FINAL REPORT

(due within 3 months on completion of project)

Part 1 - Summary Details

Cotton CRC Project Number: **2.04.12**

Project Title: Identifying habitat requirements for birds on cotton farms in the Lower Namoi

Project Commencement Date: 1 July 2006 **Project Completion Date:** 30 June 2008

Cotton CRC Program: **Catchment**

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Part 3 – Final Report Guide (due within 3 months on completion of project)

(The points below are to be used as a guideline when completing your final report.)

ABSTRACT:
Although cotton farming is a major industry in the Namoi Valley, the status of on farm native vegetation and bird life is poorly understood. This project was implemented to improve that understanding.

On farm (mostly cotton farms) remnant native vegetation was inspected and sites representative of the main vegetation types were established. A rapid biodiversity assessment method was used to determine and record the vegetative characteristics. Bird surveys were conducted each summer, autumn, winter and spring season over two years and the bird species and individual bird numbers were recorded.

Shannon's Diversity Index *H* was calculated for the bird population of each site and then compared with the recorded vegetative characteristics, The results showed a clear, positive correlation of the bush bird species richness and abundance with vegetation complexity and at sites where vegetation has become simplified as a consequence of 150 years of livestock and farming activities, bird diversity is lower.

The results provide guidance for actions most likely to be productive to protect and enhance both vegetative and bird diversity into the future.

Another result is the finding that habitat complexity within a wetland and its water body is more attractive to water bird life than the complexity of habitat around a wetland.

In the course of this project, relatively simple methods of observation and recording of vegetation status and bird survey were developed which are within the capacity of people not necessarily scientifically trained or with only limited available time yet which will deliver scientifically valid assessment over time.

These findings and developments will assist practical management of farm biodiversity into the future.

3.1 *Background:*

Outline the background to the project.

A rising level of concern for the future of native wildlife in the Australian agricultural and pastoral zones has been reflected in published lists of declared threatened species from Federal and State government agencies responsible for environmental monitoring and care and in the findings of various researchers studying vegetation remnants in production landscapes. The NSW Department of Environment and Conservation (DEC) lists 115 birds as threatened or vulnerable and to which recovery plans apply.(DEC 2008)

Searching for the most practical methods of monitoring the life within the vegetation remnants, scientists have found that bird populations reasonably reflect the environmental health of the countryside and monitoring the birds can deliver good information capable of extrapolating to elements of the habitat that is less easily monitored. Birds are near the top of the food chain, are numerous and relatively easy to observe. They are also charismatic and often attractive to people and therefore can be a useful tool through which good habitat management can be promoted.

Reid (1999) conducted an extensive review of available information about the birds of the New South Wales sheep-wheat belt (SWB) and listed 20 bird species as Declining species of the SWB. Rural Lands Protection Boards of the Northern Slopes of NSW commissioned a report to study the conservation value of Travelling Stock Routes and Reserves (TSRs) of their region and in which the researchers developed a method of rapid assessment of vegetation sites, to deliver a value which they called Habitat Complexity Score (HCS) against which they compared the number of bird species and their relative abundance. These researchers demonstrated that the bird populations reflected the HCS and were a reasonable proxy for the conservation value of the TSRs.(Freudenberger, D. and Drew, A. 2001)

Partridge (2004) conducted a major review of remnant vegetation on cotton farms of the Moree Shire in the course of which, using birds, she compared the HCS method of Freudenberger and Drew with a Vegetation Condition Score (VCS) developed by DIPNR, and found the VCS assessment delivered a better explanation for the bird population found. Both assessment methods were sufficiently scientifically rigorous to fully support her findings but would require more time and skill than likely to be available to a farm manager or other person trying to assess the effectiveness of management actions on a remnant.

Jarman and Montgomery (2002) studied waterbirds and irrigation storages in the Gwydir Valley using birds and detailed observation of some wetland features. Some of the detailed observations required closely controlled laboratory and green house conditions which delivered them their excellent results but which would not be available to farm managers and in any case would be too time consuming to be of practical value to farm managers. Both of these excellent projects demonstrated promising monitoring pathways which required further research before monitoring methods useful to farm/land managers could be developed.

Ekert (2005) conducted a study in the Liverpool Plains in the Upper Namoi Valley using HCS and birds to determine what he called bird Focal Species appropriate as an iconic tool for managing habitat remnants and restoration in that region. The survey methods used by Ekert were sufficiently straight forward that his team were able to sample a large number of sites (302) and deliver useful analysis with results sufficient to satisfy the objectives of his study. Again, birds were found to be a satisfactory reflection of site condition and his vegetation method sufficiently rapid and simple that a large number of sites could be monitored.

The above mentioned studies together, represent a major body of research with important scientific outcomes in and near the Namoi Valley, yet the major cotton growing region of the valley remained almost unknown as to the extent and condition of remnant vegetation and unknown as to the animals that may be present. Even though considerable efforts to encourage land owners to maintain remnants were being made, few monitoring tools were available for them to assess the result of their effort. This project was designed as a step on the way to understanding the extent and condition of the Lower Namoi remnant vegetation and its birds and to develop monitoring tools suitable for on farm use.

Cotton farming utilises less than five percent of the catchment land area but occupies some of the economically most productive land – land which in its natural state, would be highly productive in biodiversity terms. Perhaps twenty to thirty percent of many cotton farms are not used for cotton production but could provide an opportunity to enhance and conserve biodiversity that is well integrated with productive farming. To achieve that enhancement and conservation of biodiversity in an integrated way with farming operations, species need to be identified, benchmarks established and tools developed to allow farm managers to monitor their efforts.

The development of natural system knowledge and skills amongst the local community will result in appropriately targeted on-ground works expenditure in on-going resource management programs funded from various sources.

3.2 *Objectives*

List the project objectives and the extent to which these have been achieved.

- Identify habitat requirements for bird species found on cotton farms in the lower Namoi
- Identify iconic/priority or focal species that can be used to engage cotton growers in better habitat/vegetation management
- Provide information towards benchmarking biodiversity and vegetation condition on cotton farms in the lower Namoi
- Extend to growers simple tools and guidelines for the assessment, monitoring and management of biodiversity and vegetation that can be used by growers who have an interest in biodiversity management and/or are undertaking the cotton industry's BMP program
- Understand the most productive ways new plantings and existing vegetation can be enhanced to improve biodiversity.

All objectives have been achieved. A seminar/workshop will be held this winter to introduce the project findings and further extend the developed tools.

3.3 Methods:

Detail the methodology and justify the methodology used. Include any discoveries in methods that may benefit other related research

3.3.1. The Sites:

The sites studied are within a broad triangle from the river at Myall Vale (near ACRI) west to near the Talluba Creek junction with the river and north to about the Spring Plains-Rowena Road. The area includes the delta formed by the Namoi River's major anabranches and flood-runner channels which historically, supported ribbons of east-west oriented riverine woodland vegetation interspersed with ribbons of variously shrubby or grassy open woodlands and open grassland. Invariably, high ground occurs at the channel bank, falls slightly away from the channel forming a flood-runner system then rising to a wooded ridge system or grass plain. The vegetation system is repeated in reverse order toward the next anabranch or flood-runner so that a section taken from south of the river to its most northern floodplain edge crosses several repeats of the vegetation sequence.

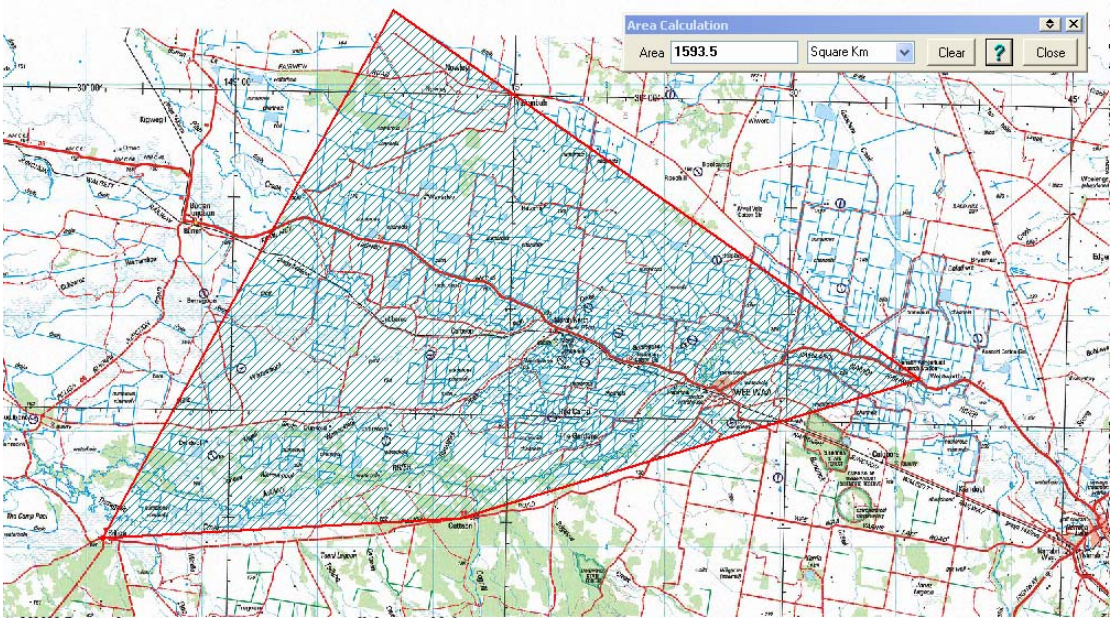


Figure 1: Map showing project area between Narrabri, Pilliga and Burren Junction, centred on Merah North.

After much on farm searching, 27 sites were selected within seven different broad vegetation types (after Specht) and three broad wetland conditions on 18 different farms. The vegetation sites were 2 ha within a much larger patch of similar vegetation and the wetland sites either 2 ha or appropriate sections of a wetland within a 500 m radius. Criteria for selection was:-

- that the site be reasonably homogeneous and reasonably representative of the larger patch of vegetation within which it was embedded and
- two or three sites on different farms of each broad vegetation type or of different sub-types and
- Wetlands selected were representative of the several different conditions found with particular reference to irrigation works.

3.3.2. Broad Vegetation Types:

The modern vegetation is comprised of remnants of the vegetation systems described above except that most of the higher ground woodlands and particularly grasslands are replaced by cultivated farmland. All of the sites studied are within the various major vegetation type remnants excepting open grassland which could not be found.

The broad types are listed in the following table. The apparent disproportionate numbers of sites between the broad types reflects sub type differences found.

Within the description “Broad Vegetation Type”, I have included three categories of “wetland” which is not a vegetation type but describes a site selected because of its expected normal condition of holding water and/or its inclusion within the constructed irrigation works

Table 1: Numbers of sites of the Broad Vegetation Types of the study area.

Broad Vegetation Type	No. of sites
Floodplain Grassy Coolibah	4
Floodplain shrubby Coolibah	2
Floodplain shrubby Coolibah/Belah	1
Floodplain shrubby Poplar Box	2
Riverine Coolibah	4
Riverine River Red Gum	2
Riverine River Red Gum/Coolibah	2
Wetland Constructed Water Storage	6
Wetland Natural	2
Wetland Natural water storage	2

Figure 2: Riverine River Red Gum

Figure 3: Riverine River Red Gum/ Coolibah

Figure 4: Floodplain Shrubby Poplar Box

Figure 5: Floodplain Grassy Coolibah

Figure 6: Riverine Coolibah

Figure 7: Floodplain Shrubby Coolibah

Figure 8: Riverine Coolibah (grazed)

Figure 9: Riverine Coolibah (ungrazed

3.3.3. Biodiversity Assessment: I used a rapid assessment Biodiversity Values Assessment form (see Appendix 4) developed by the Queensland Murray Darling Committee (QMDC) which included vegetation assessment categories similar to those used by Partridge (2004) in her VCS and more detailed than those used by Freudenberger and Drew (2001) in their HCS. The QMDC form had been tested against bird census data elsewhere and had been found to deliver a good prediction of bird population richness and abundance.

The QMDC form includes a section for recording basic wetland conditions and I used it to record the characteristics of the selected wetland sites.

During the data processing phase after the completion of all surveys, the

wetland information recorded using the QMDC form was found to be inadequate and a search for a better wetland biodiversity assessment was conducted. Jarman and Montgomery (2002) had demonstrated a set of wetland characteristics that usefully explained relationships with several families of waterbirds. I adapted the characteristics they found to be of most influence to the MDBC scoring method of 0,1,2,3 with 3 being the best condition (J&M score) and conducted a desk top, retrospective survey from my memory of each of my wetland sites and found a good fit between waterbirds species presence (richness) and the J&M score.

To assess aquatic vegetation diversity, Jarman and Montgomery (2002) systematically sampled wetland soil around the waterline and in controlled laboratory conditions germinated seed contained within the samples. An appropriately rigorous procedure for them but substantially beyond the time and facilities available to a farm manager. My desk top procedure was to rate the aquatic vegetation for percent of cover around the water edge and for number of plant species, a procedure that reflected the sort of information being sought by them but by visual observation within the capacity of farm management. That method has been used to assess the wetland sites and to compare the wetland biodiversity scores with bird richness and diversity data of this study.

One of the main project aims of this study is to develop simple monitoring tools that can be used by farmers to monitor biodiversity. Some of the methods used by Partridge (2004), Jarman and Montgomery (2002) and Freudenberger and Drew (2001) are appropriately scientific and necessarily rigorous to produce their pioneering results but are probably too onerous and exacting to be suitable for farm practice. I have used less rigorous sampling than those researchers but more suited to farm practice yet achieved similar results to those earlier researchers.

My method was to conduct the bird survey along a 400 m traverse while at the same time, maintaining an awareness of the crown separation ratio of the several layers of vegetation and ground cover. At the completion of the traverse the Assessment sheet was then completed recording my judgement of the condition of the site. I used a reference table to convert the crown separation ratio to a percent foliage cover.

3.3.4. Bush birds & water birds separation: For the purposes of this study, I have adopted an arbitrary split between birds that can be normally found in bush and grassland and which includes some species often found associated with water and those other birds normally only found associated with a wetland and shore. I have labelled the former as “Bush Birds” and the latter as “Water Birds”; the division is convenient to an attempt to better understand the habitat factors which influence each group; the division has no taxonomic meaning.

3.3.5. Bird Census: Birds Australia Atlas methods were adopted for bird surveys to identify bird species present and to count the numbers of individuals of each species identified excepting that each 2 ha site was 400 m long by 50 m wide, and conducted by a continuously walked traverse. Using a single line of traverse, always moving forward minimised the chances of counting the same bird twice. Sites were visited each season (mid winter, spring, summer and autumn) at approximately three monthly intervals over two years. Most sites had eight counts but several had seven because of later selection or weather preventing access.

3.3.6. Database: Biodiversity assessment and bird count data were entered into a Microsoft Access relational database and analysed in Microsoft Excel. All bird census data was reported to the Birds Australia Atlas and are therefore included in the national data of the world’s largest bird database and the only one covering an entire continent.

3.4. Statistical Method:

3.4.1. Shannon's Diversity Index: To calculate diversity, compare sites, site characteristics and site criteria, I used Shannon's Diversity Index ***H***, expressed in the form described by Tramer (Tramer, E. J. 1969)

$$H = -\sum_{i=1}^{S} P_i \log_2 P_i$$

where P_i is the proportion of individuals in the ***ith*** species

and Shannon's Diversity E_H

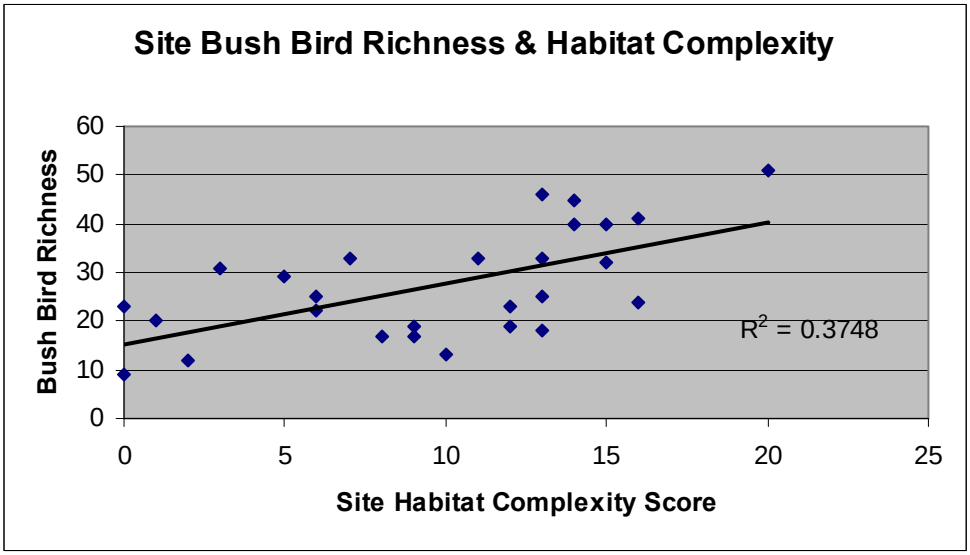
$$E_H = H/H_{max} = H/\ln_2 S$$

where ***S*** is the total number of species in the community.

Shannon's Diversity *H* is an index of species diversity in a community taking into account the relative abundance of the species present and Shannon's Diversity E_H is a measure of the evenness of the species richness within the community. Broadly, the expectation is that the closer a site is to natural condition (the less disturbed) the greater is the diversity (number of species present) and the greater the evenness (less dominance of one or few species over many).

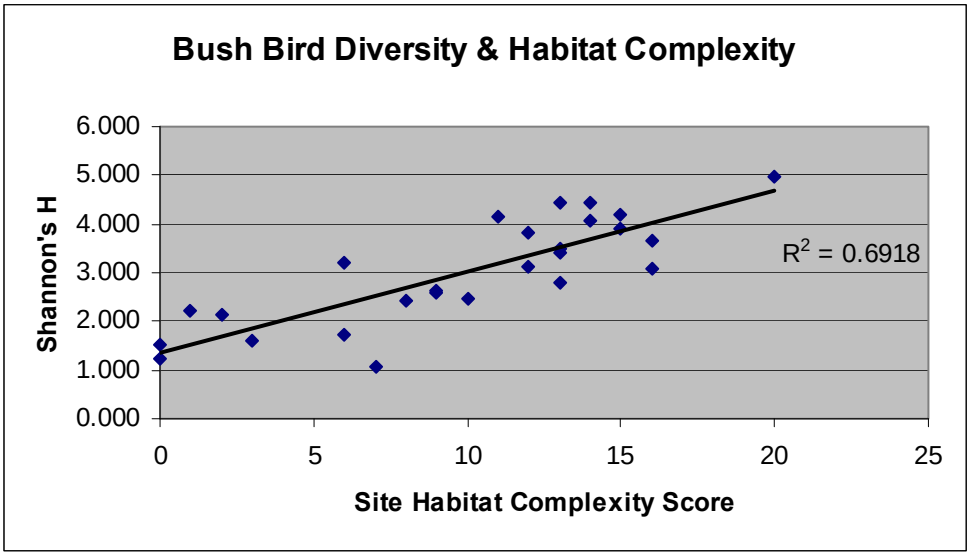
Diversity Indexes are not universally accepted as good comparative measures, some prefer to compare the separate components of the index, so before accepting the use of Shannon's Index for this work, I applied several tests and demonstrate the general result of the tests with the following two graphs The first below compares the 27 sites using bird richness as a comparative measure. It shows that bird richness is greater in the sites with more complex vegetation but there is large variation about the general trend (R_2 = 0.3748).

Chart 1: Relationship of bush bird species numbers and site HCS.



Comparing the same sites using Shannon's *H* (below) which is an index of Relative Abundance and compares numbers of individuals of each bird species with the number of individuals of all species in the bird population, shows a strong relationship between the site vegetation complexity and the Relative Abundance of the bird species present. Clearly, in the case of the Namoi sites and birds, Shannon's Index provides a more intuitive comparison as it delivers a closer relationship of the birds with site habitat complexity than richness alone (R_2 = 0.6918) and delivers a number which can be used to compare the diversity of sites, one to another, and change over time.

Chart 2: Relationship of bush bird Shannon's Diversity *H* and the HCS of sites.



3.4.2. Iconic species: Individual site bird lists were visually scanned for appropriate identified bird species that may be a proxy for healthy vegetation condition. Regression analysis was then used to examine the relationship of each candidate species with the Habitat complexity score of the nine features of Trees >8m, Tall shrubs/small trees 2-8m, Low shrubs <2m, grasses and forbs, organic litter, abundance of large, old trees with hollows and abundance of logs >2m long and >10cm diameter. With the results of that selection and analysis Icon species were selected that may best reflect healthy natural vegetation condition and which may be most responsive to good habitat management.

4. RESULTS:

Detail and discuss the results for each objective including the statistical analysis of results

4.1. Identify habitat requirements for bird species found on cotton farms in the Lower Namoi.

4.1.1. The sites and bird diversity: No attempt was made to search for night birds.153 bird species were identified across the 27 sites and the combined list represents a reasonable snap shot of the day birds of on cotton farm remnant vegetation of the Lower Namoi in 2006-2008.

Generally, bird diversity increases with vegetation complexity and is more sensitive to the projective vegetative cover of the three separate categories of trees, shrubs and grasses and forbs than any other measured category of habitat.

Chart 3: Relationship of bush bird diversity and tree cover score where Shannon's *H* increases with cover score increase

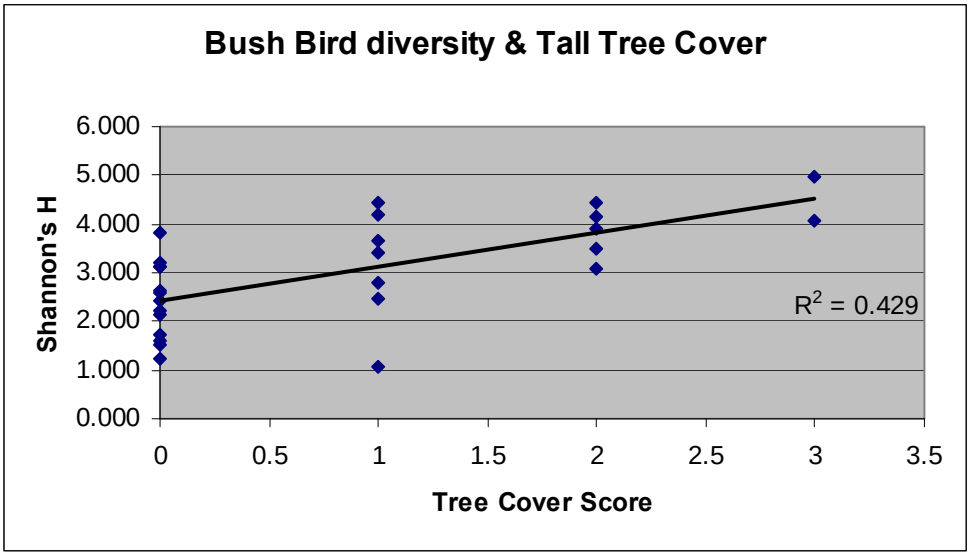


Chart 4: Relationship of bird diversity with small tree & shrub cover score where *H* increases with cover increase:
Note high proportion of sites with low small tree & shrub score

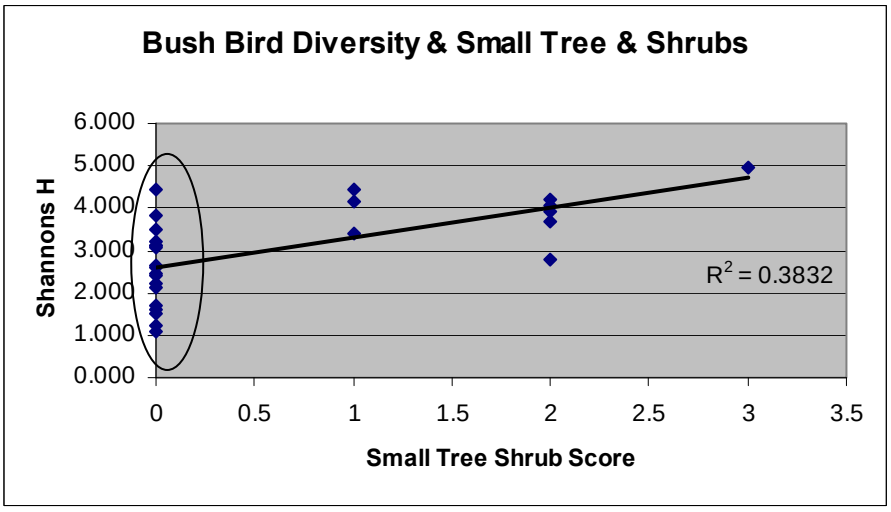
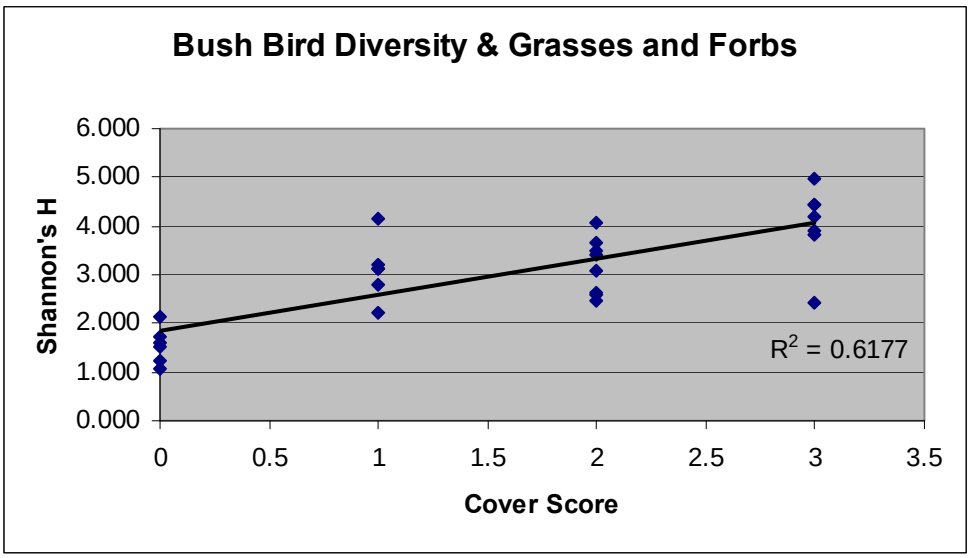


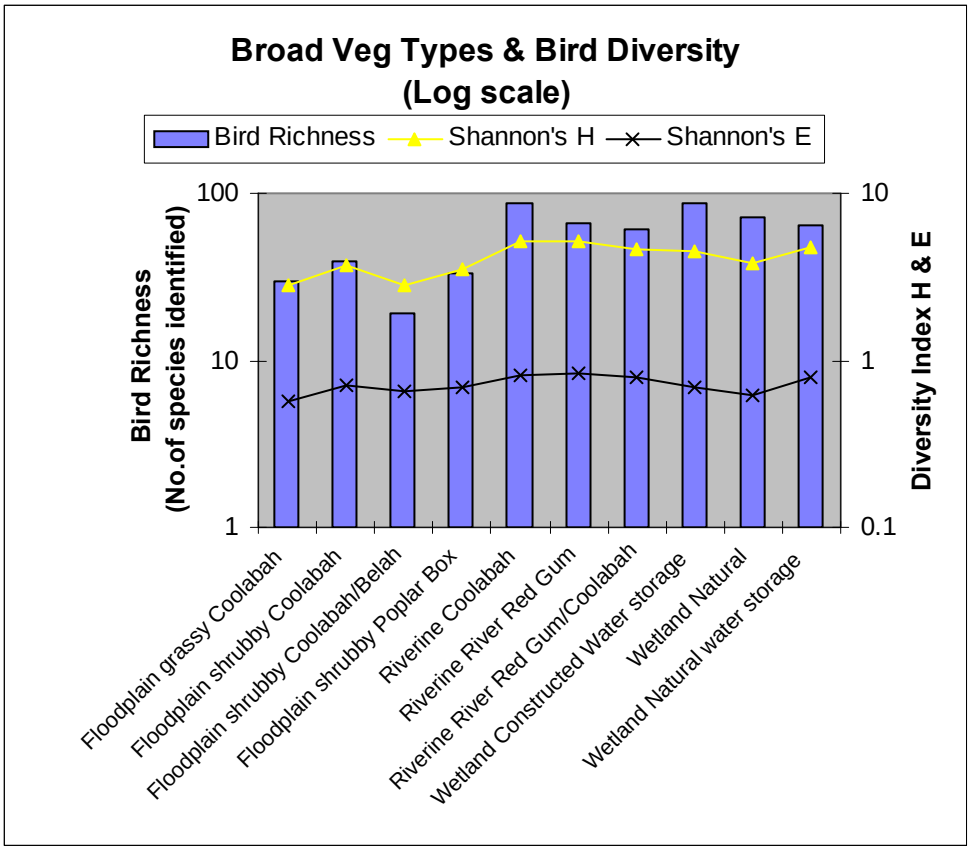
Chart 5: Relationship of bird diversity with cover of grasses and forbs where there is a strong increase of diversity *H* with increase in cover of grasses and forbs.



The bush bird sites with the greatest diversity are those with the greatest vegetative structural diversity within close proximity to permanent water. On the other hand, bush bird sites with the least structural complexity and without permanent water nearby were the least bird species diverse. Shannon's Diversity Index *H* varied from ~ 4.5 for the former to ~ 2.5 for the latter. A similar range of diversity but with larger index numbers could be expected within an immaculately undisturbed series of sites within a region containing a natural mosaic of vegetation such as the Lower Namoi but in an undisturbed situation, sites with relatively large variation from the mean would be unexpected.

4.1.2. Broad Vegetation types and bird species diversity: The ten categories of Broad Vegetation Type are listed on the graph below which shows the number of bird species identified for each, Shannons *H* and Shannon's *E* . The four floodplain vegetation types have markedly less bird richness than the riverine and wetland types partly because of the strong presence of waterbirds in the wetlands and partly because of pauperised ground condition in the floodplain sites.

Chart 6: (Note log scale) Number of bird species at Broad Vegetation Type sites and Shannons *H* and *E* of the BVTs



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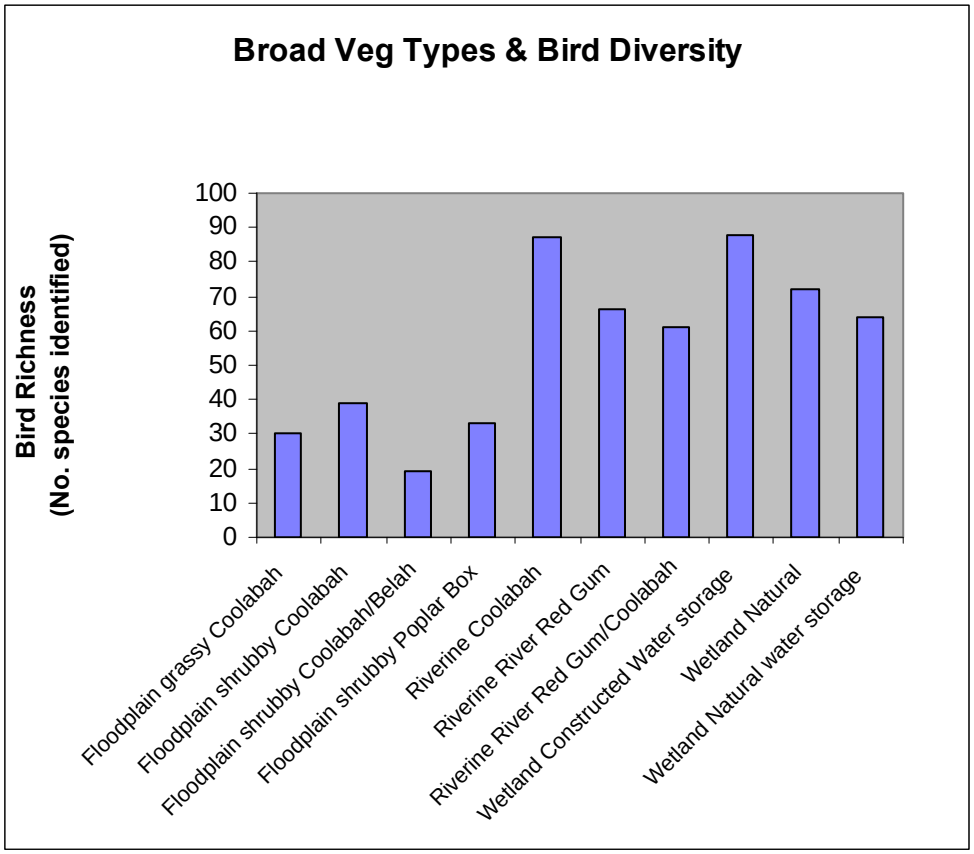
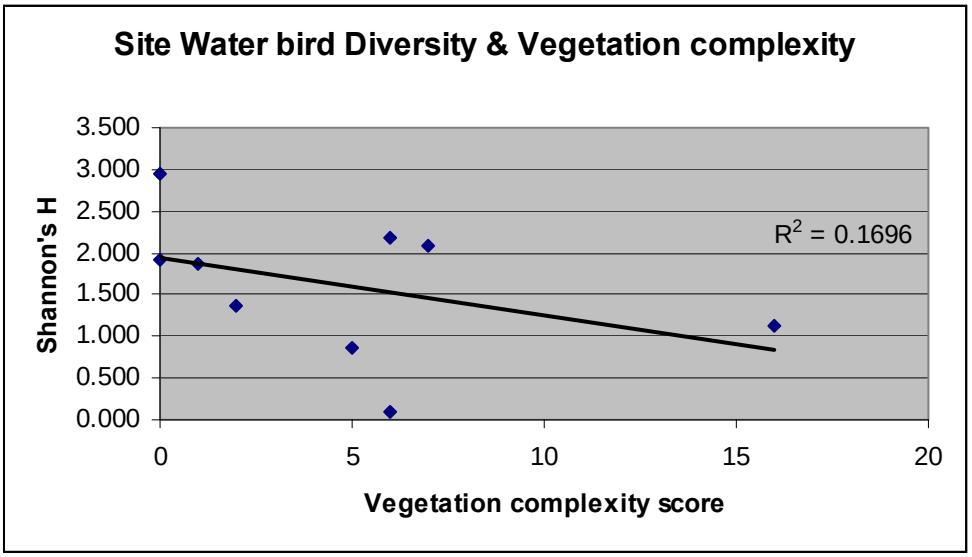
Shannon's *H* is relatively higher for the three sets of riverine sites and lower for the floodplain sites which reflects the bird richness differences of the vegetation types remarked above. The wetland sites, for the most part, are species rich but vegetatively poor. The graph above uses logarithmic scale to better display the two sets of Index numbers. The magnitude of the bird species variation in numbers (richness) is better illustrated below where bird richness is at normal scale

Chart 7: Number of bird species found at BVT sites where floodplain vegetation types have substantially fewer birds than other BVT sites.



4.1.3. Wetland Sites: Some of the sites of greatest bird richness are wetland sites (see the graph above) and the riverine sites mostly include a nearby section of a stream wetland. At all sites, bush bird diversity increases with vegetation complexity but the reverse is the case with water bird diversity; where the vegetative complexity is simplest has the greater water bird diversity.

Chart 8: Wetland site HCS and water bird Diversity *H* which shows water bird diversity is greater on sites with less complex fringing vegetation.



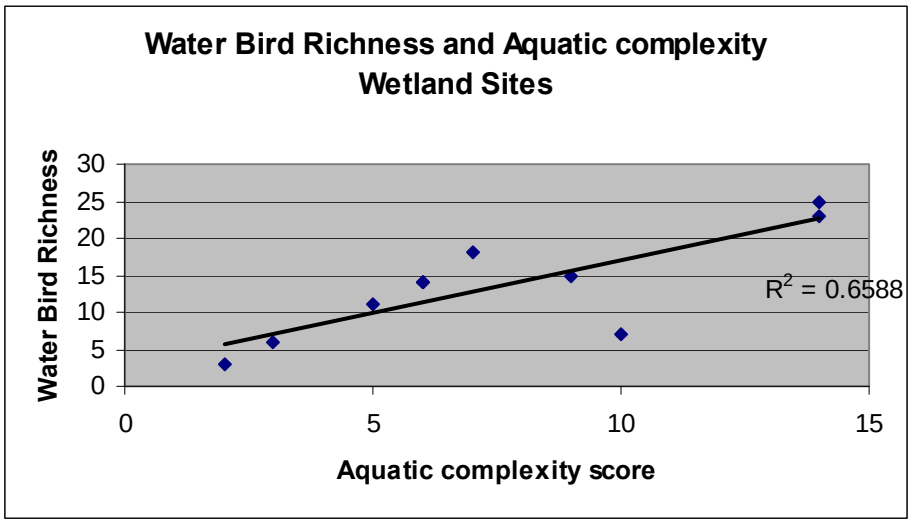
The characteristics assessed using the J&M score method are aquatic vegetation projected cover and diversity, tree stags and logs in water, water level constancy, vegetated islands, mud flats and time of undisturbed earthworks. The presence and richness of species are strongly influenced by these characteristics. (R^2=0.6588)

Figure 10: Constructed water storage. This 2 ha site was the most productive. Fringing trees, tree stags in water, fringing course reeds, submersed water grass, fish all introduced as components of construction. The birds flew in themselves.

Figure 11: Constructed water storage. Tree stags retained with heaped logs; *Typha* sp planted as erosion defence. Both simple measures add habitat complexity which has enhanced diversity.

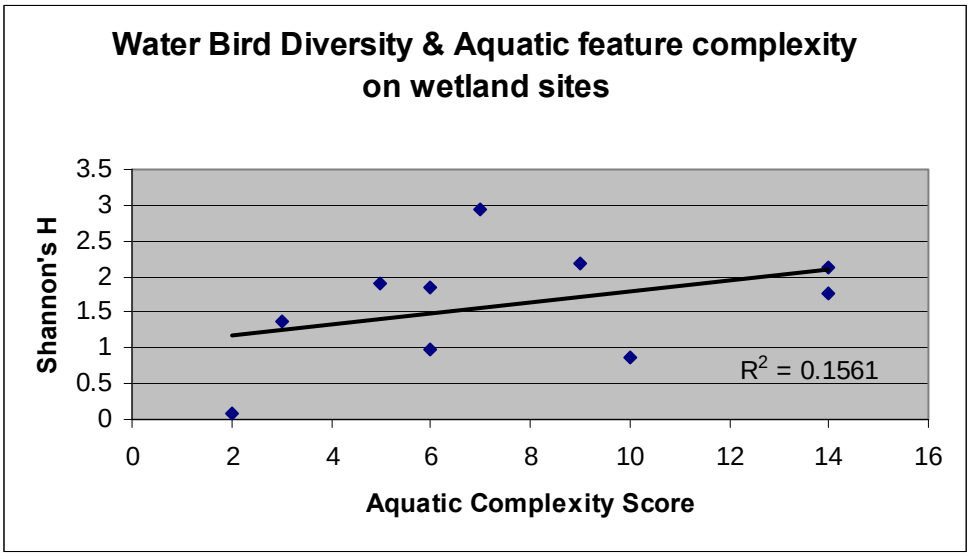
Figure 12: Irrigation main drain return established in a natural floodrunner. Naturalness of fringing vegetation retained and encouraged. Another of the most productive sites.

Chart 9 Relationship of water bird richness and J&M Aquatic Complexity Score where complexity of features within the wetland itself strongly influences the number of water bird species.



Conversely, water bird abundance is less reflective of those aquatic features (R^2=0.1561) suggesting that abundance is responsive to factors beyond the local environment.

Chart 10: In contrast to species richness, water bird diversity *H* is less influenced by the complexity of the wetland.



4.1.4. Water Bird Mobility: For the entire period of this study the Namoi Valley together with most of eastern Australia, endured drought conditions, relieved only moderately by occasional rain during the second year. During the period water bird abundance and richness varied markedly and in a manner that did not seem to be either of a regular seasonal nature nor influenced by local conditions. A peak in number of species present (richness) and abundance was reached in January 2007 and held through Autumn to the winter survey in July 2007 after which species and abundance declined through to January 2008, improving at the April 2008 survey but not to previous high levels.

Chart 11: Total species over the 2 year period of study fluctuated to a different rhythm than the four seasons

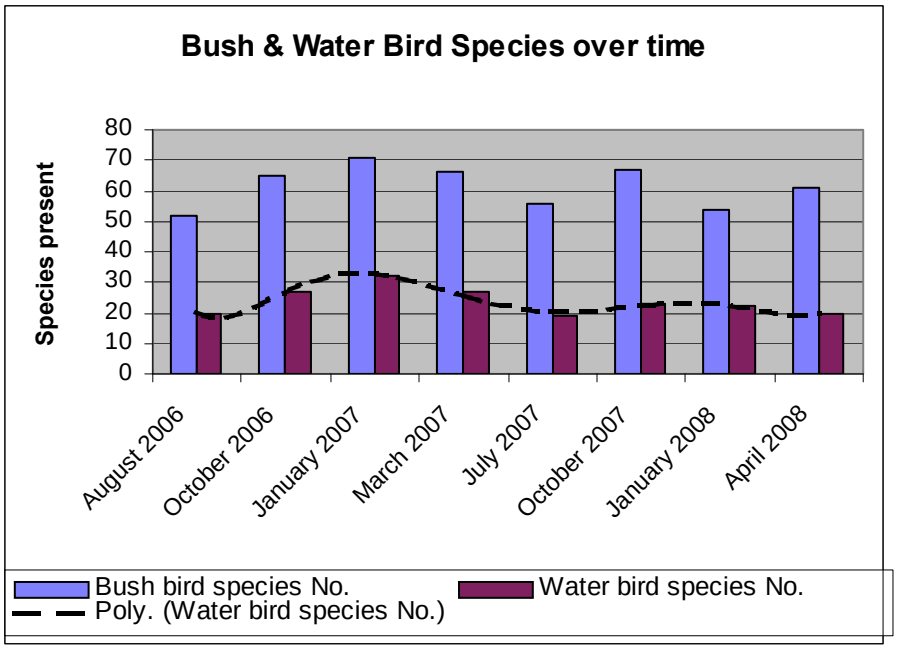
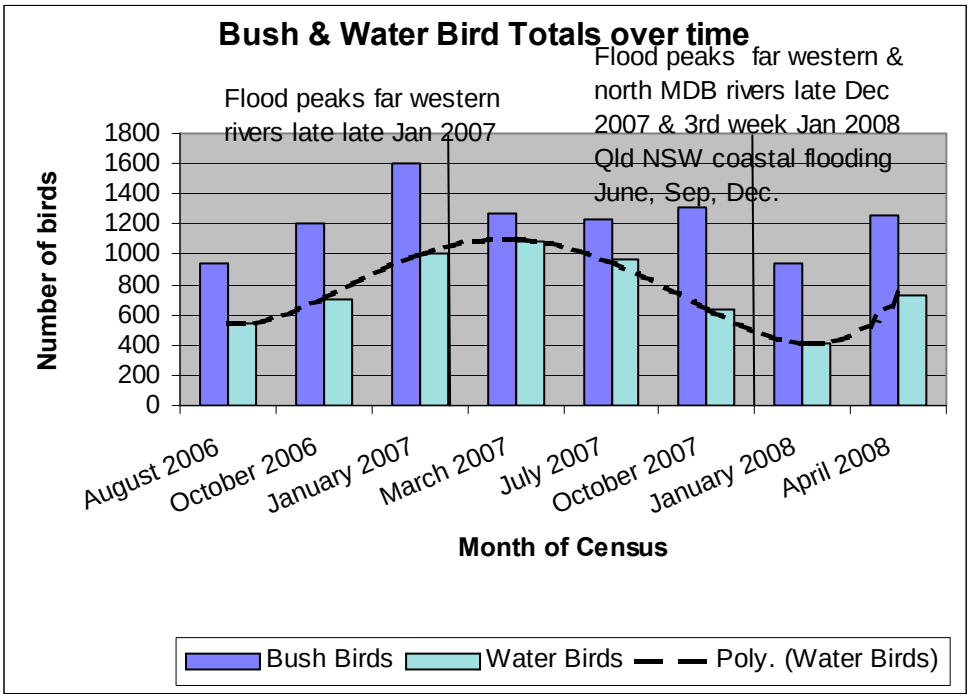


Chart 12: In contrast to bush birds, water bird individual numbers had a different pattern reflecting continental scope climatic influences.



In January 2007 the far western Queensland rivers, Georgina, Diamantina, Cooper and Paroo flooded with a discernable echo in Namoi water bird species but not abundance at the March and July 2007 surveys. In June, September and December 2007 various coastal catchments of New South Wales and Queensland recorded extraordinary rain and stream rises and which seems to be echoed in the numbers recorded in the Lower Namoi until in January 2008, water bird numbers were unusually low and increased in April 2008 by local breeding result.

4.2. Identify iconic/priority or focal species that can be used to engage cotton growers in better habitat/vegetation management.

The book, Birds on Cotton Farms at page 77 carries a section suggesting indicator species relevant to cotton farming areas and habitat management actions that may be beneficial(Ford, G. and Thompson, N. 2006). Eight of the twelve “indicator” species listed there were found during this study and nothing discovered improves on the information provided so competently by Ford and Thompson (2006). Those 8 identified indicator species found are Eastern Yellow Robin, Grey-crowned Babbler, Spiny-cheeked Honeyeater, Striped Honeyeater, White-winged Fairy-wren, Variegated Fairy-wren, Brown Treecreeper and Purple Swamphen.

The focal species approach has, as its fundamental requirement, the identification of key threatening processes and the taxon (in this project – bird species) most threatened by each process. Further, it involves the identification of a suite of species targeted for the management of threatening processes and vegetation-restoration efforts. Lambeck (1999) claimed that “because the most demanding species are selected, a landscape designed and managed to meet their needs will encompass the needs of all other species” in that landscape (Lambeck, R. J. 1997; Lambeck, R. J. 1999)

The data collected during this project found that the greatest diversity of bird species occurred in the riparian sites. Apart from the presence of water, these sites were the most structurally and floristically diverse of all the sites. It also found that the floodplain woodlands were dominated by the large parrots, butcherbird species and miner species. The floodplain woodlands have been simplified by past management

regimes and this simplification poses a threat to the medium-sized and small insectivores which inhabit these woodlands.

Two species which disappear from areas where woodlands have been simplified still exist in the riparian woodlands but should also be present in the floodplain woodlands, especially the shrubby coolibah , poplar box and belah sites, as they occur in good quality woodlands of this type throughout their range. They are presented here as Iconic species suitable for promotion of the conservation/restoration of their habitat.

The Grey-crowned Babbler whilst present in five (5) of the survey sites was absent from all the sites in Coolibah (both floodplain and riverine) and Poplar Box woodlands; its family groups were also quite small (the average group size being 7.3 birds). As it is a co-operative breeder and must retain a viable group size to breed successfully this is a concern for its future survival. It is a bird of the open woodlands; it is very easy to identify (medium-sized, with strong markings and usually present in a noisy, often engaging group). To ensure its survival in the Namoi delta it requires woodlands with an open shrub layer with sparse ground cover and fallen timber and leaf-litter. These conditions are also required by many other species of ground and lower storey feeders such as song-larks, pipits, treecreepers, small parrots and pigeons, and finches.

Chart 13:The 5 sites where Grey-crowned Babblers were found have moderate habitat complexity of open shrub layer and sparse ground cover with logs and leaf litter

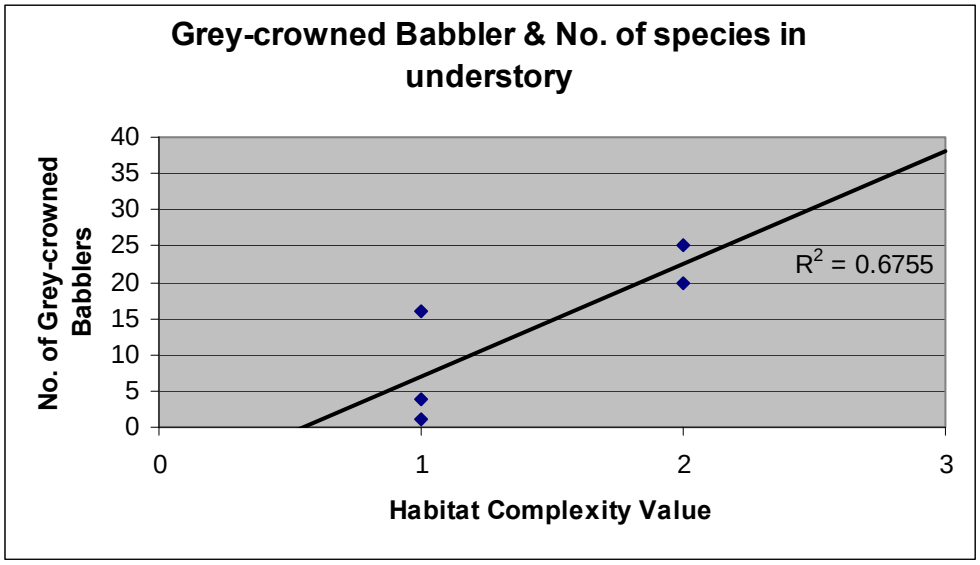


Figure 13: Grey-crowned Babblers (photos © Graeme Chapman)

The suite of small, woodland, insectivorous species is absent from most of the sites, only occurring regularly in the riverine sites. Fairy-wrens, thornbills, robins, whistlers, flycatchers and fantails require woodlands that are structurally diverse and disappear when these woodlands are simplified. Variegated Fairy-wrens and representatives of the families cited above are present in suitable complex habitats across the Australian continent However, in the Namoi Delta these species are virtually absent from all the floodplain woodland sites, occurring in the more complex habitats of the riverine woodlands. Using the Variegated Fairy-wren as an iconic species for the area would benefit the suite of small insectivores that share its preference for structurally diverse woodlands with an intact shrubby layer. It is small; but fairy-wrens are recognized by most folk and the grey, iridescent blue and rufous plumage of the nuptial male which it wears for a large part of the year is unmistakable.

Chart 14: Variegated Fairy-wrens prefer complexity of shrub & ground layers

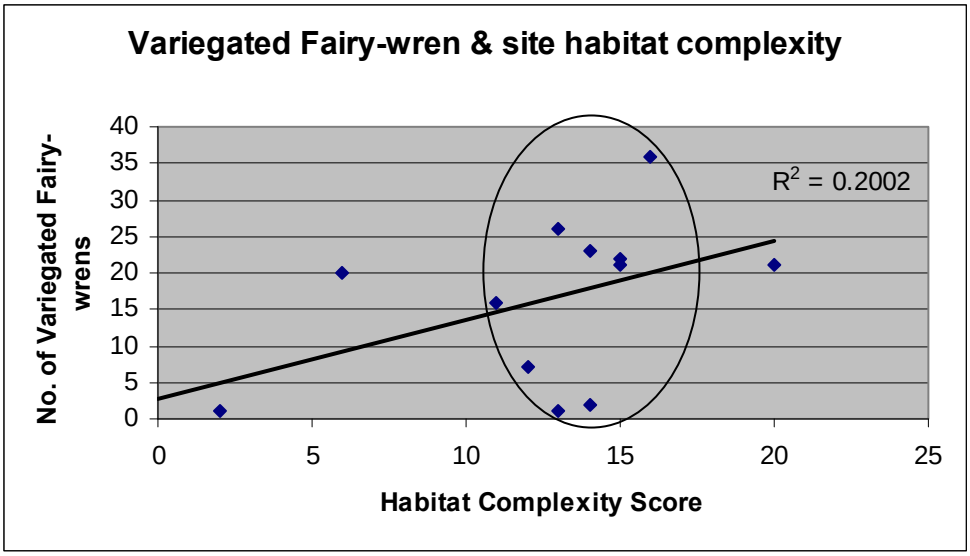


Figure 14: Variegated Fairy-wren, male left, female right. (Photo © Graeme Chapman)

4.3 Provide information towards benchmarking biodiversity and vegetation condition on cotton farms in the Lower Namoi.

4.3.1. Birds: Appendix 1 is the list of bird species identified at the 27 sites of this study. That list is a benchmark list of birds identified in the specified conditions during July 2006-May 2008. During the same period another researcher has been studying biodiversity including birds at some of the sites of this study and many other sites within the lower Namoi. Combined, the two bird lists will provide a benchmark of birds in remnant vegetation on cotton farms in the Lower Namoi and can be used for comparative purposes at any future period.

4.3.2. Vegetation. Appendix 2 is a list of species identified in the Broad Vegetation Types.

Note: The identity and location of the individual sites is confidential and not available without the expressed permission of each of the proprietors involved.

4.4. Extend to growers simple tools and guidelines for the assessment, monitoring and management of biodiversity and vegetation that can be used by growers who have an interest in biodiversity management and/or are undertaking the

cotton industry's BMP program.

4.4.1. I gave a presentation to the Cotton CRC Science Review and participated in the Birds on Cotton Farms Field Day both in August 2007.

4.4.2. Tool for bird census:
Birds Australia Atlas specifications for 2 hectare and 500 metre radius bird searches, the methods used in this study, are appropriate for any person wishing to assess and monitor bird populations in a repeatable manner. Information about the Atlas and search method is available at www.birdsaustralia.com.au

4.4.3. Tools for biodiversity assessment:
Appendix 3 is the Queensland Murray Darling Basin Committee Biodiversity Assessment form used in this study. The same form will assist anyone to make a comparative assessment at any future time.
Appendix 4 is a modified, simplified version of the sheet designed to assess and record only those categories found in this study to be significant for the bird population. It is presented as an appropriate tool for farm use.
Appendix 5 is an assessment sheet suitable for on farm wetlands
Appendix 6 is a sheet designed to be a simplified way of calculating the crown separation ratio of vegetation and converting the ratio to a percentage crown cover or a projective foliage cover percentage, information needed for completion of the Biodiversity Assessment Forms. The sheet can be printed and used in the field.

ADVISORY NOTE: Consistency is the most important ingredient when using any of the above tools or making assessments using any method; effort is required to be consistent in method and overtime from survey to survey.

4.5. Understand the most productive ways new plantings and existing vegetation can be enhanced to improve biodiversity.
This study did not include any new plantings nor areas of existing vegetation where management was specifically directed toward vegetation enhancement; consequently, no information was produced in a scientific way to assist the understanding of potentially useful vegetation enhancement strategies but the data collected does support the view that bird populations are responsive to habitat complexity. Casual observation during the course of the study has produced some personal views which are expressed in section 5 below.

5. DISCUSSION:

5.1. Birds not found: This study was conducted during a period of exceptionally low rainfall and generally, ground conditions (grasses, forbs, litter, lichens etc) reflected the dry conditions and were generally, particularly sparse. Never-the-less, the naturally structurally simple, grassy woodlands seemed unnaturally sparse of bird species with few gramineous and grass specialists found. eg, no quail, button quail, finches, ground feeding parrots, pipits, song-larks, bush-larks etc. The methods adopted for this study do not provide definitive information about species not found and it is only personal judgement which leads me to suggest they are under represented. I speculate that the low numbers of such birds reflect more the long term depletion of native pasture plant species than the dry conditions during the survey period. If my speculation is the true situation, it follows that significant gains to bird diversity can be effected by giving long-term attention to natural pasture management which may include a short term reduction of livestock pressure and likely a major change in the pattern of grazing.

5.2. Birds and Habitat Complexity Score: The good correlation between the measured aspects of vegetative complexity and bird diversity suggest that land managers can monitor vegetation and birds over time by periodic survey using the simple

techniques adopted for this study.

5.3. Broad Vegetation Type and Bird Population Tools:

This study has used Broad Vegetation Type (BVT) and the bird population that is found within as convenient tools for the analysis of actual and potential biodiversity. The results demonstrate that, at those broad levels, the tools deliver useful information that can be used by land managers to assist their land management decisions. The data accumulated by observing at those broad levels however does not provide a good understanding at the species level; the data does not provide a satisfactory understanding of the reason why one species of bird chooses to live or not to live in any particular vegetation combination or why a particular BVT has a particular mix of trees, shrubs, grasses and forbs. At the species level, the data merely indicates in which broad vegetation types a bird has been found during this study and sometimes (but not always) the habitat complexity level of preference but the data do not explain why it is preferred.

The habitat requirements for birds in vegetation remnants on cotton farms are large remnants close to natural condition of each of the original vegetation types. The further a remnant varies from natural and the smaller in area, the less productive it will be in bird species richness.

Each species of plant and bird has evolved as a specialist occupying a particular ecological niche and an understanding of the environmental subtleties that define that niche and that determine success or failure within that niche require very detailed specialist research that is well beyond the reach of the tools used here.

5.4. Shannon's Diversity Index:

Diversity is important yet it is difficult to compare between one site and another. I used Shannon's Diversity *H* to compare sites because it combines an abundance number with a species richness number and gives a better fit of the bird population with the vegetation type characteristics. The Index will be useful for other researchers wanting to compare future diversity data with mine or data at other sites with data for my sites. For time pressed land managers wishing to monitor the consequences of their own management actions however sufficient information is gathered by comparing species richness and abundance periodically over time (that is: the number of species and the number of individuals of each species identified at a site). For that purpose, the Atlas 2 ha search is the most suitable method.

5.5. Artificial Wetlands:

Three standout observations arise from this study; allowing dead trees (or erecting dead trees) to stand within a reservoir, allowing course vegetation (such as *Phragmites* or *Typha spp*) to grow about the high water mark and retaining fringing woodland will each and cumulatively, add substantially to the richness of bird life about the reservoir (Sites NAM07, NAM11, NAM14). One site (NAM15), a surge pond, that had none of the above but had several hectares of bottom subject to temporary inundation after heavy rain or irrigation events delivered a surprisingly numerous bird list including birds not often seen elsewhere.

NAM16, total area ~2 ha, is relatively small, isolated in the landscape with poor connectivity, no native woodland within one kilometre, no shallow water yet is equal second richest site of the study with 56 bird species identified and second in abundance with 2898 birds counted. The features that combined to make this little wonderland so bountiful are somewhat obscure but they probably include dead trees artificially added standing in the water, *Typhus* and *Phragmites* occasionally about the water-line, Weeping Willows planted densely around about 60% of the bank (providing both dense shelter above ground and a dense root mat under water), constant water level, planted with a submerged water grass and stocked with fish. In other words, although small, it is a complicated ecosystem in its own right.

Two of these sites had features which made them special reflecting a personal

interest of the proprietors and which has made the sites exceptional. All five sites are normal features and part of the normal farm irrigation structures; each plays a useful part. The message to be taken from these examples is that it is relatively easy to include or add features to an on farm water structure which may be capable of extraordinary wildlife outcome.

5.6. Water bird abundance:

The results indicate a disconnect between the number of water bird species at a wetland site and the abundance of the individuals present. The results suggest that water bird abundance is influenced by factors other than those measured in this study.

I speculate that the variation in species number and total water birds recorded during this study is evidence that these and other on farm wetlands are part of the continental system of refuges used by water birds during periods of reduced habitat elsewhere. As habitats dry in Eastern Australia, the inland wetlands become relatively more important – the drier the eastern continent becomes, the greater the reliance on wetland refuges wherever they may be. Jarman and Montgomery (2002) demonstrated that different water bird families and different feeding guilds respond to wetland conditions differently. Even so, they all share one characteristic that their food requirements are specialised to a high degree and they must find that specialised condition or perish. As was the case during this study, the on farm wetland features became the only local wetland sources and for a time, attracted numbers of birds from drying wetlands elsewhere. The progressive decline of water bird numbers from July 2007 to January 2008 recorded in this study, paralleled increased wetness of Eastern Australian coastal regions.

5.7. Bird Population:

The focus of this study was the remnant vegetation and the birds within. The effort was to find and count the birds using the chosen sites and then to assess their relationship with the vegetation at each site. No effort was made to maximise the bird list by chasing likely spots for particular species.

There is a large variation of the number of bird species (richness) found at each site; the highest is 57 (NAM14) species and the lowest 13 (NAM17). All of the bird rich sites contain or are very close to a water feature and all of the bird poor sites are relatively remote from water and situated in floodplain Coolibah. At all sites birds which habitually feed and or breed in the lower layers of the vegetation are in low numbers or absent – birds such as finches, song-larks, bush larks, pipits, quail, button quail, tree-creepers small parrots, etc. Thus a whole suit of expected species are likely in trouble in the region and attention should turn to understanding the problem and rectifying the causes.

5.8. Vegetation:

The variety, extent and quality of remnant vegetation on farm is greater than expected and the preservation of the east-west corridors for flood dispersal and control has delivered vegetative connectivity unusual for an agricultural landscape. With this framework of vegetation, the valley is well placed to build and maintain a sustainable system for biodiversity into the future.

With one exception, the tree and tall shrub layers of vegetation are healthy but with senescence an approaching problem at some sites. Excepting several sites where domestic stock have been excluded for a long time, the small shrub and ground layers of sites have been simplified and degraded over the ~170 years of grazing history. For the full period of this study the region was in the strong grip of drought and there is no doubt that the observed ground conditions reflected that fact. In a better rainfall situation the ground conditions would have seemed better yet the same problems of simplification and loss of native ground cover species combined with increased weediness would have been apparent.

In my view, the identification of the simplified and weedy shrub and ground layers and the suit of birds now missing provide the best and most practical opportunities for future improved conservation. The following comments reflect casual observations I made during the surveys and represent a personal judgement not necessarily supported by the statistical results of the surveys.

5.8.1. Grassiness: In the Lower Namoi, the most reduced of the natural vegetation types are the grasslands and the grassiness of the woodlands. This "grassiness" includes many low growing non grass species of plants some leguminous which were once common and are now not evident. Any action taken to improve the native grassiness will be the most productive of all restorative actions.

If the relatively better grassiness of the stock routes is any guide to an improved management regime, the periodic grazing regime typical of stock routes (but atypical of privately held grazing land) may be a good way to go.

5.8.2. Naturalness: Biodiversity is positively responsive to naturalness and, as a general rule, the closer the environment is to its natural state, the greater its biological diversity, conversely, the greater the degree of change to the environment, the lesser the biological diversity. In the region of this study there is little that is now natural (unchanged), there are areas that are not changed a lot and remain in reasonable condition and there are large areas changed a lot and now with biologically reduced diversity. In this situation, the task facing managers is to understand how they can get their best biodiversity return from their management effort. Several of the studied sites are within fenced areas with livestock excluded permanently or grazed in a controlled manner for short periods; these areas have noticeably more natural ground conditions. In terms of naturalness, the several broad vegetation communities involved here can be considered separately:-

5.8.3. Floodplain Grassy & Shrubby Coolibah: A woodland community generally of well separated Coolibah with some Black Box over a diverse grass and forb ground layer. Trees can have great age and hollows generally plentiful. Tree regeneration generally sparse but after occasional germination events following floods, regeneration can be dense along the lines of flood water edges. Possibly, the dense tree regeneration events reflect preceding depletion of the grassy ground layer. The naturalness of all of the study sites of this type has been substantially reduced by depletion of the natural ground layer with tussock grasses and native forbs replaced by *Bassia* spp and turnip etc. Conditions can be improved by reducing grazing pressure and adopting a system of short pulse grazing with long un-grazed periods between. Allow dead trees to stand and logs and fallen branches to accumulate. Strive to achieve high ground layer diversity, good litter cover and strong perennial tussock structure.

5.8.4. Floodplain shrubby Poplar Box and Belah: These are generally much more structurally and floristically diverse in their natural condition than Coolibah and remain so today. Never-the-less, the shrub and ground layers are generally reduced, simplified and weedy. As above adjust grazing regime to one of short grazing periods and long recovery periods. Allow dead trees and accumulate ground logs and litter.

5.8.5. Riverine River Red Gum and or Coolibah: In the well watered riverine situation, tree density can be quite high with touching or close crowns, a layered and complex under-story and a littered ground condition with course reedy cover in low places, grassy in high places. Depending on the history of each riverine stand, variation from the natural can be small or large and the majority of the riverine sites of this study were in reasonable condition because they have been mostly unstocked since the adjacent irrigation structures were built. Where grazing has been constant, the ground cover is simplified and *lippia* has

intruded. In other places in the presence of livestock a dense invasion of *Acacia salycina* has replaced whatever the under story once was.

Except to offer the same grazing advice as above, I do not have a view as to how the riverine condition can be managed for better result. I can observe however, that the riverine situations that have been unstocked now for several decades are pleasant to walk through are less weedy and *lippia*, although present is not dominant.

5.9. Icon species:

The area surveyed during this study is a fragmented agricultural landscape with greatly reduced levels of natural vegetation. At the broadest level the vegetation types surveyed were Floodplain woodlands, Riverine Woodlands and Wetlands which included edging vegetation. As the floodways of the original Namoi delta have been retained in the agricultural landscape and run east to west there is a higher level of connectivity through the floodplain woodlands than that which exists in many fragmented agricultural landscapes. This connectivity is fortuitous and should provide an excellent base for efforts to enhance bio-diversity in the area.

The floodplain woodlands have been in most cases simplified by past management regimes. This simplification of habitat is often a result of 'cleaning up' complex vegetation patches by removing shrubs, dead trees and logs. It can also be a result of inappropriate grazing regimes by stock. While the decline and local extinction of suites of species can be attributed to a range of numerous threatening processes (predators, fire regimes, chemicals, etc) this simplification of woodlands is a major threat that impacts on food resources and shelter.

Some restoration approaches that could be employed to restore the complexity of these habitats and to ameliorate the threatening processes of fragmentation and simplification are:

- Alteration of grazing and other management regimes within the floodplain woodlands to allow for the recovery of the shrubby layer in the woodlands.
- Actively restore a nominated percentage of the floodplain woodlands.
- Allow natural regeneration to connect the restored and/or better quality sections (areas that have retained a good shrubby layer) of the woodlands to the riverine areas.

6. ACKNOWLEDGEMENTS:

An inquiry from Guy Roth led to this project. His curiosity and subsequent support has been important. Stacey Spanswick and Jane Macfarlane have provided support and have been important links to the Cotton CRC partners involved. Rhiannon Smith has assisted particularly with the provision of some relevant scientific papers. Grahame Rogers and Gil Porter have been the essential administrative and financial controllers. Eighteen Namoi farmers and their families allowed access to their properties and provided an interested base of support without which the project could not have been accomplished.

Nicci Thompson Guy Roth and Stacey Spanswick read an early draft of this report and provided invaluable comment. Nicci wrote the iconic species paragraphs and with her unparalleled bird observing skills, provided an assured bird surveying back-up in case of my incapacity and she participated in two rounds of the surveys.

My thanks to them all are profound.

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Appendix 1: List of birds identified at all 27 sites, Lower Namoi.

Conservation Status	Common_name	Total Birds	No of records	Bush/Water Birds
D T	Emu	2	1	B
	Brown Quail	17	7	B
	Plumed Whistling-Duck	249	8	W
T	Blue-billed Duck	2	1	W
	Black Swan	35	14	W
	Australian Wood Duck	404	36	W
	Pacific Black Duck	444	60	W
	Australasian Shoveler	40	4	W
	Grey Teal	1630	40	W
	Chestnut Teal	2	1	W
	Pink-eared Duck	105	5	W
	Hardhead	182	10	W
	Australasian Grebe	115	15	W
	Hoary-headed Grebe	5	2	W
	Great Crested Grebe	5	3	W
	Darter	121	35	W
	Little Pied Cormorant	89	18	W
	Pied Cormorant	128	14	W
	Little Black Cormorant	238	16	W
	Great Cormorant	94	11	W
	Australian Pelican	90	14	W
	White-faced Heron	27	22	B
	White-necked Heron	12	10	B
	Great Egret	54	22	W
	Intermediate Egret	9	5	W
	Nankeen Night Heron	19	2	W
	Glossy Ibis	8	3	W
	Australian White Ibis	66	14	B
	Straw-necked Ibis	65	6	B
	Royal Spoonbill	46	13	W
	Yellow-billed Spoonbill	61	15	W
	Black-shouldered Kite	3	2	B
	Black Kite	15	3	B
	Whistling Kite	38	26	B
	Spotted Harrier	1	1	B
	Swamp Harrier	1	1	B
	Brown Goshawk	5	5	B
	Little Eagle	1	1	B
	Wedge-tailed Eagle	8	6	B
	Brown Falcon	2	2	B
	Australian Hobby	4	4	B
	Black Falcon	2	1	B
	Nankeen Kestrel	27	18	B

Conservation Status	Common_name	Total Birds	No of records	Bush/Water Birds
T	Brolga	6	3	B
	Australian Spotted Crake	1	1	W
	Purple Swamphen	25	9	W
	Dusky Moorhen	52	13	W
	Black-tailed Native-hen	50	6	W
	Eurasian Coot	1657	20	W
	Latham's Snipe	2	2	W
	Marsh Sandpiper	54	3	W
	Common Greenshank	2	2	W
	Sharp-Tailed Sandpiper	103	3	W
	Black-winged Stilt	142	13	W
	Red-necked Avocet	193	6	W
	Black-fronted Dotterel	3	3	W
	Red-kneed Dotterel	3	1	W
	Masked Lapwing	41	11	B
	Caspian Tern	3	1	W
	Silver Gull	2	1	B
	Whiskered Tern	23	6	B
	Rock Dove	93	7	B
	Common Bronzewing	1	1	B
	Crested Pigeon	371	92	B
	Diamond Dove	1	1	B
	Peaceful Dove	72	25	B
	Bar-shouldered Dove	3	2	B
T	Glossy Black-Cockatoo	5	2	B
	Galah	1212	132	B
	Little Corella	137	4	B
	Sulphur-crested Cockatoo	465	67	B
	Cockatiel	293	60	B
	Red-winged Parrot	3	2	B
T	Superb Parrot	2	1	B
	Eastern Rosella	91	24	B
	Pale-headed Rosella	61	24	B
	Australian Ringneck	67	29	B
	Blue Bonnet	82	20	B
	Red-rumped Parrot	323	63	B
	Channel-billed Cuckoo	1	1	B
	Southern Boobook	1	1	B
	Tawny Frogmouth	2	1	B
	White-throated Needletail	5	1	B
	Laughing Kookaburra	59	38	B
	Sacred Kingfisher	78	34	B
	Rainbow Bee-eater	1	1	B

Conservation Status	Common_name	Total Birds	No of records	Bush/Water Birds
	Dollarbird	11	5	B
	White-throated Treecreeper	4	3	B
D T	Brown Treecreeper	23	11	B
	Superb Fairy-wren	218	39	B
	Variegated Fairy-wren	196	32	B
	White-winged Fairy-wren	75	10	B
	Spotted Pardalote	9	4	B
	Striated Pardalote	46	26	B
	Weebill	83	27	B
	Western Gerygone	6	4	B
	Inland Thornbill	3	1	B
D	Chestnut-rumped Thornbill	1	1	B
	Buff-rumped Thornbill	2	1	B
	Yellow-rumped Thornbill	6	3	B
	Yellow Thornbill	16	6	B
	White-throated Gerygone	2	2	B
	Striped Honeyeater	5	2	B
	Noisy Friarbird	20	11	B
	Little Friarbird	68	25	B
	Blue-faced Honeyeater	28	12	B
	Noisy Miner	977	100	B
	Yellow-throated Miner	244	41	B
	White-plumed Honeyeater	317	56	B
D	Jacky Winter	6	4	B
D	Red-capped Robin	1	1	B
D	Eastern Yellow Robin	6	4	B
D T	Grey-crowned Babbler	66	9	B
D	Rufous Whistler	24	14	B
	Grey Shrike-thrush	37	16	B
	Leaden Flycatcher	3	2	B
D	Restless Flycatcher	8	5	B
	Magpie-Lark	225	93	B
	Grey Fantail	8	5	B
	Willie Wagtail	118	53	B
	Black-faced Cuckoo-Shrike	31	19	B
	White-bellied Cuckoo-Shrike	6	4	B

Conservation Status	Common_name	Total Birds	No of records	Bush/Water Birds
	Ground Cuckoo-Shrike	3	1	B
	White-winged Triller	5	3	B
	Olive-backed Oriole	1	1	B
	White-breasted Woodswallow	67	9	B
	Masked Woodswallow	15	1	B
D	White-browed Woodswallow	11	2	B
	Black-faced Woodswallow	3	1	B
	Grey Butcherbird	101	53	B
	Pied Butcherbird	108	54	B
	Australian Magpie	164	74	B
	Crow and Raven spp.	10	9	B
	Australian Raven	125	54	B
	Little Raven	4	3	B
	Torresian Crow	26	10	B
	White-winged Chough	225	20	B
	Apostlebird	382	29	B
	Spotted Bowerbird	3	3	B
	Richard's Pipit	18	5	B
	Zebra Finch	23	4	B
	Double-barred Finch	10	5	B
	Mistletoebird	1	1	B
	White-backed Swallow	1	1	B
	Welcome Swallow	137	14	B
	Tree Martin	277	20	B
	Fairy Martin	17	4	B
	Clamorous Reed-Warbler	151	22	W
	Little Grassbird	12	6	B
	Rufous Songlark	19	6	B
	Brown Songlark	1	1	B
	Golden-headed Cisticola	2	2	B
	Silvereye	13	1	B
	Common Starling	1408	56	B
	TOTALINDIVIDUAL BIRDS	16504		
	TOTAL SPECIES	154		

D = Declining species

T = Threatened species

Appendix 2: List of bird species identified in the Broad Vegetation Types.

Common_name	SumOfSum Of Sum Of Counts1	SumOfCount Of Species Records Query	Floodplain grassy Coolabah	Floodplain shrubby Coolabah	Floodplain shrubby Coolabah/Bela	Floodplain shrubby Poplar Box	Riverine Coolabah	Riverine River Red Gum	Riverine River Red Gum/Coolabah	Wetland Constructed Water storage	Wetland Natural	Wetland Natural water storage
Emu	2	1	2									
Brown Quail	15	6				5	9		1			
Plumed Whistling-Duck	249	8								207	40	
Blue-billed Duck	2	1								2		
Black Swan	33	13					4			22	5	
Australian Wood Duck	402	35	13				3	16	27	249	93	1
Pacific Black Duck	444	60		2		1	18	4	11	338	42	26
Australasian Shoveler	40	4								3	37	
Grey Teal	1630	40					9	1	11	279	1289	32
Chestnut Teal	2	1								2		
Pink-eared Duck	105	5								21	84	
Hardhead	182	10					15			126		
Australasian Grebe	115	15					5			102		5
Hoary-headed Grebe	5	2					1			4		
Great Crested Grebe	5	3								5		
Darter	120	34						1	1	97	2	17
Little Pied Cormorant	89	18					2			77		10
Pied Cormorant	128	14								113		15
Little Black Cormorant	238	16								228		
Great Cormorant	94	11					1			86	5	2
Australian Pelican	90	14					8	2	1	78	1	
White-faced Heron	27	22					6	4	2	7	1	7
White-necked Heron	10	8						1		4	3	2
Great Egret	54	22					7		5	38		4
Intermediate Egret	9	5					5		1	2		1
Nankeen Night Heron	19	2							1	18		
Glossy Ibis	8	3									8	
Australian White Ibis	66	14					1		33	22	9	1
Straw-necked Ibis	65	6	2								63	
Royal Spoonbill	46	13					1		19	25		1
Yellow-billed Spoonbill	61	15					1		20	20	3	17
Black-shouldered Kite	3	2								3		
Black Kite	15	3							1			14
Whistling Kite	38	26	1					6	1	12	8	10
Spotted Harrier	1	1								1		
Swamp Harrier	1	1				1						
Brown Goshawk	5	5					1	3		1		
Little Eagle	1	1							1			
Wedge-tailed Eagle	8	6	3			2				1		2
Brown Falcon	2	2								1	1	

Common_name	SumOfSum Of Sum Of Counts1	SumOfCount Of Species Records Query	Floodplain grassy Coolabah	Floodplain shrubby Coolabah	Floodplain shrubby Coolabah/Bela	Floodplain shrubby Poplar Box	Riverine Coolabah	Riverine River Red Gum	Riverine River Red Gum/Coolabah	Wetland Constructed Water storage	Wetland Natural	Wetland Natural water storage
Australian Hobby	4	4				2	1				1	
Black Falcon	2	1							2			
Nankeen Kestrel	26	17	4	1		1	1			11	4	4
Brolga	6	3									6	
Australian Spotted Crake	1	1									1	
Purple Swamphen	25	9					1			3	21	
Dusky Moorhen	52	13								18	31	1
Black-tailed Native-hen	50	6					2			15	12	6
Eurasian Coot	1657	20					19			1458	3	1
Latham's Snipe	2	2									2	
Marsh Sandpiper	54	3								1	53	
Common Greenshank	2	2									2	
Sharp-Tailed Sandpiper	103	3								98	5	
Black-winged Stilt	142	13								22	120	
Red-necked Avocet	193	6								5	188	
Black-fronted Dotterel	3	3					1			1	1	
Red-kneed Dotterel	3	1									3	
Masked Lapwing	41	11								21	18	2
Caspian Tern	3	1								3		
Silver Gull	2	1								2		
Whiskered Tern	23	6								18	1	4
Rock Dove	93	7									93	
Common Bronzewing	1	1					1					
Crested Pigeon	371	92	10	18	6	107	107	8	17	36	5	55
Diamond Dove	1	1					1					
Peaceful Dove	66	22					18	20	27			1
Bar-shouldered Dove	3	2						3				
Glossy Black-Cockatoo	5	2		3	2							
Galah	1210	131	401	23	17	86	130	69	92	122	141	141
Little Corella	137	4				2		11	124			
Sulphur-crested Cockatoo	462	66	3	9		2	80	86	125	8	52	97
Cockatiel	293	60	31	8	4	19	59	11	6	70	43	42
Red-winged Parrot	3	2		1				2				
Superb Parrot	2	1		2								
Eastern Rosella	91	24	23	14		5	18	2	6	1	2	20
Pale-headed Rosella	58	22	24	6			9		2	14	2	3
Australian Ringneck	61	27	15	21		4	5	2	3	12		3
Blue Bonnet	82	20	15	10	2	20				34	1	
Red-rumped Parrot	321	62	2	1	10	14	56	15	5	66	102	50
Channel-billed Cuckoo	1	1										1
Southern Boobook	1	1						1				
Tawny Frogmouth	2	1		2								
White-throated Needletail	5	1					5					

Common_name	SumOfSum Of Sum Of Counts1	SumOfCount Of Species Records Query	Floodplain grassy Coolabah	Floodplain shrubby Coolabah	Floodplain shrubby Coolabah/Bela	Floodplain shrubby Poplar Box	Riverine Coolabah	Riverine River Red Gum	Riverine River Red Gum/Coolabah	Wetland Constructed Water storage	Wetland Natural	Wetland Natural water storage
Laughing Kookaburra	59	38	5	1	2		22	9	6	5	2	8
Sacred Kingfisher	78	34		1			26	31	11	4		5
Rainbow Bee-eater	1	1						1				
Dollarbird	11	5						8	3			
White-throated Treecreeper	4	3						4				
Brown Treecreeper	23	11					17	5	1			
Superb Fairy-wren	218	39		1			86	12	15	13	1	31
Variegated Fairy-wren	196	32		1			61	23	20	1		53
White-winged Fairy-wren	75	10					9		1	18		11
Spotted Pardalote	9	4				1	6	2				
Striated Pardalote	42	22	1	4		3	14	5	2		12	1
Weebill	83	27	1	4		1	32	10	28		7	
Western Gerygone	6	4					4	2				
Inland Thornbill	3	1					3					
Chestnut-rumped Thornbill	1	1		1								
Buff-rumped Thornbill	2	1									2	
Yellow-rumped Thornbill	6	3					6					
Yellow Thornbill	16	6					4	10		2		
White-throated Gerygone	2	2					1	1				
Striped Honeyeater	5	2					1		4			
Noisy Friarbird	18	9					6	11	1			
Little Friarbird	65	23		1			25	27	3			9
Blue-faced Honeyeater	28	12		5		6	2		3	2	6	4
Noisy Miner	898	92	256	160	81	188	115	5	31	34	1	33
Yellow-throated Miner	244	41		33		4	33	20		23	52	79
White-plumed Honeyeater	317	56		2			190	79	38			8
Jacky Winter	6	4					6					
Red-capped Robin	1	1								1		
Eastern Yellow Robin	6	4					1	5				
Grey-crowned Babbler	66	9		4	1	14		16			2	
Rufous Whistler	22	12		1	2		4	14	1			
Grey Shrike-thrush	37	16	1			2	16	17	1			
Leaden Flycatcher	3	2						3				
Restless Flycatcher	8	5					3	3		1		1
Magpie-Lark	225	93	2	5		4	54	19	15	56	53	16
Grey Fantail	8	5					2	4	1	1		
Willie Wagtail	116	51		1			48	15	12	12	22	6
Black-faced Cuckoo-Shrike	31	19					14	6	10			1
White-bellied Cuckoo-Shrike	6	4					1	5				
Ground Cuckoo-Shrike	3	1									3	
White-winged Triller	5	3			1		2		2			
Olive-backed Oriole	1	1						1				
White-breasted	67	9					13	24		25	1	

Common_name	SumOfSum Of Sum Of Counts1	SumOfCount Of Species Records Query	Floodplain grassy Coolabah	Floodplain shrubby Coolabah	Floodplain shrubby Coolabah/Bela	Floodplain shrubby Poplar Box	Riverine Coolabah	Riverine River Red Gum	Riverine River Red Gum/Coolabah	Wetland Constructed Water storage	Wetland Natural	Wetland Natural water storage
Woodswallow												
Masked Woodswallow	15	1						15				
White-browed Woodswallow	11	2						10			1	
Black-faced Woodswallow	3	1								3		
Grey Butcherbird	93	48	19	15	21	19	16	2	5			3
Pied Butcherbird	107	53	44	11	1	18	12	1	9	3	5	4
Australian Magpie	162	72	45	32	2	16	4	11	11	25	7	9
Crow and Raven spp.	10	9	1		1		1			6		1
Australian Raven	125	54	20	5	5	22	26	5	18	8	3	13
Little Raven	4	3		1			3					
Torresian Crow	26	10	1			2	1	1	12	4	1	4
White-winged Chough	225	20	14	1		2	28	14	21			24
Apostlebird	381	28		40	12	44	28	1	13	12	23	16
Spotted Bowerbird	3	3			2							1
Richard's Pipit	18	5					16			2		
Zebra Finch	23	4								8	14	1
Double-barred Finch	10	5					8		2			
Mistletoebird	1	1						1				
White-backed Swallow	1	1					1					
Welcome Swallow	137	14					2			69	46	10
Tree Martin	277	20					41			188	43	4
Fairy Martin	17	4								3	14	
Clamorous Reed-Warbler	151	22						1	1	107	24	13
Little Grassbird	12	6								2	10	
Rufous Songlark	14	5					12		2			
Brown Songlark	1	1								1		
Golden-headed Cisticola	1	1					1					
Silvereye	13	1						13				
Common Starling	1408	56	1			12	73		11	548	494	118
TOTAL INDIVIDUAL BIRDS	16362		960	451	172	629	1711	740	859	5420	3456	1085
TOTAL SPECIES	155		30	39	19	33	87	66	61	88	72	64
SHANNON'S *H*			2.80	3.71	2.78	3.49	5.19	5.09	4.67	4.45	3.81	4.78
SHANNON'S E_H			0.57	0.70	0.66	0.69	0.81	0.84	0.79	0.69	0.62	0.80

Appendix 3: QMDC form Biodiversity Values Assessment (used in this project)

BIODIVERSITY VALUES ASSESSMENT

Site number: Office only…… ***Location :*** ……

Assessing officer:…… ***Date of assessment:***……..

GPS datum: ***GPS reading:*** Geog S °E

Describe the vegetation community:

1. Landscape context

Is the site a remnant patch in a fragmented landscape?

Yescomplete 1.1 & 1.2 **No**go to 2. Wetland features

1.1 Site context

	Score				Write score below
Patch characteristics	***0***	***1***	***2***	***3***	
Patch size	<2Ha	2-10Ha	10-50Ha	>50Ha	
Patch shape					
Minimum patch width	<20 m	20-50 m	50-100 m	>100 m	

Connectivity with core habitat

How far is the patch from the nearest remnant >50 Ha?	>5 km	1-5 km	<0.5-1 km	<0.5 km	

1.2 Neighbourhood context

	Score				
	0	***1***	***2***	***3***	
What proportion of the surrounding landscape has un-cleared native vegetation (including natural grasslands)?					
within 1 km of patch edge	<10%	10-30%	30-70%	>70%	
within 5 km of patch edge	<10%	10-30%	30-70%	>70%	

On the cleared country within 1 km of the site, what is the predominant land use?

	annual cropping	crop / pasture in rotation	introduced pasture	native pasture	

1.3 Water Source

How far is it to the nearest permanent water source?	>500m	200-500m	<200m	on site	

2. Wetland features

Is the site part of a wetland, or does it contain a wetland?

Yescomplete this section **No**go to 3. Habitat complexity

2.1 Wetland type

Natural	1.permanent stream	2.ephemeral stream	3.billabong or lagoon	4.lake	

	5.grass/sedge swamp	6.shrub swamp	7.wooded swamp	8.other	
Artificial	1.large dam/lake	2.small dam/pond	3.wastewater treatment	4.Irrigation structure	
2.2 Area of wetland	<2ha	2-8ha	8-100ha	>100ha	

3. Habitat complexity

Users of this form are encouraged to use the crown separation method of assessment. Tables modified from Walker and Hopkins Table 13 & 14 are a useful aid.

	% cover			
3.1 Woody vegetation cover	***0***	***1***	***2***	***3***
Trees >8m	<10%	10-25%	26-50%	>50%
Tall shrubs/small trees 2-8m	<10%	10-25%	26-50%	>50%
Low shrubs <2m	<10%	10-25%	26-50%	>50%
3.2 Ground cover				
Grasses and forbs ("herbage")	<10%	10-30%	31-70%	>70%
Organic litter (leaves/woody debris)	<10%	10-30%	31-70%	>70%
3.3 Habitat features				
Abundance of large old trees with hollows	none present	1-2 trees per hectare	3-5 trees per hectare	>5 trees per hectare
Abundance of logs >2m long & >10cm diameter	none present	1-5 logs every 100 m	5-10 logs every 100 m	>10 logs every 100 m
3.4 Woody species diversity				
Number of species in the tree canopy layer	1	2-3	3-5	>5
Number of species in the understorey	<3	3-5	5-10	>10

4. Habitat condition

	Score			
	0	***1***	***2***	***3***
4.1 Regeneration of dominant species				
Tree layer	no regen. evident	scarce regen.	some regen. mostly single age	sustainable regen. of mixed ages
Shrub layer				
4.2 Health of dominant species				
Tree layer	Most plants dead or dying	Many plants >50% canopy dead/dying	Some trees up to 25% canopy dead/dying	Little or no canopy death
Shrub layer				
4.3 Weediness of site (Note reverse order of cover %)				
Exotic ground-layer plants (e.g. buffel grass, thistles)	>50%	11-50%	1-10%	<1%
Exotic woody plants (e.g. box-thorn, tree pear)	>50%	11-50%	1-10%	<1%

Invading native woody plants (e.g. cypress, short-lived wattles)	>50%	26-50%	10-25%	<10%	

4.4 Disturbance on site

Land use	clearfell cultivation intensive thin	heavy grazing intensive thin	light-moderate grazing and/or slective thin	conservation + limited or no grazing	
Fire intensity	recent hot extensive damage	old hot some recovery	moderate recent some recovery	none or moderate old + good recovery	

Supplementary observations

Appendix 4: Simplified Biodiversity Values Assessment Sheet suitable for Namoi vegetation and Birds.

BIODIVERSITY VALUES ASSESSMENT - NAMOI					
Site number: Office only……	***Location :***	……			
Assessing officer:……		***Date of assessment:***……..			
GPS datum: ***GPS reading:***	Geog	°S		°E	
Describe the vegetation community:					

1. Landscape context

Is the site a remnant patch in a fragmented landscape?

Yes		**No**		

NB: Score 0, 1, 2, 3 does not indicate a better or worse condition, it is a label for the condition observed. Some users of this form may sum the scores, others may not.

1.1 Site context	**Score**					
Patch characteristics	***0***	***1***	***2***	***3***		Write score below
Patch size	<2Ha	2-10Ha	10-50Ha	>50Ha		
Patch shape						
Minimum patch width	<20 m	20-50 m	50-100 m	>100 m		

Connectivity with core habitat						
How far is the patch from the nearest remnant >50 Ha?	>5 km	1-5 km	<0.5-1 km	<0.5 km		

2. Wetland features

Is the site part of a wetland, or does it contain a wetland?					
Yes	complete Wetland Assessment Form	**No**			

3. Habitat complexity

Users of this form are encouraged to use the crown separation method of assessment. Tables modified from Walker and Hopkins Table 13 & 14 are a useful aid.

	% cover				
3.1 Woody vegetation cover	***0***	***1***	***2***	***3***	
Trees >8m	<10%	10-25%	26-50%	>50%	
Tall shrubs/small trees 2-8m	<10%	10-25%	26-50%	>50%	

Low shrubs <2m	<10%	10-25%	26-50%	>50%		
3.2 Ground cover						
Grasses and forbs ("herbage")	<10%	10-30%	31-70%	>70%		
Organic litter (leaves/woody debris)	<10%	10-30%	31-70%	>70%		
3.3 Habitat features						
Abundance of large old trees with hollows	none present	1-2 trees per hectare	3-5 trees per hectare	>5 trees per hectare		
Abundance of logs >2m long & >10cm diameter	none present	1-5 logs every 100 m	5-10 logs every 100 m	>10 logs every 100 m		
3.4 Woody species diversity						
Number of species in the tree canopy layer	1	2-3	3-5	>5		
Number of species in the understorey	<3	3-5	5-10	>10		
4. Habitat condition	**Score**					
	0	***1***	***2***	***3***		
4.1 Regeneration of dominant species						
Tree layer	no regen. evident	scarce regen.	some regen. mostly single age	sustainable regen. of mixed ages		
Shrub layer						
4.2 Health of dominant species						
Tree layer	Most trees/shrubs dead or dying	Many trees/shrubs >50% canopy dead/dying	Some trees/shrubs up to 25% canopy dead/dying	Little or no canopy death		
Shrub layer						
Supplementary observations						

Appendix 5: Biodiversity Values Assessment – Wetland.

BIODIVERSITY VALUES ASSESSMENT - WETLAND						
Site number: Office only……	***Location :***	……				
Assessing officer:……			***Date of assessment:***……..			
GPS datum: ***GPS reading:***	Geog	°S		°E		
Describe the vegetation community:						
1. Landscape context						
1.1 Site context	**Score**					

NB: Score - 0, 1, 2, 3 does not indicate a better or worse condition, it is a label for the condition observed. Some users of this form may sum the scores other users may not. The aspect of most importance is how biota relate to each condition.

Patch characteristics	***0***	***1***	***2***	***3***		Write score below
Patch size	<2Ha	2-10Ha	10-50Ha	>50Ha		
Patch shape						
Minimum patch width	<20 m	20-50 m	50-100 m	>100 m		
Connectivity with core habitat						
How far is the patch from the nearest remnant >50 Ha?	>5 km	1-5 km	<0.5-1 km	<0.5 km		
2. Wetland features						
2.1 Wetland type						
Natural	1.permanent stream	2.ephemeral stream	3.billabong or lagoon	4.lake		
	5.grass/sedge swamp	6.shrub swamp	7.wooded swamp	8.other		
Artificial	1.large dam/lake	2.small dam/pond	3.wastewater treatment	4.Irrigation structure		
2.2 Area of wetland	<2ha	2-8ha	8-100ha	>100ha		
3. Wetland Habitat Complexity	Users of this form are encouraged to use the crown separation method of assessment. Tables modified from Walker and Hopkins Table 13 & 14 are a useful aid.					
	% cover					
3.1 Woody vegetation cover around shore	***0***	***1***	***2***	***3***		
Trees >8m	<10%	10-25%	26-50%	>50%		
Tall shrubs/small trees 2-8m	<10%	10-25%	26-50%	>50%		
Low shrubs <2m	<10%	10-25%	26-50%	>50%		

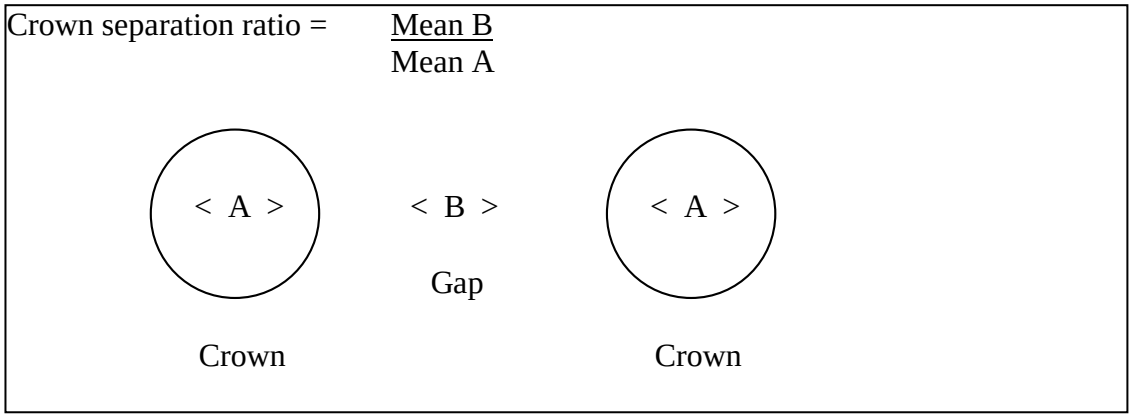
3.2 Ground cover around shore						
Grasses and forbs ("herbage")	<10%	10-30%	31-70%	>70%		
Organic litter (leaves/woody debris)	<10%	10-30%	31-70%	>70%		
3.3 Aquatic Vegetation	**% of shore circumference**					
Submerged	<10%	10-30%	31-70%	>70%		
Emergent	<10%	10-30%	31-70%	>70%		
3.3 Habitat features						
Abundance of large old trees standing in water	none present	1-2 trees per hectare	3-5 trees per hectare	>5 trees per hectare		
Abundance of logs >2m long & >10cm diameter in water	none present	1-5 logs every 100 m	5-10 logs every 100 m	>10 logs every 100 m		
3.4 Vegetation species diversity	**number of species**					
Fringing tree canopy layer	1	2-3	3-5	>5		
Fringing understorey	<3	3-5	5-10	>10		
Grassy verge	1	2-3	3-5	>5		
Aquatic vegetation	1	2-3	3-5	>5		
4. Physical features	**Score**					
	0	***1***	***2***	***3***		
4.1 Vegetated Islands	not present	present, not vegetated	vegetated	vegetated with aquatic plant fringe		
4.2 Mud flats	not present	present at lower level	present at normal water level	present & vegetated at normal level		
4.3 Disturbance on site						
Earthworks - time since	recent extensive works, no vegetation	recent works vegetation retained	old works, vegetated	no earth works		
4.4 Weediness of site (Note reverse order of cover %)						
Exotic ground-layer plants (e.g. buffel grass, thistles)	>50%	11-50%	1-10%	<1%		
Exotic woody plants (e.g. box-thorn, tree pear)	>50%	11-50%	1-10%	<1%		
Invading native woody plants (e.g. cypress, short-lived wattles)	>50%	26-50%	10-25%	<10%		
Supplementary Observations						
Final Report Version						

Appendix 6:

Conversion of crown separation ratios to percentage crown cover

	x	Overlap		x		Touching	x	Crowns separate																			x
Crown separation ratio	-0.25	-0.1875	-0.125	-0.0625	0	0.05	0.1	0.15	0.2	0.25	0.3	0.4	0.5	0.6	0.75	1	1.25	1.5	2	3	4	8	10	15	20	30	
Percentage crown cover	100	95	89	84	78	72	65	59	55	51	47	40	34	31	26	20	16	13	9	5	3	1	0.6	0.3	0.2	0.1	

When crowns are touching the ratio is zero; when the crowns are separated by half the size of the crowns the ratio is 0.5.
When the tree crowns are touching the percentage crown cover is 78%; when the ratio is 0.5 the percentage crown cover is 34%.
Overlapping cover can also be estimated; in this case the fraction of overlap is recorded and the ratio recorded as a negative number.



	Closed Forest	Open forest, open scrub, open heath	Woodland, shrubland	Open

Relationships between crown separation ratio, percentage crown cover and projective folio cover

Field criteria	**D** Closed or dense Touching to overlapping	**M** Mid-dense Touching to slight separation	**S** Sparse Clearly separated	**V** Very sparse Well separated	**I** Isolated plants Isolated plants	**L** Isolated clumps Isolated clumps
Crown separation ratio	<0	0-0.25	0.25-1	1-20	>20	>20
Percentage crown cover	>75	50-75	20-50	0.25-20	<0.25	<0.25
Projective foliage cover	>70	30-70	10-30	<10		

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