Results

Case Study 1 – Nullamanna Landcare Group, Border Rivers NSW

The Nullamanna Landcare Group (21,000 hectares) is located 20 km north east of Inverell and centred on the township of Nullamanna. In its Catchment Action Strategic Plan (June 2000), The Nullamanna Landcare Group has identified a number of major issues affecting the catchment including salinity, soil erosion, better pastures, nightshade, windbreaks, water quality and vegetation. From this list of primary issues and through a community consultation process, the group has identified three priority issues to address in their catchment planning including (a) salinity, (b) water quality and (c) vegetation. Of particular interest to this study is issue (c) which has as its objective the improvement of biodiversity across the catchment via revegetation and remnant protection activities.

Over the past decade the group has attracted substantial funding for a range of vegetation enhancement activities with diverse objectives. This primarily consists of Envirofund funding to mitigate salinity and erosion, and extensive NHT funding to support native vegetation enhancement activities through primarily corridor establishment. The case study was conducted in collaboration with Col Meacham (Chairperson, Nullamanna Landcare Group and with the assistance Mr. Dick Walker (President, Gwydir and Macintyre Resource Management Committee) and Mr. Warwick Browne (General Manager, Gwydir Border Rivers Catchment Management Authority). A total of 13 NHT projects totalling $296,000 dollars were assessed across the Nullamanna Landcare Group with funding extending from 1994 to 2003. Based on DEH project information from between 1996 and 2005, the entire Border Rivers NHT region received a total of $1.29 million dollars of NHT funding (J. Tomkins 2005, pers. comm.). Consequently, the Nullamanna Landcare Group accounts for approximately 24 % of all activities in this NHT region (excluding data for 1994 as this was not available). Figure 2 shows the boundary and extent of on-ground activities across the Nullamanna Landcare group.

Mapping of the Nullamanna Landcare Group was conducted in November 2005 by Mr. Damian Wall (Minchem Pty. Ltd) using specifications developed by CSIRO (Appendix A & B). Vegetation enhancement activities were mapped using landholder interviews and a SPOT5 false colour composite image (acquisition date: 15/11/2004) using 'on-screen' digitising with ArcView GIS. In addition to mapping the boundaries of vegetation enhancement activities, site coordinates were also collected including a reference coordinate for each enhancement activity (site) and the location of this reference coordinate relative to the patch. This information was included in the relational database to provide a spatial reference between attribute information and spatial information in the event spatial and attribute data are separated. At present the link between the spatial information and the relational database is via the 'SiteID' identifier which is maintained manually.

In addition to primary data acquisition for this case study, ancillary contextual data was also made available and added to the GIS to enable analysis and mapping. A key dataset for conducting such an analysis is detailed vegetation mapping for the study region. Detailed vegetation mapping, particularly if accompanied by pre-European mapping, enables regions to assess improvements in vegetation cover, representativeness of vegetation communities, and allows one to examine any improvements in landscape connectivity. Existing vegetation mapping was sourced from Border Rivers-Gwydir Catchment Management Authority (Steenbeeke 2001). Extant woody vegetation was mapped from Landsat 5 satellite imagery. However, deficiencies have been identified in the ability of this mapping product to adequately represent extant woody vegetation across the Nullamanna Landcare Group. The primary concern is that smaller remnants are entirely ignored owing to the sensor limitations of Landsat 5. Discriminating paddock trees from such sensors is an even greater challenge. The concern arises when one considers the size of the vegetation enhancement activities across a management zone such as the Nullamanna Landcare Group. Table 2 shows that most vegetation enhancement activities are less than 2.5 hectares in area and few are greater than 10 hectares.

Attribute data collection used the *BioAudit FieldAudit* tool to collect vegetation enhancement activity attribute information directly via landholder interviews. After primary data collection, the *FieldAudit* data files were synchronised by CSIRO using an email transfer from the mapping contractor. The major post processing requirement was to apply site identifiers (SiteID element) from the database to all relevant activities in the GIS file (Shapefile attribute table).

Table 2 and Table 3 provide a summary of key revegetation and remnant fencing activities for the Nullamanna study site. The impact of revegetation in this landscape is small relative to the total amount of existing vegetation in this landscape (0.39 %) although as is discussed in Appendix D, these figures can be misleading as mapping scale and accuracy will impact upon these results. Fencing is more cost effective in terms of its ability to protect larger areas of remnant vegetation relative to revegetation (452 ha versus 83 hectares). Fencing efficiencies of 39.4 ha/km are commensurate with those described in Freudenberger and Harvey (2004) (32 ha/km) however, this study region has received significantly less funds than comparable study areas hence it may be fare to assume that the in-kind contribution has been larger. Relative to other case studies, the average size of revegetation patches is also quite high (8.9 ha). There has also been a small decrease in the nearest neighbour distance for this region indicated a small improvement in connectivity. The GIS database highlights that activities have included a mix of shelter belt establishment, major areas of riparian protection which also serves to connect habitat, and isolated revegetation activities.

Figure 3 provides a box plot showing the objectives by the total area for that objective for the vegetation enhancement activities in the Nullamanna Landcare Group. The box plot also indicates the range for each objective (stems in the plot) and the median value (solid bar). This data allows for multiple objectives at individual sites hence total areas are greater than the total area of the enhancement activities in this region. The primary objective in this region is the protection of threatened species although the total area for this activity is skewed by one large activity (268 ha). As with the other case studies there is a peak in funding and activity between 1999-2000. Interestingly, funding continues to increase towards 2005 but this is associated with an overall decrease in area enhanced. Without further analysis of the database, it can be assumed that this highlights a shift away from fencing towards revegetation activities. As with most case studies, patch-area histograms for vegetation enhancement activities (Figure 5) highlight the fact that enhancement activities achieve very small increases in total vegetation cover. Figure 7 highlights that most of the revegetation has been located on average, 8 km from other remnants in this landscape.

Table 2. Nullamanna Study Site: Revegetation activities summary

Revegetation Activities	Statistics
Total amount of revegetation (ha)	83.5
Total perimeter of revegetation (km)	41.6
Number of revegetation patches	31
Average revegetation patch size (ha)	8.9
Revegetation as percentage of study site	0.39
Pre (extant & remnant enhancement) vegetation as percentage of the study site	27.3
Total area of study site (ha)	21036

Table 3. Nullamanna Study Site: Fencing of remnant vegetation

Fencing Activities	Statistics
Area of remnants fenced and enhanced (ha)	55.9
Total area of mapped remnants (ha)	5754.4
Area of mapped remnants fenced (ha)	452.5
Remnant area fenced as percentage of all remnants	7.8
Total number of remnants greater or equal to 10ha	29
Total number of remnants less than 10ha	4828
Fenced remnants greater than 10ha	14
Fenced remnants less than 10ha	1
Total perimeter of mapped remnants (km)	1148.5
Total length of funded fencing for remnant protection (km)	56.8
Area of remnant protected per km of funded fence (ha/km)	20.54

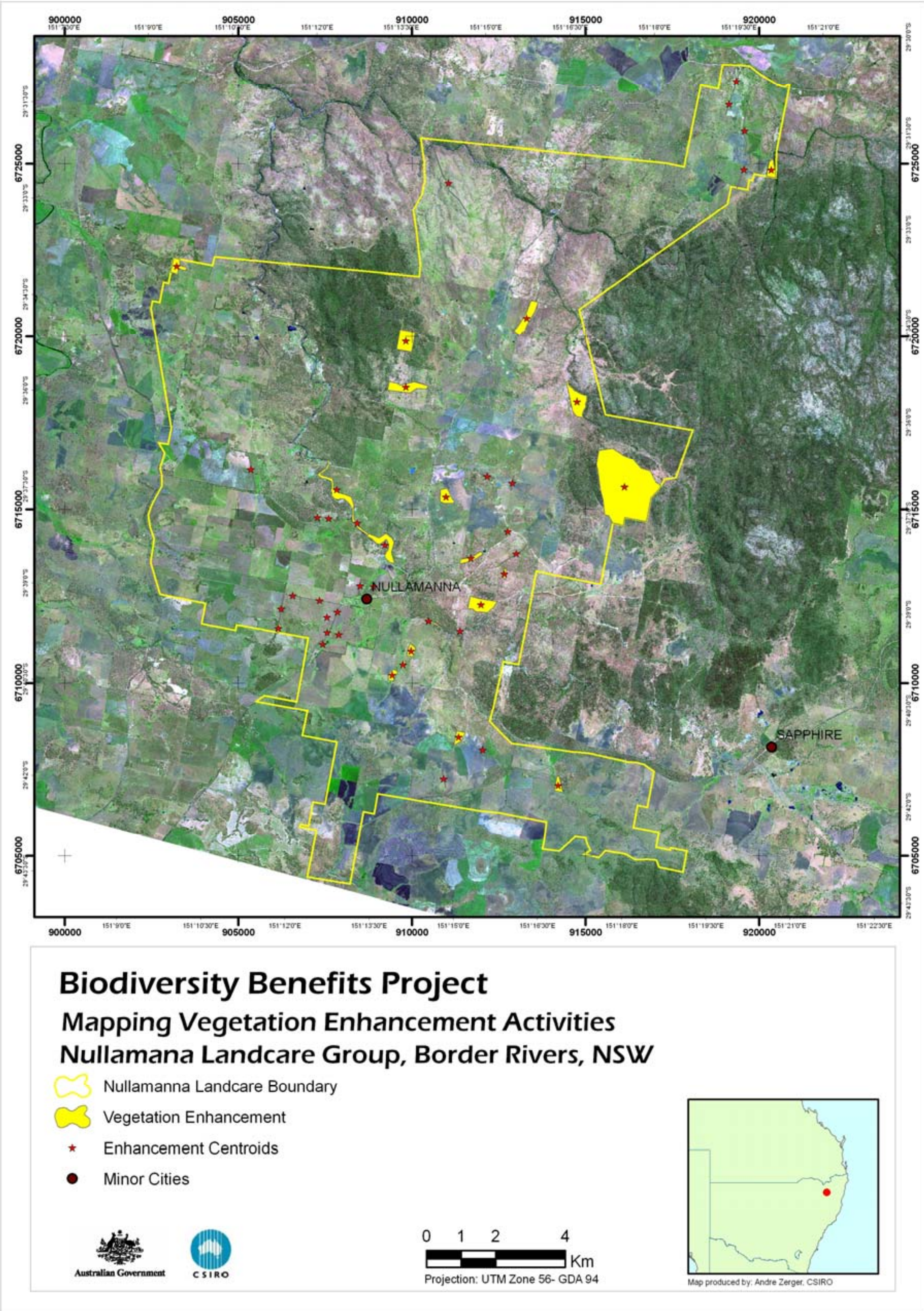

Figure 2. Nullamanna Landcare Group – study area boundary and mapped vegetation enhancement activities.

Table 4. Nullamanna case study: Nearest neighbour indexes for vegetation enhancement activities

Vegetation Enhancement Activity	**Mean Nearest Neighbour Distance (metres)**	**Mean Nearest Neighbour Distance Index**
Pre mapped vegetation enhancement activities	68.5	0.46
Post mapped vegetation enhancement activities	67.3	0.45

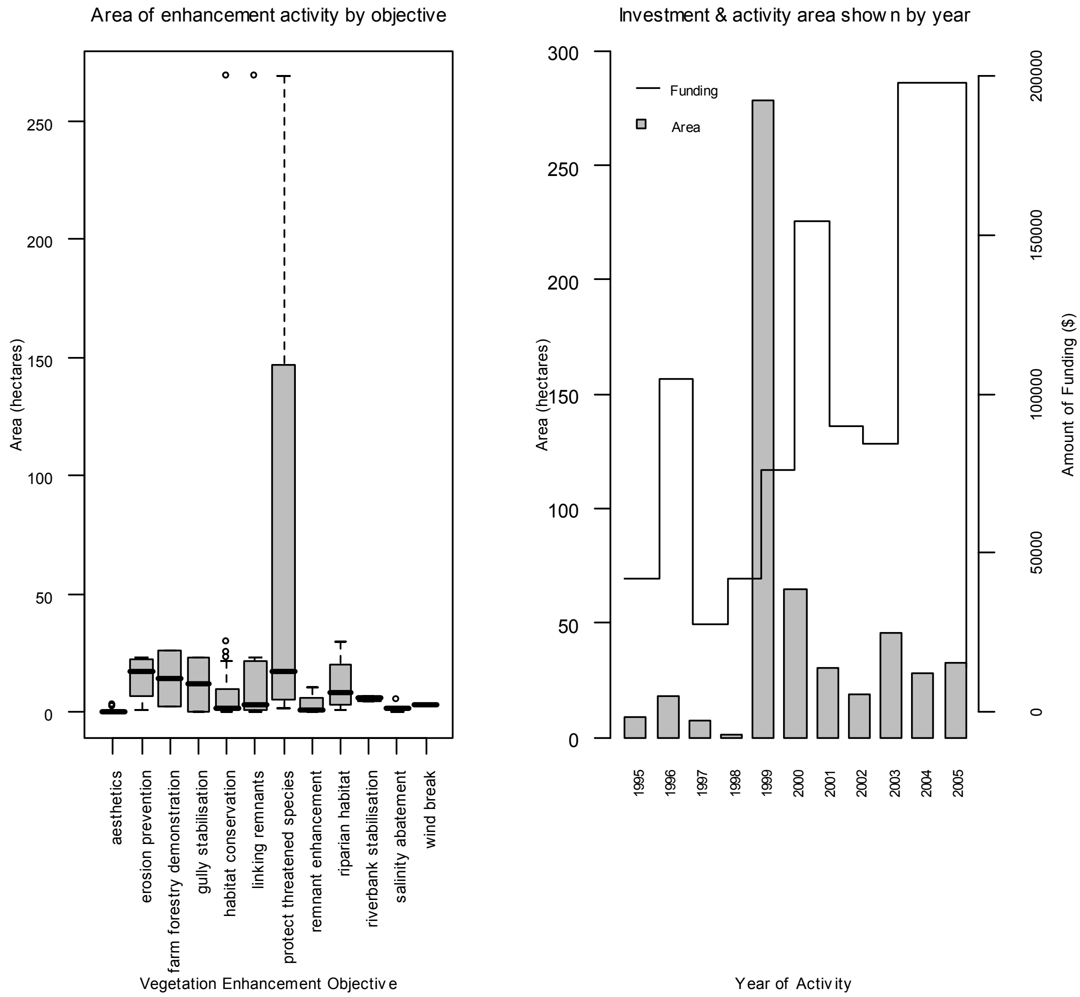

Figure 3. Nullamanna Landcare Group – Area of vegetation enhancement activity shown by enhancement objectives and amount of funding and area of activity shown by funding years. The BioAudit data model allows for multiple objectives at individual sites hence total areas are greater than the total area of activities in this study site (stems in the plot show the data range and the solid bar is the median value).

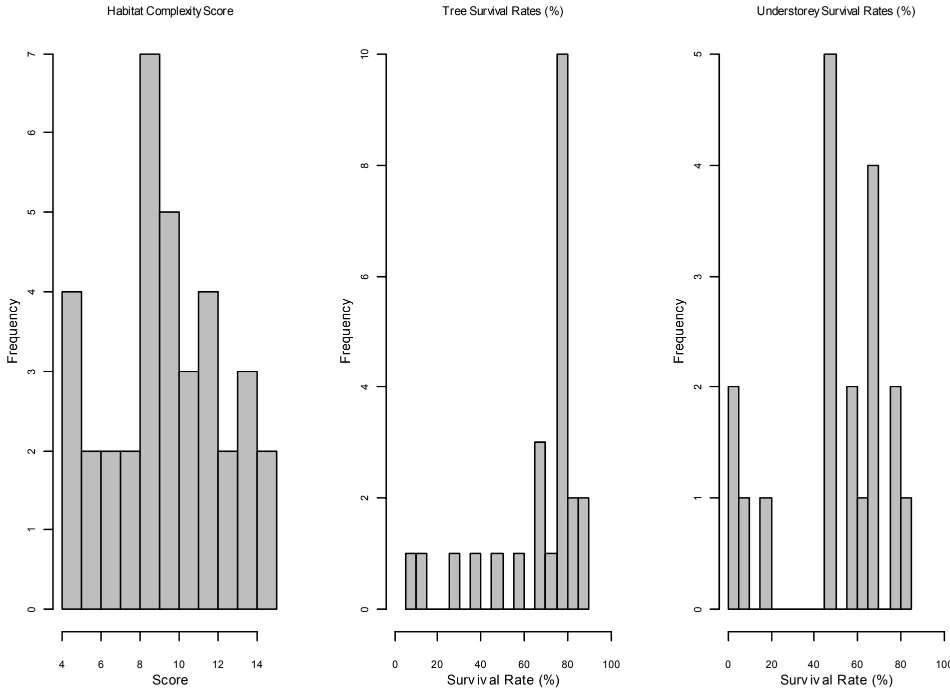

Figure 4. Nullamanna Landcare Group – Vegetation enhancement activity outcomes. Histograms showing range of condition scores and tree and understorey survival rates from mapped vegetation enhancement activities (including remnant protection, enhancement and revegetation)

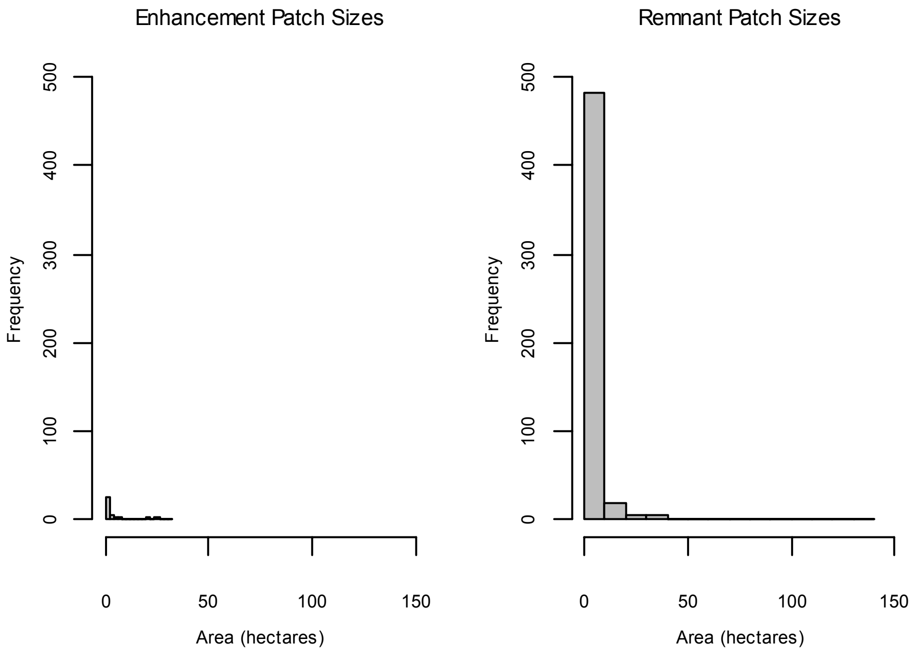

Figure 5. Patch area histograms for new on-ground vegetation enhancement activities including revegetation and fencing (enhancement patch sizes), and existing remnant patch size distribution from Landsat 5 vegetation mapping. Only patches less than 268 hectares are shown as one large revegetation site in Nullamanna skews these graphs.

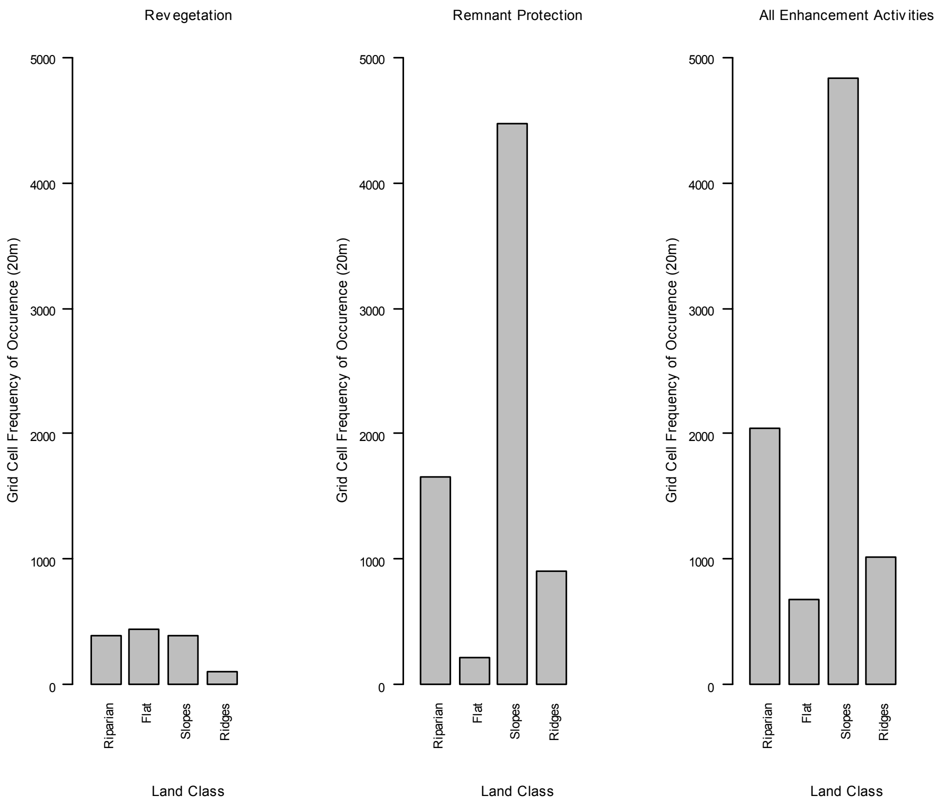

Figure 6. Nullamanna Landcare Group – Area of vegetation enhancement activity shown by land classification for revegetation polygons, remnant protection polygons (fencing) and all activities. The land classification raster utilised a 20 metre cell resolution.

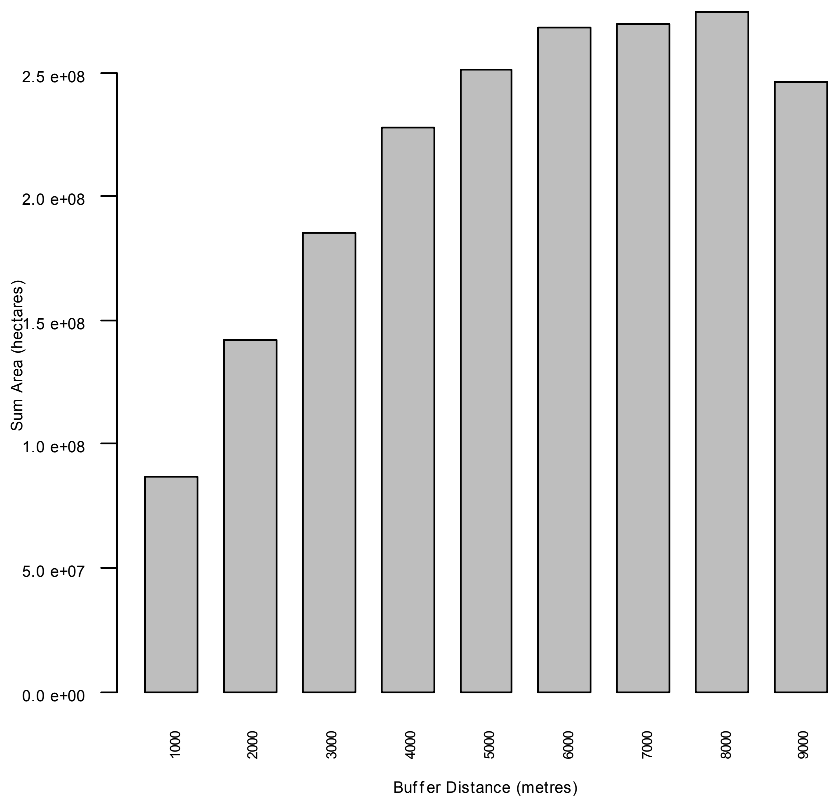

Figure 7. Nullamanna Landcare Group – habitat buffers algorithm results showing relative increases in vegetation area for increasing buffer distances from 1 km to 10 km in 1 km increments. Bar plot shows that most revegetation is on average 8 km from other remnants in the landscape.

Case Study 2 – Cudgewa and Tintaldra, North East Victoria

The Cudgewa study site is located in the western foothills of the Australian Alps, some 40km west of Corryong and 80km east of Wodonga. The case study was conducted in collaboration with the Cudgewa and Tintaldra Landcare Groups and the study is confined to the administrative boundary of the Cudgewa and Tintaldra Landcare Groups. The Landcare groups are responsible for some 42,240ha of land surrounding the Cudgewa Creek in the lower reaches of the catchment. This area extends south west from the Murray River at Tintaldra, along the valley floor and lower slopes to Cudgewa, then west to Lucyvale and Berringama. Much of the upper catchment is forested public land and is managed by government agencies. Generally, clearing has occurred on the valley floor and lower foot slopes while leaving the surrounding ridges and hilltops forested.

The Cudgewa Catchment Landcare Group was formed in 1993. Since then they have been involved in a wide range of programmes including whole farm planning workshops, control of Patterson's curse, bent grass, blackberry, St Johns Wort, and rabbits, enhancement of eucalypt remnants through fencing and understorey plantings, and stock control fencing of riparian sites. The Tintaldra Landcare Group was formed in 1995. They have been involved in the Corridors of Green Program to establish vegetation corridors along the Murray River as well as undertaking other revegetation and weed control projects. Both the Tintaldra and Cudgewa groups have been involved with other groups in the catchment-wide Water Quality Monitoring and Catchment Planning Project.

In 1998, communities in the Cudgewa catchment developed a catchment plan to provide a basis for future actions which addressed the specific needs and concerns of the local community while meeting the aims of the North East Regional Catchment Strategy. Among others, the plan identified erosion, water quality, declining remnant vegetation health, salinity and pest species as issues that needed to be addressed.

The high rainfall and hilly terrain of Cudgewa catchment, in combination with the erodability of the granitic soils of the area, mean that erosion can be a problem. Examples of streambed, bank, sheet and gully erosion, as well as landslips, can all be found within the Cudgewa catchment. Erosion can result in loss of productive land, degradation of water quality and access problems for stock and landholders. The Landcare groups have begun to address these issues by raising awareness of erosion issues, processes and control methods and by promoting stream erosion prevention processes including controlling or excluding stock access, revegetation of riparian areas and control of willows through the establishment of demonstration sites.

Water quality, and in particular high turbidity levels and algal blooms, have been a concern to the community of the Cudgewa catchment for some time. The Cudgewa catchment is a net exporter of water to the Murray so a large number of downstream users will be affected by water quality issues. Water quality monitoring is undertaken monthly to identify changes in water quality and problem areas. This has enabled promotion of water quality issues and has raised the community's awareness of best management practices. Two Natural Heritage Trust projects have provided assistance in riparian fencing, revegetation and bank stabilisation programmes.

Concern about ongoing tree decline and its relationships with salinity, water quality, agricultural productivity and biodiversity has been identified by the Cudgewa and Tintaldra Landcare Groups. Tree declines are an increasing problem throughout the catchment on farmland, roadside reserves and public land. In particular, areas of Blakely's red gum woodland and river red gum in the lower catchment are suffering serious dieback. As well as providing shade and shelter for stock and habitat for wildlife, trees control the recharge of groundwater, minimising problems associated with water logging and salinity. The 'Remnant protection' and 'Reversing Red Gum Decline' NHT projects have been implemented to help maintain and improve remnants in the region. These projects have been complimented by the establishment of revegetation sites by landholders and activities aimed at improving the awareness of the community to the causes of tree decline and best management practices to prevent and address decline.

Mapping of the Cudgewa and Tintaldra Landcare Groups was conducted in February 2006 by Mr. Damian Wall (Minchem Pty. Ltd) using specifications provided by CSIRO (Appendix A & B). Vegetation enhancement activities were mapped using landholder interviews and a SPOT5 false colour composite image using on-screen digitising with ArcView GIS. In addition to mapping the boundaries of vegetation enhancement activities, site coordinates were also collected including a reference coordinate for each enhancement activity (site) and the location of this reference coordinate relative to the patch. Existing vegetation mapping was provided by the Victorian Department of Sustainability and Environment in the form of a 1:100,000 scale EVC map tile for Corryong. Figure 8 shows the boundary of the study region and maps the on-ground vegetation enhancement activities.

Table 5 and Table 6 summarise the key statistics for the on-ground vegetation enhancement activities in the Cudgewa and Tintaldra case study. The region has revegetated 73.7 ha and fenced 86.3 ha. The average size of revegetation activities is relatively small (0.76 ha) and the GIS highlights that this is owing to the large number of linear shelterbelts and riparian protection zones created in this landscape. This is also highlighted by the relatively low perimeter to area ratio of 1.2. Relative to other study sites, few of the activities were fencing only with the majority consisting of revegetation, combined with fencing. The nearest neighbour distance has decreased from 362 metres to 318 metres indicating that some improvements in connectivity have been achieved, probably owing to the extensive establishment of linear corridors and riparian protection which will lead to such results (Table 7).

The major vegetation enhancement activity in this study site is revegetation for riparian protection followed by the protection of threatened species. As with the Nullamanna case study, Figure 10 shows a steady increase in funding leading up to about 2004, however this also corresponds to a net increase in area enhanced which reflects the fact that this region has focussed on revegetation rather than fencing of existing remnants. Figure 12 shows that revegetation activities have been successful with relatively high survival rates of tree species, although understorey survival rates have been significantly less.

Table 5. Cudgewa and Tintaldra case study: Revegetation activities summary

Revegetation Activities	Statistics
Total amount of revegetation (ha)	73.7
Total perimeter of revegetation (Km)	59.9
Number of revegetation patches	97.0
Average revegetation patch size (ha)	0.76
Length of fencing for revegetation (km)	60.4
Average perimeter to area ratio of funded fences	1.2
Revegetation as percentage of study site	0.17
Pre (extant & remnant enhancement) vegetation as percentage of the study site	39.3
Total area of study site (ha)	42240

Table 6. Cudgewa and Tintaldra case study: Fencing of remnant vegetation

Fencing Activities	Statistics
Area of remnants fenced and enhanced (ha)	70.1
Total area of mapped remnants (ha)	16510.5
Area of mapped remnants fenced (ha)	86.3
Remnant area fenced as percentage of all remnants	0.5
Total number of remnants greater or equal to 10ha	190
Total number of remnants less than 10ha	427
Fenced remnants greater than 10ha	2
Fenced remnants less than 10ha	31
Total perimeter of mapped remnants (km)	1741.2
Total length of funded fencing for remnant protection (km)	17.2
Area of remnant protected per km of funded fence (ha/km)	0.9

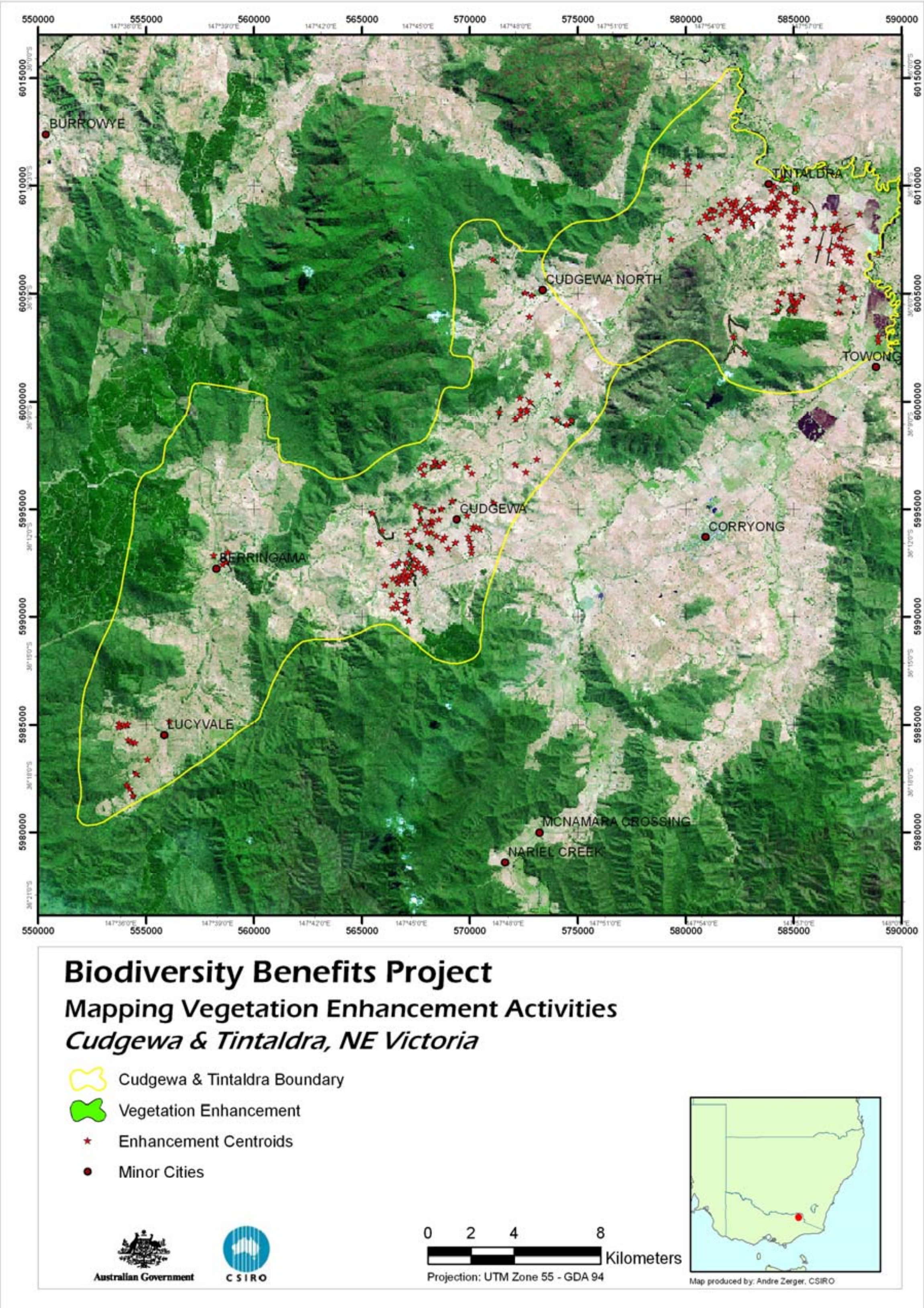

Figure 8. Cudgewa and Tintaldra Landcare Group – study area boundary and mapped vegetation enhancement activities.

Table 7. Cudgewa & Tintaldra case study: Nearest neighbour indexes for vegetation enhancement activities

Vegetation Enhancement Activity	Mean Nearest Neighbour Distance (metres)	Mean Nearest Neighbour Index
Pre mapped vegetation enhancement activities	362	0.49
Post mapped vegetation enhancement activities	318	0.51

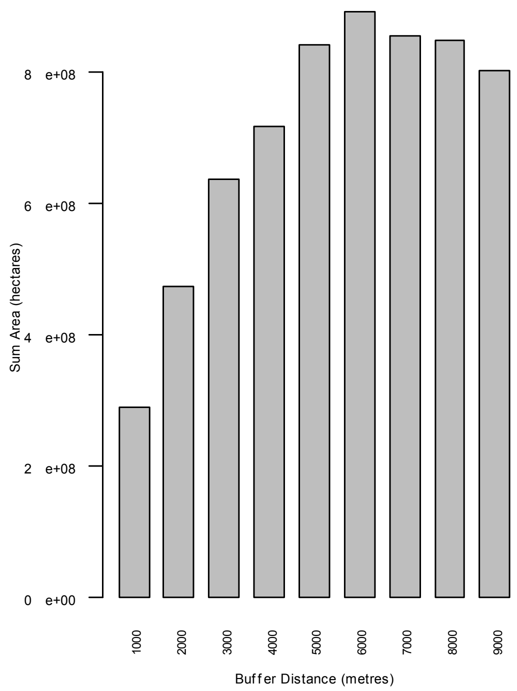

Figure 9. Cudgewa and Tintaldra Landcare Group – habitat buffers algorithm results showing relative increases in vegetation area for increasing buffer distances from 1 km to 10 km in 1 km increments. This shows that most revegetation, on average was 5-6km from other remnants in the landscape.

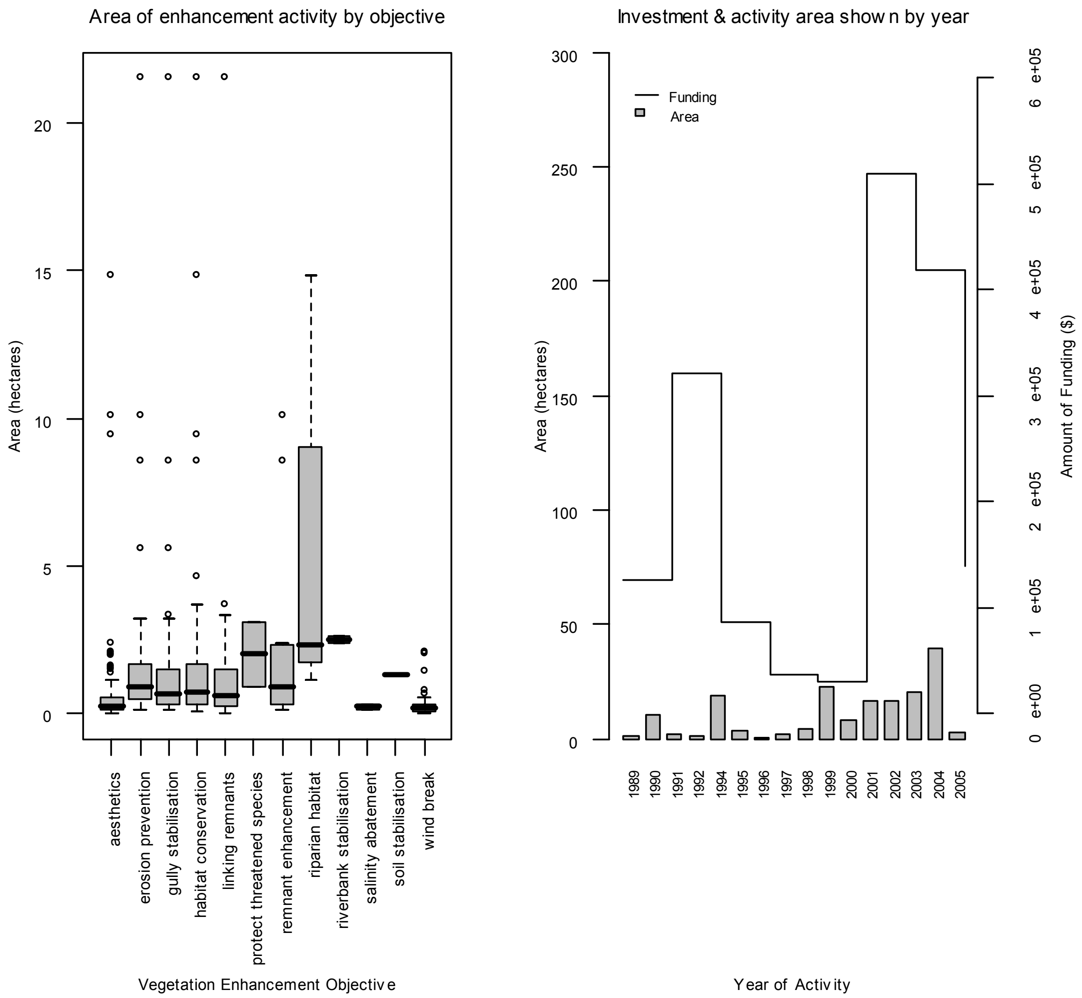

Figure 10. Cudgewa and Tintaldra Landcare Group – Area of vegetation enhancement activity shown by enhancement objectives and amount of funding and area of activity shown by funding years. The BioAudit data model allows for multiple objectives at individual sites hence total areas are greater than the total area of activities in this study site (stems in the plot show the data range and the solid bar is the median value).

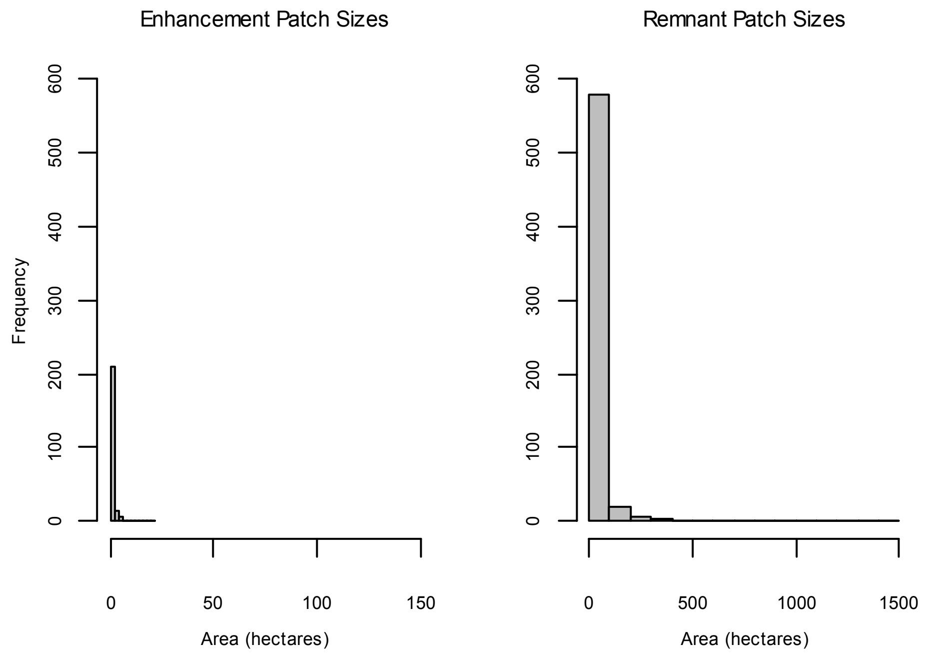

Figure 11. Patch area histograms for new on-ground vegetation enhancement activities including revegetation and fencing (enhancement patch sizes), and existing remnant patch size distribution from EVC vegetation mapping.

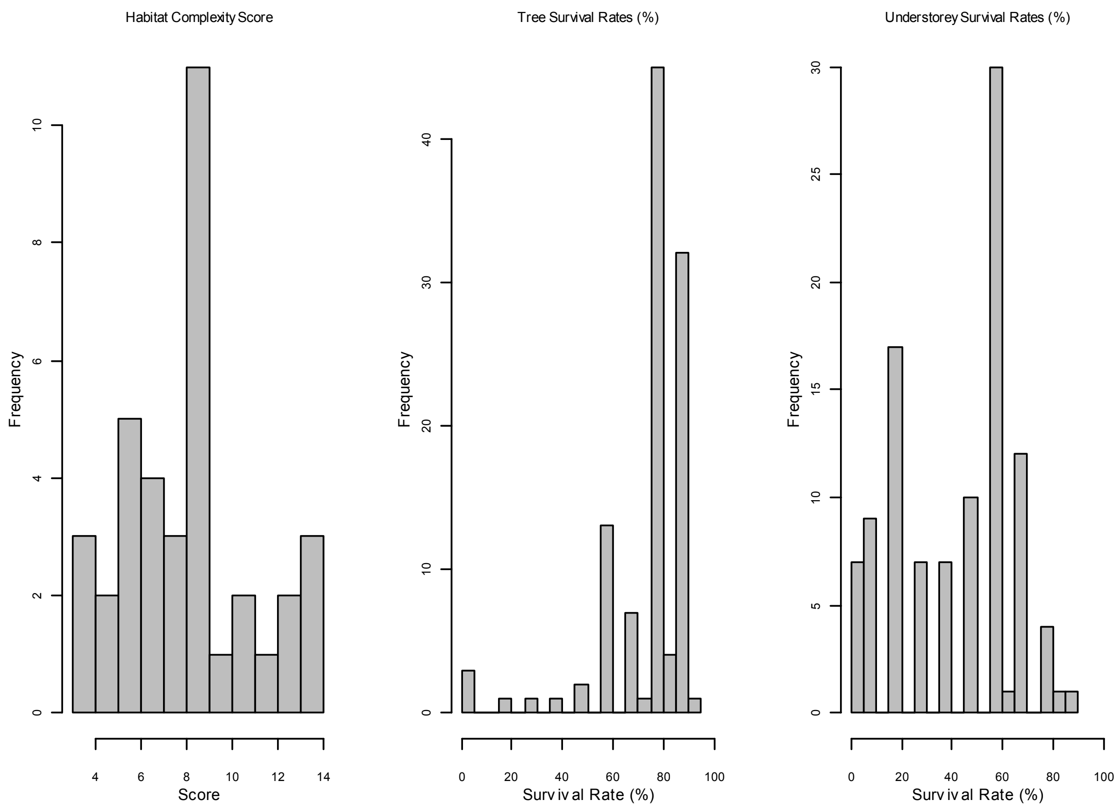

Figure 12. Cudgewa and Tintaldra Landcare Group – Vegetation enhancement activity outcomes – histograms showing range of condition scores and tree and understorey survival rates from vegetation enhancement activities (including remnant protection, enhancement and revegetation).

Case Study 3 – Avon WA – Wallatin Wildlife and Landcare Inc.

The Upper Wallatin Creek Catchment Group was the first group formed in the Kellerberrin Land Conservation District in the Yilgarn Catchment. Landholders in the upper catchment responded to a request by the newly formed Kellerberrin Land Conservation District in 1984 to inspect problems arising in the catchments. As a result of this initial investigation the Upper Wallatin Creek Catchment became involved in a number of studies. A significant amount of on-ground works have been done in the catchment since 1984 with external funding and individual landholder funding assisting the group in addressing land degradation problems on a catchment scale. Works implemented included revegetating recharge and saline discharge areas, establishing trees along drainage lines and establishing wildlife corridors. The landholders of the upper catchment area recognized the advantages of working with the lower Wallatin Creek catchment and in July 1996 formed Wallatin Wildlife and Landcare Inc. encompassing the upper and lower catchment. The catchment consisted of 19 landholders and covered 26,066 hectares. The catchment runs in a north west direction from Doodlakine to the north of Kellerberrin. The catchment was expanded on 30th June 1998 to encompass O'Brien Creek catchment which is situated west of the Wallatin catchment. Many of the landholders in Wallatin catchment are also in the O'Brien catchment. The number of landholders making up Wallatin Wildlife and Landcare Inc. now totals 25 and the catchment covers over 40,000 hectares. The study site is located within the Avon NHT region and represents approximately 0.32 % of this region. Relative to the other case studies, this is a significantly low representation; however the Avon is a large NHT region.

This study site was mapped by Dr. Patrick Smith at CSIRO Sustainable Ecosystems Floreat (WA) in Perth using air photo interpretation and extensive landholder interviews. It formed the basis of a larger research project titled 'Best practice management for salinity and biodiversity in the Wallatin and O'Brien Creek Sub-catchments' which is determining the biodiversity value of past vegetation enhancement work. The broader project is utilising detailed field work to evaluate the biodiversity benefits of these activities including plant, fungi, bird, mammal, reptile and invertebrate surveys. This case study mapped a total of 414 activity polygons which is a large number when compared to the other case studies. However, because a major effort was made to capture all the activities, less attention was devoted to the collection of attribute information and hence only primary data has been incorporated into BioAudit. Figure 13 shows the study area boundary and the location of on-ground vegetation enhancement activities mapped for this case study.

Table 8 and Table 9 provide summary statistics for the Avon case study which mapped 414 vegetation enhancement activities. Owing to the limited list of descriptive attributes which could be collected for this case study, the results focus on the spatial component of the database. This region has achieved high rates of revegetation (1750 ha) and high fencing rates (2241 ha) for a study area of 37,667 ha. This has lead to high revegetation ratios of 4.64 % of the study area being revegetated. This is significantly greater than the seven case studies examined in Freudenberger and Harvey (2004) which documented increases between 0.17 % to 2.61%. Consequently this case study stands out as one which has achieved significant landscape change from on-ground vegetation enhancement activities. Fencing ratios (9.5 ha/km) are comparable to the Nullamanna case study although this study region has fenced some five times as much remnant vegetation. As with the other case studies, the mean patch size of revegetation activities is about 5 ha which is at the higher end of what is commonly seen, although as explained earlier this value can be skewed by large individual activities. Owing to the relatively rich time series available for this case study, nearest neighbour distances were examined with greater temporal detail and are shown in Table 10. Nearest neighbour distances have steadily decreased from 303 m to 221 m over this 14 year period. This is the largest improvement in connectivity of all the case studies. Figure 16 highlights the pattern seen with other case studies showing a steady increase in on-ground vegetation activities leading up to 2000 followed by a general decrease in activity after this period which returns to pre 1990 levels of activity.

Table 8. Avon case study: Revegetation activities summary

Revegetation Activities	Statistics
Total amount of revegetation (ha)	1750
Total perimeter of revegetation (Km)	698
Number of revegetation patches	414
Average revegetation patch size (ha)	5.6
Length of fencing for revegetation (km)	305
Average perimeter to area ratio of funded fences	0.06636
Revegetation as percentage of study site	4.64622
Pre (extant & remnant enhancement) vegetation as percentage of the study site	23.02462
Total area of study site (ha)	37667

Table 9. Avon case study: Fencing of remnant vegetation

Fencing Activities	Statistics
Area of remnants fenced and enhanced (ha)	127.6
Total area of mapped remnants (ha)	8672.9
Area of mapped remnants fenced (ha)	2241
Remnant area fenced as percentage of all remnants	25.8
Total number of remnants greater or equal to 10ha	99
Total number of remnants less than 10ha	283
Fenced remnants greater than 10ha	32
Fenced remnants less than 10ha	39
Total perimeter of mapped remnants (km)	996.7
Total length of funded fencing for remnant protection (km)	233.8
Area of remnant protected per km of funded fence (ha/km)	9.5

Table 10. Avon case study: Nearest neighbour indexes for vegetation enhancement activities shown by year of activity

Vegetation Enhancement Activity	Mean Nearest Neighbour Index (metres)	Mean Nearest Neighbour Index
1990	303	0.61
1992	299	0.60
1993	304	0.60
1994	293	0.61
1995	293	0.61
1996	273	0.60
1997	264	0.60
1998	246	0.58
1999	236	0.57
2000	226	0.56
2002	223	0.56
2004	221	0.57

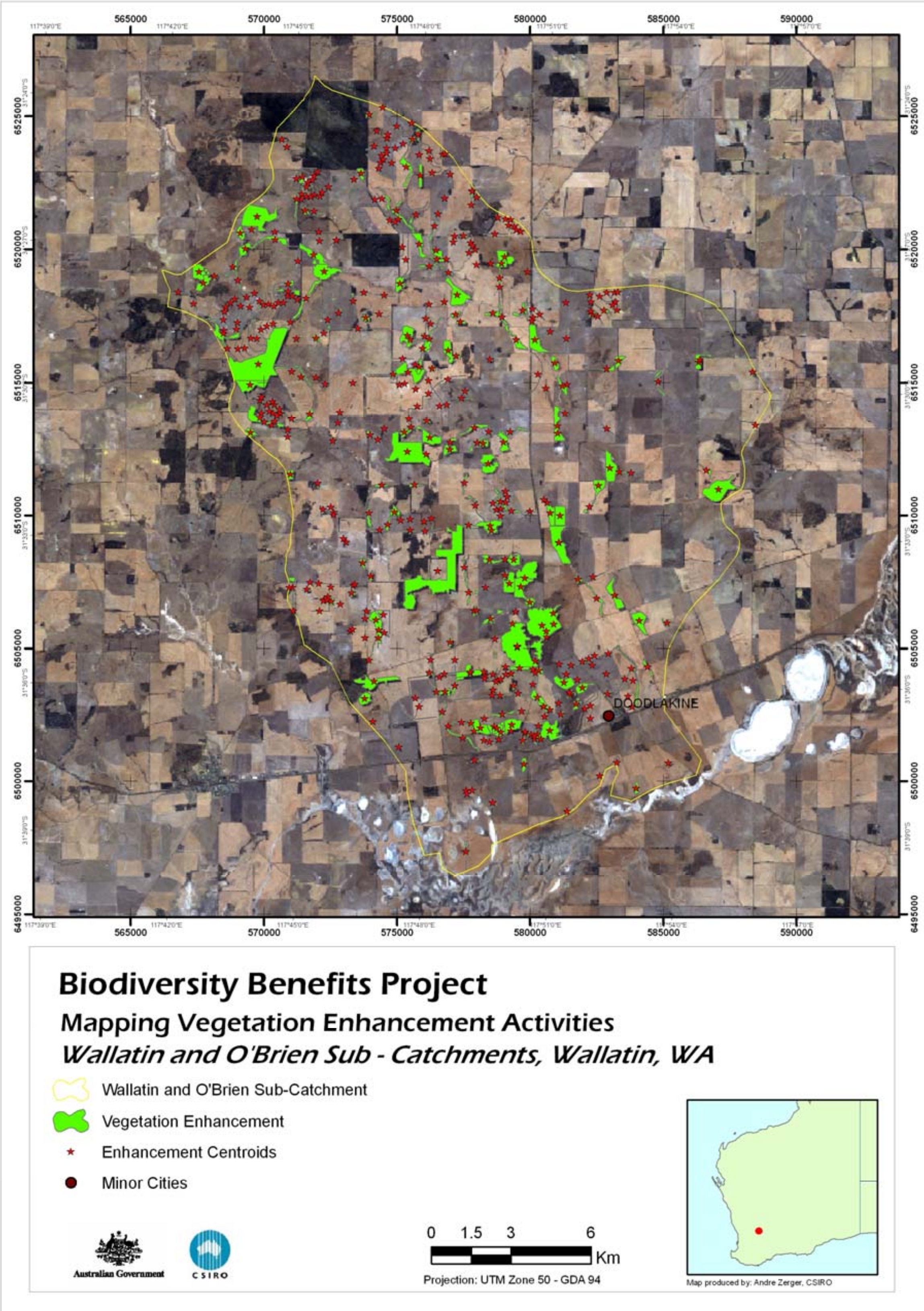

Figure 13. Wallatin and O'Brien Sub-catchments, WA – study area boundary and mapped vegetation enhancement activities.

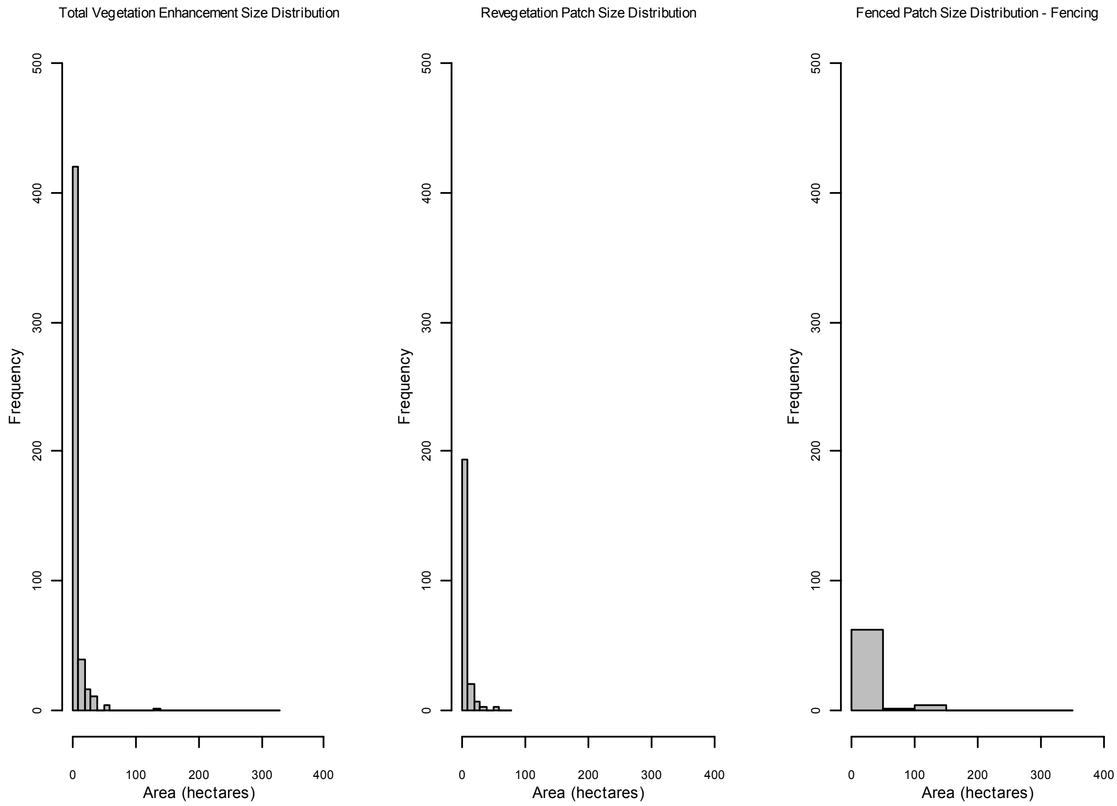

Figure 14. Wallatin and O'Brien Sub-catchments, WA – patch area histograms for all vegetation, revegetation only and fenced remnants (Histograms do not account for remnants which were enhanced, enhanced and protected, or revegetated and protected).

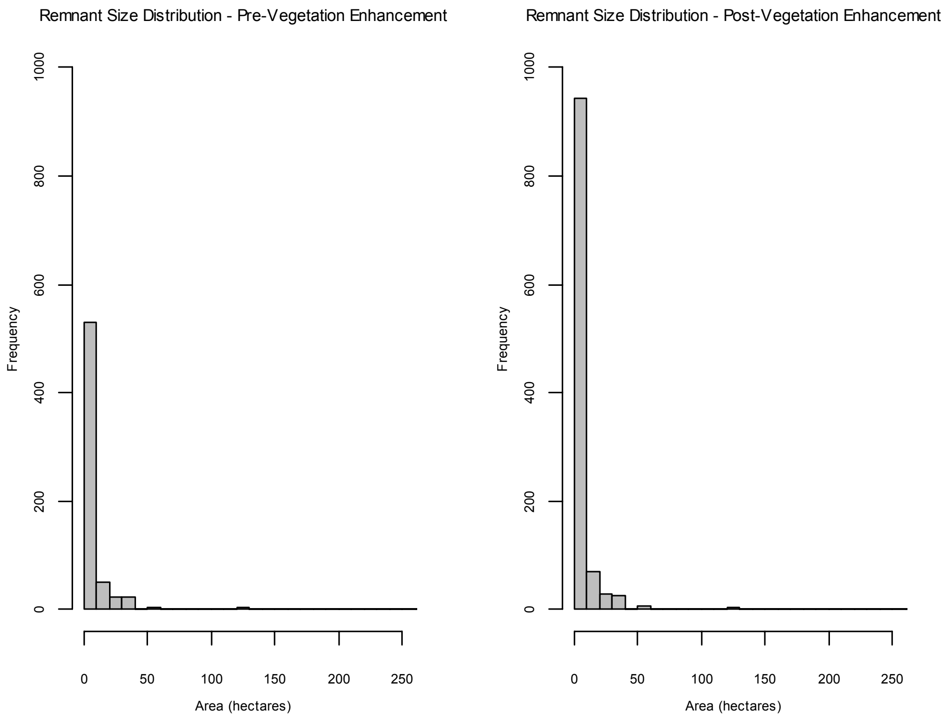

Figure 15. Wallatin and O'Brien Sub-catchments, WA – patch area histograms for period preceding major revegetation activities (1990) and current (2004).

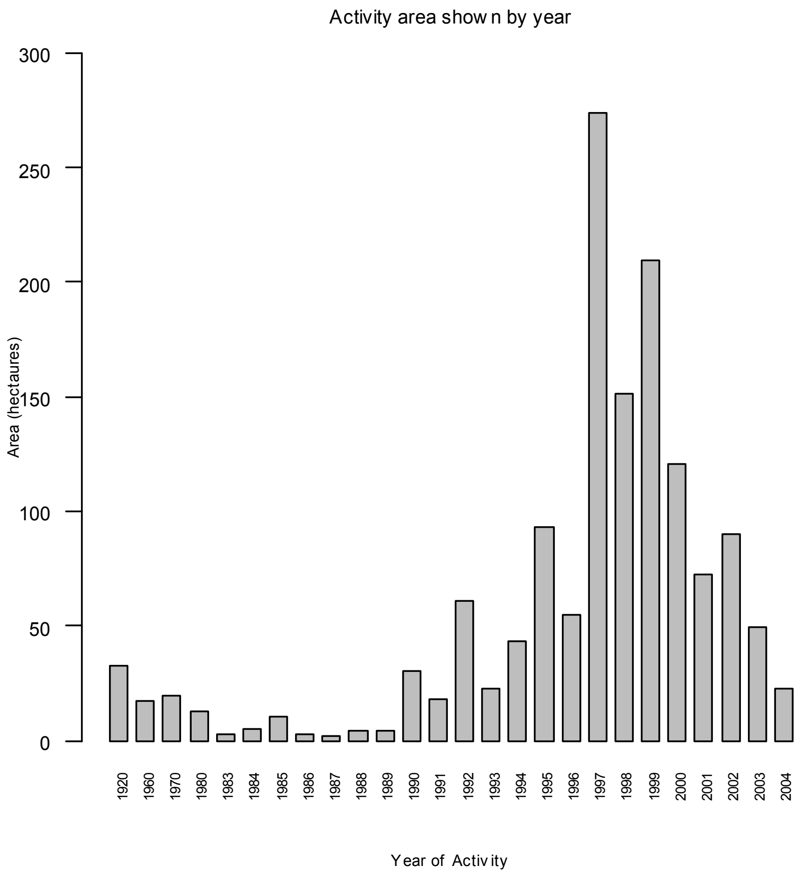

Figure 16. Wallatin and O'Brien Sub-catchments, WA – Area of vegetation enhancement activity shown by years.

Case Study 4 – Wet Tropics, Qld

The Queensland Wet Tropics case study was conducted in collaboration with the Trees for the Evelyn and Atherton Tablelands Inc. (TREAT) and focussed on the Peterson Creek Wildlife Corridor Project. The Queensland Wet Tropics abuts the Queensland coastline for over 400 km, between south latitudes 15°40′ and 19°15′. The width varies from 20 to 80 km. The Queensland Wet Tropics conforms to the Wet Tropics Bioregion (Goosem *et al.,* 1999) and is part of a larger area identified by WWF as the Queensland Tropical Forests Ecoregion. Occupying less than 0.2% of the land area of the continent and about 1% of Queensland, the Queensland Wet Tropics contain a vastly disproportionate share of the biodiversity of Australia, including 3,181 vascular plant species in 224 families representing approximately 18% of Australia's vascular flora, 107 mammal species, 368 bird species, 113 reptiles species, 51 native species of freshwater fish and 51 amphibians. These include many endemics (Stanton *et al.*, 2006).

Since European settlement, 23% of all the vegetation of the area has been totally cleared for sugarcane and pastures. This clearing has been mostly in the lowlands and on the Tablelands to the west of the main coastal range. Of the 14,242 km^2 remaining uncleared, an estimated 3,000 km^2 has been subject to selective logging activity, and some areas of woodland have also been subject to light grazing activity. For the region as a whole, it is estimated that 58% of the Queensland Wet Tropics remains in pristine condition (Stanton *et al.*, 2006)

Much of the region is officially protected as part of a World Heritage Site, but clearing of forest for agriculture, pastoral activities, and urban infrastructure development continue outside the World Heritage Area. This clearing, however, is increasingly being regulated by legislation. The greatest threats to the area now arise from altered fire regimes, introduced weeds, feral animals, water extraction from streams and aquifers, and drainage of lowland areas (Stanton *et al.*, 2006). Global warming also poses serious threats to the region, which have yet to be clearly defined (Williams *et al.*, 2003).

TREAT is a community-based tree planting group of over 500 members, operating mainly on the Atherton Tableland in the Wet Tropics Region of far North Queensland. It was formed in 1982 with the principal objective of encouraging people to plant native rainforest trees. Native trees have been planted on a number of farms or urban gardens for a variety of reasons, including the rehabilitation of degraded lands, improvement of water quality, provision of windbreaks, the restoration of forest remnants, rebuilding of vegetated wildlife corridors and to enhance landscape aesthetics (TREAT, 2006). The organisation’s members work voluntarily throughout the year with the Queensland Parks and Wildlife Service - Restoration Services - Lake Eacham Nursery, rearing trees to rebuild the framework of the tropical rainforests of the Atherton and Evelyn Tablelands. Over the past 20 years, almost a half a million native plants have been propagated and planted. Production involves seed collection and preparation, the rearing of seedlings and the care of the young trees until they are ready to be planted out (TREAT, 2006).

TREAT volunteers are involved in a number of activities beyond tree-planting. These activities include monitoring of wildlife populations, studying vegetation changes and running school awareness programmes. Operating within priority frameworks set by Integrated Catchment Management Committees and government bodies, TREAT works with government and non-government agencies, landowners and other community groups (TREAT, 2006). TREAT projects have ranged from the revegetation of 7 hectares on the shores of Lake Tinaroo, to the planting of 70 trees in a Kindergarten school yard and helping to build a 3 km wildlife corridor to facilitate wildlife movement between two isolated forest remnants. Refer to http://www.treat.net.au/PROJECTS.html for a listing of projects that TREAT has been involved in. The six key projects currently being managed by TREAT are estimated to cost a total of $900,000. Each project is of several years duration. Part of this cost is being met with grants of $400,000 provided by the Natural Heritage Trust. The balance is met by TREAT in the form of voluntary in-kind labour. A number of smaller projects are supported with grants from various sources (TREAT, 2006). Figure 17 shows the study area boundary and the location of all on-ground vegetation enhancement activities for the Peterson Creek study area.

Mabi Forest is a type of rainforest that occurs in North Queensland. Its pre-clearing extent on the Atherton Tablelands covered the area north and west of Malanda, occurring on highly fertile basalt-derived soils in areas where rainfall is between 1300 and 1600mm (TREAT, 2006). It is now found only in small patches on the Atherton Tablelands, between the towns of Atherton, Kairi, Yungaburra and Malanda, with a remnant patch also located at Shiptons Flat, near Cooktown. Mabi Forest is otherwise known as Complex Notophyll Vine Forest 5b and includes the Queensland Regional Ecosystem 7.8.3. Mabi Forest is characterised by an uneven canopy (25–45m) with many tree layers, scattered deciduous and semi-evergreen trees, and a dense shrub and vine layer. The dense shrub layer distinguishes Mabi Forest from similar rainforests, and provides important habitat for up to 114 bird species.

A variety of plants and animals make their homes in Mabi Forest, including the nationally threatened Large-eared Horseshoe Bat and Spectacled Flying-fox. Other species, such as the Musky Ratkangaroo and the nationally endangered Southern Cassowary, used to occur in Mabi Forest. However, the remaining patches of Mabi Forest are too small for these animals to survive in, and so the Musky Rat-kangaroo and Southern Cassowary have become locally extinct. Three plant species occurring in Mabi Forest are listed as 'vulnerable to extinction'. These are the Pink Silky Oak, Atherton Sauropus (*Sauropus macranthus*) and Atherton Turkey Bush (*Hodgkinsonia frutescens*). Four plants are listed as 'rare': the pink leaf Haplostichanthus, Coorangooloo Quandong (*Elaeocarpus coorangooloo*), Red Penda and Gray's Cryptolepis (*Cryptolepis grayi*) (TREAT, 2006).

Mabi Forest is listed as a critically endangered ecological community under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (DEH, 2006). Mabi Forest was listed due to its restricted distribution and vulnerability to ongoing threats. There are only 1 050 ha of Mabi Forest left, and this occurs as a series of small, isolated patches. Many of the remnant patches of Mabi Forest are being invaded by exotic smothering vines and feral and domestic animals. The use of remnant patches of Mabi Forest by stock can impact on this ecological community through trampling, grazing and soil compaction (DEH, 2006). National listing of Mabi Forest recognises that its long-term survival is under threat. The purpose of the listing is to prevent its further decline, and assist community efforts toward its recovery. State protection under Queensland's Vegetation Management Act 1999 only applies to those parts of the Mabi Forest ecological community classified as an ‘endangered regional ecosystem' (DEH, 2006).

The Wet Tropics case study was delivered in collaboration with research staff based at CSIRO Sustainable Ecosystems, Atherton (Caroline Bruce and Andrew Ford) and TREAT (Simon Burchill). The case study utilised pre-existing vegetation mapping, but commenced a BioAudit assessment from first principles for each vegetation enhancement site. Initial vegetation enhancement mapping was carried out in 2001 by Brian Grant (University of Queensland) with assistance from Simon Burchill. The vegetation enhancement polygons were derived mainly using GPS-derived points. These were subsequently corrected by Simon Burchill using GPS points opportunistically collected during field planting days – these points mapped some fence posts and boundaries. The polygons were then checked using aerial photography current to 1997 (geo-rectified by the Wet Tropics Management Authority (WTMA)) and to 2004 (geo-rectified by Kay Dorricott, Atherton Queensland Parks and Wildlife Service (QPWS)).

Owing to the small number of study sites, discussion of Table 11 and Table 12 is not warranted and hence the major emphasis of this case study became the collection of detailed vegetation condition information to act as a baseline to monitor outcomes in the future. Although this discussion focuses on the development of condition assessment methods for these landscapes, it highlights the importance of adopting documented or published condition assessment methods, and allowing flexibility for regions to utilise methods best suited to their conditions. Similarly, this case study has highlighted the fact that at local scale, it is difficult to generate one condition metric which can be monitored over time and rather, the individual components of a condition score must be retained to allow for future analysis.

Considerable effort was devoted to assessing the condition of vegetation enhancement activities along the Peterson Creek corridor. This was necessary as methods used in the southern Australia (i.e. Habitat Hectares, Biometric) are not ideally suited to the rainforest communities targeted in this case study. Vegetation condition is a relatively new field of science that provides important quantitative and qualitative data, in the form of attributes, for real time scale comparisons to be made of a permanently marked, or positioned, monitoring site. Much debate has occurred in recent years as to the most appropriate vegetation assessment technique and methodology. However, to date each state in Australia appears to be presiding over its own assessment protocols.

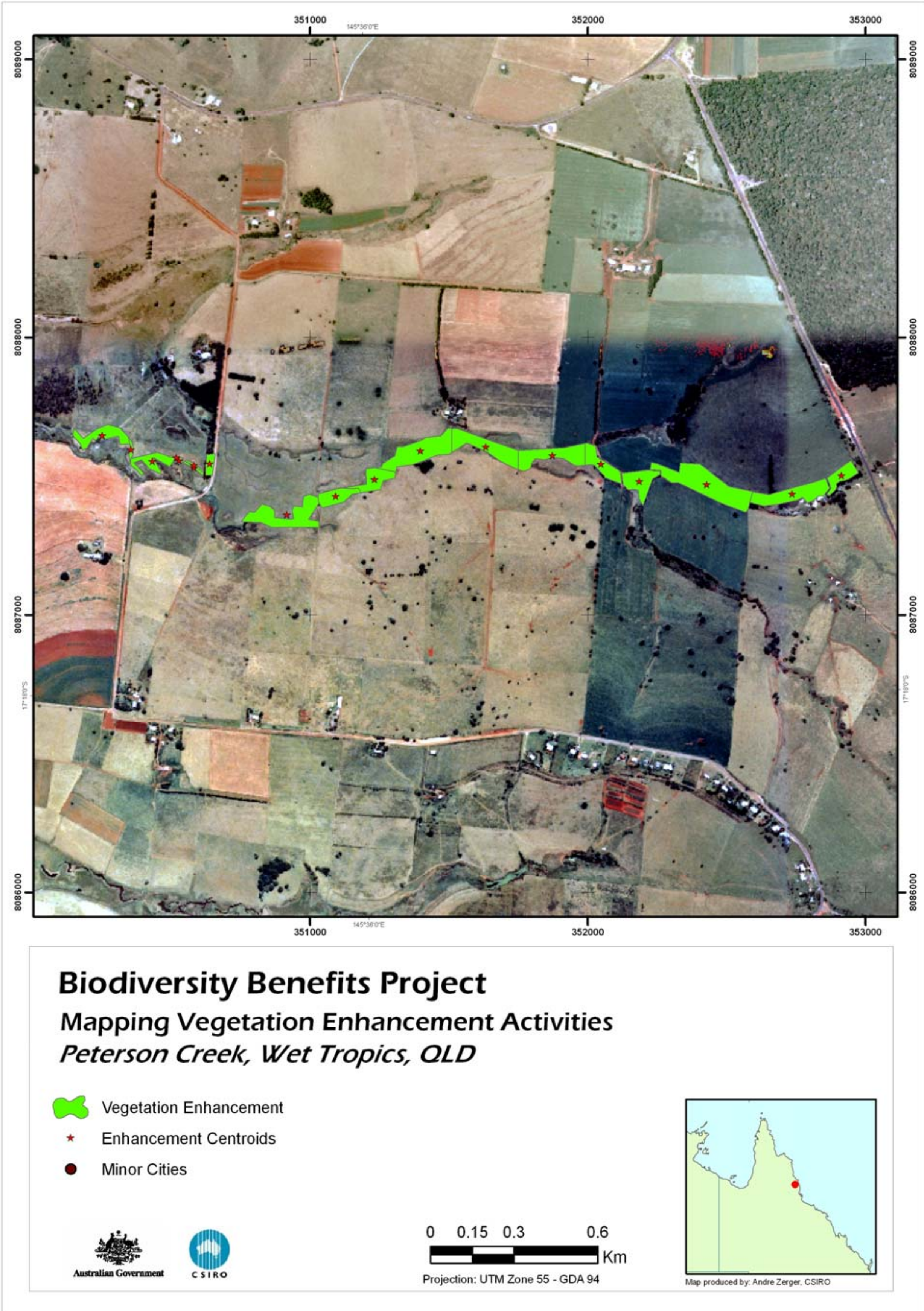

Figure 17. Peterson Creek Wildlife Corridor Project – study area boundary and mapped vegetation enhancement activities.

Parkes *et al.* (2003) developed the 'Habitat Hectares' assessment framework for Victoria in order to, 'assess native vegetation quality'. A similar technique, based upon 'Habitat Hectares', called 'BioCondition' is currently being trialled and developed for Queensland (Environmental Protection Agency, unpublished data) to "provide a framework that provides a measure of how well a terrestrial ecosystem is functioning for the maintenance of biodiversity values". Other state-based manuals include Greening Australia (2002) for the greater ACT area and Gibbons *et al.* (2005) ('BioMetric') for NSW. Greening Australia (2002) is unique in that its technique is designed to monitor and document revegetation projects that involve the conservation, protection and maintenance of grassy ecosystems. Similarly, Kanowski and Catterall (2006) have developed the 'monitoring toolkit' specifically to monitor and assess revegetation projects in rainforest landscapes.

The choice as to which method to follow for the Peterson Creek Biodiversity Benefits Project was ultimately relatively straightforward. Having said that, it needs to be noted that there was an expectation that community groups will follow-up the baseline monitoring that CSIRO performed in mid 2006. With this in mind, a simple and non-ambiguous assessment model was required. For this project the 'BioMetric' method was too complex and has too many quantitative protocols to follow. The 'Habitat Hectares' and 'BioCondition' methods are similar and warranted consideration. However, both methods are intended to assess native (or natural) vegetation. As Peterson Creek is a revegetation site these methods were deemed to lack some important rainforest revegetation attributes and characteristics. This is not to say that the above methods won't work in revegetation projects, but they don't consider aspects of rainforest revegetation which the 'monitoring toolkit' places high emphasis upon. For example, vectored recruitment shows how "attractive" a revegetation site is to frugivorous birds. Such recruitment occurs naturally in natural ecosystems, but is not a given in revegetation activities. Adopting a method that records such recruitment has the potential to highlight the ecosystem functioning in revegetation sites, which will be seen as an improvement upon the original enhancement activity.

Further, the 'Habitat Hectares' and 'BioCondition' methods have the potential to dramatically increase the number of assessments, as both require distinct 'patches' of vegetation for their respective assessment methodologies. It is therefore conceivable that for one even-aged revegetation site/enhancement activity that 2 or 3 assessments need to be undertaken as the structure and compositional attributes of the site may vary considerably in relation to the floristic assemblage planted, or even local edaphic effects. With increasing size of each enhancement activity, there is the expectation to undertake more than one assessment to account for such variability. Kanowski and Catterall (2006) suggest that one assessment in an "average" area would be sufficient. At Peterson Creek there are 9 enhancement activities, and if other methods were chosen some 15-20 assessments would need to be made to conform to respective acceptable protocols and attributes.

In addition, the time to complete an assessment was taken into account. The 'BioCondition' and 'Habitat Hectares' methods are estimated to take about 2 hours per assessment, whereas Kanowski and Catterall (2006) suggest 45-60 minutes per assessment. This is true as most monitoring sites at Peterson Creek took 40-50 minutes, depending upon the age of the revegetation site. With the above considerations taken into account, it was decided to adopt the 'monitoring toolkit' assessment technique. And in particular the proforma for their 'building phase' of revegetation sites has been used, irrespective of the age of the revegetation (Appendix F). This is to ensure a consistent method and recording scheme across the revegetation sites. Normally the proforma for the 'establishment phase' would be utilised for sites in which canopy closure hasn't occurred and usually refers to the actual original planting time or shortly afterwards. Finally, the attributes collected in the 'monitoring toolkit' have shown to be correlated with the use of revegetated sites by rainforest wildlife (Kanowski and Catterall, 2006). This wildlife includes not only vertebrates such as birds, but also invertebrates such as beetles and mites. Thus, by using this toolkit the community groups will be gathering data which are known to be good surrogates for faunal assemblages without actually sampling for them. Appendix F provides a completed example template for such as assessment for one of the study sites in Peterson Creek. The complete vegetation condition assessment results for all sites in Peterson Creek can be obtained from the authors.

Table 11. Wet Tropics case study: Revegetation activities summary

Revegetation Activities	**Statistics**
Total amount of revegetation (ha)	15.1
Total perimeter of revegetation (Km)	8.8
Number of revegetation patches	19
Average revegetation patch size (ha)	2.1
Length of fencing for revegetation (km)	10.2
Average perimeter to area ratio of funded fences	0.002
Revegetation as percentage of study site	0.41
Pre (extant & remnant enhancement) vegetation as percentage of the study site	42.8
Total area of study site (ha)	3659

Table 12. Wet Tropics case study: Fencing of remnant vegetation

Fencing Activities	
Area of remnants fenced and enhanced (ha)	NA
Total area of mapped remnants (ha)	1567
Area of mapped remnants fenced (ha)	NA
Remnant area fenced as percentage of all remnants	NA
Total number of remnants greater or equal to 10ha	47
Total number of remnants less than 10ha	41
Fenced remnants greater than 10ha	NA
Fenced remnants less than 10ha	NA
Total perimeter of mapped remnants (km)	178.7
Total length of funded fencing for remnant protection (km)	NA
Area of remnant protected per km of funded fence (ha/km)	NA

Case Study 5 – Kangaroo Island, SA

The Kangaroo Island project was conducted in collaboration with the Kangaroo Island Natural Resource Management Board (KINRMB) and centred on the Eleanor River sub catchment in the Seddon Plateau Fragmented Habitat Area and the Bugga Bugga Creek sub catchment in the Dudley/Haines Plateau Threatened Habitat Area (Figure 18 & Figure 19). Kangaroo Island is located off the southern coastline of South Australia, some 14km south west of the Fleurieu Peninsula at the closet point and roughly 130km south west of Adelaide. Kangaroo Island is approximately 150km long from east to west and about 55km wide from north to south. The island has been described as roughly wedge shaped, with high sea cliffs on the north western shoreline and a central lateritic plateau which slopes downwards to limestone plains and sand dunes along the southern shore.

Much of the following background information is derived from Willoughby et a. (2001). In 1991, 47% of the islands 440,188 ha area was covered by native vegetation while 51% had been cleared for cropland and pasture. The remaining 2% comprised sand dunes or cliffs, lakes and swamps, agro forestry and urban areas. Of the remaining native vegetation, 55% is protected in national parks and Wildlife reserves, 9% are subject to heritage agreements on private land, with 36% occurring on unprotected private land. The most common native vegetation type on Kangaroo Island is mallee, accounting for 64% of all mapped native vegetation. The mallee is dominated by communities of *Eucalyptus diversifolia* or *E. remota* with smaller areas of *E. cosmophylla*, *E. cneorifolia,* and *E. rugosa*. Woodland dominated by *E. cladocalyx* and *E. baxteri* communities are the next most common accounting for a further 29% of mapped native vegetation while the remaining native vegetation comprises shrubland (6%), forest (1%) and fernland. Three mallee, two woodland and two shrubland communities are considered regionally threatened.

Soils and geology play a large part in determining the distribution of vegetation communities on Kangaroo Island. Mallee occurs mainly on sandy or stony soils over limestone or laterite whereas forests and woodlands generally occur on deeper or more fertile soils. Estimates of pre-European vegetation cover indicate that woodland occurred over 56% of the island while mallee occurred over roughly 43%. This highlights the preferential clearing of woodland for agriculture, in part due to the more fertile soils on which woodlands occur

Native vegetation on Kangaroo Island is highly fragmented, with nearly 90% of blocks being less than 20 hectares in size and 97.3% of blocks being less than 100 hectares. These blocks however, account for only 8.2% of native vegetation. Indeed, 76.8% of native vegetation occurs in just two blocks, the Flinders Chase National Park and Cape Gantheaume CP and contiguous areas. While these and other large remnants have sufficient native vegetation to sustain populations in the long term, the viability of smaller fragments is limited, as their isolation limits movement and increases the risk posed by catastrophic events such as disease, fire and genetic isolation. The Biodiversity Plan for Kangaroo Island states that many species and plant communities, including some which are endemic to the island, face extinction due to the immediate effects arising from fragmentation, isolation and degradation of remnant vegetation. Strategies for the management of threatened habitat areas on Kangaroo Island include; retaining all areas of native vegetation, fencing and destocking native vegetation, increasing the size of remnants by buffering with native species, and linking isolated remnants

The Kangaroo Island case study was coordinated in collaboration with the Kangaroo Island Natural Resources Management Board (KINRMB) through staff including Grant Flanagan and Mark Morris. Mapping commenced in March 2006 and concluded in June 2006 with some 106 on-ground vegetation activities being mapped and assessed for two distinct study regions (Bugga Bugga Creek and Eleanor River). On ground mapping and landholder assessments were conducted by KINRMB staff according to mapping and attribute collection protocols developed by CSIRO (Appendix A & B). For this case study, data was entered into an Excel spreadsheet and then normalised into the BioAudit database once delivered to CSIRO.

Table 13 and Table 14 provide summary statistics for revegetation and fencing activities aggregated over the two Kangaroo Island case studies (Eleanor River and Bugga Bugga Creek). The total impact of revegetation relative to the study area bounds is relatively small at 0.56 % and as with the other case studies (Nullamanna and Cudgewa), fencing efficiencies are significantly greater than for revegetation (1202 ha compared to 65 hectares). Revegetation ratios need to be treated with caution as arbitrary square study bounds were developed for the two Kangaroo Island case studies which will impact upon the ratios observed. For other case studies administrative units such as Landcare boundaries were used. Fencing efficiencies across the two Kangaroo Island case studies are relatively low (7.3 ha/km) although factors such as site accessibility will be a primary influence over these rates.

The average size of revegetated patches is also relatively low at 2.05 ha and this is also highlighted in Figure 22 which provides patch-area histograms for remnants and enhancement activities. In regard to connectivity, the Kangaroo Island case studies provide one of the greatest decreases in nearest neighbour distances for enhancement activities. This indicates that although the magnitude of the activities is not necessarily as large as other regions, on-ground activities have been established proximal to other revegetation sites and to existing remnant vegetation. In both instances, nearest neighbour distances decreased by half (from 475 to 209 metres, and 604 to 254 metres for Bugga Bugga Creek and Eleanor River respectively).

Figure 20a highlights the fact that most on-ground activities have focussed on activities which enhance existing remnants. In regard to the investment and activities shown through time (Figure 20b), the trends identified for Kangaroo Island are commensurate with those seen for almost all other case studies. Namely, there is a steady increase in activity shown by area from the early 1990's and culminating in a major peak in 1999 followed by a steady decline towards 2005. These results mirror those identified in Nullamanna, Cudgewa and Wallatin. Indeed for all these case studies, the period from 1998 to 2000 makes up the majority of on-ground activities observed through the entire period of NHT-type funding. An interesting analysis could utilise these temporal trends and develop future revegetation scenarios for specific targets.

Table 13. Kangaroo Island case studies: Revegetation activities summary

Revegetation Activities	Statistics
Total amount of revegetation (ha)	65.63
Total perimeter of revegetation (Km)	29.13
Number of revegetation patches	32.00
Average revegetation patch size (ha)	2.05
Length of fencing for revegetation (km)	0.00
Average perimeter to area ratio of funded fences	0.00
Revegetation as percentage of study site	0.56
Pre (extant & remnant enhancement) vegetation as percentage of the study site	22.63
Total area of study site (ha)	11620.00

Table 14. Kangaroo Island case studies: Fencing of remnant vegetation

Fencing Activities	
Area of remnants fenced and enhanced (ha)	2564.67
Total area of mapped remnants (ha)	763.84
Area of mapped remnants fenced (ha)	1202.91
Remnant area fenced as percentage of all remnants	29.78
Total number of remnants greater or equal to 10ha	52.00
Total number of remnants less than 10ha	124.00
Fenced remnants greater than 10ha	24.00
Fenced remnants less than 10ha	46.00
Total perimeter of mapped remnants (km)	402.56
Total length of funded fencing for remnant protection (km)	164.5
Area of remnant protected per km of funded fence (ha/km)	7.3

Table 15. Bugga Bugga Creek case study: Nearest neighbour indexes for vegetation enhancement activities

Vegetation Enhancement Activity	Mean Nearest Neighbour Index (metres)	Mean Nearest Neighbour Index
Pre mapped vegetation enhancement activities	475	1.00
Post mapped vegetation enhancement activities	209	0.71

Table 16. Eleanor River case study: Nearest neighbour indexes for vegetation enhancement activities

Vegetation Enhancement Activity	Mean Nearest Neighbour Index (metres)	Mean Nearest Neighbour Index
Pre mapped vegetation enhancement activities	604	1.25
Post mapped vegetation enhancement activities	254	0.86

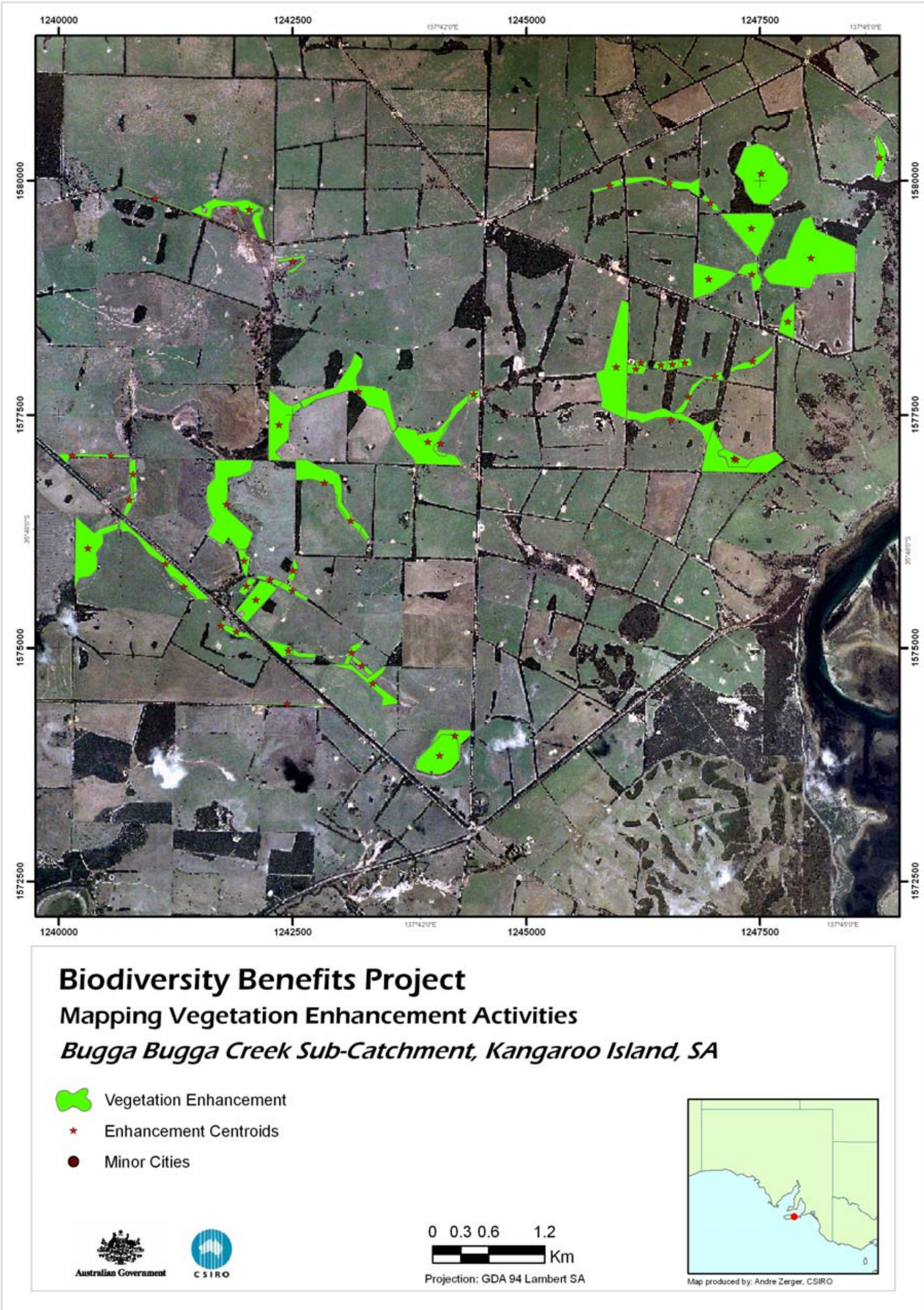

Figure 18. Bugga Bugga Creek, Kangaroo Island – study area boundary and mapped vegetation enhancement activities.

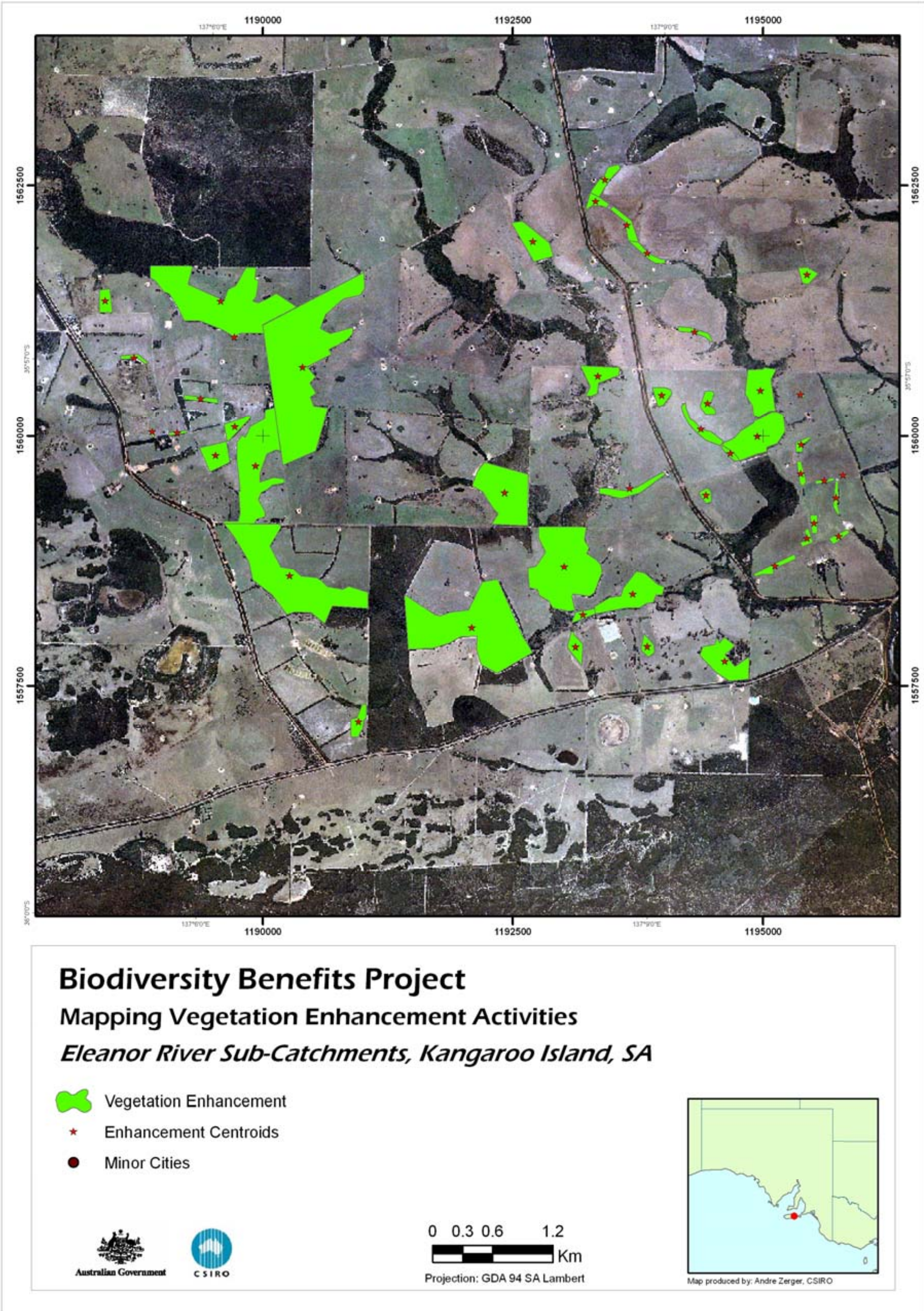

Figure 19. Eleanor River, Kangaroo Island – study area boundary and mapped vegetation enhancement activities.

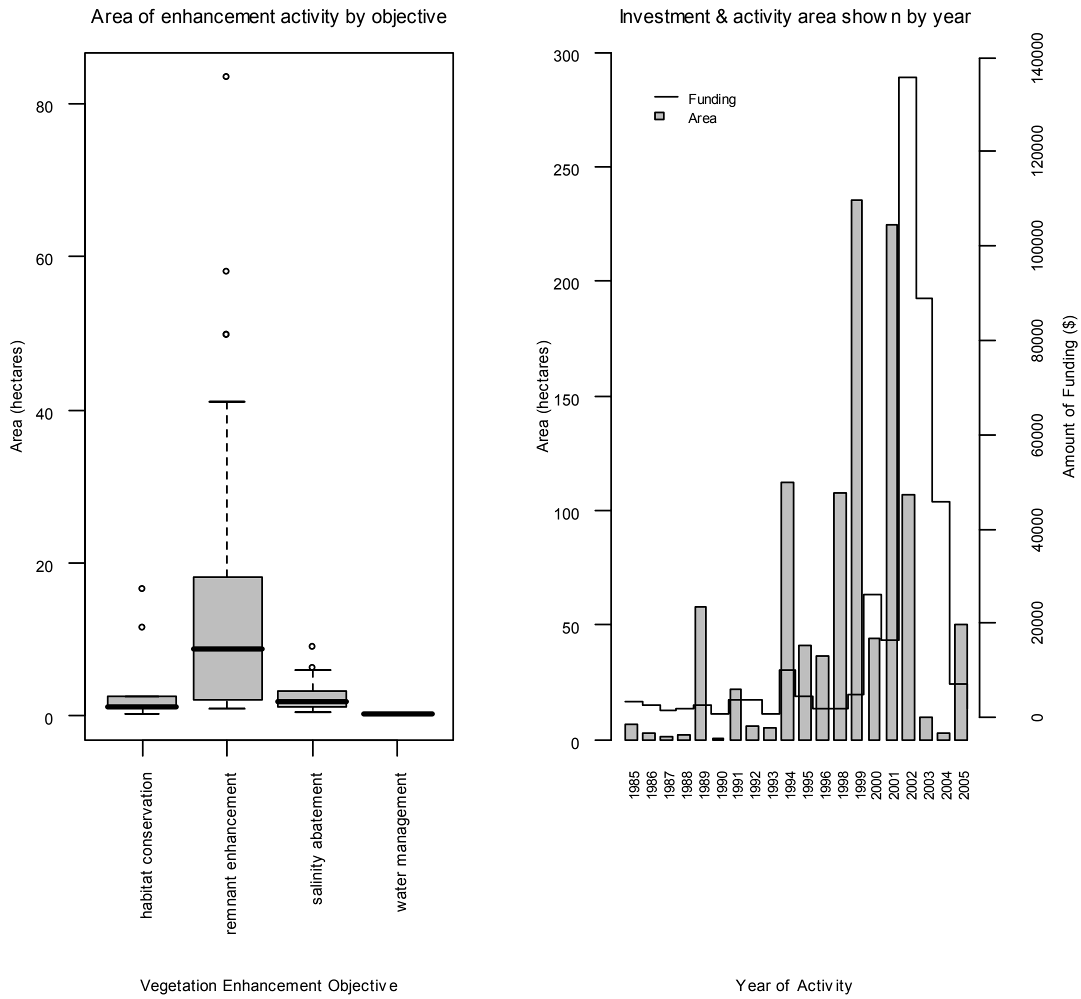

Figure 20. Eleanor River and Bugga Bugga Creek, Kangaroo Island – Area of vegetation enhancement activity shown by enhancement objectives and amount of funding and area of activity shown by funding years. The BioAudit data model allows for multiple objectives at individual sites hence total areas are greater than the total area of activities in this study site (stems in the plot show the data range and the solid bar is the median value).

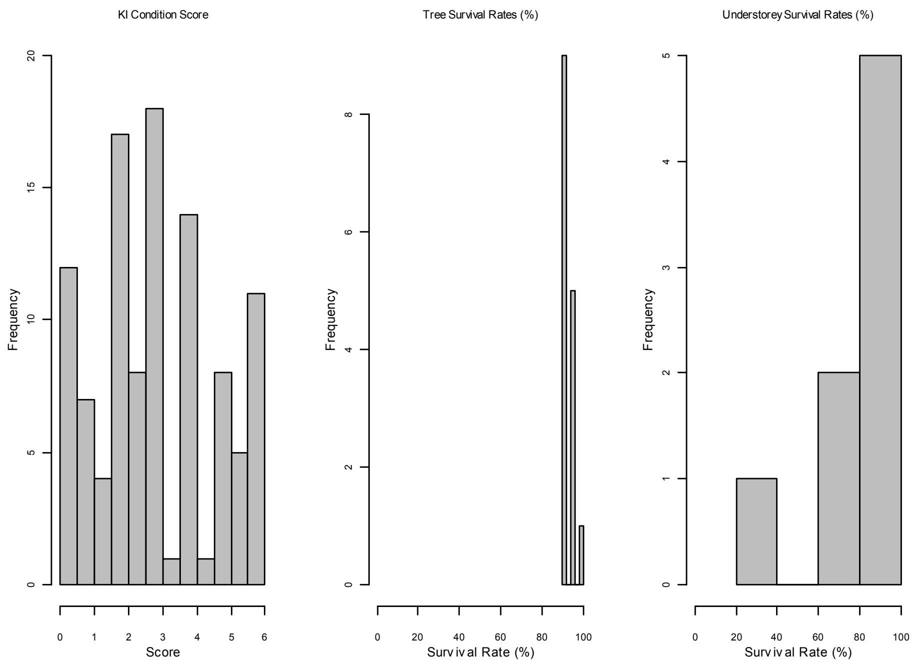

Figure 21. Eleanor River and Bugga Bugga Creek, Kangaroo Island – Vegetation enhancement activity outcomes – histograms showing range of condition scores and tree and understorey survival rates from vegetation enhancement activities (including remnant protection, enhancement and revegetation).

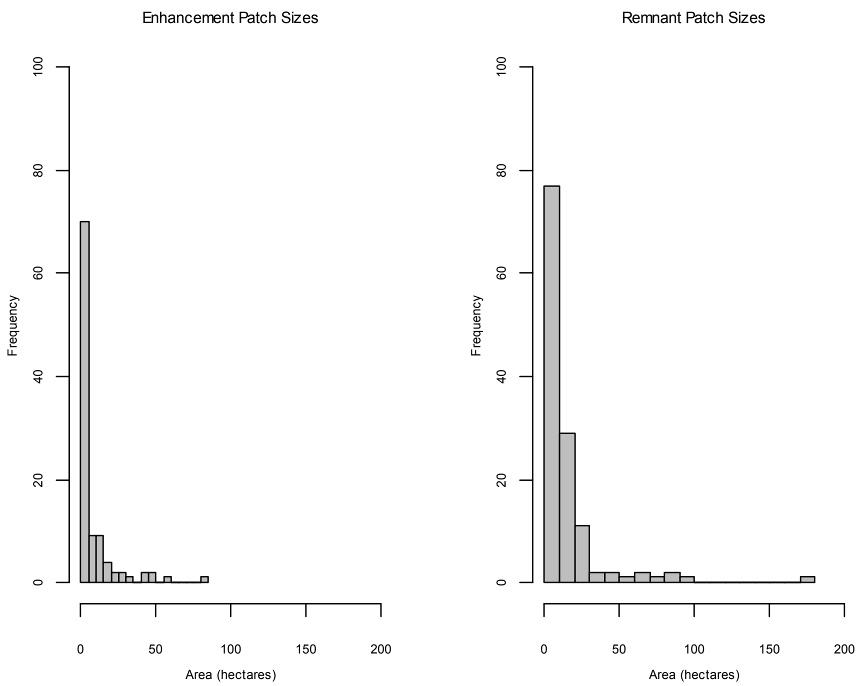

Figure 22. Patch area histograms for new on-ground vegetation enhancement activities including revegetation and fencing (enhancement patch sizes), and existing remnant patch size distribution from state NVIS vegetation mapping.

Case Study 6 – Gascoyne Murchison, WA

The only rangelands case study in the Biodiversity Benefits Project Phase 3 was conducted in collaboration with the Murchison Land Conservation District Committee (MCDC) which is based in the Murchison Shire, Western Australia. The primary collaborator was Mark Halleen. This case study was a challenging case study to deliver owing to two unexpected major cyclonic events (cyclone Claire and Floyd) which delayed the field component of this project a number of months. These events resulted in extended flooding along the Murchison River making field work in early 2006 impossible. The study site was finally mapped at the end of May 2006. The study area covers approximately 44,000 square kilometres (Figure 23) and primarily focuses on wool production although many landholders are diversifying into other agricultural practices. The committee was formed in 1986 and is concerned with all aspects of Landcare with a primary focus on controlling grazing pressures by ensuring conservative stocking rates and removal of feral animals. Other MCDC Landcare priorities include the following:

- Relocating watering points from degraded areas;
- Fencing to land types to achieve better control of preferred grazing areas;
- Slowing down water flow by brushing up gullies and neck points in creeks;
- Fenced enclosures to allow natural regeneration;
- Revegetation work on degraded areas;
- Monitoring vegetation and soil condition;
- Control of introduced animals such as foxes and cats with baiting program; and
- Control and eradication of weeds.

The primary Landcare activity in this region is the Murchison River Restoration Project which seeks to fence the floodplain of the Murchison River to primarily control grazing (up to 334 km of fencing). Consequently, this is the primary on-ground vegetation enhancement activity which has been mapped and evaluated in this case study. Interestingly, a large proportion of the cost of fencing in this case study is provided by landholders. According to the original NHT proposal, the project description is as follows:

'This project involves nine neighbouring pastoral stations (totalling 1,880,317 hectares) who, with community support, aim to create a corridor to improve the biodiversity of flora and fauna through the restoration and protection of the riparian zone and flood plain of the Murchison River. The centre-piece of this project is the fencing of 206,200 hectares of river land systems. This will have substantial positive environmental outcomes by reducing the damaging effects of overgrazing, implementing total grazing management and thus reducing domestic and feral grazing pressure in these fragile landscapes. Ultimately, this project aims to demonstrate the benefits of a commitment to ecologically sustainable pastoral management. The project has the potential to demonstrate the relevance of integrated catchment management in Western Australian Rangelands'

According to the LCDC (http://landcare.murchison.wa.gov.au/projects last accessed July 25, 2006) the fencing of the Murchison River is expected to achieve the following broad outcomes:

- Reduction in native plant degradation;
- Reduction in soil erosion;
- Less sediment load in the river;
- Improved litter accumulation and nutrient cycling;
- Improved water retention;
- Improved water quality;
- Improved biodiversity conservation through improved habitats;
- Improved riparian drought refuges for native animals; and
- Recreation of landscape linkages and conservation corridor.

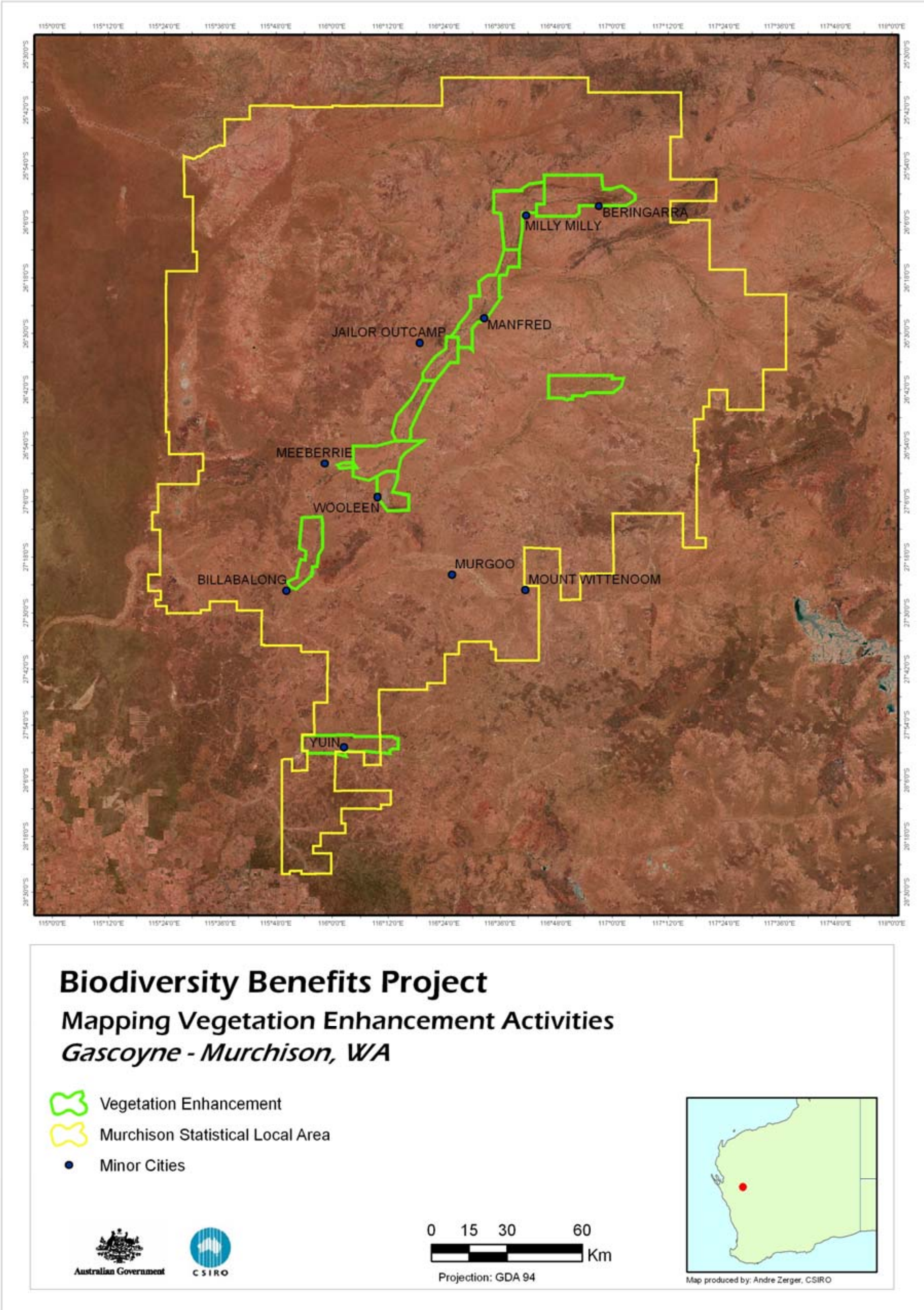

Figure 23. Gascoyne-Murchison Case Study, WA – study area boundary and mapped vegetation enhancement activities.

Mapping of the Murchison case study was conducted in May 2006 by Mr. Damian Wall (Minchem Pty. Ltd) using specifications provided by CSIRO. Vegetation enhancement activities were mapped using landholder interviews and a Landsat 5 false colour composite image sourced from the Australian Greenhouse Office (1994 imagery) using on-screen digitising with ArcView GIS. Owing to the extent of this study area, SPOT5 imagery provided too much detail to effectively map the on-ground activities and it was found that Landsat 7 imagery addresses this. In addition to mapping the boundaries of vegetation enhancement activities, site photographs and site coordinates were also collected including a reference coordinate for each enhancement activity (site) and the location of this reference coordinate relative to the area mapped.

Table 17. Gascoyne Murchison case study: Fencing of remnant vegetation

Fencing Activities	Statistics
Total area of mapped remnants (ha)	217123
Area of mapped remnants fenced (ha)	210736
Remnant area fenced as percentage of all remnants	97
Total number of remnants greater or equal to 10ha	98
Total number of remnants less than 10ha	235
Fenced remnants greater than 10ha	11
Fenced remnants less than 10ha	0
Total perimeter of mapped remnants (km)	1532
Total length of funded fencing for remnant protection (km)	425
Area of remnant protected per km of funded fence (ha/km)	5.27

As this is a rangelands case study, the use of analyses such as those adopted in Nullamanna or north east Victoria are not warranted. For instance, inter-patch distance metrics or measures of change in mean patch sizes are not appropriate in these landscapes. The Gascoyne-Murchison case study is one which best utilises contextual GIS data to support an analysis. The West Australian rangelands have a number of excellent monitoring systems available which compliment the mapping of on-ground vegetation enhancement activities. The primary example of this is the West Australian Rangelands Monitoring System (WARMS, Watson et al. 2006, Holm et al. 1987)). Although it was not possible to obtain the primary data from WARMS in time for inclusion in this report, there are 16 WARMS sites which occur in the mapped BioAudit regions along the Murchison River and these could be used to conduct an analysis of rangeland condition. An alternative source of regional scale vegetation condition information which did not provide coverage across over this particular case study is West Australia's LandMonitor project (http://www.landmonitor.wa.gov.au/index.html last accessed September 7, 2006)

To highlight the potential utility of contextual GIS data, ancillary vegetation condition data was sourced from the Department of Agriculture's inventory and condition survey of the Murchison River catchment and surrounds (Curry et al. 1994). By intersecting the land systems mapping with BioAudit mapping it is possible to generate vegetation condition and erosion status summaries based on data from the survey (Curry et al. 1994). Figure 24 shows frequency histograms of vegetation condition for mapped BioAudit regions in the Gascoyne-Murchison case study. It is important to note that this is shown only for illustrative purposes as the Curry et. al. (1994) study was conducted before the establishment of most of the on-ground activities more current rangelands survey data would need to be included to asses the current status.

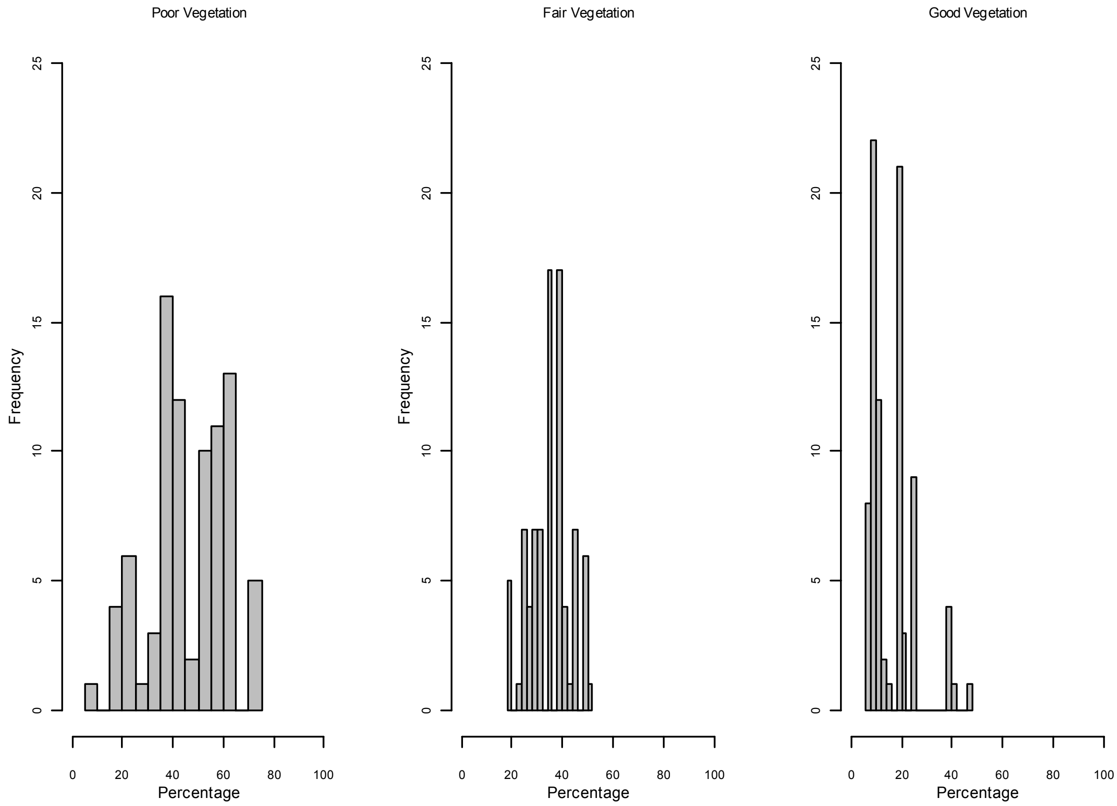

Figure 24. Gascoyne-Murchison Case Study, WA – distribution of vegetation condition scores for enhancement polygons based on Murchison River rangelands survey data.

An additional assessment of biodiversity benefits was conducted for the Gascoyne-Murchison case study by utilising landscape-scale Birds Australia bird atlas data. The analysis compares bird abundance data at treatment sites (vegetation enhancement sites) against a randomly selected control region. The analysis highlights the potential value of contextual, spatially explicit data to monitor the effect of vegetation enhancement activities and although the analysis is preliminary, the results are very promising. The occurrence of bird species was compared between the first Atlas of Australian Birds (Atlas 1) which continued for five years between 1 January 1977 and 31 December 1981, and the New Atlas of Australian Birds (Atlas 2), which ran for three years and five months, from 1 August 1998 to 30 December 2001. During Atlas 1, volunteer observers searched a 10-minute grid (approximately 15 km × 17 km) recording all bird species seen or heard, producing a bird list for each grid. were compared with two types of survey from Atlas 2; Area Searches within 500 m and Area Searches within 5 km, both focused around a central point and lasting at least 20 minutes (no longer than a day). For a full description of the data collection, as well as the vetting and processing methods used in Atlas 1, see Blakers et al. (1984) and for Atlas 2, see Barrett et al. (2003).

In order to quantify the effect of survey method on the comparison of atlases, observers who took part in *Atlas 1* were encouraged to repeat some surveys using the same method they had used during that first atlas. As a result, 1,771 × 10-minute grid surveys (*Atlas 1* method) were completed during *Atlas 2* (1998-2001), mostly in NSW. For a description of the analysis of *survey method effect* between the two atlases, see Garnett *et al*. (2002) or Barrett *et al*. (2003). The total number of bird species, number of woodland-dependent ground-foraging species, and number of understorey-dependent species per survey was estimated within a 1000m buffer of the revegetation site. Note that *Atlas 1* surveys were collected at the 10-minute scale, so a portion of *Atlas 1* surveys will extend beyond this buffer.

To assess the potential impact of vegetation enhancement activities on bird species, a control region was delineated for this study area. The control region was delineated in the GIS and was chosen to contain the same amount of river length as existed along the enhanced section of the Murchison River and in a similar landscape. Figure 25 shows the treatment and control study regions and the distribution of Atlas 1 and Atlas 2 Birds Australia data. The number of species per survey was compared for *Atlas 1* control sites (n = 5 surveys), *Atlas 1* revegetation sites (n = 25 surveys), *Atlas 2* control sites (n = 29 surveys) and *Atlas 2* revegetation sites (n = 17 surveys). Woodland-dependent ground-foraging species and understorey-dependent bird species were defined as per Ford *et al*. (1986).

The overall number of bird species recorded per survey was greater during *Atlas 2* compared with *Atlas 1* (Figure 26), partly due to there being more rainfall during this second atlas period (Barrett et al. 2003). Nevertheless, the increase in bird species reported per survey tended to increase more steeply in the fenced sites compared with the control sites (Figure 26), suggesting that the biodiversity value in these sites have been enhanced by the on-ground activities. A stronger response was shown by understorey-dependent bird species and ground-foraging woodland bird species, with the number of species recorded per survey increasing in the revegetation sites during *Atlas 2* compared with *Atlas 1*, while decreasing in the control sites over this same period (Figure 27 and Figure 28 respectively).

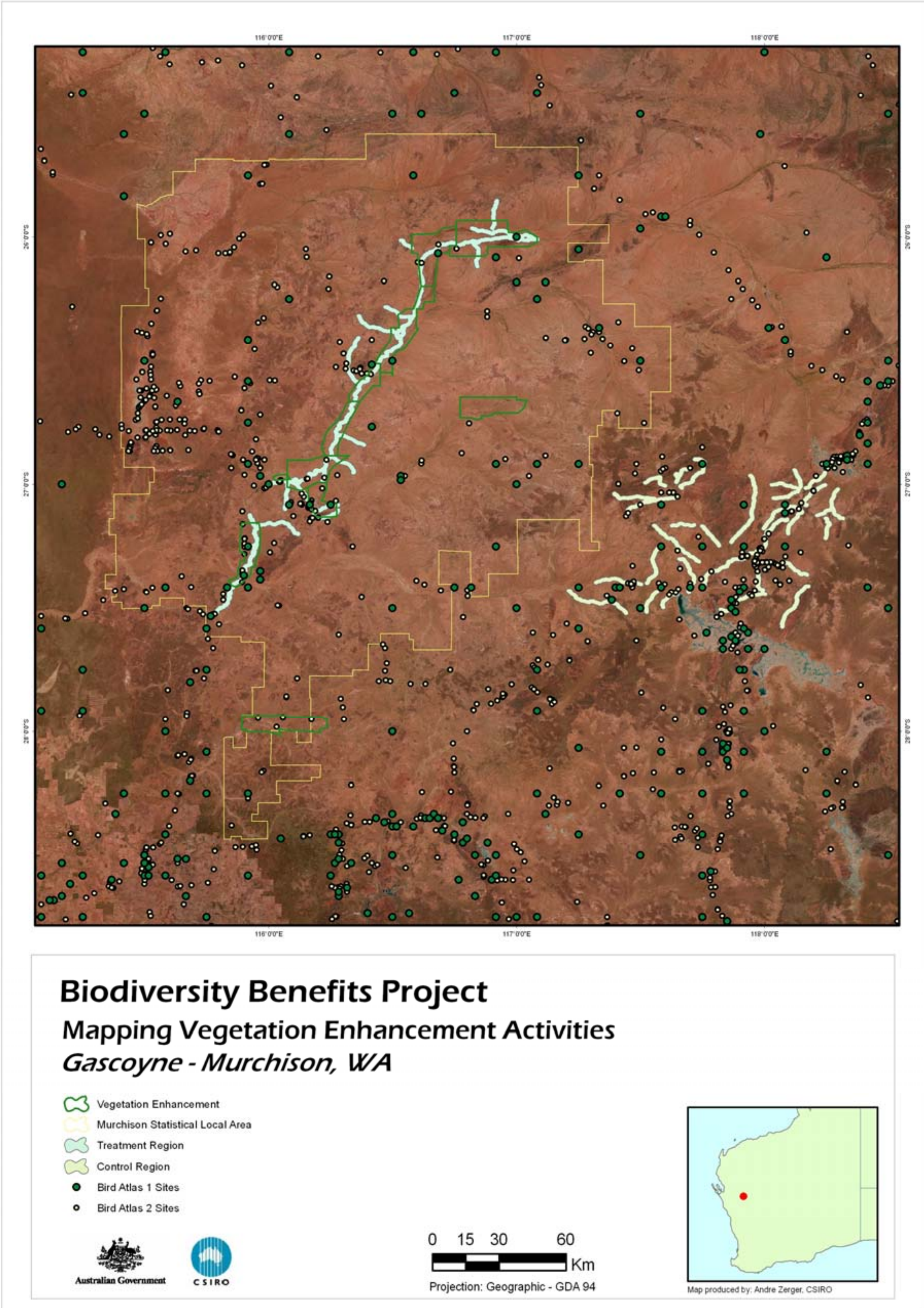

Figure 25 Gascoyne-Murchison case study showing the treatment (vegetation enhancement activities) and control region

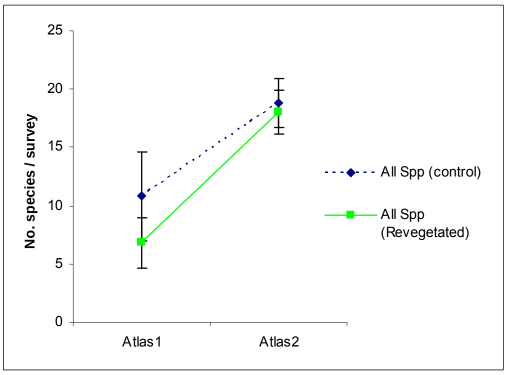

Figure 26. Total number of bird species recorded per survey during *Atlas 1* and *Atlas 2* in revegetated sites vs. control sites.

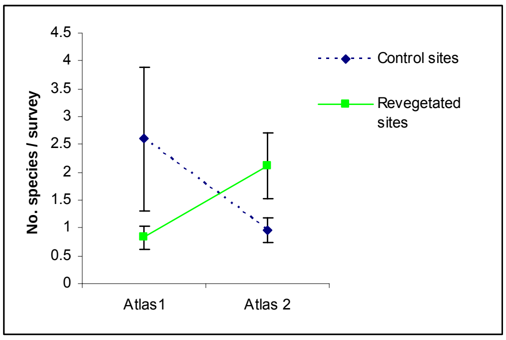

Figure 27. Number of understorey-dependent bird species recorded per survey during *Atlas 1* and *Atlas 2* in revegetated sites vs. control sites.

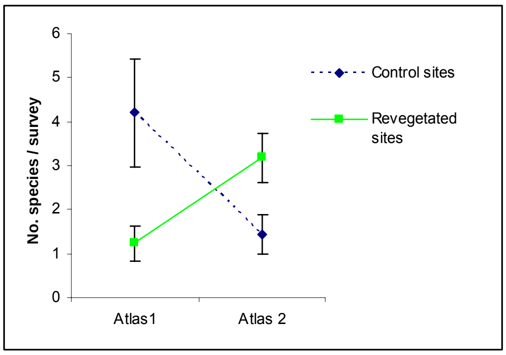

Figure 28. Number of ground-foraging, woodland bird species recorded per survey during *Atlas 1* and *Atlas 2* in revegetated sites vs. control sites.