Chapter 5
Ecosystem Health

Key Points

	Indicator	Status of Indicator
5.1	Ecosystem water quality	Since the 2003 Audit period, the number of locations exceeding ANZECC water quality guidelines has increased for physical parameters such as conductivity, remained high for nutrient parameters and reduced for toxicants.
5.2	Macroinvertebrates	There are less sampled locations with similar to reference ratings compared with the 2003 Audit period. Macroinvertebrate assemblages at 32% of the sampled locations in the Catchment were found to be significantly impaired and 5% of all sampled locations had a severely impaired rating.
5.3	Fish	Monitoring of fish communities in the Catchment is still needed as a potentially useful indicator of ecosystem health.
5.4	Riparian vegetation	Riparian zones outside the Special Areas are likely to be under variable pressure due to little to no standing vegetation cover, stock access, and the presence of exotic species. Change in condition of vegetation in the riparian zone is not able to be determined.
5.5	Native vegetation	Native vegetation covers approximately 50% of the Catchment. Approved land clearance substantially decreased over the 2005 Audit period.

Healthy and intact natural ecosystems play a crucial role in maintaining water quality as they provide processes that help purify water, and mitigate the effects of drought and flood. An overall picture of the ecological health of a catchment can be achieved using tools such as water quality, habitat descriptions, biological monitoring and flow characteristics (Qld DNRM 2001). Ecosystem health assessment has become more ecologically based in recent years with biological measures such as ecosystem structure and species diversity having been added to traditional physico-chemical water quality analysis to provide a more comprehensive picture of the condition or catchment health (Qld DNRM 2001). This audit examines:

- traditional ecosystem water quality parameters
- aquatic communities, namely macroinvertebrate and fish communities
- terrestrial ecosystems of riparian and native vegetation communities.

Pressures in the Catchment

Sydney's drinking water supply is managed using a multi-barrier approach to control risks to water quality, including catchment management, storage management, delivery system management and treatment systems (SCA, WQRMF, 2005). Healthy natural systems in the Catchment and around storages contribute to this multi-barrier approach by reducing risks to water quality.

Many water supply authorities have tried to secure ecosystem processes by closing off, or in some way protecting, the hydrological catchments of their storages. The SCA has taken a similar approach through the Special Areas which comprise 370,000 hectares, or about a quarter of the total Catchment area. Special Areas are tracts of largely native vegetation in good condition around water storages and lands containing the SCA's canals and pipelines. The Special Areas are particularly important as part of the multi-barrier approach to protecting water quality as they provide ecosystems in reasonably good condition that buffer against nutrients and other pollutants near storages and bulk water off-take points. These barriers appear effective under low and moderate flow conditions when water can take several years to travel between the outer catchment and the dam wall. However, under periods of high flow, the barrier effect of the storage breaks down and the capacity of the ecosystem in the remainder of the Catchment becomes critically important. This capacity is strongly dependent on the integrity and health of the ecosystems across the entire Catchment. Pressures on ecosystem health therefore need to be managed across the entire Catchment.

Ecosystem health is affected by a number of natural and human induced pressures. Natural pressure on ecosystem health and condition include fire, flood and drought. The primary human induced pressures on ecosystem health in the Catchment are land use change (Chapter 4), water demand and management (Chapter 3), and land management (Chapter 4). These human induced pressures can directly disturb or destroy ecosystems, as well as indirectly affect ecosystem processes through impacts on water quality, flow regimes, and biodiversity.

Aquatic ecosystems are particularly important as an indicator of a range of pressures resulting from water and land based activities in the Catchment. Aquatic ecosystem health is a function of many factors including water quality, community structure and diversity (for example, macroinvertebrates and fish), and the extent and condition of riparian and native vegetation in the Catchment. All these factors contribute to the ability of aquatic ecosystems to support and maintain a balanced, integrated, adaptive biological system (Milligan *et al.* 2002).

Chemical, nutrient and cold water pollution are some of the possible threats to aquatic ecosystems caused by human practices and land uses. Clearing of native vegetation and riparian zones can also affect land condition, biodiversity and runoff volumes which ultimately impact water quality and aquatic ecosystem processes. Riparian vegetation is particularly crucial for water quality and aquatic ecosystem processes, and also provides habitat for terrestrial fauna. Managing native vegetation clearing, particularly in riparian areas, is therefore important to maintaining ecosystem health.

The presence of exotic fauna is also a pressure on ecosystem health in the Catchment, with exotic species causing physical damage to soil and vegetation, and preying on native species and disrupting natural ecosystem processes. Exotic plant species can also affect ecological processes in vegetation communities.

State of the Catchment

5.1 Ecosystem water quality

Background

Healthy ecosystems generate and maintain good water quality. This audit examines 12 water quality parameters that signal whether the state and pressures in the Catchment are impacting on water quality required to maintain aquatic ecosystems. These parameters were assessed against the guidelines for ecosystem health in the Australian and New Zealand Environmental Conservation Council (ANZECC) and Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) guidelines (2000).

The auditors used the same methods as the 2003 Audit to provide a visual presentation of ecosystem water quality across the Catchment (see Map 5.1). The 12 parameters were combined into the following four groups:

- Physical – Turbidity (NTU), pH and Conductivity (µS/cm)
- Toxicants – Total Aluminium (Al) (mg/L) and Total Iron (Fe) (mg/L)
- Nutrients – Total nitrogen (µg/L), Total phosphorus (µg/L), Oxidised nitrogen (µg/L), Ammonia (µg/L) and Filtered phosphorus (µg/L)
- Chlorophyll–a (µg/L) and Dissolved Oxygen (%).

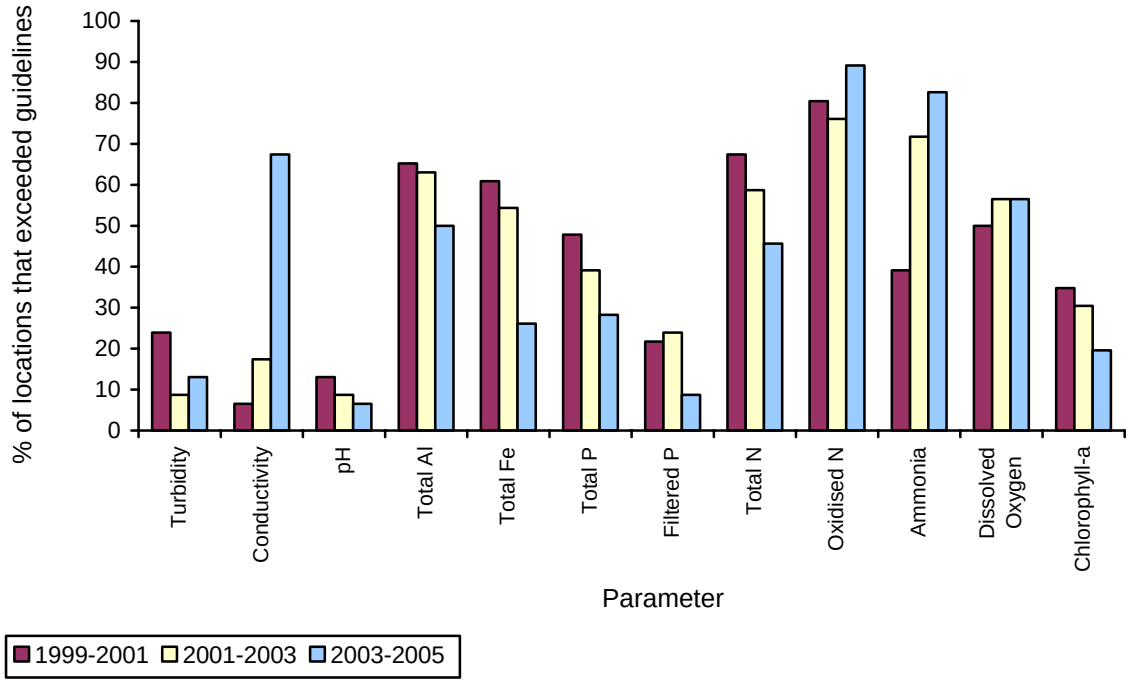
The parameter with the highest level of exceedence within a group was then used to rate that group. The groups were rated as:

- 'Very Poor' when one or more parameters exceeded the guidelines in more than 75% of samples
- 'Poor' when one or more parameters exceeded the guidelines in 50 – 75% of samples
- 'Fair' when one or more parameters exceeded the guidelines in 25 – 50% of samples
- 'Good' when less than 25% of samples for all parameters exceeded the guidelines.

Findings

The percentage of locations that exceeded the ANZECC guidelines for aquatic ecosystem protection was lower in the 2005 Audit period than in the 2003 Audit period for 7 out of the 12 parameters tested (Figure 5.1). The parameters that had an increase in percentage of locations where there was an exceedence of the guidelines during the 2005 Audit period were turbidity, conductivity, oxidised nitrogen and ammonia (Figure 5.1). Conductivity had the largest increase in the percentage of locations exceeding guidelines (from 17% in the 2003 Audit period to 67.4% in the 2005 Audit period). Total Iron had the greatest decrease in percentage of locations exceeding guidelines (from 54% in the 2003 Audit period to 26% in the 2005 Audit period).

Figure 5.1 – Percentage of locations that exceeded the ANZECC and ARMCANZ 2000 guidelines for ecosystem health for the 2001, 2003 and 2005 Audit periods



Source: SCA 2005

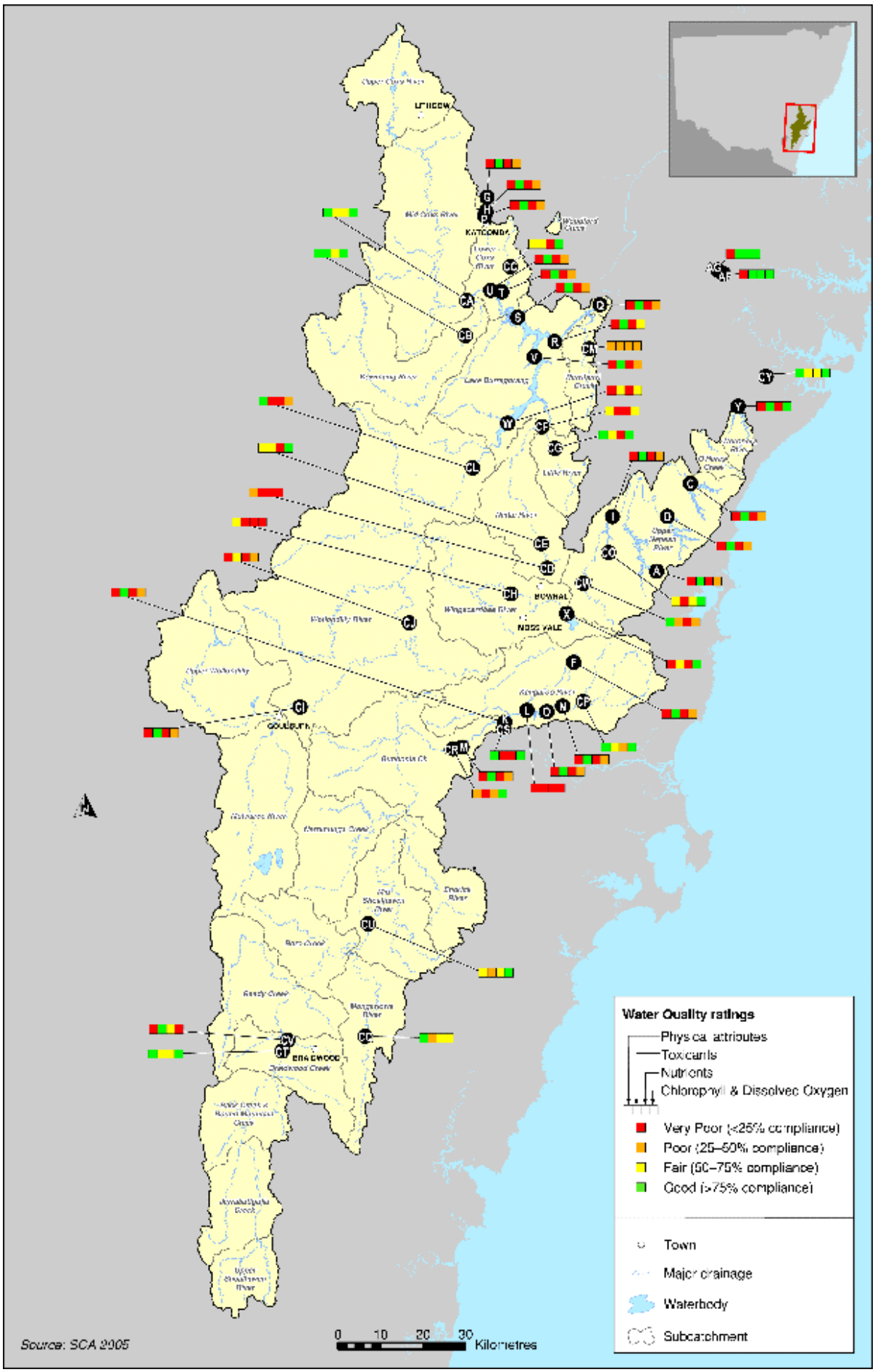
Lake Yarunga (L*) was the only location that rated very poor across all four groups for the 2005 Audit period. During the 2003 Audit period, Lake Yarunga (L*) rated very poor in three water quality groups.

Wingecarribee River (CH*) had three water quality groups rated very poor for both the 2003 and 2005 Audit periods. Gillamatong Creek (CV*), Wollondilly River (CI*), and Werriberri Creek (CM*) rated very poor in three water quality groups during the 2003 Audit period, and have all improved in at least two water quality groups during the 2005 Audit period.

During the 2003 Audit period Gibbergunyah Creek (CD*) and Mulwaree River were rated as very poor in all four water quality groups. Gibbergunyah Creek (CD*) improved in Physical parameters, but still had very poor ratings for Toxicants, Nutrients and Chlorophyll-a and Dissolved Oxygen. Mulwaree River was not re-sampled during the 2005 Audit period.

The majority of the high exceedences of ANZECC guidelines related to the Nutrient parameters during both the 2003 and 2005 Audit periods. The percentage of locations exceeding ANZECC guidelines for Physical parameters in catchments, lakes and reservoirs increased from 33% in the 2003 Audit period to 78% in the 2005 Audit period. The percentage of locations exceeding ANZECC toxicant guideline levels decreased from 70% during the 2003 Audit period to 48% in the 2005 Audit period, while the number of locations exceeding nutrient guideline levels remained relatively constant and high at 93% (Appendix E Table 2 and 3).

* See Map 5.1 for locations of sampling sites and Appendix E Table 5 for explanation of codes.



Map 5.1 – Water quality monitoring sites showing the 4 parameter groups and percentage compliance in the Sydney Drinking Water Catchment

For Physical parameters, there was a 66% increase in the number of locations exceeding ANZECC guidelines compared to the 2003 Audit period, 9% of locations improved and 25% of locations experienced no change (Appendix E Table 4).

For Toxicant parameters, 48% of locations experienced no change from the 2003 Audit period, 11% of locations increased in the percentage of samples exceeding ANZECC guidelines, and 41% of locations improved (Appendix E Table 4).

For Nutrient parameters, 64% of locations experienced no change from the 2003 Audit period, 32% of locations had an increase in the percentage of samples exceeding ANZECC guidelines, and 5% of locations improved from the 2003 Audit period (Appendix E Table 4).

For Chlorophyll and Dissolved Oxygen, 66% of locations experienced no change in the frequency of exceedance of ANZECC guidelines since the 2003 Audit period, 18% of locations had an increase in the percentage of exeedences of guidelines, and 16% of locations had a reduction in the number of exceedances of ANZECC guidelines (Appendix E Table 4).

Pesticides are monitored at 22 locations in the Catchment. ANZECC (2000) specifies an ecosystem health guideline value for some, but not all pesticides. This audit has adopted an interim benchmark that was established by DEC using available data on lethal and effect concentrations (LC50 and EC50) on macroinvertebrates, where there is no ANZECC (2000) guideline. In the 2005 Audit period all pesticide levels were below the relevant ANZECC guidelines and interim DEC benchmarks.

Implication

Water quality exceeded ANZECC water quality guidelines for ecosystem health over the 2005 Audit period for 50% of the water quality parameters tested at over 40% of locations. Since the 2003 Audit period, the percentage of locations in exeedence of nutrient parameters has remained high, the number of locations at which physical parameters were exceeded has increased, and exceedence of Chlorophyll-a and Dissolved Oxygen has changed little. However, the percentage of locations at which toxicant parameters exceeded ANZECC guidelines for ecosystem health has decreased over the 2005 Audit period. While the auditor is concerned by the increased locations exceeding ANZECC guidelines for nutrients (93% of locations) and the substantial increase in locations exceeding guidelines for conductivity, it is acknowledged that low flow from current drought conditions may be influencing these results.

The majority of high exceedences were in the Nutrients group in both the 2003 and 2005 Audit periods. Oxidised Nitrogen exceeded guidelines in 76–98% of locations between 1999 and 2005. The number of locations at which ammonia levels have exceeded guidelines has continually increased from 39% between 1999 and 2001, to 83% of locations during the 2005 Audit period. High levels of nutrients in the water column may be caused by a combination of decreased flushing and increased residence times resulting from drought conditions, diffuse nutrient sources from catchment land use and run-off (rural and urban), and point sources of pollution including sewage treatment plant discharge and sewage overflow events. High nutrient levels are associated with eutrophication and nuisance growth of aquatic plants and algae, and are therefore a concern for both ecosystem health and bulk water supply.

High exceedences in the Physical parameters (predominantly conductivity) and an increase in the number of locations exceeding the ANZECC guidelines could also be related to low flow resulting from drought because groundwater contribution to surface flow may have more influence on water quality than under average flow conditions. While an appropriate concentration of salts (measured by conductivity) is vital for aquatic plants and animals, salinity beyond the normal range can cause stress or death of aquatic organisms. Highly saline conditions can also affect the availability of nutrients to plant roots, and therefore disturb aquatic plant growth and aquatic ecosystems.

The continued exceedence of Dissolved Oxygen guideline values in over 55% of locations from the 2003 Audit and the 2005 Audit may be having a direct impact on aquatic biota. In addition, low Dissolved Oxygen levels can also cause changes in redox conditions, aiding the release of phosphorus from sediments which can increase nutrient levels in water.

The low pesticide levels observed in the Catchment during the 2005 Audit period may be related to drought conditions, and improved pesticide management practices.

The SCA's water quality monitoring program is largely restricted to the north east region of the Catchment. There are several sub-catchments with few or no monitoring sites where water quality could be expected to be under stress (see Future Directions below). A number of the priority sub-catchments have only one or two water quality monitoring sites, and the priority sub-catchments of Mulwaree River, Upper Wollondilly River and Upper Coxs River have no water quality monitoring sites. The current SCA water quality monitoring program does not give a comprehensive picture of water quality throughout the Catchment.

Future directions

Routine ecosystem water quality monitoring is currently undertaken at 17 of 28 sub-catchments. Some of the sub-catchments with few or no routine water quality monitoring have been identified as areas under environmental stress by other indicators or as priority sub-catchments by the SCA. These sub-catchments include the Upper Coxs River (priority), Mid Coxs River (priority), Upper Wollondilly (priority), Mulwaree River (priority) and Nerrimunga Creek sub-catchments.

The integration of monitoring programs by sampling for multiple indicators at the same location would also be beneficial to understanding the reason for Catchment condition, and would provide more confidence in selection of action and response programs. See Recommendation 3.

Recommendation 21: The SCA review its water quality monitoring program to ensure that appropriate ecosystem water quality monitoring is undertaken in all sub-catchments.

5.2 Macroinvertebrates

Background

'River health' is a concept that goes beyond suitability of water for particular uses and integrates a range of ecosystem values and functions. Macroinvertebrate assemblages integrate many aspects of the 'health' of streams and rivers, complementing the more traditional assessments of water quality.

Macroinvertebrates are typically visible with the naked eye and exist in a variety of habitats in streams, lakes and wetlands. Of all biological communities used to assess health, macroinvertebrate assemblages are most widely used, as they are abundant and diverse, sensitive to changes in water quality, flow regime and habitat conditions and they allow detection of impacts some time after the impact has occurred (Qld DNRM, 2001). Additionally, there is reasonably good taxonomic knowledge of freshwater macroinvertebrates, and they are relatively easy to collect.

The AusRivAS system is widely practised and supported for use in environmental audits by independent studies (Cullen & Cottingham, 1999) and national water monitoring programs. The AusRivAS sampling protocols were developed as part of the National River Health Program's Australia-wide Assessment of River Health. Since 1994, more than 1500 reference sites across Australia have been sampled to build predictive models to interpret field sampling results. The AusRivAS system generates river health assessments by predicting the macroinvertebrates that would be present (expected) and compares this with the macroinvertebrates collected (observed) to create an index of health. The lower the observed/expected value, the more impaired the macroinvertebrate assemblage. The SCA is required by its Operating Licence to undertake annual macroinvertebrate sampling during spring. The Spring 2005 AusRivAs data was unavailable for this audit due to the spring sampling.

This audit presents the 2001 to 2004 Spring AusRivAS scores at 73 sampling location.

Findings

During Spring 2004, the macroinvertebrate assemblages at 33% of the sampled locations in the Catchment were significantly impaired, and 6% of all sampled locations had severely impaired ratings. On average, between the 2001 Spring sampling and the 2004 Spring sampling:

- locations with a similar to reference rating decreased
- locations with a significantly impaired rating increased
- locations severely impaired and locations with a richer than reference had little to no change.

Jacqua Creek at Lumley Rd (NZ*) received an AusRivAS health rating of severely impaired during Spring 2003. Three locations had an AusRivAS health rating of severely impaired from the 2004 Spring sampling. The severely impaired locations during Spring 2004 were Werriberri Creek at The Oaks (OE*), Woronora River at The Neddles (MT*), and Tarlo River at Tarlo (MB*). Tarlo River at Tarlo (MB*) also had a decreased health rating in the 2003 Audit period (Map 5.2).

The AusRivAS health rating decreased at the following nine sites between Spring 2001 and Spring 2004: Shoalhaven River at Farrington crossing and at Hillview (NG* and MQ*), Jacqua Creek at Lumley Road (NZ*), Mulloon Creek at Tawarri (OK*), Tarlo River at Tarlo (MB*), Waratah Rivulet at Flat Rock crossing (OJ*), Werriberri Ck at Serenity Park and The Oaks (MV* and OE*) and Wollondilly River at Baw Baw Bridge (OO*) (Map 5.2).

Richer than reference ratings between Spring 2001 and Spring 2004 were recorded at Jerrabuttgulla Creek at Warragandra (NB*), Corang River at Meangora (MN*), Mongarlowe River at Monga (OI*), Shoalhaven River at Yarra Glen (MY*), Kowmung River at Kowmung fire trail (NE*), Coxs River at Kelpie Point (MC*) and Wollondilly River at Goonagulla (NK*) (Map 5.2).

The AusRivAS health rating improved from Spring 2001 to Spring 2004 at the following six sites: Woodford Creek at Woodford Dam (NR*), Currembene Creek at Krawaree Rd crossing (OL*), Little River at fire trail and Six Foot Track (MX* and OC*), and Coxs River at Lidsdale and McKanes Bridge (OV* and NP*) (Map 5.2).

The AusRivAS health rating remained unchanged at the other 19 sampling sites between Spring 2001 and Spring 2004. A number of locations with a health rating of significantly and severely impaired macroinvertebrate assemblages in Spring 2004 also exceeded ANZECC (2000) guidelines in 3 or 4 groups of physico-chemical water quality (See Maps 5.1 and 5.2). These locations include Gillamatong Creek at Braidwood (CV-MS) and Shoalhaven River at Hillview (CU-MQ). Shoalhaven River at Hillview (MQ) has declined in AusRivAs health, from similar to reference in Spring 2001and Spring 2002 to significantly impaired in Spring 2003 and Spring 2004, and also had a decline in water quality compared to the 2003 Audit period for toxicant parameters (see Section 5.1 and Map 5.1).

Implication

In general, the AusRivAs macroinvertebrate health ratings have declined since 2001. While this suggests overall diminishing health, it is unclear whether this is due to deteriorating water quality or drought conditions.

During Spring 2004, the macroinvertebrate assemblages at 33% of the sampled locations in the Catchment were significantly impaired, and 6% of all sampled locations had severely impaired ratings. The sites with an AusRivAS health rating of severely impaired in Spring 2004 are in the Wollondilly River (priority), Werriberri Creek (priority) and Woronora River sub-catchments. The sampling locations in the Wollondilly River (MB) and Werriberri Creek (OE) sub-catchments are located near pasture land (see Map 4.1 for land use locations), although the reason for the macroinvertebrate rating was not investigated.

* See Map 5.2 for macroinvertebrate sampling locations and Appendix E Table 5 for explanation of codes.

Sites with a richer than reference rating can occur because of either a naturally high biodiversity, or an impact such as mild nutrient enrichment (Barmuta *et al.* 2002). Seven sub-catchments had a richer than reference rating between Spring 2001 and Spring 2004. All richer than reference locations from the Spring 2004 sampling were adjacent or close to pasture land (see Map 4.1 for land use), although there is no water quality monitoring at these locations to assist with the interpretation. Follow up macroinvertebrate monitoring should be considered at all these locations to determine whether the AusRivAS health rating results from natural processes or human induced impacts.

The spatial coverage of macroinvertebrate monitoring across the Catchment is generally better than for the water quality monitoring assessed in Section 5.1, as more sub-catchments are monitored. The current SCA macroinvertebrate sampling design requires two 'core' or fixed, long-term monitoring sites per sub-catchment, and one 'roaming' site which changes from year to year. This is not reflected in the data provided by the SCA for the audit as only 53 sites were sampled for Spring 2003 and Spring 2004. The inclusion of annual roaming sampling sites allows a wider area of each sub-catchment to be monitored over time. However, it can also result in locations where impacts on macroinvertebrate are detected on one sampling year not being monitored in subsequent years. For example, Wollondilly River at Murrays Flat (MH) had a significantly impaired macroinvertebrate rating in Spring 2002, but was not sampled in subsequent years. Consequently, it is not possible to determine whether the results were a short term, natural occurrence or whether there is a continued impact that needs to be investigated and addressed to ensure ecosystem health in that location. It is suggested that consideration also be given to follow-up sampling at sites with high macroinvertebrate impairment ratings to aid in longer term analysis. This will provide greater confidence in management responses to macroinvertebrate health ratings.

In addition to follow-up macroinvertebrate monitoring, the integration of macroinvertebrate and water quality monitoring in the Catchment would be beneficial to provide capacity for a more comprehensive assessment of Catchment condition, and interpretation of results. Such integration may also enable more focussed management responses to identified changes in the condition of macroinvertebrate assemblages. See Recommendation 3 and Recommendation 22 below.

Recommendation 22: The SCA review its macroinvertebrate monitoring program to ensure that monitoring is further integrated with water quality monitoring (i.e. the sites are monitored for both macroinvertebrates and water quality parameters).

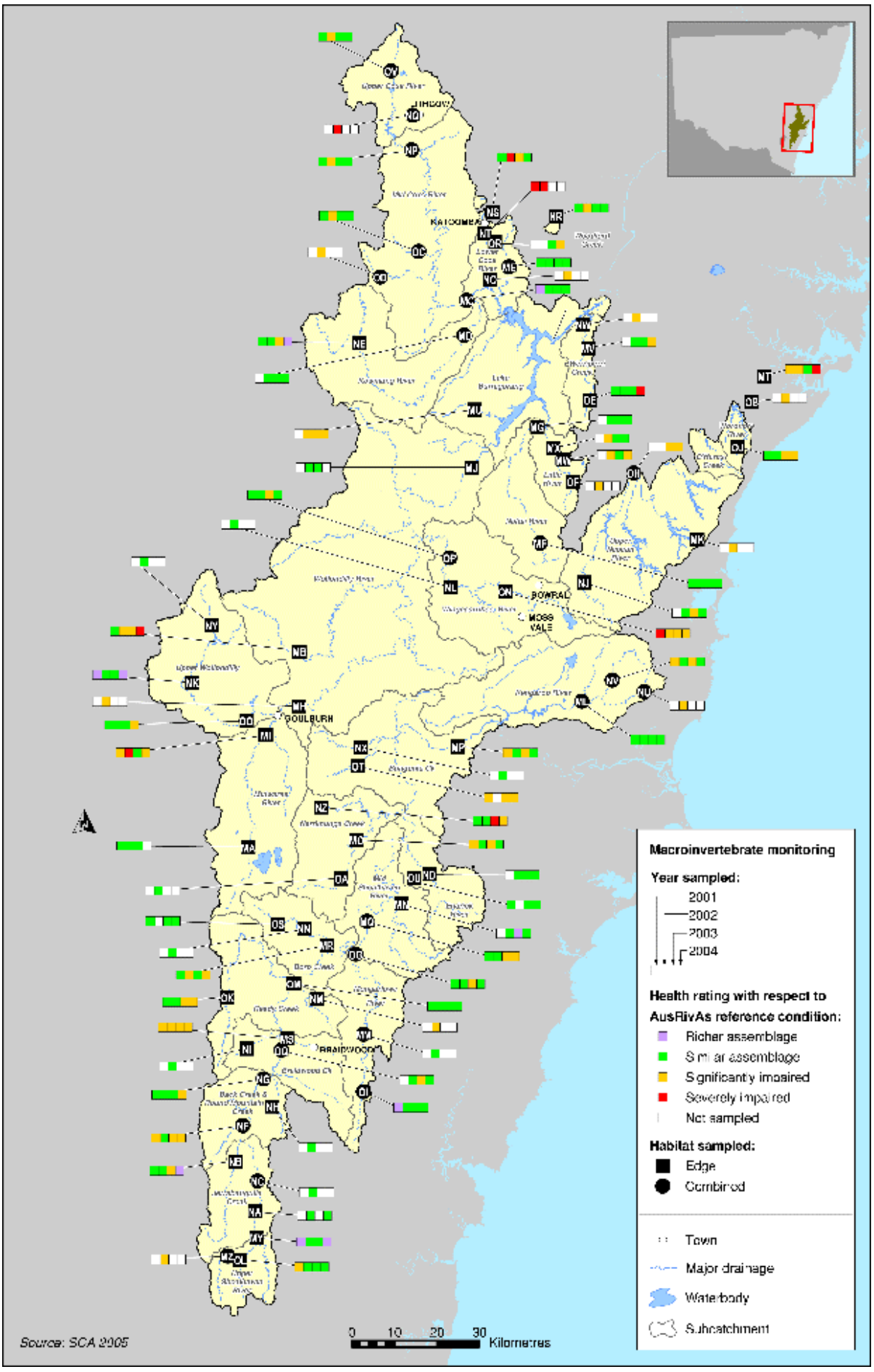
Recommendation 23: The SCA consider follow-up monitoring at macroinvertebrate monitoring locations that have significantly impaired or severely impaired AusRivAS ratings.

5.3 Fish

Background

The abundance and diversity of many native fish and crustacean species has declined in most regions of Australia since European settlement. The natural range of about one third of native inland-water fish has been significantly reduced. Continued pressures from habitat modification, introduced pests, pollution and harvesting continue to affect native fish species and fish communities. Fish populations in the Catchment are also likely to have been especially impacted by the modification of river flows and physical barriers caused by dams and weirs, the temperature of water released from dams, and competition with exotic fish species.

Dams and weirs modify and disrupt natural flows of rivers and streams by collecting variable flows and then releasing constant or regulated water-flows downstream. The modification of flows can affect a wide range of aquatic organisms, including fish, potentially reducing the species diversity and increasing the success of introduced species (Gehrke and Harris, 2001).



Map 5.2 – Macroinvertebrate AusRivAS health rating for Spring 2001 – Spring 2004 in the Sydney Drinking Water Catchment

Water released from dams is also often colder than downstream flow, especially if the dam has a bottom valve off-take. Cold water pollution can affect fish growth and survival and can potentially limit the distribution of fish within rivers to warmer areas (Astles *et al.* 2003).

Dams, weirs, and many types of in-stream works also act as significant barriers to fish passage, reducing the abundance and diversity of fish throughout a river system (Thorncraft and Harris, 2000). Physical barriers prevent the upstream and downstream passage of migratory fish, and inhibit access of fish to other areas of rivers over shorter distances.

There is only limited new data on fish communities in the Catchment since the 2003 Audit Report. However, this indicator remains relevant as a measure of ecosystem health which should be retained for future audits, as fish interact on many trophic levels and are sensitive to many kinds of human disturbance. Fish are also considered useful for environmental assessments due to their mobility and longevity. The abundance of fish individuals and species can decrease in areas with degraded riparian vegetation and poor water quality (Growns *et al.* 1998).

Given the limited additional data, this audit examines:

- numbers of native and exotic fish species, for limited locations where data is available
- removal of barriers to fish migration.

Findings

There are three sets of localised data that update information presented in the 2003 Audit Report. These data sets are a:

i) NSW Department of Primary Industries (NSW DPI) survey for the presence of Macquarie Perch (*Macquaria australasica*) in April and May 2005

ii) NSW DPI research of Carp (*Cyprinus carpio*) communities, with sampling in the Catchment undertaken at Fitzroy Falls reservoir, Lake Alexandra at Mittagong and at Tallow Dam

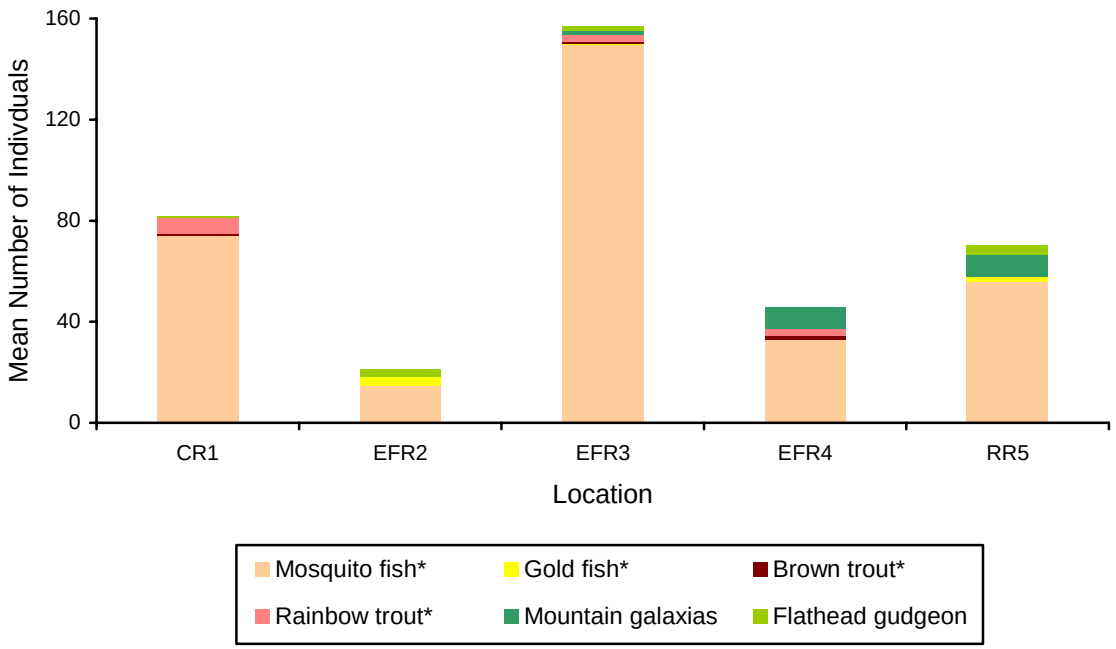
iii) Fish survey in the Coxs River undertaken by Delta Electricity in accordance with its Water Management Licence, to assess the impacts of new flow regimes.

The Macquarie Perch (*M. australasica*) is listed as a vulnerable species under the *Fisheries Management Act 1994* and has been found in the Mongarlowe River, Warragamba, Nepean, Avon, Cordeaux and Cataract Dams and in the Lower Nepean and Cataract Rivers below the storages. The NSW DPI surveyed for the presence of Macquarie Perch at seven locations in the Catchment during April and May 2005. Macquarie Perch were present at Coxs River at Kelpie Point, Kowmung River at Cedar Ford and Little River.

Carp (*C. carpio*) is a noxious species in a number of Australian states. The NSW DPI is currently undertaking research into the comparative age, sex and genetic analysis of carp populations. Carp were present at all sites sampled by the NSW DPI in the Catchment. These sites were at Fitzroy Falls Reservoir, Tallowa Dam in the Kangaroo River (priority) sub-catchment, and at Lake Alexandra in the Nattai River sub-catchment.

Delta Electricity operates two power stations, Mount Piper and Wallerawang, in the Upper Coxs River (priority) sub-catchment. Delta Electricity undertakes a range of monitoring in accordance with requirements of its Water Management Licence including water quality, biological and geomorphic parameters to assess ecosystems responses in the Coxs River to environmental flow releases from Lyell Reservoir. The biological monitoring includes using standard electrofishing techniques to identify species presence and number of individuals in each species (Ecology Lab, 2005). From March 2001 to April 2005, two native fish species (Flathead Gudgeon (*Philypnodon grandiceps*) and Mountain galaxias (*Galaxias oildus*)) and four exotic species (Goldfish (*Carssius auratus*), Mosquito fish (*Gambusia holbrooki*), Brown trout (*Salmo trutta*) and Rainbow trout (*Oncorhynchus mykiss*)) were found at eight sampling sites on the Coxs River (Figure 5.2). Exotic species of fish were recorded in greater numbers than native species in most locations over all years between 2001 and 2005, with a total of 191 native fish individuals found, and 2686 exotic fish individuals found. Mosquito fish (*Gambusia holbrooki)* occurred in the greatest numbers at all locations over all years (Figure 5.2).

Figure 5.2 – Mean number of native and exotic (*) fish species recorded in the Coxs River



Source: Ecology Lab 2005

Note: See Appendix E Table 7 for location descriptions

Implication

There is inadequate data across the Catchment to assess change in fish communities during the 2005 Audit period. However, at a localised level, the number of exotic fish species in the Coxs River may indicate a moderate level of disturbance to native species, flows or riparian vegetation structure in this area.

The large proportion of exotic fish species was highlighted in the 2003 Audit Report as a priority and a number of management options discussed including managing the health of riparian areas, and direct removal of exotic species through initiatives such as the 'daughterless carp' program. The 2003 Audit Report also suggested that management initiatives be prioritised to infested areas, particularly in storages and inflows to storages. The 2005 auditor has inadequate new information to suggest an alternative approach. More information about fish communities across the Catchment should be obtained for the next audit.

Cold water pollution

The SCA monitors the temperature of water releases at a number of sites downstream of dams. During 2003 and 2004 the SCA monitored downstream of Woronora, Warragamba and Tallowa Dams. There was little difference between the median annual temperatures upstream and downstream of Woronora Dam. There were inconclusive results for releases from the Warragamba Dam due to confounding factors and variable results. Releases from Tallowa Dam caused a decrease in Shoalhaven River temperatures with median annual water temperatures above Tallowa Dam ranging from 15°C to 21°C and median downstream temperatures of 14.6°C. Temperatures 10 degrees below ambient have been shown to have negative effects on some fish species and other organisms (Astles *et al.* 2003).

Disruption to fish passage

Instream structures such as weirs, causeways and bed-control structures can prevent fish movement and migration. The SCA confirmed the presence of 68 weirs in the Catchment. None of these weirs were found to provide effective fish passage.

The Sydney Metropolitan CMA funded a project to review fish passage in urbanised areas in 2004–05. The project, undertaken by DPI, identified in-stream structures that disrupt fish passage, prioritised them in order of importance and presented options for remediation. Woronora River and O'Hares Creek sub-catchment were included in the study. Seven structures in the Woronora River sub-catchment were identified as impeding fish passage, with two recommended for remediation. These included a causeway in Woronora River and a weir on Heathcote Creek. Two river gauging stations in the O'Hares Creek sub-catchment were recommended for removal (if the structures were no longer required).

DPI is currently undertaking several state-wide projects that relate to fish passage, including two Environmental Trust-funded projects within the Hawkesbury–Nepean and Shoalhaven River catchments. One project includes a review of waterway crossings requiring fish passage remediation. The second project aims to build on the outcomes of the NSW Initial Weir Review by undertaking detailed reviews of 80 high-priority fish passage barriers in NSW. Eight weirs were investigated in the Hawkesbury catchment and 10 weirs in the Shoalhaven catchment as part of this program. Both the waterway crossings and weirs projects are due for completion in January 2006 and will include an on-ground works component where remediation options for barriers are demonstrated.

Figure 5.3 – Berrima Weir is an example of a weir that was identified as a barrier to fish – requiring a detailed review in the Initial Weir Review project.

Future directions

A fish monitoring program in the Catchment is still needed, as recommended in the 2003 Audit Report. As indicated in the background of this Chapter, fish interact on many trophic levels, they are mobile and have a lifespan which enables fish populations to be used to assess changes in ecosystem health over time. Integrated with monitoring programs for water quality, macroinvertebrates and riparian vegetation, a fish monitoring program is likely to provide greater knowledge of Catchment health, and provide greater confidence that management responses address identified ecosystem health concerns.

Sampling of fish at designated sites should be carried out approximately every three years to determine the status of, and changes in, the composition of fish communities and to measure the success of any exotic fish control initiatives. This timeframe is consistent with that used in the Sustainable Rivers Audit of the Murray Darling Basin. Such integration may also enable more focussed management responses to identified issues. See Recommendation 3 and Recommendation 24 below.

Recommendation 24: The NSW DPI, in consultation with the SCA, develop a fish community monitoring program for the Catchment to assist the management of aquatic ecosystem health.

Case Study – Mosquito Fish (*Gambusia holbrooki*)

Gambusia holbrooki, common name Mosquito fish, is native to the rivers of south-eastern America. The species was initially introduced into NSW waters sometime during the 1920s because of its reputation for mosquito control. However its ability to control mosquito larvae appears no greater than that of small native fish that feed on insects.

Mosquito fish are now widespread in fresh coastal and inland waters throughout most Australian states, spreading widely throughout NSW, especially in modified waterways. The Mosquito fish is a major pest species in the freshwaters of eastern New South Wales. Mosquito fish have been declared as a Class 1 noxious fish (outside the greater Sydney area), with no possession of individuals allowed in aquariums, garden ponds or farm dams (NSW DPI (Fisheries), 2001).

Mosquito fish prefer warm water that is still or gently flowing, feeding on a wide variety of food such as ants and flies together with aquatic beetles, bugs and other fauna. They can tolerate a wide range of temperatures and water quality, with their high reproductive rate and extended breeding season, mosquito fish can overwhelm suitable native habitats with juveniles and deplete food supplies. Mosquito fish greatly outnumber native species in many waterways.

Mosquito fish have been associated with the decline of abundance or range of 35 fish species worldwide, including Australian native species such as gudgeon, hardyheads and some rainbow fish (NSW NPWS, 2003). Mosquito fish are known to prey upon the eggs and juveniles of other fish species.

Figure 5.4 – Mosquito fish (*Gambusia holbrooki*)
Source: NSW Fisheries

Predation by Mosquito fish is listed as a key threatening process on Schedule 3 of the NSW *Threatened Species Conservation Act 1995*. The NSW Scientific Committee determined that predation by Mosquito fish is a serious threat to the survival of threatened species such as the green and golden bell frog (*Litoria aurea*) and the New England bell frog (*Litoria castanea*) and could cause other native frog species to become threatened (NSW NPWS 2003).

Figure 5.5 - Mosquito fish (*Gambusia holbrooki*)
Source: NSW Fisheries

There are presently no completely effective or specific methods to control Mosquito fish, although the National Parks and Wildlife Service (NPWS) recommends a combination of water reform, river health programs and aquatic restoration programs as part of a threat abatement plan published in 2003.

5.4 Riparian vegetation

Background

Riparian zones typically consist of vegetated corridors adjacent to stream channels where the vegetation is influenced by the water. These areas can be effective barriers to pollution from land based activities, including agricultural and urbanisation. The riparian zone also contributes to ecosystem health by providing shade, stabilising banks, minimising erosion, limiting downstream flooding, supporting fisheries, taking up and storing nutrients and contaminants and by providing habitat for a range of species.

Riparian zones are often the most fertile part of the landscape and are subject to many pressures from land management practice, land use change and human activities. The primary pressures on riparian vegetation are removal of riparian vegetation, introduced plant species (eg. Willows) and stock access.

This Audit focuses on the extent and condition of riparian vegetation in the Catchment. The Audit also reports on the area of vegetation cleared in the riparian zone during the audit period, and provides information on restoration and protection programs in the Actions and Response section of this chapter.

Findings

The SCA estimated there is 81,125 hectares of riparian zone in the Catchment of which native vegetation covers 54,787 hectares and 23,806 hectares is pasture (SCA, 2003a). It was estimated in SCA's Annual Environment Report (2001) that 21,000 km (38%) of watercourse within the Catchment is presently being, or has the potential to be, accessed by stock.

The SCA developed a riparian zone index in 2002 to measure the proportion of standing vegetation (with no discrimination between native and exotics) in the riparian zones in the Catchment. The SCA applied this index across the Catchment in 2004. Based on this index, riparian zones in National Parks and Special Areas have a good proportion of standing vegetation, while the Braidwood Creek, Back and Round Mountain Creek and Jerrabattgula Creek sub-catchments have a low proportion of standing vegetation cover, and Upper Wollondilly River (priority) and Mulwaree River (priority) sub-catchments have little to no standing vegetation along riparian zones (SCA, 2004).

The CRC for Freshwater Ecology (Williams and Roberts, 2005) undertook a Synoptic Biodiversity Survey funded by the SCA in 2001. The purpose of this survey was to provide a preliminary assessment of the distribution and variability of riparian biodiversity within the Catchment. The study examined 40 riparian sites (see Map 5.3 for locations). Three (7.5%) of these sites had less than 25% cover of native species. These three sites were located in urban areas at Lithgow, Bowral and Goulburn. Fifteen of the 40 sites (37.5%) had 25–50% native species in the riparian zone, many of which were in the priority sub-catchments of Upper Coxs River, Mid Coxs River, Wingecarribee River, Wollondilly River, Upper Wollondilly River and Mulwaree River. The Reedy Creek, Braidwood Creek, Back and Round Mountain Creek and Jerrabattgula Creek sub-catchment also had sites with 25-50% native species. Seven sites (17.5%) had more than 75% of native species in the riparian zone, and these sites are located in the Nattai River, Woronora River, Nerrimunga Creek, Mongarlowe River and Upper Shoalhaven River sub-catchments.

The exotic plant species which occurred in more than 50% of sites surveyed in the CRC for Freshwater Ecology riparian study (Williams and Roberts, 2005) are listed in Table 5.1. Both Blackberry *(Rubus fruticosus*) and Scotch thistle (*Cirsium vulgare)* are classified as W2 or W3 weeds under the *Noxious Weeds Act 1999.* Landholders are required to fully and continuously suppress and destroy W2 species, and W3 species are to be prevented from spreading, and to have their numbers and distribution reduced.

Table 5.1 – Exotic plant species occurring in more than 50% of riparian sites in the Catchment

Common Name	Species Name	% of sites
Flatweed	*Hydrochaeris radicata*	75
Plantain	*Plantago lanceoloata*	58
Blackberry	*Rubus fruticosus*	53
Yorkshire fog grass	*Holcus lanatus*	53
Scotch thistle	*Cirsium vulgare*	53
Self heal	*Prunella vulgaris*	50

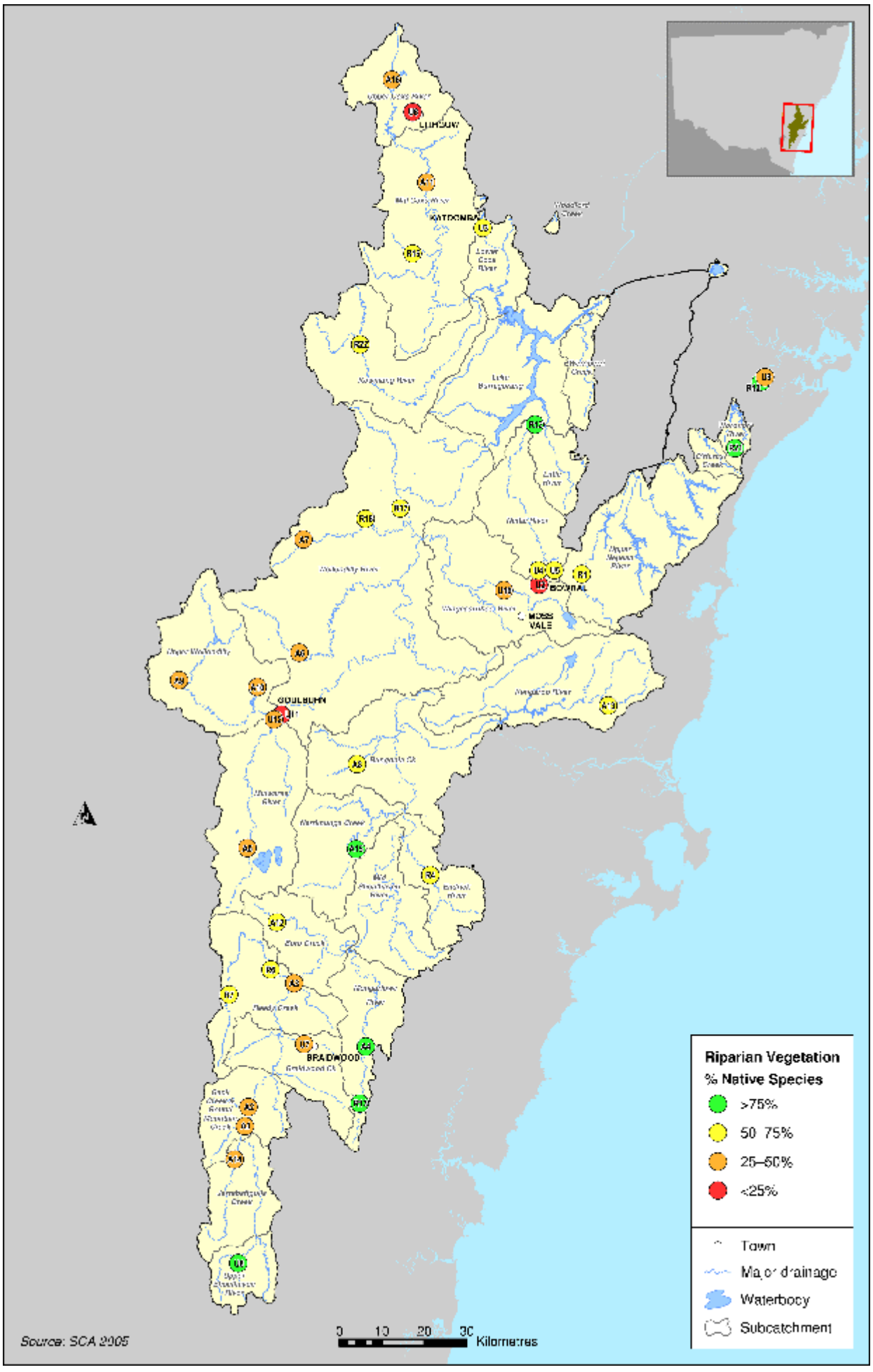
Source: Williams and Roberts, 2005

A number of clearing applications were approved during the 2005 Audit period under the *Native Vegetation Conservation Act 1997* to remove a total of 240.43 hectares of exotic species in riparian zones across the Catchment. The majority of applications were to remove willow species from the riparian zone of the Wollondilly River (61.9 ha), Mulwaree Ponds (2.27 ha), Mulwaree River (1.72 ha), Wingecarribee River (21.55 ha), Shoalhaven River (19.71 ha), Tarlo River (4.89 ha), Coxs River (110.68 ha), Jinden Creek (0.43 ha) and Sooley Creek (3.07 ha). The SCA also removed 357 hectares of willows during the 2005 Audit period which was an increase from the 202 hectares removed during the 2003 Audit period.

Figure 5.6 – Poisoned willow as part of a willow removal program along the Coxs River, October 2005

Implication

There are riparian areas within the Catchment with good proportions of standing vegetation and native vegetation cover, particularly in the Special Areas. However, there are also riparian zones within the catchment that are likely to be under variable pressure, from little to no standing vegetation cover, areas of pasture, stock access, and the presence of exotic species. These conditions can threaten ecosystem health and water quality. More information is needed on the extent and condition of riparian vegetation outside the Special Areas to quantify the pressure and assist with prioritising management programs.



Map 5.3 – Percentage of native species in the riparian zone in the Sydney Drinking Water Catchment

Healthy riparian zones assist in maintaining the health of rivers and streams in the Catchment, thereby enhancing the first of the multiple barriers in protecting drinking water quality (Section 2.2). Riparian zones are particularly important for water quality in areas where the adjacent land is subject to activities such as agricultural or urban land use.

The Braidwood Creek, Back and Round Mountain Creek and Jerrabattgula Creek sub-catchments have low standing vegetation cover in the riparian zones as shown by the SCA's Riparian Zone Index. The Upper Wollondilly River (priority) and Mulwaree River (priority) sub-catchments have little to no vegetation in the riparian zone. Water quality and ecosystem health is potentially at risk in these sub-catchments.

Weed removal along riparian zones, such as willow elimination, can cause disturbance in the riparian zone and can lead to erosion and water quality impacts. Management of weed removal sites in the riparian zone should include follow up measures to prevent secondary impacts.

Future directions

The SCA's Healthy Catchment Protection Riparian Strategy outlines a number of on-ground works to protect and rehabilitate riparian zones. The on-ground rehabilitation works should be targeted in the Upper Wollondilly River (priority), Mulwaree River (priority), Braidwood Creek, Back and Round Mountain Creek and Jerrabattgula Creek sub-catchments, as these sub-catchments have low to no standing vegetation in the riparian zone.

There are many programs for restoration and rehabilitation of riparian zones, which are all likely to contribute to an improvement in the health of riparian zones and provide improved protection of water quality. While records are maintained by relevant agencies and organisations about individual programs for riparian management, there does not appear to be a systematic use of measures to record the extent of this work. The auditor is therefore not able to report aggregate information about the extent of riparian restoration and rehabilitation across sub-catchments or the whole Catchment, although information about individual programs is presented in the Actions and Response section of this Chapter. This information should be collected systematically across the Catchment to enable better information for both future audits and development and co-ordination of management decisions (See recommendation 2). The type of information on riparian works that may be useful includes:

- areas of weed removed from riparian zones
- length of riparian zone fenced to prevent stock access
- area of riparian zone revegetated or rehabilitated.

5.5 Native vegetation

Background

Native vegetation within the Catchment is important for maintaining the health of individual species of flora and fauna, ecosystem process and genetic diversity. The degradation or clearing of native vegetation can impact on critical ecosystem services such as water quality, nutrient recycling and resources such as food and fibre. Impacts on native vegetation can also induce soil salinity and acidity, soil erosion, loss of nutrients, changes to flow regimes and climate change. The presence of exotic weed species can affect the condition of native vegetation and the extent to which it can provide habitat. The rate of biodiversity loss accelerates dramatically when a vegetation community declines below approximately 30% of its original area.

Native vegetation mapping in the outer Catchment was undertaken during the 2005 Audit period by the former DIPNR (Map 5.4). This mapping is more descriptive than what was presented in the 2003 Audit report. There are however, small areas in the Upper Coxs River (priority), Kowmung River and Upper Wollondilly River (priority) sub-catchments, which are currently being mapped as part of a project funded by the Hawkesbury–Nepean CMA.

This audit examines the extent and condition of native vegetation in the Catchment, as well as the area of:

- native vegetation cleared
- weeds removed
- revegetated and rehabilitated parts
- vegetation protected in National Parks and Reserves.

Findings

Native vegetation covers approximately 50% of the Catchment (Map 4.1) based on new land-use mapping completed during the 2005 Audit period by the DNR. It should be noted that the 2003 Audit report estimated that 63% of the Catchment is covered by native vegetation based on data from the Eastern Bushland Database.

The Kowmung River, Lower Coxs River (priority), Lake Burragorang, Little River, Nattai River, Woronora River, O'Hares Creek, Upper Nepean River and Upper Shoalhaven River sub-catchments have a large percentage of native vegetation cover (>80%). The sub-catchments with the lowest percentage of native vegetation cover (<20%) are the Upper Wollondilly River (priority) and Mulwaree River (priority) (see Map 5.4).

The SCA has recently undertaken an analysis of the change in the extent of native vegetation between March 1988 and October 2002, and the levels of clearing within each sub-catchment. While outside the 2005 Audit period, this analysis provides useful information about the rate of change in extent of native vegetation in key sub-catchments. The extent of native vegetation decreased by 0.76% in the Catchment during the study period (1988–2002). The highest increase in cleared land between 1988 and 2002 was in Back and Round Mountain Creek and Werriberri Creek (priority) sub-catchments. Wollondilly River (priority), Lake Burragorang and Reedy Creek had 0.5% of the total native vegetation cleared during the study period, and there was a decrease of 0.65% of land cleared at Upper Wollondilly (priority) during the study period.

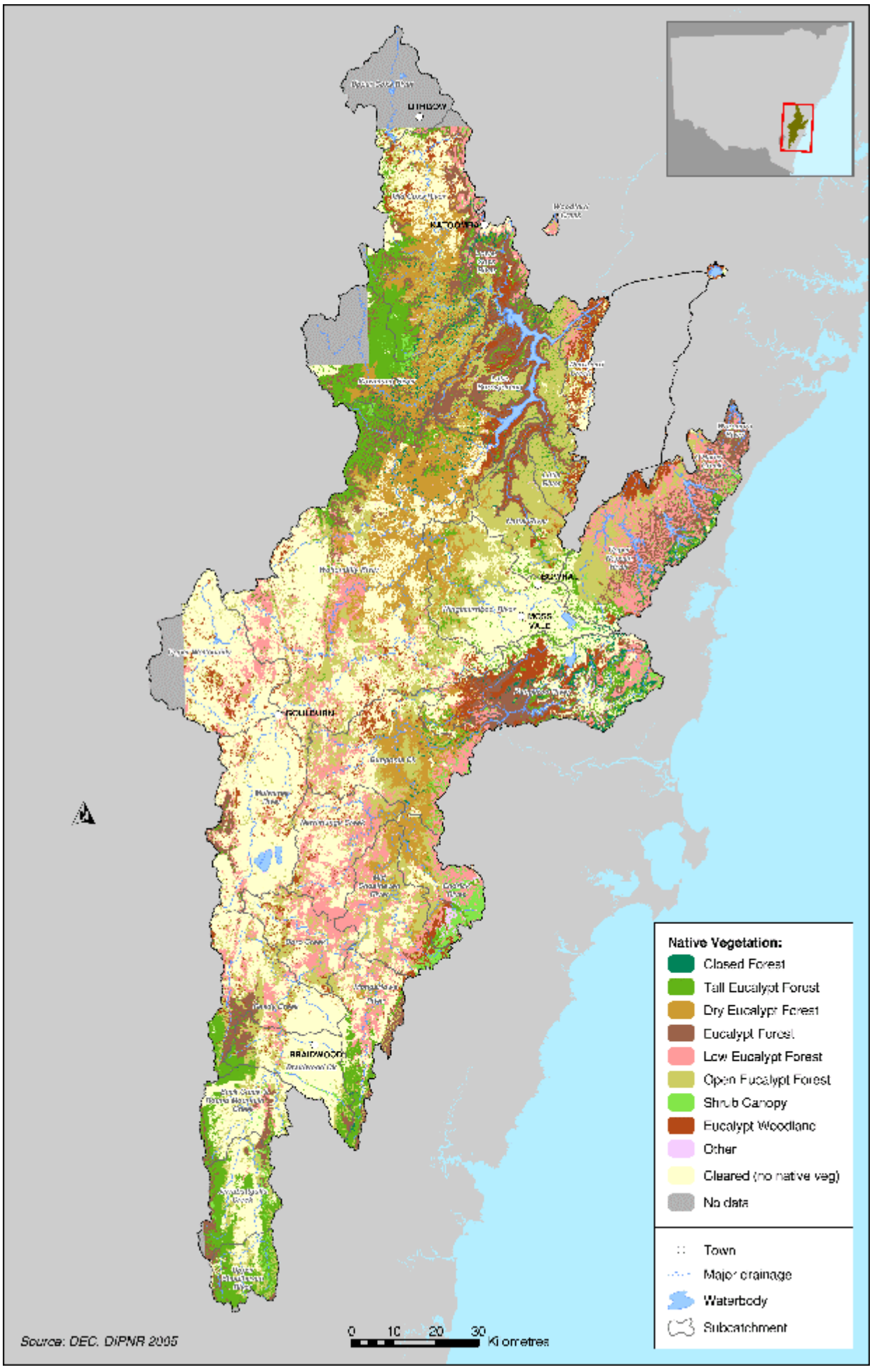
Approvals under the *Native Vegetation Conservation Act* 1997 were granted for the removal of 30.96 hectares of native vegetation in the Catchment during the 2005 Audit period. This is far less than the 728.76 hectares of native vegetation removed from the Braidwood district alone during the 2003 Audit period. The extent of clearing in the Braidwood Creek sub-catchment during the 2005 Audit period was limited to 4.56 hectares of *Eucalyptus seeberi* for the construction of a high voltage electricity line to supply Rose Meadow customers, and 22.1 hectares of native Poa tussock grass (*Poa labillardieri)* removed by aerial spraying and re-seeded with improved pasture.

Track construction in protected land resulted in 0.18 hectares of clearing of *Eucalyptus macrohyncha* in the Wollondilly River (priority) sub-catchment and the clearing of 0.18 hectares of *Eucalyptus eugenoides* in the Upper Coxs River (priority) sub-catchment.

During the 2005 Audit period, DEC acquired a total of 3,665 hectares in the Catchment, including land in the Bees Nest Nature Reserve, Blue Mountains National Park, Deua National Park, Hartley Historical Site, Illawarra Escarpment State Conservation Area, Marangaroo (Mt Walker) and Morton National Park. A number of Wilderness Areas in the Catchment were also declared in 2003–04, including Budawang, Kanangra-Boyd, Nattai and Woila Deua (DEC, 2004).

Restoration and protection programs are detailed in the Actions and Response section of this Chapter.

The majority of the native vegetation in the Warragamba and Metropolitan Special Areas have low disturbance (Map 5.5 and Figure 5.7). There are however, large areas in the Special Areas where native vegetation has been cleared or impacted.



Map 5.4 – Native vegetation in the Sydney Drinking Water Catchment

Figure 5.7 – Nepean River in the Metropolitan Special Area, October 2005

Implication

There was a significant reduction in the area of native vegetation cleared with approval under the *Native Vegetation Conservation Act 1997* compared to during the 2003 Audit period, which is a positive outcome for ecosystem health and protection of water quality in the Catchment.

The lowest percentage of native vegetation cover is in the Upper Wollondilly River (priority) and Mulwaree River (priority) sub-catchments. The low percentage cover of native vegetation in these sub-catchments may put water quality and ecosystem health at risk.

Some areas of the Catchment play a particularly important role in preventing pollutants entering the water supply and proper management and ongoing monitoring of vegetation within these areas is clearly important in maintaining water quality and quantity. These areas include those in immediate proximity to the water storages, riverine corridors (over 18°) and flood prone lands. Detailed studies of the extent and condition of native vegetation can indicate the general state of ecosystem diversity and promote greater understanding of a catchments capacity to yield high water quality.

Future directions

Vegetation mapping for the entire Catchment should be completed by December 2005. Additional information and mapping is needed on the condition of native vegetation in the outer Catchment to provide greater capacity and support to decisions about where management responses are required, particularly for areas outside the Special Areas where there is less direct and formal management arrangements for vegetative communities. The condition and relative significance of the native vegetation that is not in protected or managed areas should be determined using similar methodology used in DEC Special Areas condition assessment (Map 5.5).

All on-ground works being undertaken or funded by Government to revegetate and rehabilitate native vegetation should be integrated and a spatial database of location, type and area of works created and maintained. See Recommendation 2.

Recommendation 25: The DNR, DEC and the SCA jointly undertake vegetation condition mapping of areas outside the Special Areas.

Actions and Response

Response to Issue

There are many responses to the degradation of ecosystem health including programs to reduce the impacts of pollution (Chapter 2), new water management rules under statutory water sharing plans (Chapter 3) and programs to improve land management (Chapter 4). In addition there are specific responses to the degradation of ecosystem health, including:

- ***programs to monitor ecosystem water quality***
- ***programs to monitor macroinvertebrates***
- ***programs to maintain and enhance native fish communities***
- ***programs to maintain and enhance riparian zones***
- ***programs to maintain and enhance native vegetation.***

Programs to monitor ecosystem water quality and macroinvertebrates

In addition to SCA's water quality monitoring program, there are several more localised long-term water quality monitoring programs in the Catchment including:

- Streamwatch Program – community/school-based assessment of water quality and macroinvertebrates in local streams. There are 112 Streamwatch locations across the Catchment
- Wingecarribee Shire Council – water quality assessment survey to examine the performance of STP upgrades and assess the impacts on local receiving waters
- Goulburn City Council – Wollondilly and Mulwarree Ponds Water Quality Survey – assessment of water quality in Wollondilly and Mulwaree ponds for managing ecosystems health
- Lithgow City Council – recreational water quality assessment of Lake Lyall
- Blue Mountains City Council – Blue Mountains Water Monitoring Program to measure physical parameters for recreational and aquatic values.

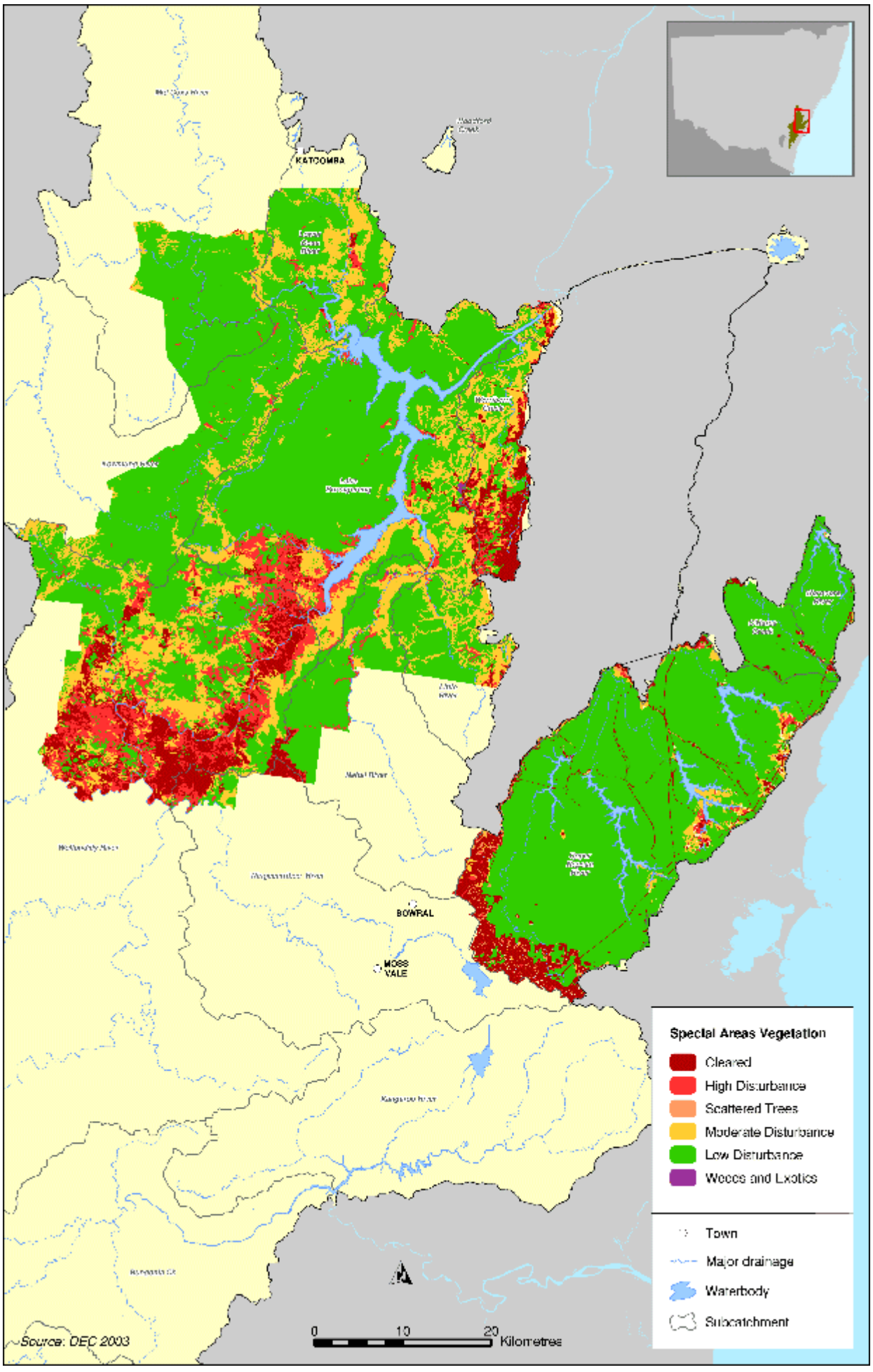
The draft Regional Environmental Plan (REP) includes a Catchment Management Strategy which states that a water quality monitoring program will be undertaken at a sub-catchment level to inform rectification action planning and enable assessment of achievement against water quality objectives.

Programs to maintain and enhance native fish communities

CSIRO is researching Daughterless carp gene technology. This technology involves manipulating the genes of carp to produce an inheritable 'daughterless carp' gene which prevents fish from developing as females. This would result in fewer and fewer females being produced each generation until the carp population was mostly male. However, the technology needs to be further developed and thoroughly tested before it can be released.

The NSW DPI has initiated the following relevant programs for fish management:

- Fisheries have been undertaking surveys of carp populations within the Catchment for the Australian Invasive Animals CRC. This has included sampling for both larval and adult fish in order to determine 'hot-spots' of carp breeding. It is also undertaking a comparative analysis of age, sex, genetic, spatial and temporal dynamics of carp populations. This project continues to provide insights into the ecology of invasive carp and will help to create a very sound basis for the design of integrated pest management approaches.



Map 5.5 – Vegetation disturbance in the Special Areas in the Sydney Drinking Water Catchment

- National Plan for Macquarie Perch, including a Macquarie perch survey to be undertaken in the Woronora River.
- Bass Habitat Restoration at Broughton Creek and Kangaroo River, funded by the Recreational Fishing Freshwater Trust Habitat Grant. The project was undertaken during 2003, and involved the removal of privet and replanting endemic riparian species to improve the habitat for Macquarie Perch and Australian Bass.
- Reducing the impact of road crossings on environmental flows, water quality and fish passage funded by the Environmental Trust – 75% of road crossings in the Hawkesbury–Nepean catchment have been assessed and the priority road crossing for remediation identified.
- Weir Review Program**,** as discussed in Section 5.3.

The SCA commenced design for a $7 million fishway and multi-level offtake point at Tallowa Dam in 2003. The fishway would enable migratory fish species to access the Shoalhaven and Kangaroo Rivers, upstream of the 42 metre high dam wall at Tallowa.

The Sydney Metropolitan CMA undertook a project between May 2004 and May 2005 to review fish passage in urbanised areas. The project identified in-stream structures that disrupt fish passage, prioritised them in order of importance and presented options for remediation. The Woronora River and O'Hares sub-catchment were included in this project.

Programs to maintain and enhance riparian zones

The SCA's Healthy Catchment Program includes a Riparian Strategy to improve the condition of riparian zones in the Catchment. The Strategy requires the identification of the condition of the riparian zone within the Catchment and provides for grants and assistance schemes, education programs and regulatory processes in consultation with appropriate authorities. As discussed in Section 5.4, the SCA has completed a riparian zone index in 2003–04 to assist implementation of this strategy.

The SCA has provided financial assistance to various organisation and landholders for on-ground work to improve riparian vegetation, including:

- Almost $100,000 of funding to landholders during 2003–04 in the Coxs River sub-catchment for on-ground works including the removal of *Salix cinerea* willows and other weeds, revegetating with native trees and removing rubbish. 13 km of works have been completed to date.
- Willow control above and within Cecil Hoskins Nature Reserve and along other sections of the Wingecarribee River. The work above the Reserve was part of a three year *Salix cinerea* program undertaken by SCA in partnership with the then DIPNR and Wingecarribee Shire Council.
- Riparian revegetation and weed control along Werriberri Creek in conjunction with the Hawkesbury Nepean CMA and Wollondilly Shire Council. The work was undertaken in May and June 2005 and involved the removal of about one hectare of privet, Blackberry and Japanese Honeysuckle.
- Various riparian restoration projects in the Kangaroo River sub-catchment to eradicate privet and madeira vine infestations.

The Hawkesbury–Nepean CMA is also preparing a River Health Strategy at the request of the Minister for Natural Resources. The Strategy has been developed by assessing 150 river reaches to understand values ad pressures on each reach. The Strategy aims to maintain the condition of natural or near natural reaches, maintain and improve good condition reaches and improve environmental condition in the remaining reaches. While broader than riparian vegetation, the Strategy will assist the CMA to invest in programs such as riverbank management in a prioritised manner. The Strategy is expected to be submitted to the Minister for Natural Resources in December 2005.

The Hawkesbury–Nepean CMA removed Willows from a 750 m length of the Wollondilly River under the Catchment Protection Scheme in 2004–05. In addition, the Hawkesbury–Nepean CMA has developed a number of riparian zone management projects which help to protect riparian vegetation. These include:

- Warragamba Riparian Biodiversity Project, which provides technical advice and funds to landholders to carry out on-ground works including revegetation, weed and erosion control, fencing and providing stock with alternate watering sources. The following works were completed during 2004–05:
    - 585 ha of riparian landscape rehabilitated or protected
    - 39 km of riparian zone fenced and protected from stock
    - 80,367 native tubestock planted to enhance riparian zones
    - 85 km of riparian zone treated for weeds
    - 11 off-river stock watering systems installed.
- Targeted Pussy Willow Control Program, which aims to control and where possible stop the spread of Pussy Willow (*Salix cinerea*) across the Wingecarribee Shire. The following works were undertaken during 2003–04:
    - 14 properties were treated for pussy willow
    - 75% of a large infestation at Cecil Hoskens Nature Reserve in Moss Vale was controlled.

The Southern Rivers CMA is also administering a South-east integrated river and wetland protection and rehabilitation program, a Riparian partnership project and the Kangaroo River and Broughton Creek Privet Reduction Program in the Kangaroo River (priority) sub-catchment.

The degradation of native riparian vegetation along NSW water courses was also listed in November 2001 as a key threatening process under the *Fisheries Management Act 1994*. Once listed, the NSW DPI may prepare a threat abatement plan to identify actions required to manage the key threatened process so as to abate, ameliorate or eliminate its adverse effects on threatened biodiversity.

Programs to maintain and enhance native vegetation

Actions to maintain and enhance native vegetation include formally protecting high conservation areas, minimising clearing, removing weed infestation and revegetating cleared areas to restore biodiversity values.

Programs to protect high conservation areas

As discussed in Section 5.5, the areas of land protected in National Parks and reserves has increased during the 2005 Audit period. In addition, DEC also administers three mechanisms that enable landholders to formally protect conservation value, including native vegetation. These mechanisms are:

- Voluntary conservation agreements (VCAs) which are a permanent legal protection for the property's special features, through an agreement between the landholder and the Minister for the Environment
- Wildlife refuges, where specified land is legally declared a wildlife refuge, and the terms of the agreement can be changed over time
- Land for Wildlife, where information is provided to landholders to help conserve the bushland.

Other initiatives such as the Southern Rivers CMA's Southern Rivers Bush Incentives program funds the management of selected sites on private land that have high conservation native vegetation. The Southern Rivers CMA has also implemented a comprehensive voluntary biodiversity conservation scheme for south-east NSW, as well as projects to protect biodiversity in the Southern Catchment and revegetation of the Braidwood Granites.

Programs to manage vegetation clearing

The *Native Vegetation Act 2003* sets a legal framework for ending broadscale clearing unless it improves or maintains environmental outcomes, encouraging revegetation and rehabilitation of land with native vegetation, and rewarding farmers for good land management. Landholders seeking to clear native

vegetation are now required to either submit a development application, or enter into a legally binding agreement with the local CMA called a Property Vegetation Plan.

The NSW Government has recently amended the *Threatened Species Conservation Act 1995*. The key amendments included:

- the integration of biodiversity into strategic land use planning under the EP&A Act
- the accreditation of flora and fauna consultants
- embedding threatened species conservation in native vegetation protection and incentives schemes
- transparent prioritisation of recovery and threat abatement actions
- upgraded enforcement and compliance provisions.

Weed control and native vegetation management programs

- The SCA's Pest and Weed Control Program for Special Areas focuses on the control of blackberry, serrated tussock, pampas, willows and privet, and on feral goats, deer and pigs.
    - The control of serrated tussock included the SCA treating 264 hectares in Braidwood, Upper Nepean, Shoalhaven and Warragamba catchments, with DEC treating 1,210 hectares in the Joorilands area.
    - Control of willows included the SCA treating 128 hectares in the Shoalhaven Catchment.
    - SCA also funded a $5 million weed control program on the Wingecarribee Swamp. The program aims to eradicate or reduce infestations of pussy willows to a manageable level.
- The Hawkesbury–Nepean CMA has implemented a Warragamba Terrestrial Biodiversity Program which aims to protect and improve good quality remnant vegetation including native grasslands, woodlands and forests to increase the biological diversity of these remnants and to protect them from future degradation. As part of this program the following works were undertaken during 2004–05:
    - 588 hectares of remnant vegetation was protected by 42 kilometres of fencing
    - 27 kilometres of direct seeding
    - 15,600 tubestocks were planted
    - 230 hectares of direct weed control.
- Various other restoration projects in the Catchment during the 2005 Audit period were funded through the National Heritage Trust, including:
    - Glowworm Glen Wetland Study undertaken by the Glowworm Glen Bushcare Group and Wingecarribee Shire Council
    - Mount Gibraltar Forest Regeneration and Protection Project undertaken by the Mount Gibraltar Landcare and Bushcare and Wingecarribee Shire Council
    - Linking a Bushland Remnant to a Riparian Zone on the Wollondilly River undertaken by F Downes and C Pryma at Canyonleigh
    - Protecting High Conservation Value Riparian Vegetation Along Trimble Creek at Kangaroo Valley in the Kangaroo River (priority) sub-catchment, undertaken by Centre For Leadership Pty Ltd
    - Berkeley Brush Dry Rainforest Restoration Project in the Nerrimunga Creek sub-catchment, by the Budjong Creek Land Care group
    - Protection and Restoration of a Mulloon Creek Drained Wetland for Biodiversity and Sustainable Land Use in the Reedy Creek sub-catchment, by Coote, Anthony Edmund Rundle.
- Landcare and Bushcare groups operate in the Catchment, undertaking work to protect and restore native vegetation.

- Local Councils undertake or facilitate many on-ground works for restoring and maintaining native vegetation in the Catchment. A few examples include:
    - Wollondilly Council restoration of Werriberri Creek in the Werriberri Creek (priority) sub-catchment
    - Wollongong City Council carried out riparian zone restoration in the Mid Shoalhaven River sub-catchment with Gallaghers Creek Bushcare group
    - Wingecarribee Shire Council programs included:
        - blackberry control on Wingecarribee River at Berrima, in collaboration with the Hawkesbury–Nepean CMA, local landholders and Berrima Bushcare
        - creek bank restoration at Gibbergunyah Creek, Mittagong Creek, Whites Creek at Moss Vale, Iron Mines Creek, Medway Rivulet at Sutton Forest, Caalang Creek at Robertson, Wingecarribee River and the creekline below Lake Alexandra
        - Bushland rehabilitation at Penrose, Mt Gibraltar, Robertson, Mt Alexandra Reserve, Berrima Common, Bong Bong Common, Hammock Hill, Mansfield Park, Wingello Forest, Cunningham Park, Yerrinbool and Welby
        - Bush regeneration work in 15 bushland reserves by council's bush regeneration team.
    - Blue Mountains City Council has a number of programs including:
        - support of 50 local Bushcare and Landcare groups
        - a noxious weeds program is focused on treating weeds in our urban areas
        - Weedpoint – a system that allows officers to use portable computers to map the location of noxious weeds on private land on-site
        - BlueSpace weed mapping database – the weed mapping system was redesigned to accommodate new weed mapping information in conjunction with the CRC for Australian Weed Management
        - Bush Backyards Scheme to set up a network of landowners who have a commitment to native plant and animal conservation on their property to provide significant habitat
        - assistance to rural landowners to develop weed management plans, subsidised participation in land management workshops and courses, and facilitation of grant applications for sustainable pasture management, fencing, weed control and revegetation
    - Goulburn-Mulwaree Council completed a South Goulburn Vegetation Management Plan.

Other programs

The Local Government Association has developed the Urban Forest Policy which aims to improve urban forest planning, management and practices throughout NSW Local Government areas.

The Lithgow and District Community Nursery is providing between 30,000 and 40,000 local trees and shrubs to the community and rehabilitation of *Paralucia spinifera* (copper winged butterfly) habitat adjacent to the nursery property (see case study).

Gaps in the response

The monitoring of ecosystem water quality and macroinvertebrate communities provides useful information about the state of the Catchment. Actions that respond to and investigate reduced water quality and impaired macroinvertebrate communities now need to be developed and implemented based on this monitoring information.

Programs to improve fish passage now need to be implemented. Partnerships between a number of stakeholders will be needed to ensure major projects such as the removal or modification of barriers to fish passage are achieved.

There are many programs for the restoration of riparian and native vegetation which will contribute to improved ecosystem health. These programs need to be coordinated across the Catchment to ensure priority areas are targeted for funding and on-ground works.

Case Study – Lithgow and District Community Nursery

Lithgow and District Community Nursery has been established on the old Hermitage Colliery site for the past 4 years. Rehabilitation of the former washery site included removal of coal piles, levelling and application of pebbles over the entire surface.

The nursery grows only local native plants from seed (Figure 5.8). For the past 14 years the nursery has been working to protect threatened plant and animal species, re-green Lithgow valley and educate the local community. It provides between 30, 000 and 40,000 local trees and shrubs per annum to groups such as Landcare, Delta Electricity, RTA and schools.

Figure 5.8 – Lithgow and district community nursery native plants

Along with the rehabilitation of the degraded mine site a large section of *Paralucia spinifera* (Copper winged butterfly) habitat is being rehabilitated beyond the fence of the nursery grounds (Figure 5.9). The butterfly (Figure 5.10) is an endangered species that is only found in 15 locations within this immediate area. The rehabilitation involves clearing pest and weed species and revegetating with *Bursaria spinosa* the native blackthorn shrub.

Figure 5.10 – Copper winged butterfly

Figure 5.9 – Rehabilitation of Copper winged butterfly habitat beyond the fence of the Lithgow and district community nursery