream Order 1-3		Stream Order 4-7		Floodplain	
Bioregion	No Plots	Condition A	No Plots	Condition A	No Plots	Condition A
NET	9	52 ± 9	14	36 ± 12	-	-
NAN	24	51 ± 6	74	52 ± 4	-	-
BBS	30	56 ± 5	25	40 ± 8	39	54 ± 6
DRP	-	-	25	57 ± 5	52	65 ± 3

A. Excluding national park, state forest and reserved crown land

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River Red Gum (RVC 73) on Bobbiwaa Creek (order 3)
Brigalow Belt South (Score = 64. Good condition)

River Oak (RVC 71) on Cobrabald River (order 4)
New England Tablelands (Score = 34. Poor condition)

4.5.3.6 Plot condition in the cotton-growing regions

Figure 31 shows vegetation plots which were sampled within the cotton growing region of the riverine zone - 105 plots in total. Excluding plots in National Park, State Forest and Reserved Crown Land, the mean condition score for riparian plots adjacent to cotton growing areas was 50.1 (n = 39), while the mean condition score for riparian plots in non-cotton areas was 50.5 (n = 163). Similarly, the mean condition score for floodplain plots adjacent to cotton growing areas was 59.9 (n = 56) while the mean condition score for floodplain plots in non-cotton areas was 60.5 (n = 35). These results indicate that for both riparian and floodplain vegetation, proximity to cotton growing areas has no effect on inherent vegetation condition.

Excellent condition remnant native grassland (RVC 26) on the Ginudgera floodplain (score = 88), about 250m from a flood-irrigated cotton field

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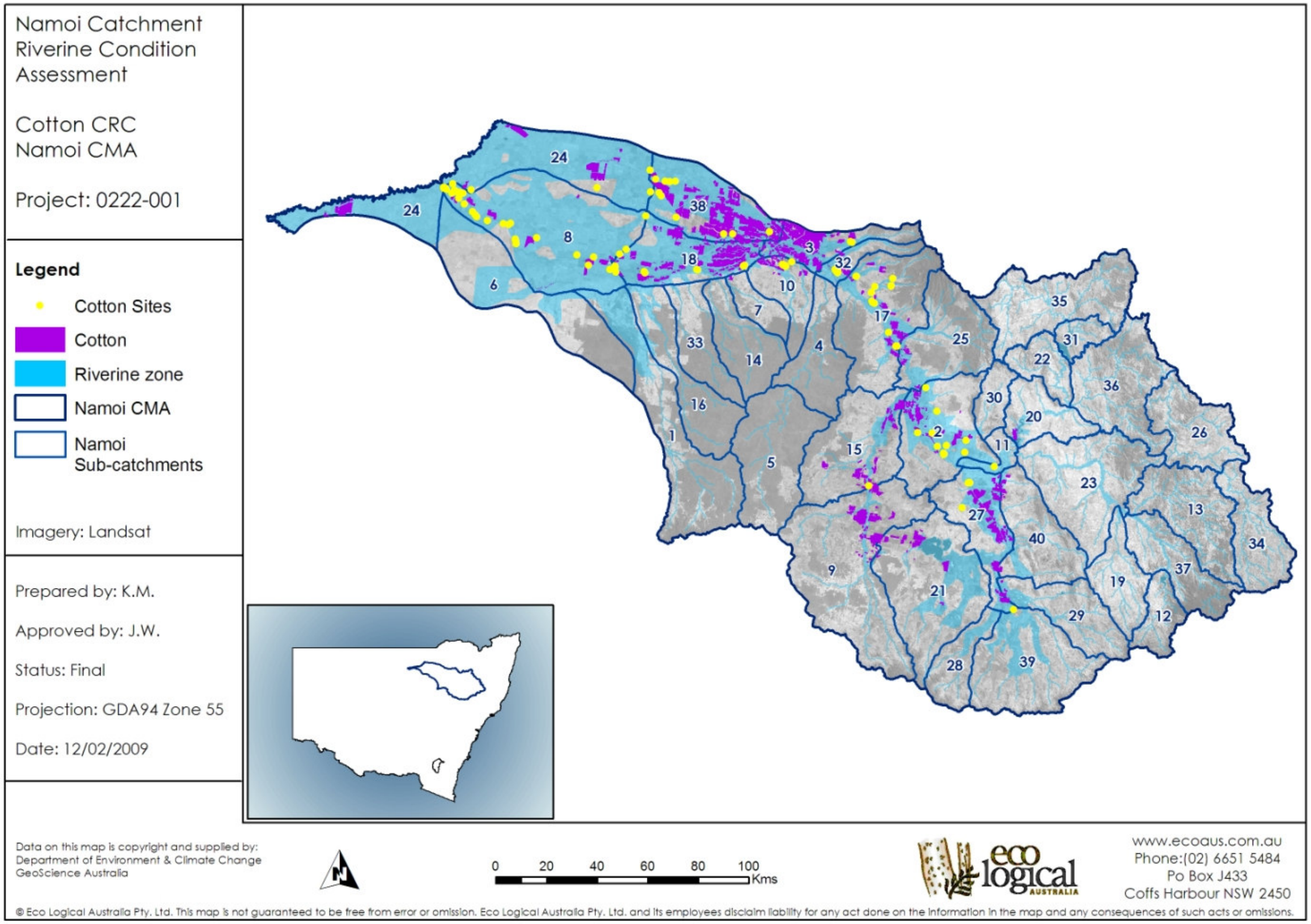
Figure 31. Vegetation plots within cotton growing areas of the Namoi catchment (from DECC land-use data)



1 Baradine
2 Bluevale
3 Bobbiwaa
4 Bohena
5 Borah
6 Box Creek
7 Brigalow
8 Bugilbone
9 Bundella Creek
10 Bundock
11 Carroll
12 Chaffey
13 Cockburn River
14 Coghill
15 Cox's Creek
16 Etoo
17 Eulah Creek
18 Ginudgera
19 Goonoo Goonoo
20 Keepit
21 Lake Goran
22 Lower Manilla
23 Lower Peel
24 Lower Pian
25 Maules
26 Mid MacDonald
27 Mooki
28 Phillips
29 Quirindi
30 Rangira
31 Split Rock
32 Spring Creek
33 Tallaba
34 Upper MacDonald
35 Upper Manilla
36 Upper Namoi
37 Upper Peel
38 Upper Pian
39 Warrah
40 Werris Creek

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4.5.3.7 *Plot condition by vegetation types*

A total of 30 RVCs was sampled in the Namoi, across which vegetation condition was found to vary considerably. Table 40 lists the major riverine RVCs in the Namoi within which at least five plots were sampled, and their condition scores. Native floodplain grassland (RVCs 26 and 29) and Inland wetland (RVC 70) is in relatively good condition, as is Blakelys Red Gum woodland of the Pilliga (RVC 96) and Coolibah and Black Box types of the western part of the Namoi floodplain (RVCs 76, 77 and 78). The major channel types - River Oak (RVC 71) and River Red Gum (RVC 73) - each exhibit a relatively low condition score (52 and 48, respectively). Box-gum woodlands (RVC 17) scores poorly where it was sampled, mainly in the Nandewar.

Table 40. Mean condition score for RVCs sampled in the riverine zone

RVC	RVC Name	No. plots	Mean condition
26	Dry grasslands of alluvial plains, Darling Riverine Plains and Brigalow Belt South	7	74
70	Wetlands and marshes, inland NSW	5	73
96	Blakely's Red Gum riparian woodland of the Pilliga	23	69
80	Poplar Box grassy woodland on alluvial clay soils, Brigalow Belt South and Nandewar	8	64
78	Coolibah - River Coobah - Lignum woodland of frequently flooded channels, mainly Darling Riverine Plains.	27	63
77	Black Box woodland on floodplains, mainly Darling Riverine Plains	6	62
76	Coolibah - Poplar Box - Belah woodlands on floodplains, mainly Darling Riverine Plains and Brigalow Belt South	6	60
29	Plains Grass - Blue Grass grasslands, Brigalow Belt South and Nandewar	8	60
64	Fens and wet heaths, Nandewar and New England Tablelands	5	56
68	Lignum - River Coobah shrublands on floodplains, Darling Riverine Plains and Brigalow Belt South	7	53
71	River Oak riparian woodland, eastern NSW	106	52
75	Weeping Myall open woodland, Darling Riverine Plains, Brigalow Belt South and Nandewar	8	52
73	River Red Gum riverine woodlands and forests, Darling Riverine Plains, Brigalow Belt South and Nandewar	71	48
72	Bracteate Honey Myrtle riparian shrubland, Brigalow Belt South	7	45
17	Box - gum grassy woodlands, Brigalow Belt South and Nandewar	6	31

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Blakely's Red Gum Riparian Woodland (RVC 96)
Talluba Creek. Excellent condition (Score = 84)

River Oak Woodland (RVC 71)
Quirindi Creek. Poor condition (Score = 34)

4.5.3.8 Plot condition by sub-catchment

Mean plots scores for each of 33 sub-catchments are listed in Table 41 and illustrated in Figure 32 (Borah, Box Creek, Goonoo Goonoo, Keepit, Phillips, Split Rock and Werris Creek sub-catchments had insufficient or no data).

The best condition sub-catchments in the Namoi, according to plot-based condition sampling, were Baradine, Bugilbone, Bundock, Bundella Creek, Coghill, Etoo, Ginudgera, Maules, Tallaba, Upper Manilla, Upper Peel and Upper Pian, each of which scored 60+. Each of these sub-catchments, other than Bugilbone and Bundella Creek, also scored in the top half according to landscape metrics (Table 31; Figure 25). Conversely, the worst condition sub-catchments in the Namoi were Carroll, Cox's Creek, Lower Peel, Mid MacDonald, Rangira, Spring Creek and Upper MacDonald, each of which scored <40. Of these, all but Spring Creek and Upper MacDonald scored in the bottom half according to landscape metrics.

Black Box woodland (RVC 77), Baradine floodplain
Good condition (Score 60)

The general pattern of improved condition from east to west is evident in Figure 32, with eight of 12 good quality sub-catchments (score 60+) occurring in west, while five of seven poor quality sub-catchments (score <40) occur in the east. Sub-catchments containing a relatively high proportion of remnant vegetation comprise vegetation which locally, is in relatively good condition (e.g. Baradine and Upper Peel), while those sub-catchments cleared extensively for grazing are expressed locally by vegetation in relatively poor condition (e.g. Mid and Upper MacDonald).

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Table 41. Mean condition scores for Namoi sub-catchments, based on plot data

Sub Catchment	No. plots	Mean	Sub Catchment	No. plots	Mean
1. Baradine	8	65 ± 14	22. Lower Manilla	7	52 ± 9
2. Bluevale	18	56 ± 10	23. Lower Peel	10	37 ± 7
3. Bobbiwaa	5	56 ± 14	24. Lower Pian	6	56 ± 11
4. Bohena	2	57 ± 25	25. Maules	9	62 ± 11
7. Brigalow	2	59 ± 25	26. Mid MacDonald	8	39 ± 16
8. Bugilbone	52	62 ± 3	27. Mooki	6	47 ± 10
9. Bundella Creek	3	60 ± 24	29. Quirindi	8	40 ± 17
10. Bundock	9	70 ± 12	30. Rangira	3	30 ± 15
11. Carroll	9	37 ± 13	32. Spring Creek	9	39 ± 10
12. Chaffey	11	55 ± 12	33. Tallaba	5	73 ± 12
13. Cockburn River	18	55 ± 7	34. Upper MacDonald	10	36 ± 13
14. Coghill	2	62 ± 25	35. Upper Manilla	7	60 ± 11
15. Cox's Creek	2	21 ± 21	36. Upper Namoi	14	54 ± 6
16. Etoo	6	67 ± 13	37. Upper Peel River	12	61 ± 13
17. Eulah Creek	15	55 ± 8	38. Upper Pian	12	70 ± 6
18. Ginudgera	13	60 ± 9	39. Warrah	23	55 ± 8
21. Lake Goran	2	44 ± 19			

River Red Gum woodland (RVC 73), tributary of Peel River
Poor vegetation condition on account of high weed cover in the understorey, and associated low native species diversity and a lack of native recruitment (Score = 39), despite canopy intactness and health.

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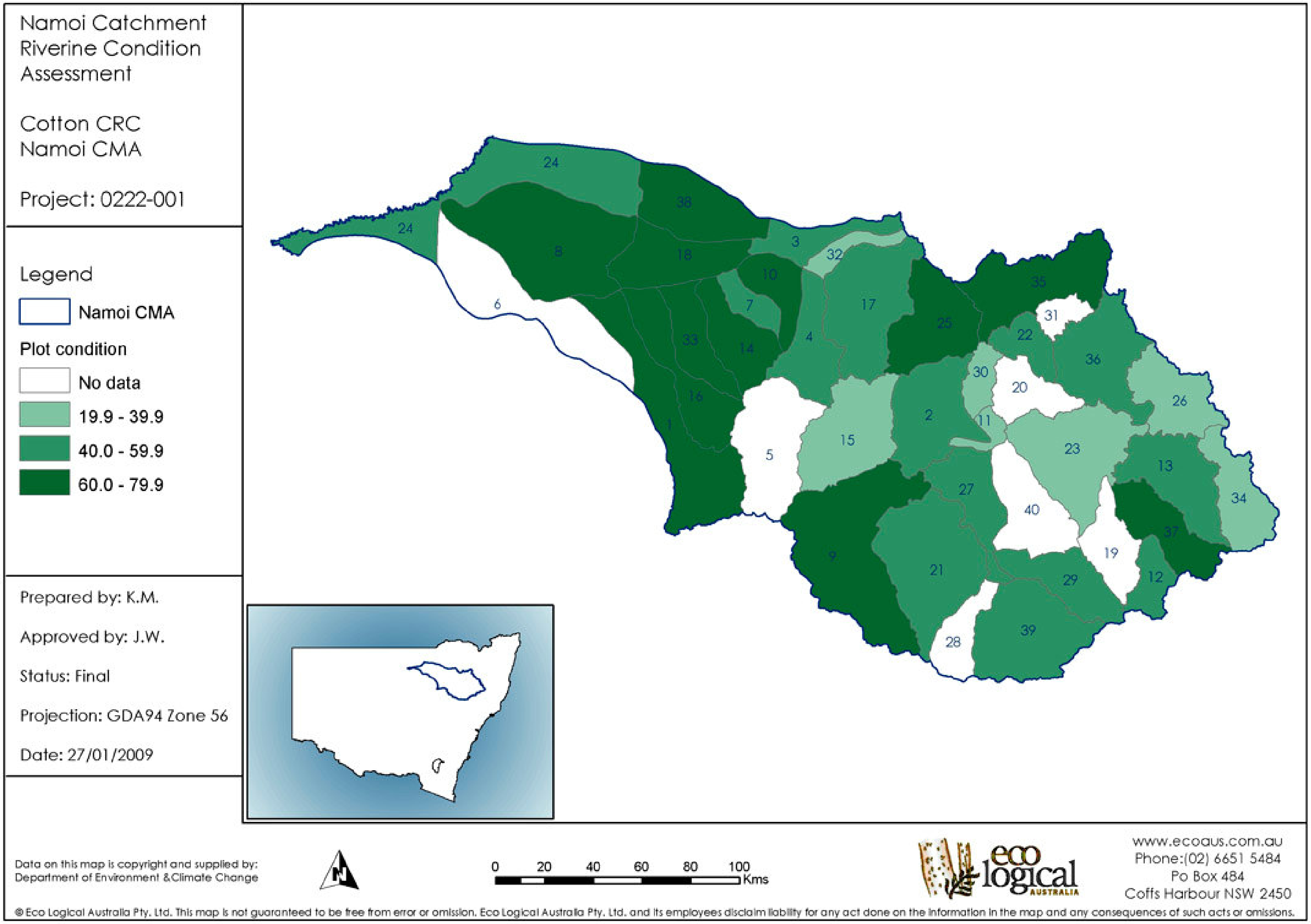
Figure 32. Distribution of riverine vegetation condition scores, derived from condition plots, across the Namoi catchment



1 Baradine
2 Bluevale
3 Bobbiwaa
4 Bohena
5 Borah
6 Box Creek
7 Brigalow
8 Bugilbone
9 Bundella Creek
10 Bundock
11 Carroll
12 Chaffey
13 Cockburn River
14 Coghill
15 Cox's Creek
16 Etoo
17 Eulah Creek
18 Ginudgera
19 Goonoo Goonoo
20 Keepit
21 Lake Goran
22 Lower Manilla
23 Lower Peel
24 Lower Pian
25 Maules
26 Mid MacDonald
27 Mooki
28 Phillips
29 Quirindi
30 Rangira
31 Split Rock
32 Spring Creek
33 Tallaba
34 Upper MacDonald
35 Upper Manilla
36 Upper Namoi
37 Upper Peel
38 Upper Pian
39 Warrah
40 Werris Creek

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4.5.3.9 Vegetation condition of individual rivers

At least two plots were sampled within 47 major streams and rivers in the Namoi, providing a broad indication of the relative condition of the riverine vegetation within each (Table 42). Two were found to be in excellent condition, Jacks Creek (score = 80) and a tributary to Duncans Creek (score = 85), ten were in good condition, including Baradine, Dungowan, Ironbark and Talluba Creeks (score 60-79), 26 were in average condition, including the MacDonald, Namoi and Peel Rivers, and Eulah, Spring and Warrah Creeks (score 40-59), eight were in poor condition, including the Cobrabald and Mooki Rivers and Narrabri and Quirindi Creeks (score 20-39), and one was in very poor condition, Ingleba Creek (score 18).

Blakely's Red Gum Riparian Woodland (RVC 96)
Bundock Creek. Good condition (Score = 74)

River Red Gum woodland (RVC 73) on the Namoi
Average condition (Score = 42)

Plains Grass Grassland (RVC 79) of the Mooki River
Average condition (Score = 50)

Figure 33 shows the distribution of sampled streams and rivers in the Namoi, according to broad plot-based condition. The relatively good condition streams are associated with contiguous areas of native vegetation such as the Pilliga forest (e.g. Etoo and Talluba Creeks) and the Upper Peel forests of the Walcha Plateau (Dungowan Creek), but also in the Pian Creek on the north-western part of the floodplain, Bundella Creek feeding into the Liverpool Plains, and Maules Creek in the central north. Vegetation condition is generally poor in streams of the far eastern part of the New England Tableland (Upper MacDonald sub-catchment) where clearing in riparian zones has been prevalent.

It is noted that over 332 streams and rivers identified in the riverine layer were either not sampled, or were only sampled once, and those with fewer than five plots should be considered with some caution.

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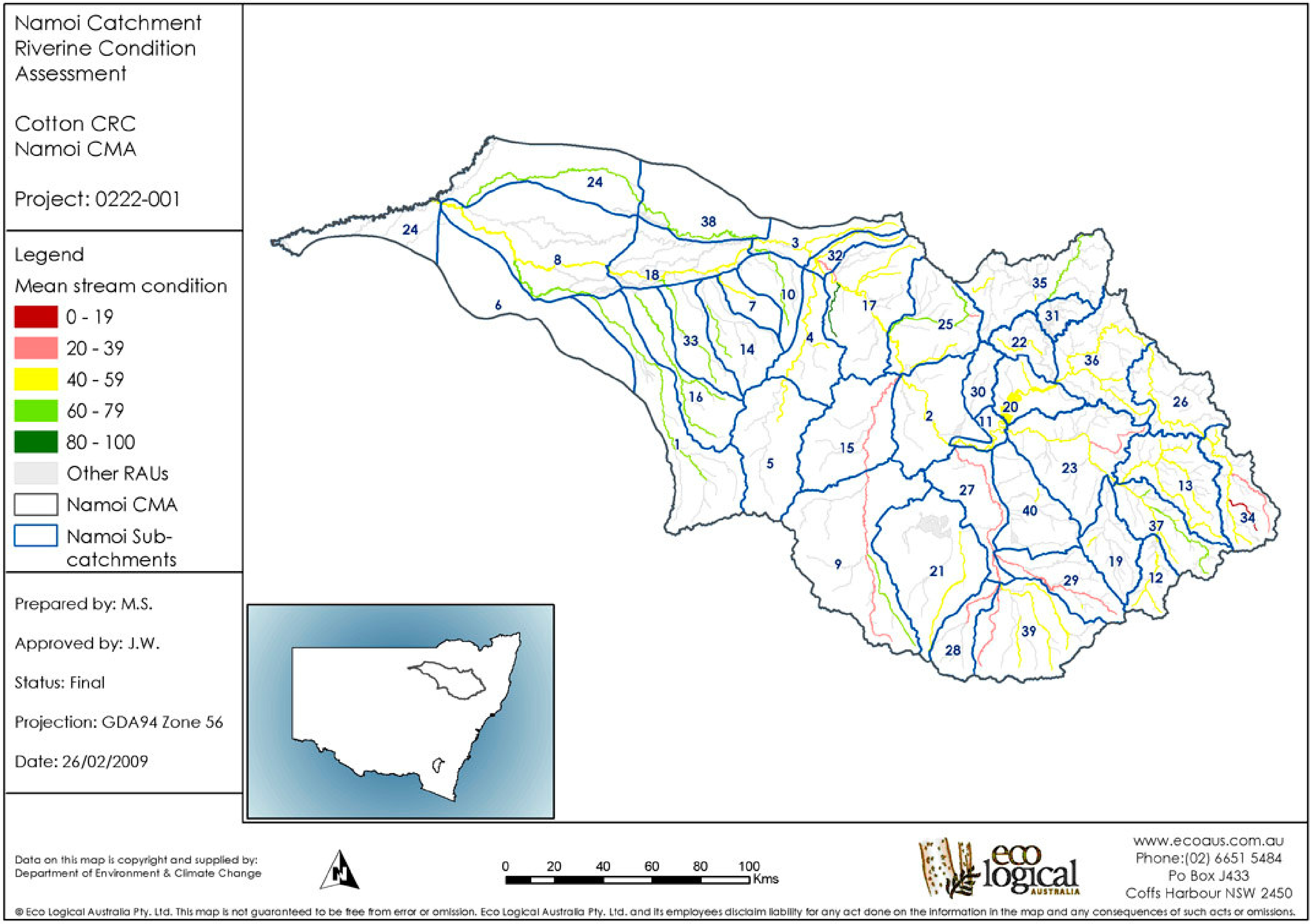
Table 42. Plot-based condition scores for major streams and rivers in the Namoi

Name	No. Plots	Mean condition
Baradine Creek	5	62
Bobbiwaa Creek	5	56
Bohena Creek	2	57
Bollol Creek	3	47
Borah Creek	5	53
Borambil Creek	8	52
Brigalow Creek	2	59
Buchanans Creek	2	30
Bullawa Creek	2	57
Bundella Creek	3	60
Bundock Creek	8	74
Cobrabald River	4	35
Cockburn River	7	55
Coxs Creek	2	21
Duncans Creek	2	47
Duncans Creek trib.*	2	85
Dungowan Creek	6	64
Etoo Creek	6	67
Eulah Creek	2	58
Halls Creek	10	51
Ingleba Creek	2	18
Ironbark Creek	3	66
Jacks Creek	2	80
Jamiesons Creek	5	49
MacDonald River	8	42
Maules Creek	6	70
Millers Creek	3	57
Mooki River	3	35
Moore Creek	4	38
Mulla Mulla Creek	2	57
Namoi River	34	53
Narrabri Creek	4	30
Oaky Creek	2	50
Peel River	11	47
Perrys Creek *	5	51
Pian Creek	5	61
Quirindi Creek	6	38
Rocky Creek	2	62
Spring Creek	4	52
Surveyors Creek	2	50
Swamp Oak Creek	2	58
Talluba Creek	5	73
Tareela Creek	3	59
Warrah Creek	2	55
Wombramurra Creek	5	58
Yarraman Creek	2	44
Yarramanbah Creek	2	39

* Sampled streams not in the RAU layer

River Oak Woodland (RVC 71)
Ironbark Creek
Excellent condition
(Score = 80)

Figure 33. Condition of sampled rivers and streams in the Namoi catchment



1 Baradine
2 Bluevale
3 Bobbiwaa
4 Bohena
5 Borah
6 Box Creek
7 Brigalow
8 Bugilbone
9 Bundella Creek
10 Bundock
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12 Chaffey
13 Cockburn River
14 Coghill
15 Cox's Creek
16 Etoo
17 Eulah Creek
18 Ginudgera
19 Goonoo Goonoo
20 Keepit
21 Lake Goran
22 Lower Manilla
23 Lower Peel
24 Lower Pian
25 Maules
26 Mid MacDonald
27 Mooki
28 Phillips
29 Quirindi
30 Rangira
31 Split Rock
32 Spring Creek
33 Tallaba
34 Upper MacDonald
35 Upper Manilla
36 Upper Namoi
37 Upper Peel
38 Upper Pian
39 Warrah
40 Werris Creek

4.5.3.10 Contribution of individual attributes to benchmark scores

Analysis of the relative contribution of component ecological attributes to the overall benchmark score for each RVC is summarised in Table 43. The relative 'performance' of each attribute, measured as the average score across all RVCs (final row in Table 43), is listed from best to poorest as follows:

Organic litter cover = 4.1	Benchmark = 5	Performance = 82%
Native species richness (canopy) = 4.0	Benchmark = 5	Performance = 80%
Native species richness (groundcover) = 3.7	Benchmark = 5	Performance = 68%
Native groundcover = 9.9	Benchmark = 15	Performance = 66%
Native canopy cover = 6.3	Benchmark = 10	Performance = 63%
Coarse woody debris = 3.0	Benchmark = 5	Performance = 60%
Weed cover (i.e. nativeness) = 8.3	Benchmark = 15	Performance = 55%
No. hollow trees = 2.7	Benchmark = 5	Performance = 54%
Native species richness (midstorey) = 2.3	Benchmark = 5	Performance = 46%
No. large trees = 6.4	Benchmark = 15	Performance = 43%
No. recruiting canopy species = 4.1	Benchmark = 10	Performance = 41%
Native midstorey cover = 1.2	Benchmark = 5	Performance = 24%

It is evident from these data that low midstorey diversity and cover, lack of canopy species recruitment, and absence of large trees have the greatest downward impact on vegetation condition in the Namoi riverine zone. Lack of shrub diversity and cover and lack of canopy species recruitment is most pronounced within the floodplain woodland RVCs dominated by Black Box (RVC 77), Coolibah (RVCs 76 and 78) and Poplar Box (RVC 80), the western channel woodland dominated by River Red Gum (RVC 73), and the Nandewar box-gum woodland (RVC 17). Continuous grazing and physical removal of shrubs are likely to be the principle reasons. Absence of large trees is most notable in the shrublands dominated by Lignum (RVC 68) and Weeping Myall (RVC 75), and again the Nandewar box-gum woodland (RVC 17). Proliferation of weeds in River Oak (RVC 71) and River Red Gum woodlands (RVC 73), and in tablelands communities including box-gum woodlands (RVC 17) and fens and wet heaths (RVC 64) contribute to the overall impact of weediness on average condition scores in the Namoi.

Native species richness and foliage cover in the canopy and ground layer appear to be relatively intact within RVCs in the Namoi. The average RVC exhibits a canopy species richness of 1.6 taxa, a canopy cover of 9.8%, an understorey species richness of 15.1 taxa, and a groundcover of 31.2%. This is encouraging as it suggests that local species diversity is resilient to major landscape modification. Organic litter cover and coarse woody debris appear to be relatively intact as well, although coarse woody debris is largely absent in the box-gum woodland (RVC 17) through activities associated with firewood collection and piling and burning.

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Table 43. Contribution of ecological attributes to RVC benchmark scores

RVC No	RVC Name	Native richness (canopy)	Native recruitment richness (canopy)	No. large trees	No. hollow trees	Native richness (midstorey)	Native richness (ground-cover)	Native canopy cover	Native midstorey cover	Native ground-cover	Organic litter cover	Weed cover	Coarse Woody Debris
17	Box - gum grassy woodlands, mainly Nandewar	0.8 (2) 2.2	0 (2) 0	0.8 (3) 4.5	1.7 (4) 2.3	0 (2) 0	12.5 (25) 2.3	4.1 (15) 4.3	0 (5) 0	25.8 (50) 7.5	21.3 (30) 4.2	38.8/0 (0) 2.5	18.8 (30) 1.2
26	Dry grasslands of alluvial plains, Darling Riverine Plains and Brigalow Belt South						14.7 (20) 3.6			40.6 (50) 11.1	21.7 (30) 4.3	6.1/0 (0) 11.1	
29	Plains Grass - Blue Grass grasslands, Brigalow Belt South and Nandewar						12.8 (20) 3.0			44.9 (60) 10.9	22.1 (25) 4.3	26.3/0 (0) 5.6	
64	Fens and wet heaths, Nandewar and New England Tablelands						14.6 (15) 4.4			26.4 (50) 6.6	15.2 (10) 4.0	30.6/0 (0) 4.2	
68	Lignum - River Coobah shrublands on floodplains, Darling Riverine Plains and Brigalow Belt South	1.7 (1) 5.0	1.1 (1) 7.1	0 (3) 0	0.3 (1) 1.4	2.3 (3) 3.6	14.9 (15) 4.7	2.6 (25) 3.0	4.4 (30) 1.4	27.5 (35) 10.7	23.1 (25) 4.4	9.9/0 (0) 9.0	19.1 (20) 3.0
70	Wetlands and marshes, inland NSW						14.6 (15) 4.4			51 (50) 11.4	16.8 (30) 3.6	12.6/0 (0) 8.4	
71	River Oak riparian woodland, eastern NSW	1.6 (1) 4.4	0.8 (1) 5.7	1.2 (4) 5.9	1.1 (3) 2.2	1.2 (2) 2.5	13.6 (20) 3.3	15.3 (35) 6.3	1.7 (5) 1.3	20.7 (35) 7.6	20.7 (25) 4.1	26.8/2.5 (0) 5.5	32.1 (50) 3.0
72	Bracteate Honey Myrtle riparian shrubland, Brigalow Belt South	3.6 (2) 4.3	1.6 (2) 7.4	11.9 (4) 9.9	0.3 (0) 0	4.9 (3) 3.9	18.0 (15) 4.6	26.0 (50) 7.4	12.1 (10) 3.1	26.6 (50) 8.6	27.0 (20) 4.0	23.3/0.6 (0) 5.6	55.6 (50) 4.0
73	River Red Gum riverine woodlands and forests, Darling Riverine Plains, Brigalow Belt South and Nandewar	1.5 (2) 3.5	0.7 (2) 3.8	2.1 (5) 6.7	2.1 (7) 2.5	1.6 (3) 2.0	12 (20) 2.9	11.7 (25) 6.5	4.3 (10) 1.8	18 (35) 7.3	25 (35) 3.4	31.5/1.6 (0) 5.2	33.2 (70) 2.6

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Table 43. cont'd

RVC No	RVC Name	Native richness (canopy)	Native recruitment richness (canopy)	No. large trees	No. hollow trees	Native richness (midstorey)	Native richness (ground-cover)	Native canopy cover	Native midstorey cover	Native ground-cover	Organic litter cover	Weed cover	Coarse Woody Debris
75	Weeping Myall open woodland, Darling Riverine Plains, Brigalow Belt South and Nandewar	0.9 (1) 3.8	0.6 (1) 6.3	0.8 (3) 4.5	0.3 (1) 1.3	0.9 (2) 2.3	16.3 (17) 4.6	5.1 (30) 4.0	0.5 (5) 0.8	38.4 (50) 10.9	23.1 (30) 4.4	22/0.6 (0) 6.4	8.1 (10) 3.4
76	Coolibah - Poplar Box - Belah woodlands on floodplains, mainly Darling Riverine Plains and Brigalow Belt South	1.3 (2) 3.7	0.3 (1) 3.3	1.5 (4) 8.2	1.8 (6) 2.7	0.7 (2) 1.3	16.8 (25) 3.0	7.4 (15) 7.0	0 (5) 0	27.8 (40) 10.0	19.9 (25) 4.0	1.8/0 (0) 13.5	20 (20) 3.3
77	Black Box woodland on floodplains, mainly Darling Riverine Plains	1.3 (1) 5.0	0.2 (1) 1.7	1.2 (3) 6.5	2 (4) 3.5	0.7 (2) 1.8	14.7 (20) 3.8	7.2 (15) 7.3	0 (5) 0	36.5 (40) 12.0	25.7 (25) 5.0	3.5/0 (0) 12.5	8.8 (20) 2.8
78	Coolibah - River Coobah - Lignum woodland of frequently flooded channels, mainly Darling Riverine Plains.	1.3 (2) 3.5	0.6 (2) 3.4	1.5 (4) 6.6	2.6 (5) 3.4	1.4 (2) 3.3	14.3 (20) 3.6	6.7 (15) 6.9	1.4 (10) 1.2	27.2 (30) 12.1	25.8 (30) 4.2	7.4/0.1 (0) 11.2	18.6 (20) 3.2
80	Poplar Box grassy woodland on alluvial clay soils, Brigalow Belt South	1.1 (2) 3.3	0.1 (2) 0.8	2.5 (4) 11.3	3.5 (5) 4.4	0.4 (3) 0.8	14.6 (25) 2.8	8 (15) 8.5	0.3 (5) 0.4	39.2 (40) 13.5	31.9 (30) 4.6	5/0 (0) 10.9	21.5 (25) 3.4
96	Blakely's red gum riparian woodland of the Pilliga	2.3 (2) 4.8	1.0 (2) 5.3	1.3 (4) 6.2	2.1 (4) 3.7	2.5 (2) 4.2	22.6 (20) 4.9	13.8 (20) 8.0	8.0 (10) 3.0	17.2 (30) 8.7	34.8 (30) 3.7	2.2/0 (0) 13.4	36.3 (30) 3.4
	ALL	1.6 : 4.0	0.6 : 4.1	2.3 : 6.4	1.6 : 2.7	1.5 : 2.3	15.1 : 3.7	9.8 : 6.3	3 : 1.2	31.2 : 9.9	23.6 : 4.1	16.5/0.5 : 8.3	24.7 : 3.0

Key : **X (Y)** X = plot value for attribute Y = benchmark value for attribute
Z Z = condition score for ecological attribute

for weed cover, **X1/X2 (Y)** X1 = groundcover weeds X2 = canopy & midstorey weeds
Z

note: mean benchmark score (Y) not included in **ALL** row

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5. Discussion and Recommendations

5.1 Comparison of Landscape-Derived and Plot-based Condition Scores

5.1.1 All plots

As indicated in section 4.5.3.8 above, there appears to be a very broad relationship between plot based and landscape-derived condition scores. Most of the sub-catchments which score highly from plot data, also score relatively highly from landscape analysis, while most sub-catchments scoring poorly from condition plots, also exhibit a below-average landscape score. This trend is evident in Figure 34, although the relationship between plot and landscape-derived condition scores is weak (r^2 = 0.25), suggesting that field condition cannot be confidently predicted by metrics derived using remotely sensed data.

The slope in Figure 34 shows that plot scores increase at a proportionally greater rate than landscape scores, suggesting that vegetation can exhibit reasonably good condition on the ground even when the level of sub-catchment disturbance as measured by landscape metrics suggest otherwise. This is supported by Figure 35, which shows the distribution of sub-catchments in the Namoi as derived from landscape and plot data. Of the 33 sub-catchments in which plots were sampled, a total of 13 (about 45%) possess the same broad condition category derived from landscape and plots. A further eight sub-catchments possessed a plot-based condition category which was one category above its respective landscape-derived condition category (e.g. 60 - 79.9 [good] cf. 40 - 59.9 [average]), and 10 sub-catchments possessed a plot-based condition category which was two categories above its respective landscape-derived condition category (e.g. 60 - 79.9 [good] cf. 20 – 39.9 [poor]). Only one sub-catchment, Spring Creek, exhibited a plot based condition category which was less than its landscape-derived condition category.

Figure 34. Relationship between landscape-derived and plot-based riverine vegetation condition scores within Namoi sub-catchments

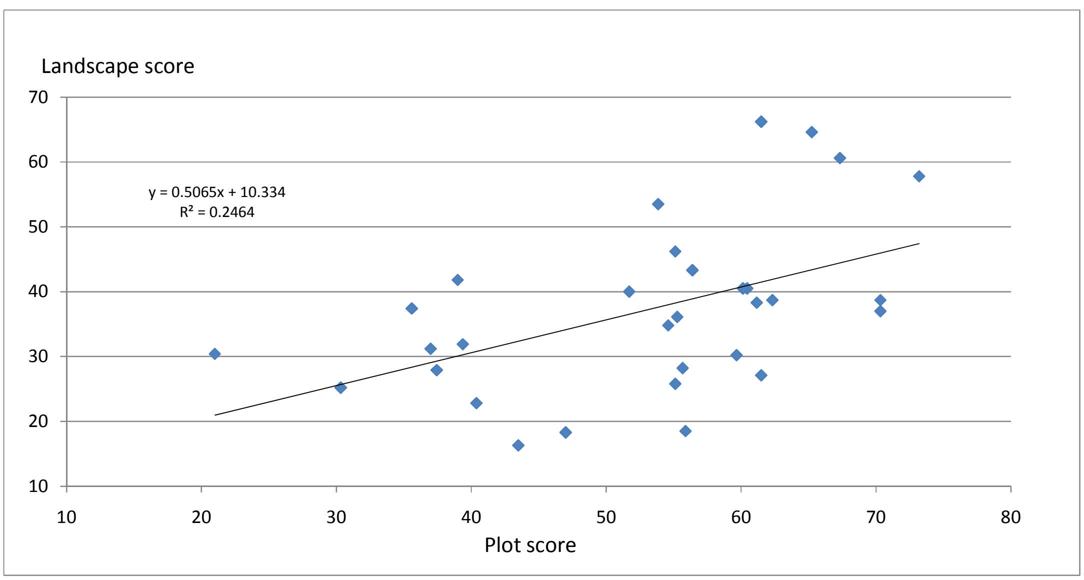
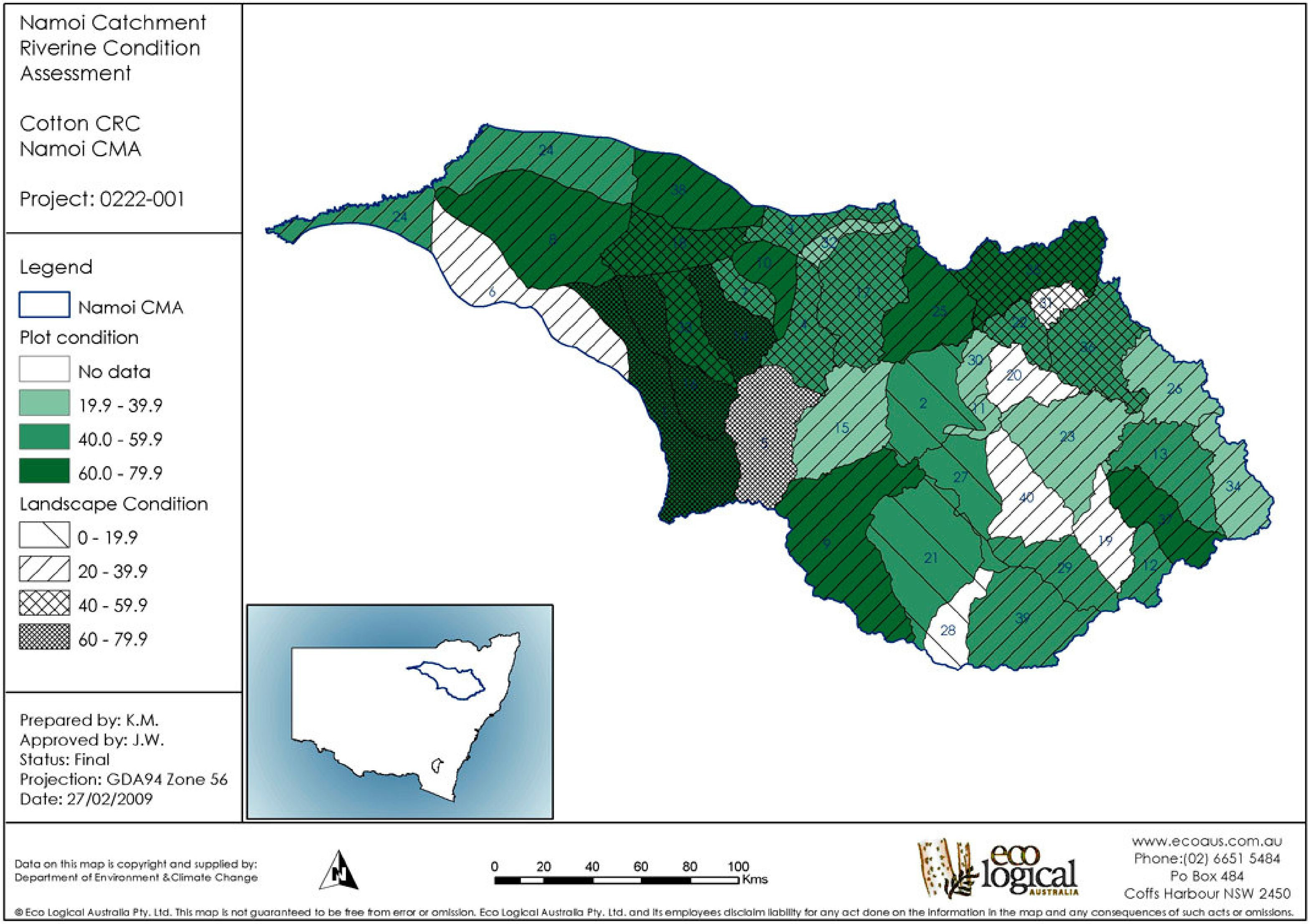


Figure 35. Distribution of riverine vegetation condition scores, derived from plots and landscape metrics, across the Namoi catchment



1 Baradine
2 Bluevale
3 Bobbiwaa
4 Bohena
5 Borah
6 Box Creek
7 Brigalow
8 Bugilbone
9 Bundella Creek
10 Bundock
11 Carroll
12 Chaffey
13 Cockburn River
14 Coghill
15 Cox's Creek
16 Etoo
17 Eulah Creek
18 Ginudgera
19 Goonoo Goonoo
20 Keepit
21 Lake Goran
22 Lower Manilla
23 Lower Peel
24 Lower Pian
25 Maules
26 Mid MacDonald
27 Mooki
28 Phillips
29 Quirindi
30 Rangira
31 Split Rock
32 Spring Creek
33 Tallaba
34 Upper MacDonald
35 Upper Manilla
36 Upper Namoi
37 Upper Peel
38 Upper Pian
39 Warrah
40 Werris Creek

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5.1.2 Floodplain plots

Four floodplain metrics contributed to the landscape score generated for each sub-catchment - % native vegetation cover, % non-native vegetation cover, % habitat links, and % native patches > 20 ha (Table 2). To investigate the relationship between the mean score of plots sampled on the floodplain (i.e. within FAUs), and the landscape-derived score for floodplains, an alternative landscape-metric was derived using the four metrics listed above, and comparison was made with sub-catchments in which plots were reasonably sampled. The results are shown in Table 44 and Figure 36.

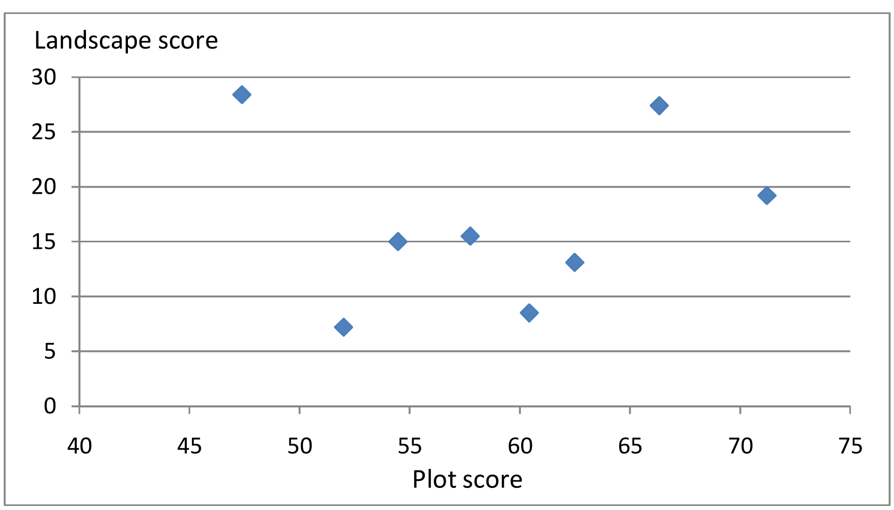
No relationship was observed between mean plot-based condition scores and landscape-derived metric scores for the floodplain region of eight sub-catchments the Namoi. The only meaningful observation is that plot-based vegetation condition is consistently higher than equivalent landscape-derived condition for vegetation of the Namoi floodplain.

Table 44. Landscape-derived and plot-based riverine vegetation condition scores for the floodplains of eight sub-catchments

Sub-catchment	No. plots	Mean plot score	Landscape score [A]
Bluevale	15	54 ± 11	15.0
Bugilbone	35	62 ± 3	13.1
Eulah Creek	8	47 ± 8	28.4
Ginudgera	3	66 ± 34	27.4
Lower Pian	4	58 ± 8	15.5
Mooki	4	52 ± 12	7.2
Upper Pian	9	71 ± 7	19.2
Warrah	7	60 ± 22	8.5

A. Mean of 4 FAU metrics in Table 2

Figure 36. Relationship between landscape-derived and plot-based riverine vegetation condition for the floodplains of eight sub-catchments



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5.1.3 Channel plots

Plots sampled within the major channels of the Namoi can be compared with landscape-derived metrics at two levels – the RAU level and the sub-catchment level. At the RAU level, at least two condition plots were sampled within each of 61 RAUs in the Namoi catchment. A landscape-derived score was also derived for each of these RAUs using relevant variables in Table 2. At the sub-catchment level, landscape and plot condition scores were contrasted for sub-catchments containing at least 3 condition plots. Figure 37 shows the relationship between the mean plot-based score and the landscape-derived metric for each RAU, and Figure 38 shows the relationship between the mean plot-based score and the landscape-derived metric for each sub-catchment.

Similar to Figure 34, the relationship between plot-based condition measured in the field and landscape condition derived from the mean of various metrics which are likely to affect condition to some extent, is weak at both the RAU level and the sub-catchment level. Again the trend in both relationships is an increase in plot-based condition with an increase in landscape-scale metrics such as %vegetated, %connectivity and so on. However, within RAUs the plot scores are generally similar to associated landscape scores, suggesting that the inherent condition of riparian vegetation is related to the extent to which the riparian landscape has been modified.

Figure 37. Relationship between landscape-derived and plot-based riverine vegetation condition scores within the channels, sampled at the RAU level.

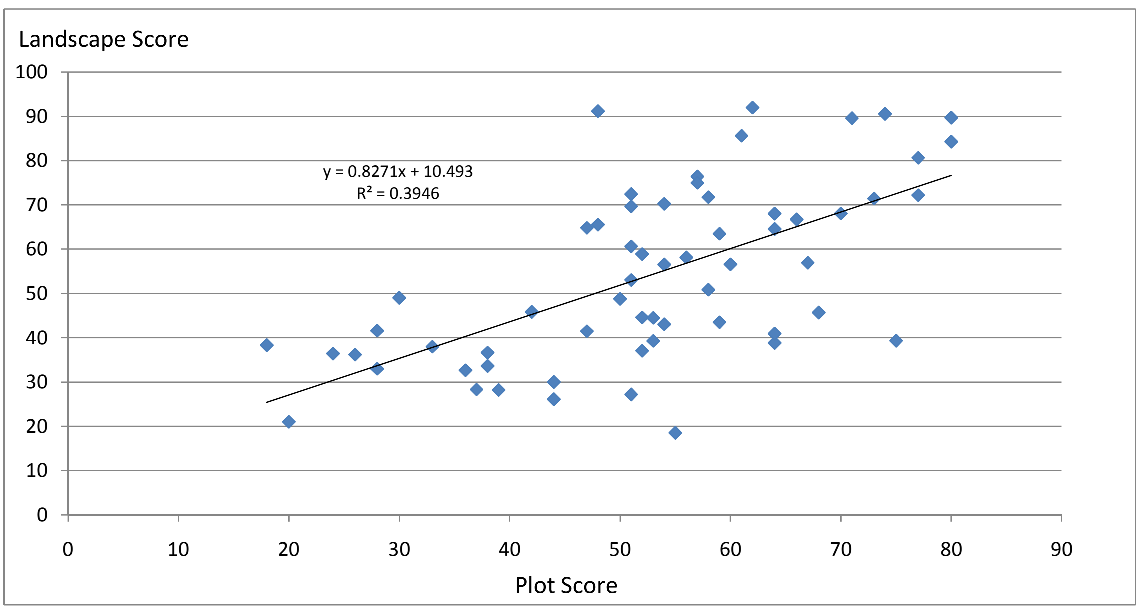

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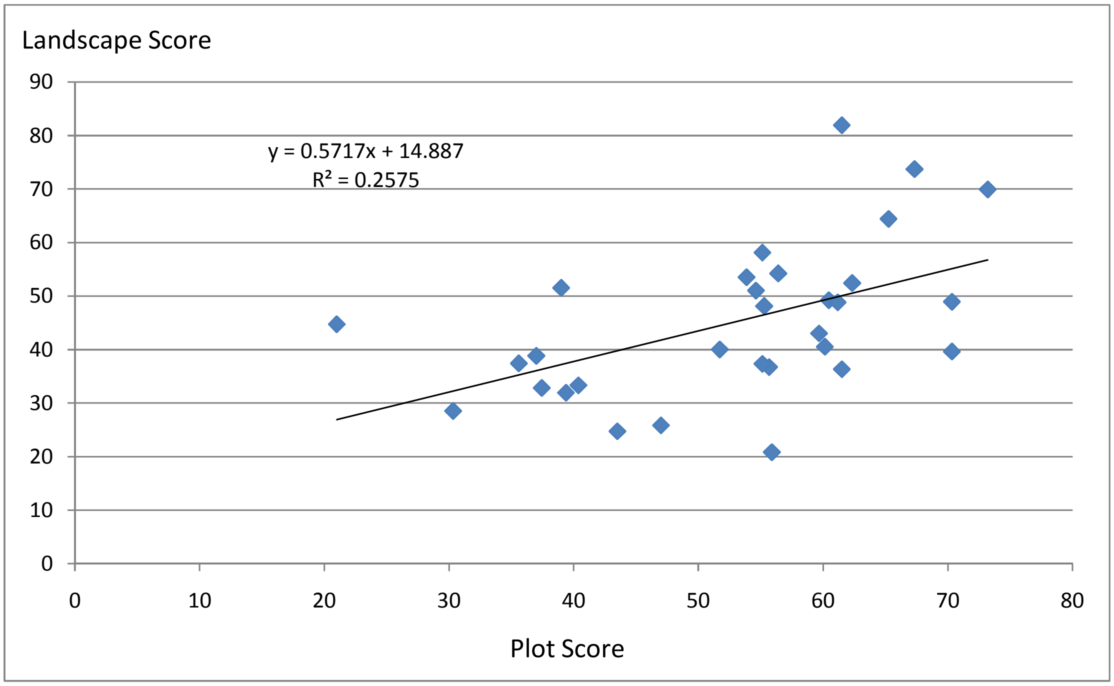
Figure 38. Relationship between landscape-derived and plot-based riverine vegetation condition scores within the channels, sampled at the sub-catchment level



The relationships between mean RAU plot scores and individual RAU metrics were investigated as a final check of correlation between plot scores and individual landscape metrics. While the relationships were generally weak, that with %native cover provided the best regression (Figure 39), suggesting that improved %cover data may provide a reasonable surrogate for vegetation condition on the ground. Elimination of all RAUs containing fewer than four plots revealed a much improved regression (Figure 40), although the number of samples was reduced appreciably.

The trend lines in Figures 39 and 40 are similar. Both suggest that the inherent condition of local and often isolated stands of vegetation can be relatively greater than the proportion of remnant vegetation remaining along the local channel reach. Again, this implies that isolated stands of vegetation may provide good building blocks for any program to improve landscape function through strategic reforestation and conservation management.

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Figure 39. Relationship between % native cover and plot-based riverine vegetation condition scores within RAUs of the Namoi

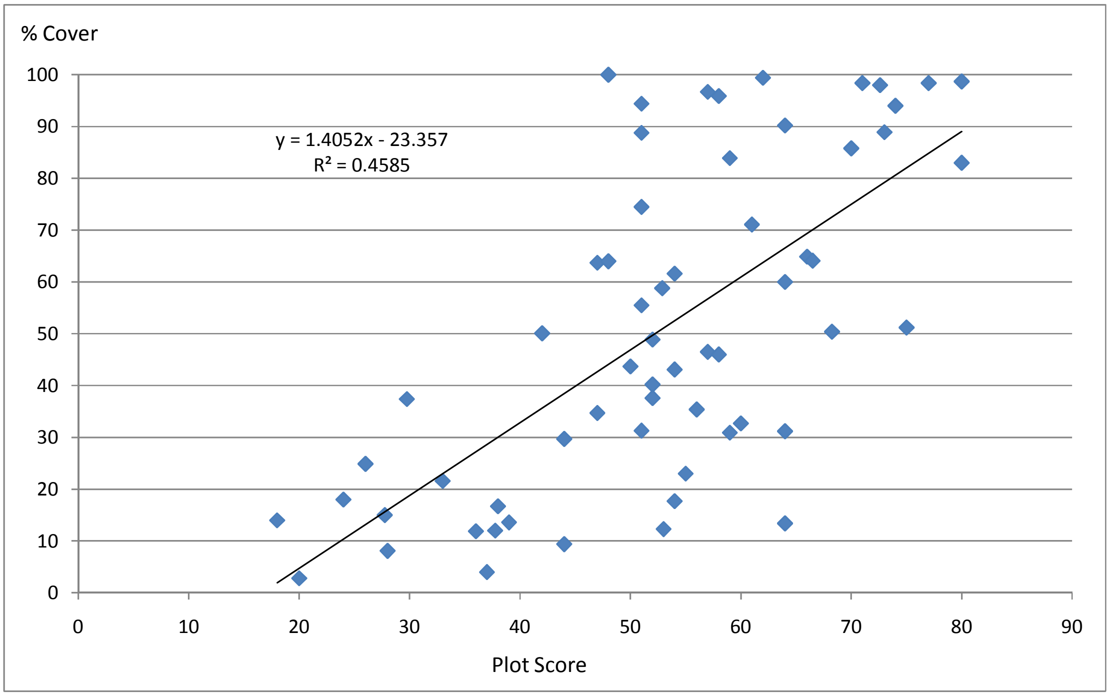
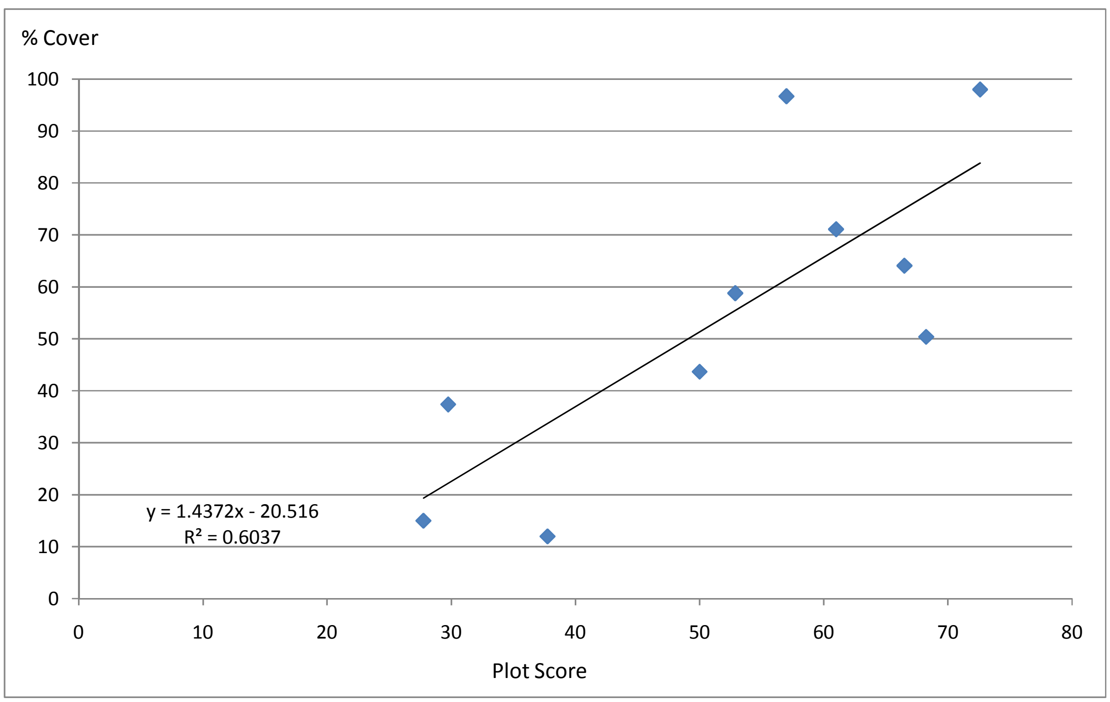


Figure 40. Relationship between % native cover and plot-based riverine vegetation condition scores within RAUs of the Namoi
(only includes RAUs containing 4 or more plots)



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5.2 Condition Scores and River Style Scores

5.2.1 Background

River Styles provides a geomorphic summary of river character and behavior, based primarily on the relationship between channel and valley morphologies and broader landscape, which provides a range of other measurable biophysical attributes which enable development of river conservation and rehabilitation priorities. Broad analysis of the Namoi catchment resulted in delineation of 23 river styles, each separated into three broad categories of indicative geomorphic condition – good, moderate and poor (Lampert and Short 2004). Indicative condition was derived using an assumptive process involving expert consideration of various factors, including geomorphic features such as degree of bed and bank degradation, floodplain/channel relationships, sediment characteristics, and also vegetation features, namely riparian continuity and weediness. Riparian vegetation continuity was derived using aerial photographic interpretation (API), while weediness was inferred from site reconnaissance of different river styles. Vegetation informed river style condition as follows (from Lampert and Short 2004):

Good condition	Riparian vegetation cover is continuous, however weed species can be present and linkages to slope vegetation are minimally disrupted.
Moderate condition	Riparian vegetation can be discontinuous with moderate infestations of exotic weed species. Limited linkages to non-riparian remnants.
Poor condition	Riparian vegetation is either non-existent or dominated by weed species.

5.2.2 Landscape Scores

Because longitudinal vegetation continuity and weediness were key metrics in this project, we would presume a reasonable correspondence between associated categories of condition derived for this project, and broad categories derived and mapped by Lampert and Short (2004). To test this supposition, landscape scores derived for each RAU were classified into good (score 60+), average (score 40-59) and poor (score < 40), then tabulated and mapped against corresponding river style categories (Table 45).

A total of 1140 RAUs each comprised a river style index and were available for comparison with RAU landscape-derived condition scores. The general correlation is satisfactory, with 627 of RAUs (55%) possessing the same broad categories, while only 49 RAUs (4%) possess starkly contrasting categories (i.e. good-poor or poor-good) (Table 45). The current analysis allocated proportionally more RAUs to the ‘good’ and ‘poor’ categories than the River Styles project, which allocated proportionally more to the ‘moderate’ category.

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Table 45. Comparison of RAU and River Style condition categories

		River Styles Condition			
	Condition Category	Good	Moderate	Poor	ALL
Landscape condition scores (RAUs)	Good (60+)	186 *(16.3%)*	153 *(13.4%)*	30 *(2.6%)*	369 *(32.2%)*
	Moderate (40-59.5)	65 *(5.7%)*	201 *(17.6%)*	85 *(7.5%)*	351 *(30.8%)*
	Poor (< 40)	19 *(1.7%)*	161 *(14.1%)*	240 *(21.1%)*	420 *(36.9%)*
	ALL	270 *(23.7%)*	515 *(45.1%)*	355 (*31.2%)*	1140

Plot-derived condition scores were also averaged across the 'good', 'moderate' and 'poor' condition classes of the River Styles classification. The results are also consistent, with a near significant difference between plot scores in the 'good' condition reaches (60 ± 4) and 'moderate' condition reaches (55 ± 3), and a significant difference between plot scores in 'poor' condition reaches (40 ± 4) and those in both 'moderate' and 'good' condition reaches.

5.3 Recommendations

Numerous guidelines have been published for managing riparian vegetation in rural landscapes in eastern Australia (e.g. Oates, J. 2000; Middleton and Smith 2002; Taman 2002). Most are prescriptive and are suitable for application to local riparian reaches or individual wetlands, but not to extensive areas of riverine vegetation or large floodplain areas such as those in the Namoi catchment. To date, most funding for conservation works has been allocated to individual landholdings or patches of vegetation to carry out targeted conservation works using management practices advocated in the above-mentioned guidelines (e.g. local weed control, tree planting, fencing, soil conservation works). However, relatively little has been used to support more strategic and perhaps more cost-effective approaches to riverine vegetation management at the regional or landscape scale.

The following recommendations leverage off some of the key findings of this paper. They aim to achieve a diversity of outcomes in the Namoi landscape, and are consistent with stated targets of the Catchment Action Plan (CAP) for the Namoi catchment (Namoi CMA 2007), specifically:

MTL1 – From 2006, increase the area of land managed according to Best Management Practice.

MTW1 – From 2006, there will be an improvement in riverine structural stability, and the condition and extent of native riverine vegetation in priority riverine areas

MTB1 – From 2006, maintain or improve the extent, distribution and condition of the existing native vegetation of the catchment.

MTB2 – From 2006, support the recovery of priority fauna populations, and Threatened Species, Populations and Communities.

Recommendation 01 – Protect remaining areas of native vegetation in cotton (and other cropping) areas.

The direct impacts of cropping on native vegetation have been significant, with most of the native grassy woodlands and grasslands having been removed from the extensive Namoi floodplain to support cotton and other crops. Despite this, the condition of remaining areas of native vegetation occurring on uncleared parts of the floodplain and in adjoining channels is in relatively good condition, compared to riverine vegetation in the pastoral landscape. Maintenance of remnant vegetation condition within major areas of cropping is important for two main reasons:

1. It will provide the natural capital for development of a strategic network of major and minor corridors and habitats across the floodplain (recommendation 2), thus facilitating movement, dispersal and perpetuation of native fauna and flora species, and their capacity to adapt to climate change.
2. It will enable the native biodiversity of the cotton growing regions to continue to provide ecological services such as river-bank protection and regulation of crop pests.

Recommendation 02 – Identify key links and habitats across the floodplain

The Namoi Catchment Conservation Strategy (EASystems 2008) establishes a spatial footprint for conservation priorities (those areas contributing most to positive biodiversity outcomes), restoration priorities (those areas most likely to benefit from restoration activities) and corridor priorities (those areas where existing or potential corridors can be created or improved upon to increase the connectivity between reserves or protected habitats). While information available at the time of this study contributed to identification and mapping of these spatial maps, EASystems (2008) recognised that the final products might be improved by incorporating data that were absent at the time of the assessment (e.g. pre-European mapping, accurate grassland mapping).

We recommend that Namoi CMA support further work to improve the baseline mapping of the current extent of true native grasslands and grassy open woodlands within the floodplain environment, which is currently provided as a compilation of various datasets of varying ages and quality (ELA 2008). It will be possible from this work to delineate a network of corridors across the catchment (focussing on major cropping regions) which inter-connect the biggest and best patches, utilise a standard corridor width (e.g. Scotts 2003), and address long-term aspirational goals of linking main blocks of forest across the Namoi and other floodplains, such as Pilliga and Kaputar, and Liverpool Range and Kaputar (via Melville Range and Kelvin forests). The relatively good condition of remnant floodplain vegetation within cotton cropping areas suggests that the biggest and most intact native remnants on offer be prioritised for protection and enhancement by Namoi CMA (recommendation 1), as they will ultimately provide the building blocks of a strategic landscape-scale reforestation project.

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Recommendation 03 – Prioritise protection and conservation of least degraded streams and rivers in the Namoi catchment, over rehabilitation of the more degraded streams and rivers

Protecting and maintaining reaches in good condition is afforded the highest priority in the River Styles framework (Lampert and Short 2004), a strategy that is strongly supported by ELA for the following reasons:

- Cost per unit effort to maintain good-condition riverine vegetation than to restore or improve poor condition riverine vegetation is much less;
- Likeliness of long-term success associated with protection/maintenance of good condition vegetation is much greater than that associated with restoration, thus the risk of failure (and loss of dollars) is much less;
- The potential rate of decline in condition of good quality riparian vegetation as a result of poor or inappropriate management is far greater than the potential rate of improvement in poor condition vegetation as a result of restorative works, so that a program that concentrates on restoration may result in long term decline in overall condition over time.

Recommendation 04 – Target identified priority areas for protection and restoration

Consistent with its current charter, it is important that Namoi CMA continue to support site-specific enhancement of native vegetation patches within the riverine zone, particularly where they co-exist with high-value priority landscapes. Part of the conservation funding streams should be directed to activities including:

- control of infestations of nationally significant weed species,
- fencing and management of important wetlands and sensitive areas of river channels,
- improved stock management through placement of strategic watering points
- protection of identified threatened species habitat, communities and species populations, and
- erosion control in degraded and incised channels through tree planting and local engineering works

Broad priorities for riverine conservation works should consider both the inherent nature of the site, and its contribution to the long-term ecological function of the Namoi landscape. The Namoi CMA should thus aim to protect good quality patches of remnant native vegetation, cognisant of the need to develop a network of core habitats linked by vegetated corridors. Specific priorities for the Namoi include:

1. protection of remnant parcels of intact native woodland and grassland within the cropping footprint of alluvial floodplains in the Namoi catchment, with emphasis on Eulah Creek sub-catchment which provides the potential link between Pilliga and Kaputar forest blocks, and Bugilbone, Bundock, Maules and Upper Pian sub-catchments where remnant floodplain vegetation exhibits relatively good condition.

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2. Undertaking targeted reforestation along Bibbla, Bullawa, Deriah, Eulah, Jacks, Kurrajong, Sandy and Tea-tree Creeks in the Eulah sub-catchment, thus building links between the Pilliga and Kaputar blocks via riparian corridors.

3. Undertaking targeted restoration along the whole length of the Namoi River – providing a major east to west riparian corridor from the tablelands to the Barwon River.

4. Instituting a scheme which targets and protects good condition reaches through agreements with landholders, particularly on the New England Tablelands and Nandewar where continuous grazing continues to degrade riparian vegetation. Consistent with River Styles priorities (Lampert and Short 2004), examples include Cockburn River, Ironbark Creek, Maules Creek, and the north-western reaches of the Pilliga outwash streams which link the Pilliga forest to the Namoi.

5. Undertake targeted restoration in the Upper MacDonald catchment, particularly the headwater fens and bogs, which represents a unique upland part of the Namoi catchment, and is also supported by Lampert and Short (2008) as a priority.

6. Undertake targeted restoration of riparian vegetation adjacent to large contiguous blocks, or adjacent to significant lateral corridors in the form of travelling stock reserves, which provide links from the floodplain to the forested hills.

Recommendation 05 – Institute a catchment-wide riparian planting scheme along major channels

Plot-based condition scoring carried for this project suggests that lack of native species recruitment, low native shrub diversity and cover, and absence of large and hollow trees contribute most to a reduction in vegetation condition in the Namoi riverine zone (Section 4.5.3.11). Maintenance of overstorey structure, cover and composition is critical to the long-term persistence and condition of riverine vegetation communities, thus actions to address these specific ecological features are arguably more important than actions to address features which may not necessarily lead to an improvement of vegetation condition over the longer term (e.g. weed control). Restoration or reconstruction of regional vegetation communities is largely founded on the encouragement of native woody taxon, principally in the overstorey. The following priority actions are advocated for channel reaches in which the canopy vegetation is no longer present.

1. Targeted planting of native canopy and shrub species to increase continuity of vegetation along major streams and rivers, and

2. Targeted placement of nest boxes to encourage nesting and breeding of native bird and arboreal mammal species.

These activities would improve vegetation condition in the short-term as they directly increase recruitment, woody diversity and tree hollow (thus ecological function) scores. Incremental planting along major channels would also contribute towards long term development of a network of riparian corridors throughout the catchment. A strategic reforestation effort would require a minimum level of protection and maintenance of seedlings immediately post-establishment, and might be linked via a sequestration pool to the National Emissions Trading Scheme due to commence in July 2010.

Recommendation 06 – Develop a Riverine Vegetation Condition Monitoring Strategy

This project demonstrates a weak relationship between vegetation 'condition' measured by landscape metrics, and that derived directly through ecological sampling within plots. Although stronger relationships may be established using LiDAR or other high-resolution photography, the most reliable measurement of vegetation condition will always be at the field plot level. Ecological attributes such as species richness, native groundcover, recruitment and tree hollows, all of which contribute to condition of local vegetation, cannot be reliably estimated from remotely sensed data. In this respect, we believe that condition monitoring should be reliant on continued collection of plot data. As demonstrated by this project, the sampling protocol is rapid, reliable and repeatable.

Monitoring vegetation condition using plot data can be undertaken at two levels – plot and landscape. The plot level requires permanent fixation of an individual condition plot using a marker, undertaking an initial reference measurement of condition, then repeating and comparing measurements of condition over time. This approach is being adapted by the Namoi CMA for landholdings in which direct conservation measures are being carried out, and may provide some useful results over time. However, the approach is limited within channel vegetation given problems associated with permanently pegging out an area subject to major flooding and geomorphic change, and uncertainty about pinpointing a pre-existing GPS point. Until a point and bearing in the riparian landscape can be relocated with absolute certainty, and cost-effectively (triangulation would be possible but costly), plot-based condition monitoring in these environments will prove challenging.

Monitoring at the landscape scale involves averaging across many 'non-permanent' plots, and provides a better option for Namoi CMA to report on change in condition of riverine vegetation over time. Average plot condition can be established for individual vegetation types, streams and sub-catchments, as long as an adequate number of plots are sampled and scored across each feature. At the broadest level, this project has sampled 329 plots to derive an average condition score of 53 for channel vegetation and 60 for floodplain vegetation – a good point of reference for future sampling initiatives.

Given that a large part of this project involved delineation of the riverine footprint, development and application of the scoring framework and reporting, the amount of time available to carry out field sampling was constrained, so the number of plots used to calculate mean scores for some features (e.g. individual streams) was often not adequate. Ideally, sampling a total of 40 - 100 riverine plots in each of the 40 sub-catchments over five year periods would provide a robust and defensible approach to evaluating annual change in riverine vegetation condition, and thus being able to report on MTW1 and MTB1 performance targets within the Namoi CAP. Plots would be pre-selected randomly throughout the riverine landscape, possibly stratified by stream order or other variables, and 300 - 500 plots would be completed within a 20 week period each year (ideally from February to June). An annual sampling program of this type would enable Namoi CMA to chart average riverine vegetation condition year by year, across different parts of the landscape (Figure 41).

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Figure 41. Example of hypothetical condition monitoring charts, based on proposed annual sampling of 300 – 500 plots/year
(2008 data are results of this project; 2009-2015 data are hypothetical)

Recommendation 07 – Completion and Maintenance of the Vegetation Condition Database and Benchmarks

On completion of this project, the vegetation condition database will store all completed plot data and benchmark data for sampled RVCs, and will provide the capacity to calculate and report a plot condition score. To improve the database further, the following are advised:

- Develop capacity to link plot-photos
- Complete benchmark scores for remaining Namoi RVCs
- Add contextual regional data into the database (e.g. bioregion, sub-catchments, stream order, stream name)
- Develop capacity to report current condition, and annual change in condition, across the above data (e.g. sub-catchments)

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Appendix I. VEGETATION CONDITION SURVEY PROFORMA

Recorder/s………………………………………..   Date: _ _ / _ _ /20_ _

Property

Property Name:____

Owner:______________________________________ Phone number:_____________________________

Plot

Plot number:___________________________________ Projection: GDA94 Zone: 54 / 55 / 56

Start Easting: _ _ _ _ _ _ _ Start Northing: _ _ _ _ _ _ _ _

Baseplot size: 50 x 20m Transect Bearing(°): _ _ _

EEC: Y / N Type: ______________________________ Photo: ☐ ________________________________

Keith Class:____

Regional Vegetation Community (RVC):____

Biometric Vegetation Type (optional):____

Notes of structure:____

General Comments/Seasonal condition:____

____

Baseplot (50 x 20m)

Number of native canopy species - mature:_______ - regenerating (dbh ≤ 5cm):______

Number of large Callitris (incl. dead trees) (≥ _____cm dbh): _________

Number of other large trees (incl. dead trees) (≥ _____cm dbh): _________

Number of trees with hollows – (incl. dead trees):_________

Length of dead fallen timber (diameter ≥ 10 cm and length ≥ 50 cm):_________________

Canopy health (% of expected canopy in good condition)______Reason: ______________________________

Canopy species (note order of dominance):____

____

Subplot (20 x 20m)

Number of native shrub and small tree species (>1m high):______________________________

Number of native groundcover species: ______________________________

2.5m radius around points along transect

Projected foliage cover (%)	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Native canopy										
Native midstorey >1m										
Weeds canopy & midstorey										

Quadrats (1 x 1m) along transect

Ground Cover %	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Native groundcover (plants <1m)										
Weeds (plants <1m)										
Mosses and lichens										
Organic litter										
Rock/bare ground										
Total (%)	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

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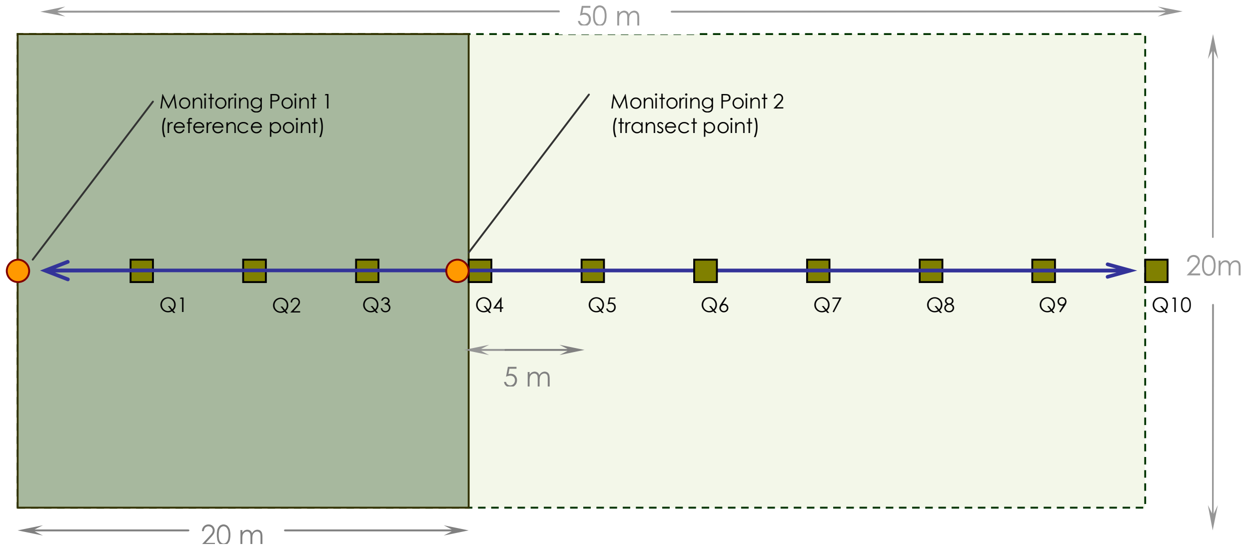
Proposed plot and sampling design for NCMA (based on ELA 2008)

Plot layout and dimensions:



Baseplot	Number of native canopy (tree) species Number of regenerating native canopy (tree) species Number of large trees & number of trees with hollows Canopy health (i.e. health of tree foliage) Canopy species Length of dead fallen timber (logs)
20 x 20m subplot	Number of native shrub and small tree species (> 1m high) Number of native groundcover species
50m transect	Native canopy (tree) cover Native midstorey (i.e. cover of native shrubs/small trees >1m) Weed canopy/midstorey cover (i.e. cover of weeds >1m)
1 x 1m quadrat	Native groundcover plants (< 1m) % cover Mosses and lichens % cover Weeds % cover Organic litter % cover Rock/bare ground % cover

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Sampling Steps

1. locate a reference point in the field using GPS, and record coordinates in GDA94
2. place a permanent marker (e.g. fibreglass post or star picket) at the start of the transect
3. take and record a bearing along the contour, or plot orientation for flat land
4. run a 50m tape out along the bearing, thus defining the transect and the plot position (10 m either side) place another permanent marker at the transect point, 20m along the transect
5. assign to the plot its Keith Class and Regional Vegetation Community (RVC) based on diagnostic canopy species and geographic location
6. enter benchmark large tree diameter at breast height (dbh) value(s) for the RVC (refer to large trees table below)
7. meandering back to the start point within the confines of the baseplot, record **number of mature native canopy species, number of regenerating native canopy species** (this could be more than the number of mature native canopy species), **number of large trees, number of trees with hollows, length of fallen dead timber (diameter ≥ 10 cm length ≥ 50 cm),** and estimate **canopy health** to the nearest 10% as the proportion of the expected healthy canopy cover that is present
8. record **canopy species** (including exotics) in order of abundance, and provide comments on structural characteristics of the vegetation (such as grassy or shrubby, woodland, forest or shrubland, and any other unusual features), and any other observations (such as seasonal conditions, feral animals, grazing).
9. take a photograph of the plot from the reference point, along the tape bearing (tape included in photo)
10. delineate a 20 x 20m subplot, starting at the reference point, and record **number of native shrub and small tree species > 1m high** (including mistletoes and epiphytes) and **number of native groundcover species**
11. starting at a point 5m from the reference point along the 50m transect, estimate **native canopy cover, native midstorey cover (>1m)** and **weed canopy and midstorey cover (> 1m)** within a 2.5m radius cylinder extending vertically upwards above the point - all cover scores to be measured as the proportion of sunlight prevented from reaching the ground by leaves and branches (i.e. projected foliage cover)
12. At 5m from the reference point along the 50m transect (point reached in step 11 above), delineate a 1x1m quadrat forward of the point and record the proportion of **native groundcover, moss/lichen cover, weed cover, organic litter cover** and **rock/bare ground cover** (not occupied by moss/lichen), each expressed as a percentage to the nearest 5%. The five individual scores should add up to 100%.
13. repeat steps 11 and 12 at each 5m point along the transect, until 10 recordings have been completed (the last will be at the end of the transect). Rewind tape**.**

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Large trees benchmarks

DBH benchmark for **white cypress pine** (*Callitris glaucophylla*) in any RVC is **40 cm**.
DBH benchmark for **black cypress pine** (*Callitris endicheri*) in any RVC is **30 cm**.
DBH benchmark for all other canopy species shown in the following table.

Regional Vegetation Community	Large Tree DBH
1. Giant Stinging Tree - Fig dry subtropical rainforest, mainly NSW North Coast	75
2. Rusty Fig - Wild Quince - Native Olive dry rainforest of rocky areas, Nandewar and New England Tablelands	40
3. Shatterwood - Giant Stinging Tree - Yellow Tulipwood dry rainforest, mainly NSW North Coast	45
4. Wilga - Western Rosewood shrubland, Darling Riverine Plains and Brigalow Belt South	30
5. Ooline forests, Brigalow Belt South and Nandewar	50
6. Semi-evergreen vine thicket of basalt hills, Brigalow Belt South and Nandewar	35
9. Messmate - gum moist forests of the escarpment ranges, eastern New England Tablelands and NSW North Coast	80
11. Silvertop Stringybark - Nandewar Box open forests in the Kaputar area, Nandewar	75
12. Snow Gum - Black Sallee grassy woodlands, New England Tablelands	45
13. Gum grassy woodlands, New England Tablelands	60
14. New England Peppermint grassy woodlands, New England Tablelands	55
15. Bendemeer White Gum grassy woodland, southern New England Tablelands	60
16. Box - gum grassy woodlands, New England Tablelands	70
17. Box - gum grassy woodlands, mainly Nandewar	70
18. White Box grassy woodland, Brigalow Belt South and Nandewar	70
19. White Cypress Pine - Silver-leaved Ironbark grassy woodland, Nandewar	55
20. Rough-barked Apple - Blakely's Red Gum riparian grassy woodlands, mainly Nandewar	70
21. Inland Grey Box tall grassy woodland on clay soils, Brigalow Belt South and Nandewar	70
22. Poplar Box - Belah woodlands, mainly Darling Riverine Plains and Brigalow Belt South	60
31. Broombush shrubland of the sand plains of the Pilliga region, Brigalow Belt South	30
32. Pilliga Box - Poplar Box- White Cypress Pine grassy open woodland on alluvial loams, Darling Riverine Plains and Brigalow Belt South	60
33. Ironbark shrubby woodlands of the Pilliga area, Brigalow Belt South	55
35. Mountain Gum - Snow Gum open forests, New England Tablelands and NSW North Coast	70
36. Stringybark - gum - peppermint open forests, eastern New England Tablelands	65
38. Silvertop Stringybark - gum open forest on basalts of the Liverpool Range, Brigalow Belt South and Nandewar	60
39. Silvertop Stringybark grassy open forests, eastern Nandewar and New England Tablelands	60
40. Stringybark - Blakely's Red Gum open forests, New England Tablelands	60
41. White Box - stringybark shrubby woodlands, Brigalow Belt South and Nandewar	60
44. White Box - pine - Silver-leaved Ironbark shrubby open forests, Nandewar	55
45. Stringybark - spinifex woodland, Nandewar	45
46. Mallee shrublands on granite and acid volcanic outcrops, eastern New England Tablelands	25
47. Narrow-leaved Peppermint - Wattle-leaved Peppermint open forest, eastern New England Tablelands	45

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Regional Vegetation Community	Large tree DBH
49. Black Cypress Pine - Orange Gum - Tumbledown Red Gum shrubby woodlands, Nandewar and western New England Tablelands	45
50. Stringybark - Blakely's Red Gum - Rough-barked Apple open forests, Nandewar and western New England Tablelands	60
51. New England Blackbutt - stringybark open forests, Nandewar and western New England Tablelands	55
52. Broad-leaved Stringybark - gum grassy open forests, central and eastern New England Tablelands	60
54. Black Cypress Pine shrubby woodlands, Brigalow Belt South	50
55. Black Cypress Pine - Narrow-leaved Stringybark heathy woodland, southern Brigalow Belt South	50
56. Ironbark - Brown Bloodwood - Black Cypress Pine heathy woodlands, Brigalow Belt South	50
57. Narrow-leaved Ironbark - pine - Brown Bloodwood shrub/grass open forest, Brigalow Belt South and Nandewar	55
58. Shrubby woodlands or mallee woodlands on stoney soils, Brigalow Belt South and Nandewar	40
59. Narrow-leaved Ironbark - pine - box woodlands and open forests, Brigalow Belt South and Nandewar	50
60. White Cypress Pine woodland on sandy loams of the wheatbelt plains, central NSW	40
61. Dirty Gum - pine - Smooth-barked Apple open forests, northern Brigalow Belt South and Nandewar	60
67. Eurah shrubland of inland floodplains, Darling Riverine Plains	35
68. Lignum - River Coobah shrublands on floodplains, Darling Riverine Plains and Brigalow Belt South	35
71. River Oak riparian woodland, eastern NSW	70
73. River Red Gum riverine woodlands and forests, Darling Riverine Plains, Brigalow Belt South and Nandewar	80
74. Yellow Box woodland on alluvial plains, mainly Darling Riverine Plains	70
75. Weeping Myall open woodland, Darling Riverine Plains, Brigalow Belt South and Nandewar	45
76. Coolibah - Poplar Box - Belah woodlands on floodplains, mainly Darling Riverine Plains and Brigalow Belt South	60
77. Black Box woodland on floodplains, mainly Darling Riverine Plains	60
78. Coolibah - River Coobah - Lignum woodland of frequently flooded channels, mainly Darling Riverine Plains	60
79. Brigalow - Belah woodland on alluvial clay soil, mainly Brigalow Belt South	45
80. Poplar Box grassy woodland on alluvial clay soils, Brigalow Belt South	60
81. Leopardwood woodland of alluvial plains, Darling Riverine Plains and Brigalow Belt South	40
82. Poplar Box low woodlands, western NSW	60
84. Whitewood open woodland, mainly eastern Darling Riverine Plains	35
85. Carbeen woodland on alluvial soils, Darling Riverine Plains and Brigalow Belt South	55
86. Dirty Gum tall woodland on sand monkeys, Darling Riverine Plains and Brigalow Belt South	50
87. Silver-leaved Ironbark - White Cypress Pine on alluvial sandy loam, Darling Riverine Plains	50
92. Mugga Ironbark shrubby open forests, Nandewar and western New England Tablelands	75
93. Mugga Ironbark open forest, New England Tablelands	75
96. Blakely's Red Gum riparian woodland of the Pilliga	70

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Appendix II. Average Landscape Scores for Rivers and Streams in the Namoi Catchment

CHANNEL NAME	No RAUs	LANDSCAPE SCORE	LANDSCAPE CONDITION
ALGONA CREEK	1	42.8	Average
ALICKS SWAMP CREEK	1	31.9	Poor
ANEMBO CREEK	1	38.4	Poor
ATTUNGA CREEK	11	56.0	Average
BACK 2 CREEK	1	48.9	Average
BACK CREEK	16	47.0	Average
BALD CREEK	2	33.8	Poor
BALD HILL GULLY	2	27.1	Poor
BARA CREEK	8	57.2	Average
BARADINE CREEK	31	69.8	Good
BARBERS LAGN	3	35.6	Poor
BAROKA/YARRA CREEK	1	38.7	Poor
BARRABA CREEK	3	40.0	Average
BARWON RIVER	8	52.2	Average
BASIN CREEK	2	51.4	Average
BENAMA CREEK	3	41.0	Average
BIBBLA CREEK	8	57.4	Average
BIBBLEWINDI CREEK	5	76.5	Good
BIG JACKS CREEK	10	17.4	Very poor
BILLY CREEK	1	79.6	Good
BLACK GULLY	2	39.2	Poor
BLACK MOUNTAIN CREEK	3	51.7	Average
BLACK RIDGE GULLY	1	76.5	Good
BLACK SPRINGS CREEK	1	62.9	Good
BOBBIWAA CREEK	9	59.9	Average
BOGGABRI CREEK	1	39.5	Poor
BOHENA CREEK	8	73.7	Good
BOILING DOWN CREEK	2	41.7	Average
BOILING SWAMP CREEK	1	55.3	Average
BOLLERS GULLY	1	53.7	Average
BOLLOL CREEK	8	41.6	Average
BOMERA CREEK	7	56.9	Average
BORAH CREEK	9	60.0	Good
BORAMBIL CREEK	6	39.2	Poor
BOUNDARY CREEK	2	65.0	Good
BRADYS PLAIN	1	26.9	Poor
BRANCH CREEK	1	54.4	Average
BRANDY SPRING	1	89.9	Excellent
BRANGA SWAMP	1	43.6	Average
BRICK WALL CREEK	1	36.3	Poor
BRIGALOW CREEK	7	68.7	Good
BROWNS SPRINGS CREEK	1	28.3	Poor
BROWNS SPRINGS GULLY	1	27.1	Poor

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CHANNEL NAME	No RAUs	LANDSCAPE SCORE	LANDSCAPE CONDITION
BUGALDIE CREEK	9	53.0	Average
BULLAWA CREEK	9	80.8	Excellent
BULLERAWA CREEK	6	67.8	Good
BUNDELLA CREEK	8	40.5	Average
BUNDOCK CREEK	10	56.8	Average
BUNGENDORE CREEK	6	79.4	Good
BURNT YARD CREEK	1	81.6	Excellent
BURREN CREEK	2	42.0	Average
BURROWS CREEK	4	54.4	Average
CALCHEMBOY CREEK	1	90.7	Excellent
CALLAGHANS CREEK	2	53.6	Average
CAMPBELLS CREEK	1	81.3	Excellent
CAMPBELLS GULLY	3	38.3	Poor
CANNS CREEK	2	36.4	Poor
CARLISLES GULLY	7	45.5	Average
CATONG GULLY	2	20.0	Poor
CATTLE CREEK	4	48.0	Average
CAUBORN CREEK	4	53.6	Average
CHAIN OF PONDS CREEK	2	48.0	Average
CHILCOTTS CREEK	8	53.6	Average
CHIMNEY SWAMP CREEK	1	27.3	Poor
CHINAMANS CREEK	5	39.5	Poor
CLARKES CREEK	1	41.1	Average
CLAY CREEK	3	20.7	Poor
CLAY WATER HOLE GULLY	2	15.7	Very poor
COBRABALD RIVER	9	37.0	Poor
COCKBURN RIVER	5	47.9	Average
COGHILL CREEK	8	85.6	Excellent
COGHLANS CREEK	2	69.0	Good
COLD ROCK CREEK	2	87.8	Excellent
COLLYGRA CREEK	2	24.1	Poor
CONGI CREEK	3	34.4	Poor
CONNORS CREEK	7	53.6	Average
COOCOOBOONAH CREEK	1	23.3	Poor
COOLAH CREEK	2	76.4	Good
COOLANGLA CREEK	2	80.1	Excellent
COOLIBAH WTCS	3	26.6	Poor
COOMOO COOMOO CREEK	4	27.1	Poor
COOMORE CREEK	3	91.1	Excellent
COPES CREEK	2	44.2	Average
CORYS CAMP CREEK	1	33.2	Poor
COWALLAH CREEK	3	81.0	Excellent
COXS CREEK	10	34.6	Poor
CROW MOUNTAIN CREEK	6	46.2	Average
CUBBAROO WRBL	6	42.9	Average
CUMBERDOON WRBL	3	32.0	Poor

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CHANNEL NAME	No RAUs	LANDSCAPE SCORE	LANDSCAPE CONDITION
CURRABUBULA CREEK	10	37.1	Poor
DAM - PINE CREEK	1	36.3	Poor
DAM - TRIBUTARY OF BLACK GULLY	1	26.5	Poor
DAM - WARRABAH CREEK	1	33.8	Poor
DAM GULLY	1	32.2	Poor
DANDRY CREEK	5	86.4	Excellent
DEAD BULLOCK WRBL	1	31.2	Poor
DEADMANS GULLY	2	24.8	Poor
DEANS MOUNTAIN CREEK	1	20.2	Poor
DEEP CREEK	1	91.1	Excellent
DERIAH CREEK	1	33.7	Poor
DONNELLYS SPRINGS CREEK	1	12.4	Very poor
DRIGGLE DRAGGLE CREEK	6	32.5	Poor
DRILDOOL WRBL	4	29.5	Poor
DRY CREEK	3	47.7	Average
DRY GULLY	1	34.9	Poor
DUCK GULLY	1	34.5	Poor
DUNCAN WRBL	1	67.7	Good
DUNCANS CREEK	7	47.5	Average
DUNDUCKELY CREEK	1	37.5	Poor
DUNGOWAN CREEK	10	66.9	Good
DUNNADIE CREEK	1	31.1	Poor
ETOO CREEK	13	77.1	Good
EULAH CREEK	6	75.0	Good
EUMUR CREEK	5	52.7	Average
FAIRY GROUND CREEK	1	70.9	Good
FIVE MILE CREEK	1	37.9	Poor
FLOOD CHANNEL OF BARWON RIVER	1	50.9	Average
FLOODOUT OF BORAMBIL CREEK	1	22.8	Poor
GANANNY CREEK	5	25.4	Poor
GAOL CREEK	2	65.8	Good
GAP CREEK	1	83.8	Excellent
GARRAWILLA CREEK	7	39.1	Poor
GEORGES GULLY	2	68.2	Good
GIANTS DEN CREEK	2	79.0	Good
GIBSONS ROCKY GULLY	1	36.6	Poor
GIL GIL CREEK	1	37.9	Poor
GILLS OAKY CREEK	1	83.0	Excellent
GOAT ISLAND CREEK	1	62.1	Good
GOONA CREEK	3	90.5	Excellent
GOONBRI CREEK	2	51.4	Average
GOONOO GOONOO CREEK	8	33.8	Poor
GORAN SWAMP	1	2.5	Very poor
GOSPARD CREEK	1	58.4	Average
GREENHATCH CREEK	6	34.3	Poor
GUNIDGERA CREEK	2	56.2	Average

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CHANNEL NAME	No RAUs	LANDSCAPE SCORE	LANDSCAPE CONDITION
GWABEGAR CREEK	3	34.0	Poor
HALLALINGA CREEK	1	43.6	Average
HALLS CREEK	12	53.0	Average
HARRISS CREEK	1	91.0	Excellent
HAWKINS CREEK	2	44.5	Average
HEIFER CREEK	2	15.8	Very poor
HELLOO CREEK	2	38.9	Poor
HLAROOO CREEK	2	73.2	Good
HORSEARM CREEK	15	49.0	Average
HORSEARM/MULGATE	2	33.0	Poor
HYDES CREEK	1	34.0	Poor
INGLEBA CREEK	7	42.5	Average
IRELAND CREEK	1	71.9	Good
IRONBARK CREEK	18	65.2	Good
JACKS CREEK	5	74.0	Good
JACOB AND JOSEPH CREEK	5	34.7	Poor
JAMIESONS CREEK	5	47.6	Average
JANEWINDI CREEK	1	90.7	Excellent
JERICHO CREEK	1	26.7	Poor
JOHNSTON OAK CREEK	2	65.0	Good
JUNCTION CREEK	2	56.9	Average
KANGAROO CREEK	5	43.2	Average
KEEPIT CREEK	1	44.0	Average
KICKERBELL CREEK	2	6.6	Very poor
KURRAJONG CREEK	3	37.6	Poor
LAKE GORAN	1	30.2	Poor
LARRYS CREEK	1	44.4	Average
LEVER CREEK	2	90.9	Excellent
LEVER GULLY	1	15.5	Very poor
LIMESTONE GULLY	1	21.0	Poor
LITTLE CREEK	5	55.8	Average
LITTLE GORAGILLA CREEK	1	56.6	Average
LITTLE OAKEY CREEK	1	55.2	Average
LITTLE OAKY CREEK	1	64.5	Good
LONG SWAMP CREEK	5	61.8	Good
LOOANGA CREEK	1	43.4	Average
MACDONALD RIVER	25	44.3	Average
MACDONALDS CREEK	5	18.5	Very poor
MACQUARIE RIVER	3	53.1	Average
MACQUARIE RIVER CHANNELS	3	43.1	Average
MANILLA RIVER	11	33.7	Poor
MAULES CREEK	15	62.7	Good
MENEDEBRI CREEK	1	32.2	Poor
MERRIWEE CREEK	4	52.5	Average
MIDDLE CREEK	7	60.2	Good
MIDDLEBROOK CREEK	7	37.6	Poor

CHANNEL NAME	No RAUs	LANDSCAPE SCORE	LANDSCAPE CONDITION
MIHI CREEK	5	79.1	Good
MILLE CREEK	5	38.5	Poor
MILLERS CREEK	7	20.2	Poor
MITCHELLS CREEK	3	41.7	Average
MOLLEE CREEK	6	43.7	Average
MOLLIEROI CREEK	5	90.4	Excellent
MONKEY CREEK	1	75.7	Good
MOOKI RIVER	10	20.9	Poor
MOONBI CREEK	1	27.3	Poor
MOORE CREEK	9	57.9	Average
MOUNT LOWRY CREEK	2	84.6	Excellent
MOUNTAIN CREEK	1	15.4	Very poor
MULGATE CREEK	2	52.0	Average
MULLA MULLA CREEK	8	66.7	Good
MYALL CAMP WRBL	6	53.8	Average
NAMOI RIVER	34	49.7	Average
NANGAHRAH CREEK	7	58.7	Average
NARRABRI CREEK	2	43.7	Average
NATIVE CAT CREEK	1	16.4	Very poor
NATIVE DOG GULLY	2	14.0	Very poor
NEW ENGLAND CREEK	6	57.0	Average
NOMBI CREEK	1	34.3	Poor
NUNDLE CREEK	2	34.2	Poor
OAKEY CREEK	2	81.9	Excellent
OAKY CREEK	26	52.3	Average
OAKY CREEK 2	1	66.7	Good
OAKY CREEK 3	1	76.4	Good
OAKY CREEK 4	1	78.7	Good
OLD MAN GULLY	1	51.9	Average
OMALEAH CREEK	5	26.4	Poor
ORPHANTS WELL CREEK	3	25.1	Poor
PAGAN CREEK	1	48.0	Average
PALING YARD CREEK	2	45.1	Average
PEACH TREE GULLY	4	23.8	Poor
PEEL RIVER	18	44.0	Average
PHILLIPS CREEK	4	32.6	Poor
PIALLAMORE CREEK	1	11.5	Very poor
PIAN CREEK	17	49.2	Average
PIAN CREEK FLOODOUT CHAN	3	56.4	Average
PILLIGA LAGOON CREEK	1	43.3	Average
PINE CREEK	2	45.9	Average
PINNACLE CREEK	4	50.0	Average
PIPECLAY GULLY	1	39.9	Poor
PRINGLES ROCKY CREEK	4	38.9	Poor
PUMP STATION CREEK	1	68.0	Good
QUACKANACKA GULLY	1	14.0	Very poor

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CHANNEL NAME	No RAUs	LANDSCAPE SCORE	LANDSCAPE CONDITION
QUEGOBLA CREEK	2	36.5	Poor
QUIPOLLY CREEK	13	50.9	Average
QUIRINDI CREEK	15	35.7	Poor
RANGIRA CREEK	14	30.7	Poor
RED BOBS CREEK	2	20.5	Poor
REEDY CREEK	6	39.5	Poor
Reservoir	1	20.3	Poor
ROCK WELL CREEK	1	9.8	Very poor
ROCKY CREEK	11	90.3	Excellent
ROCKY GULLY	2	40.8	Average
ROSE VALLEY CREEK	3	40.0	Average
RUNNING CREEK	1	38.1	Poor
SALTWATER CREEK	3	53.2	Average
SANDY CREEK	12	46.2	Average
SANDY CREEK 2	1	85.5	Excellent
SAVEALL CREEK	7	76.8	Good
SAWPIT CREEK	2	69.6	Good
SAWYERS CREEK	1	34.2	Poor
SEVEN MILE CREEK	1	45.1	Average
SHEARINS CREEK	3	81.5	Excellent
SHEEP STATION SK	1	58.1	Average
SHEEPSTATION CREEK	1	45.0	Average
SHINGLE HUT CREEK	2	50.9	Average
SHORTELLS CREEK	1	91.3	Excellent
SMITHS CREEK	5	41.5	Average
SOUTH HEAD CREEK	2	90.2	Excellent
SPITZBERGEN CREEK	2	37.4	Poor
SPRING CREEK	36	55.4	Average
SPRING CREEK 2	5	49.3	Average
SPRING CREEK 3	1	46.8	Average
SPRING GULLY	1	31.5	Poor
STATION CREEK	2	56.5	Average
STOCKYARD CREEK	1	64.7	Good
STONY CREEK	3	54.1	Average
SUGARLOAF CREEK	4	41.1	Average
SURVEYORS CREEK	6	42.3	Average
SWAINS CREEK	4	28.0	Poor
SWAMP CREEK	5	31.2	Poor
SWAMP OAK CREEK	13	66.4	Good
TALLUBA CREEK	17	77.0	Good
TAMATIE CREEK	1	34.7	Poor
TANGARATTA CREEK	4	19.1	Very poor
TAREELA CREEK	2	60.8	Good
TARPOLY CREEK	4	48.8	Average
TEATREE CREEK	5	38.8	Poor
TERRIBLE BILLY CREEK	2	89.0	Excellent

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CHANNEL NAME	No RAUs	LANDSCAPE SCORE	LANDSCAPE CONDITION
THE HORSE ARM CREEK	2	67.5	Good
THREE MILE CREEK	3	36.8	Poor
TIMBUMBURI CREEK	3	28.7	Poor
TIMMALLALLIE CREEK	1	88.4	Excellent
TINEGIE CREEK	1	86.0	Excellent
TRIBUTARY 2 OF BARADINE CREEK	1	74.5	Good
TRIBUTARY 2 OF CHAIN OF PONDS CREEK	1	57.3	Average
TRIBUTARY 2 OF DUNGOWAN CREEK	1	39.2	Poor
TRIBUTARY 2 OF HALLS CREEK	1	47.1	Average
TRIBUTARY 2 OF INGLEBA CREEK	1	33.9	Poor
TRIBUTARY 2 OF MACDONALD RIVER	1	32.5	Poor
TRIBUTARY 2 OF MOOKI RIVER	1	36.1	Poor
TRIBUTARY 2 OF MULLA MULLA CREEK	1	56.9	Average
TRIBUTARY 2 OF NAMOI RIVER	2	75.3	Good
TRIBUTARY 2 OF NEW ENGLAND CREEK	1	49.3	Average
TRIBUTARY 2 OF PEEL RIVER	2	49.0	Average
TRIBUTARY 2 OF SWAMP OAK CREEK	1	62.4	Good
TRIBUTARY 3 OF DUNGOWAN CREEK	1	29.6	Poor
TRIBUTARY 3 OF MACDONALD RIVER	1	31.2	Poor
TRIBUTARY 3 OF MULLA MULLA CREEK	1	67.0	Good
TRIBUTARY 3 OF PEEL RIVER	1	30.5	Poor
TRIBUTARY 4 OF PEEL RIVER	1	34.4	Poor
TRIBUTARY OF BARADINE CREEK	1	91.7	Excellent
TRIBUTARY OF BIBBLEWINDI CREEK	1	86.3	Excellent
TRIBUTARY OF BLACK GULLY	2	32.0	Poor
TRIBUTARY OF BORAH CREEK	1	57.3	Average
TRIBUTARY OF BRIGALOW CREEK	1	64.5	Good
TRIBUTARY OF CARLISLES GULLY	1	25.8	Poor
TRIBUTARY OF CHAIN OF PONDS CREEK	1	64.6	Good
TRIBUTARY OF COBRABALD RIVER	1	36.4	Poor
TRIBUTARY OF COCKBURN RIVER	1	38.7	Poor
TRIBUTARY OF CONGI CREEK	1	30.6	Poor
TRIBUTARY OF CONNORS CREEK	1	42.1	Average
TRIBUTARY OF COXS CREEK	1	29.5	Poor
TRIBUTARY OF DANDRY CREEK	1	81.0	Excellent
TRIBUTARY OF DUNGOWAN CREEK	1	40.8	Average
TRIBUTARY OF ETOO CREEK	1	90.2	Excellent
TRIBUTARY OF GWABEGAR CREEK	2	33.3	Poor
TRIBUTARY OF HALLS CREEK	1	48.5	Average
TRIBUTARY OF HAWKINS CREEK	1	42.3	Average
TRIBUTARY OF HELLOO CREEK	1	45.0	Average
TRIBUTARY OF INGLEBA CREEK	1	30.8	Poor
TRIBUTARY OF IRONBARK CREEK	1	72.0	Good
TRIBUTARY OF JACOB AND JOSEPH CREEK	1	24.2	Poor
TRIBUTARY OF JAMIESONS CREEK	1	39.5	Poor
TRIBUTARY OF JOHNSTON OAK CREEK	1	86.7	Excellent

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CHANNEL NAME	No RAUs	LANDSCAPE SCORE	LANDSCAPE CONDITION
TRIBUTARY OF LONG SWAMP CREEK	1	70.1	Good
TRIBUTARY OF MACDONALD RIVER	2	47.3	Average
TRIBUTARY OF MANILLA RIVER	1	42.1	Average
TRIBUTARY OF MIDDLEBROOK CREEK	1	38.0	Poor
TRIBUTARY OF MOOKI RIVER	2	33.5	Poor
TRIBUTARY OF MOONBI CREEK	1	49.2	Average
TRIBUTARY OF MULLA MULLA CREEK	1	59.9	Average
TRIBUTARY OF NAMOI RIVER	4	44.7	Average
TRIBUTARY OF NATIVE DOG GULLY	2	20.5	Poor
TRIBUTARY OF NEW ENGLAND CREEK	2	65.0	Good
TRIBUTARY OF NUNDLE CREEK	1	53.4	Average
TRIBUTARY OF PEEL RIVER	2	34.0	Poor
TRIBUTARY OF PINNACLE CREEK	1	27.4	Poor
TRIBUTARY OF QUIPOLLY CREEK	1	34.3	Poor
TRIBUTARY OF ROCKY GULLY	1	47.9	Average
TRIBUTARY OF SHEARINS CREEK	1	74.2	Good
TRIBUTARY OF SOUTH HEAD CREEK	1	88.7	Excellent
TRIBUTARY OF SPITZBERGEN CREEK	3	43.7	Average
TRIBUTARY OF SWAMP OAK CREEK	1	39.9	Poor
TRIBUTARY OF TALLUBA CREEK	1	91.5	Excellent
TRIBUTARY OF WARRAH CREEK	1	15.2	Very poor
TRIBUTARY OF WERRIS CREEK	2	14.3	Very poor
TRIBUTARY OF WITTENBRA CREEK	1	78.0	Good
TRIBUTARY OF WOMERA CREEK	2	37.0	Poor
TRIBUTARY OF YARRAMANBULLY CREEK	1	40.0	Average
TRIBUTARY OF YEARINAN CREEK	1	37.2	Poor
TROUGH CREEK	1	78.2	Good
TULLA MULLEN CREEK	7	41.1	Average
TURRAGULLA CREEK	4	44.0	Average
TURRAGULLA CREEK 2	1	84.6	Excellent
TURRAGULLA CREEK 3	1	57.1	Average
TWO MILE WRBL	1	31.5	Poor
WANOURIE CREEK	1	40.9	Average
WARDENS BROOK	1	42.0	Average
WARRABAH CREEK	10	65.2	Good
WARRAH CREEK	14	21.4	Poor
WARRIMOO CREEK	1	50.1	Average
WASHPEN CREEK	4	40.0	Average
WASHPOOL CREEK	1	62.0	Good
WATSONS CREEK	3	68.5	Good
WEE WAA GULLY	1	41.1	Average
WELLYARD GULLY	1	93.3	Excellent
WELSHS CREEK	2	69.8	Good
WERAH CREEK	4	73.9	Good
WERRIS CREEK	8	27.4	Poor
WHITES CREEK	2	10.4	Very poor

CHANNEL NAME	No RAUs	LANDSCAPE SCORE	LANDSCAPE CONDITION
WILES GULLY	2	48.9	Average
WILLOW TREE CREEK	1	85.4	Excellent
WISEMANS ARM CREEK	1	46.7	Average
WITTENBRA CREEK	3	89.3	Excellent
WOMAT CREEK	1	37.8	Poor
WOMBRAMURRA CREEK	4	49.2	Average
WOMERA CREEK	3	40.3	Average
WONGO CREEK	3	35.6	Poor
WOODLEYS CREEK	1	60.0	Good
YAMINBA CREEK	9	76.7	Good
YARRAMAN CREEK	8	36.5	Poor
YARRAMANBAH CREEK	5	21.0	Poor
YARRAMANBULLY CREEK	3	43.8	Average
YEARINAN CREEK	5	65.0	Good
YELLOW GULLY	2	30.6	Poor
YELLOW ROCK CREEK	3	46.5	Average
YELLOW WOMAN CREEK	1	30.2	Poor
YORRAN CREEK	1	41.0	Average

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Appendix III. Benchmark Data for RVCs Sampled in the Namoi Catchment.

(note: benchmarks for canopy health and weed canopy/midstorey = 100% and 0%, respectively, for all forest and woodland RVCs benchmark for weed groundcover = 0% for all RVCs)

RVC 9. Messmate - gum moist forests of the escarpment ranges, eastern New England Tablelands and NSW North Coast

Ecological Attribute	Benchmark
Native species richness (canopy)	3
Native species richness (midstorey)	8
Native species richness (groundcover)	30
Native canopy cover (%)	35
Native midstorey (shrub) cover (%)	20
Native groundcover (%)	60
Mosses/lichen cover (%)	5
Organic litter cover (%)	25
Rock/bare ground cover (%)	10
Number of large trees (benchmark dbh)	3 (80 cm)
Number of trees with hollows	3
Number of canopy species regenerating	2
Coarse woody debris	50

RVC 13. Gum grassy woodlands, New England Tablelands

Ecological Attribute	Benchmark
Native species richness (canopy)	3
Native species richness (midstorey)	3
Native species richness (groundcover)	30
Native canopy cover (%)	15
Native midstorey (shrub) cover (%)	5
Native groundcover (%)	60
Mosses/lichen cover (%)	0
Organic litter cover (%)	20
Rock/bare ground cover (%)	20
Number of large trees (benchmark dbh)	3 (60 cm)
Number of trees with hollows	2
Number of canopy species regenerating	3
Coarse woody debris	30

RVC 14. New England Peppermint grassy woodlands, New England Tablelands

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	4
Native species richness (groundcover)	30
Native canopy cover (%)	20
Native midstorey (shrub) cover (%)	10
Native groundcover (%)	50
Mosses/lichen cover (%)	10
Organic litter cover (%)	20
Rock/bare ground cover (%)	20
Number of large trees (benchmark dbh)	3 (55 cm)
Number of trees with hollows	2
Number of canopy species regenerating	2
Coarse woody debris	30

RVC 16. Box - gum grassy woodlands, New England Tablelands

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	2
Native species richness (groundcover)	30
Native canopy cover (%)	20
Native midstorey (shrub) cover (%)	5
Native groundcover (%)	50
Mosses/lichen cover (%)	5
Organic litter cover (%)	30
Rock/bare ground cover (%)	15
Number of large trees (benchmark dbh)	4 (70 cm)
Number of trees with hollows	5
Number of canopy species regenerating	2
Coarse woody debris	30

RVC 17. Box - gum grassy woodlands, mainly Nandewar

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	2
Native species richness (groundcover)	25
Native canopy cover (%)	15
Native midstorey (shrub) cover (%)	5
Native groundcover (%)	50
Mosses/lichen cover (%)	5
Organic litter cover (%)	30
Rock/bare ground cover (%)	15
Number of large trees (benchmark dbh)	3 (55 cm)
Number of trees with hollows	4
Number of canopy species regenerating	2
Coarse woody debris	30

RVC 18. White Box grassy woodland, Brigalow Belt South and Nandewar

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	2
Native species richness (groundcover)	35
Native canopy cover (%)	20
Native midstorey (shrub) cover (%)	5
Native groundcover (%)	50
Mosses/lichen cover (%)	5
Organic litter cover (%)	30
Rock/bare ground cover (%)	15
Number of large trees (benchmark dbh)	5 (70 cm)
Number of large *Callitris* trees (benchmark dbh)	1 (40 cm)
Number of trees with hollows	6
Number of canopy species regenerating	2
Coarse woody debris	40

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RVC 20. Rough-barked Apple - Blakely's Red Gum riparian grassy woodlands, mainly Nandewar

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	3
Native species richness (groundcover)	20
Native canopy cover (%)	30
Native midstorey (shrub) cover (%)	10
Native groundcover (%)	55
Mosses/lichen cover (%)	0
Organic litter cover (%)	25
Rock/bare ground cover (%)	20
Number of large trees (benchmark dbh)	5 (70 cm)
Number of trees with hollows	4
Number of canopy species regenerating	3
Coarse woody debris	40

RVC 21. Inland Grey Box tall grassy woodland on clay soils, BBS and Nandewar

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	2
Native species richness (groundcover)	25
Native canopy cover (%)	15
Native midstorey (shrub) cover (%)	5
Native groundcover (%)	50
Mosses/lichen cover (%)	0
Organic litter cover (%)	30
Rock/bare ground cover (%)	20
Number of large trees (benchmark dbh)	4 (70 cm)
Number of trees with hollows	4
Number of canopy species regenerating	1
Coarse woody debris	20

RVC 26. Dry grasslands of alluvial plains, Darling Riverine Plains and Brigalow Belt South

Ecological Attribute	Benchmark
Native species richness (canopy)	0
Native species richness (midstorey)	0
Native species richness (groundcover)	20
Native canopy cover (%)	0
Native midstorey (shrub) cover (%)	0
Native groundcover (%)	50
Mosses/lichen cover (%)	0
Organic litter cover (%)	30
Rock/bare ground cover (%)	20
Number of large trees (benchmark dbh)	0
Number of trees with hollows	0
Number of canopy species regenerating	0
Coarse woody debris	0

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RVC 29. Plains Grass - Blue Grass grasslands, Brigalow Belt South and Nandewar

Ecological Attribute	Benchmark
Native species richness (canopy)	0
Native species richness (midstorey)	0
Native species richness (groundcover)	20
Native canopy cover (%)	0
Native midstorey (shrub) cover (%)	0
Native groundcover (%)	60
Mosses/lichen cover (%)	0
Organic litter cover (%)	25
Rock/bare ground cover (%)	15
Number of large trees (benchmark dbh)	0
Number of trees with hollows	0
Number of canopy species regenerating	0
Coarse woody debris	0

RVC 32. Pilliga Box - Poplar Box- White Cypress Pine grassy open woodland on alluvial loams, Darling Riverine Plains and Brigalow Belt South

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	4
Native species richness (groundcover)	25
Native canopy cover (%)	25
Native midstorey (shrub) cover (%)	10
Native groundcover (%)	45
Mosses/lichen cover (%)	5
Organic litter cover (%)	20
Rock/bare ground cover (%)	30
Number of large trees (benchmark dbh)	2 (60 cm)
Number of large *Callitris* trees (benchmark dbh)	3 (40 cm)
Number of trees with hollows	2
Number of canopy species regenerating	2
Coarse woody debris	30

RVC 36. Stringybark - gum - peppermint open forests, eastern New England Tablelands

Ecological Attribute	Benchmark
Native species richness (canopy)	3
Native species richness (midstorey)	6
Native species richness (groundcover)	30
Native canopy cover (%)	30
Native midstorey (shrub) cover (%)	15
Native groundcover (%)	50
Mosses/lichen cover (%)	10
Organic litter cover (%)	20
Rock/bare ground cover (%)	20
Number of large trees (benchmark dbh)	3 (65 cm)
Number of trees with hollows	3
Number of canopy species regenerating	2
Coarse woody debris	30

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RVC 44. White Box - pine - Silver-leaved Ironbark shrubby open forests, Nandewar

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	5
Native species richness (groundcover)	25
Native canopy cover (%)	30
Native midstorey (shrub) cover (%)	25
Native groundcover (%)	30
Mosses/lichen cover (%)	5
Organic litter cover (%)	25
Rock/bare ground cover (%)	40
Number of large trees (benchmark dbh)	3 (55 cm)
Number of large *Callitris* trees (benchmark dbh)	1 (40 cm)
Number of trees with hollows	3
Number of canopy species regenerating	2
Coarse woody debris	40

RVC 64. Fens and wet heaths, Nandewar and New England Tablelands

Ecological Attribute	Benchmark
Native species richness (canopy)	0
Native species richness (midstorey)	1
Native species richness (groundcover)	15
Native canopy cover (%)	0
Native midstorey (shrub) cover (%)	5
Native groundcover (%)	50
Mosses/lichen cover (%)	15
Organic litter cover (%)	10
Rock/bare ground cover (%)	25
Number of large trees (benchmark dbh)	0
Number of trees with hollows	0
Number of canopy species regenerating	0
Coarse woody debris	0

RVC 67. Eurah shrubland of inland floodplains, Darling Riverine Plains

Ecological Attribute	Benchmark
Native species richness (canopy)	1
Native species richness (midstorey)	6
Native species richness (groundcover)	20
Native canopy cover (%)	20
Native midstorey (shrub) cover (%)	10
Native groundcover (%)	20
Mosses/lichen cover (%)	20
Organic litter cover (%)	20
Rock/bare ground cover (%)	40
Number of large trees (benchmark dbh)	6 (35 cm)
Number of trees with hollows	0
Number of canopy species regenerating	1
Coarse woody debris	10

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RVC 68. Lignum - River Coobah shrublands on floodplains, Darling Riverine Plains and Brigalow Belt South

Ecological Attribute	Benchmark
Native species richness (canopy)	1
Native species richness (midstorey)	3
Native species richness (groundcover)	15
Native canopy cover (%)	25
Native midstorey (shrub) cover (%)	30
Native groundcover (%)	35
Mosses/lichen cover (%)	0
Organic litter cover (%)	25
Rock/bare ground cover (%)	40
Number of large trees (benchmark dbh)	3 (60 cm)
Number of trees with hollows	1
Number of canopy species regenerating	1
Coarse woody debris	20

RVC 70. Wetlands and marshes, inland NSW

Ecological Attribute	Benchmark
Native species richness (canopy)	0
Native species richness (midstorey)	0
Native species richness (groundcover)	15
Native canopy cover (%)	0
Native midstorey (shrub) cover (%)	0
Native groundcover (%)	50
Mosses/lichen cover (%)	0
Organic litter cover (%)	30
Rock/bare ground cover (%)	20
Number of large trees (benchmark dbh)	0
Number of trees with hollows	0
Number of canopy species regenerating	0
Coarse woody debris	0

RVC 71. River Oak riparian woodland, eastern NSW

Ecological Attribute	Benchmark
Native species richness (canopy)	1
Native species richness (midstorey)	2
Native species richness (groundcover)	20
Native canopy cover (%)	35
Native midstorey (shrub) cover (%)	5
Native groundcover (%)	35
Mosses/lichen cover (%)	5
Organic litter cover (%)	25
Rock/bare ground cover (%)	35
Number of large trees (benchmark dbh)	4 (70 cm)
Number of trees with hollows	3
Number of canopy species regenerating	1
Coarse woody debris	50

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RVC 72. Bracteate Honey Myrtle riparian shrubland, Brigalow Belt South

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	3
Native species richness (groundcover)	15
Native canopy cover (%)	50
Native midstorey (shrub) cover (%)	10
Native groundcover (%)	50
Mosses/lichen cover (%)	0
Organic litter cover (%)	20
Rock/bare ground cover (%)	30
Number of large trees (benchmark dbh)	4 (40 cm)
Number of trees with hollows	0
Number of canopy species regenerating	2
Coarse woody debris	50

RVC 73. River Red Gum riverine woodlands and forests, Darling Riverine Plains, Brigalow Belt South and Nandewar

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	3
Native species richness (groundcover)	20
Native canopy cover (%)	25
Native midstorey (shrub) cover (%)	10
Native groundcover (%)	35
Mosses/lichen cover (%)	0
Organic litter cover (%)	35
Rock/bare ground cover (%)	30
Number of large trees (benchmark dbh)	5 (80 cm)
Number of trees with hollows	7
Number of canopy species regenerating	2
Coarse woody debris	70

RVC 74. Yellow Box woodland on alluvial plains, mainly Darling Riverine Plains

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	3
Native species richness (groundcover)	12
Native canopy cover (%)	20
Native midstorey (shrub) cover (%)	5
Native groundcover (%)	40
Mosses/lichen cover (%)	10
Organic litter cover (%)	25
Rock/bare ground cover (%)	25
Number of large trees (benchmark dbh)	3 (70 cm)
Number of trees with hollows	2
Number of canopy species regenerating	2
Coarse woody debris	30

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RVC 75. Weeping Myall open woodland, Darling Riverine Plains, BBS and Nandewar

Ecological Attribute	Benchmark
Native species richness (canopy)	1
Native species richness (midstorey)	2
Native species richness (groundcover)	17
Native canopy cover (%)	30
Native midstorey (shrub) cover (%)	5
Native groundcover (%)	50
Mosses/lichen cover (%)	0
Organic litter cover (%)	30
Rock/bare ground cover (%)	20
Number of large trees (benchmark dbh)	3 (45 cm)
Number of trees with hollows	1
Number of canopy species regenerating	1
Coarse woody debris	10

RVC 76. Coolibah - Poplar Box - Belah woodlands on floodplains, mainly Darling Riverine Plains and Brigalow Belt South

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	2
Native species richness (groundcover)	25
Native canopy cover (%)	15
Native midstorey (shrub) cover (%)	5
Native groundcover (%)	40
Mosses/lichen cover (%)	0
Organic litter cover (%)	25
Rock/bare ground cover (%)	35
Number of large trees (benchmark dbh)	4 (60 cm)
Number of trees with hollows	6
Number of canopy species regenerating	1
Coarse woody debris	20

RVC 77. Black Box woodland on floodplains, mainly Darling Riverine Plains

Ecological Attribute	Benchmark
Native species richness (canopy)	1
Native species richness (midstorey)	2
Native species richness (groundcover)	20
Native canopy cover (%)	15
Native midstorey (shrub) cover (%)	5
Native groundcover (%)	40
Mosses/lichen cover (%)	5
Organic litter cover (%)	25
Rock/bare ground cover (%)	30
Number of large trees (benchmark dbh)	3 (60 cm)
Number of trees with hollows	4
Number of canopy species regenerating	1
Coarse woody debris	20

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RVC 78. Coolibah - River Coobah - Lignum woodland of frequently flooded channels, mainly Darling Riverine Plains

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	2
Native species richness (groundcover)	20
Native canopy cover (%)	15
Native midstorey (shrub) cover (%)	10
Native groundcover (%)	30
Mosses/lichen cover (%)	0
Organic litter cover (%)	30
Rock/bare ground cover (%)	40
Number of large trees (benchmark dbh)	4 (60 cm)
Number of trees with hollows	5
Number of canopy species regenerating	2
Coarse woody debris	20

RVC 79. Brigalow - Belah woodland on alluvial clay soil, mainly Brigalow Belt South

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	3
Native species richness (groundcover)	25
Native canopy cover (%)	30
Native midstorey (shrub) cover (%)	10
Native groundcover (%)	30
Mosses/lichen cover (%)	0
Organic litter cover (%)	30
Rock/bare ground cover (%)	40
Number of large trees (benchmark dbh)	6 (45 cm)
Number of trees with hollows	1
Number of canopy species regenerating	2
Coarse woody debris	30

RVC 80. Poplar Box grassy woodland on alluvial clay soils, Brigalow Belt South

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	3
Native species richness (groundcover)	25
Native canopy cover (%)	15
Native midstorey (shrub) cover (%)	5
Native groundcover (%)	40
Mosses/lichen cover (%)	0
Organic litter cover (%)	30
Rock/bare ground cover (%)	30
Number of large trees (benchmark dbh)	4 (60 cm)
Number of trees with hollows	5
Number of canopy species regenerating	2
Coarse woody debris	25

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RVC 84. Whitewood open woodland, mainly eastern Darling Riverine Plains

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	3
Native species richness (groundcover)	12
Native canopy cover (%)	15
Native midstorey (shrub) cover (%)	10
Native groundcover (%)	30
Mosses/lichen cover (%)	10
Organic litter cover (%)	30
Rock/bare ground cover (%)	30
Number of large trees (benchmark dbh)	5 (35 cm)
Number of trees with hollows	2
Number of canopy species regenerating	2
Coarse woody debris	20

RVC 89. Copperburr chenopod shrubland, Darling Riverine Plains and Brigalow Belt South

Ecological Attribute	Benchmark
Native species richness (canopy)	0
Native species richness (midstorey)	0
Native species richness (groundcover)	20
Native canopy cover (%)	0
Native midstorey (shrub) cover (%)	0
Native groundcover (%)	50
Mosses/lichen cover (%)	15
Organic litter cover (%)	20
Rock/bare ground cover (%)	15
Number of large trees (benchmark dbh)	0
Number of trees with hollows	0
Number of canopy species regenerating	0
Coarse woody debris	0

RVC 96. Blakely's Red Gum riparian woodland of the Pilliga

Ecological Attribute	Benchmark
Native species richness (canopy)	2
Native species richness (midstorey)	2
Native species richness (groundcover)	20
Native canopy cover (%)	20
Native midstorey (shrub) cover (%)	10
Native groundcover (%)	30
Mosses/lichen cover (%)	0
Organic litter cover (%)	30
Rock/bare ground cover (%)	40
Number of large trees (benchmark dbh)	4 (70 cm)
Number of large *Callitris* trees (benchmark dbh)	1 (40 cm)
Number of trees with hollows	4
Number of canopy species regenerating	2
Coarse woody debris	30

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