Preliminary Investigation into the Management of Riparian Rainforests in South-east Queensland

Simon ODonnell*

Abstract

The project "Cost-effective Riparian Zone Revegetation Management" funded by the Queensland Department of Primary Industries (QDPI) and the National Landcare Program (NLP) drew attention to the need for careful management of remnant riparian vegetation in Queensland and the difficulties associated with attempts at re-establishment and rehabilitation. Experimental planting sites have demonstrated the differences between fast-growing dry sclerophyll species and mixed rainforest plantings as far as establishment techniques and post-establishment management are concerned. Monitored remnant strips are providing information on the different structural types of the vegetation, seedling regeneration and damage by floods. Vegetation surveys have been used to establish occurrence of species throughout the region..

1. INTRODUCTION

The Mary River catchment, 200 kilometres north of Brisbane, has been the site of preliminary investigations to prepare guidelines for the management and rehabilitation of riparian vegetation in Queensland.

In high-velocity flow areas where river-banks are steep and frosts are severe, the establishment of indigenous native rainforest tree species is time-consuming and costly. Limitations such as flooding, poor nutrition, active erosion, siltation, weeds and frosts render the re-establishment of vegetation extremely difficult. Special management techniques are required to grow plants in these areas. On the other hand, in more sheltered sites native species can be relatively easily established.

Surviving remnant strips in these situations do not escape these problems. Simply fencing out domestic stock results in woody weed and tropical grass infestations which inhibit the regeneration of native plants. Seedlings suffer badly from physical damage by flood debris, insect attack, dehydration, siltation and by being competed out by invading ground flora weeds.

2. METHODOLOGY

The project took a three-pronged approach. This involved surveying remnant strips of riparian forest to determine which species occurred on the river banks, and structural classification. Experimental sites were then planted to evaluate the potential of as many of these species as possible.

2.1 Vegetation Survey

Riparian vegetation surveys established the existing species distribution throughout the Mary River catchment and provided data on possible local native species for planting.

Aerial photographs and random selection were used to identify sites for species surveys on the Mary River mainstream and its tributaries. Species lists from local amateur botanists were also reviewed. Twenty-five-metre-wide terrain surveys were carried out to establish the nature of the different plant communities. Where possible species at each site were rated as "very common", "common", "in scattered groups of a few trees", or "rare". Fifty-four sites were surveyed.

2.2 Structural Classification

Three 0.4-hectare permanent sites are being monitored to identify structural characteristics of riparian forests, and to permit observations on natural regeneration and plant populations. Seedlings within these plots are permanently marked, and information on their survival and growth is being collected.

Details of height, the number of each species, and, if relevant, damage either by flood or cattle are recorded.

2.3 Planting Sites

Three planting demonstration sites representing the three most common plant communities were selected, at Conondale, Gympie and Maryborough. Seven thousand plants of 110 species were planted between October 1993 and June 1995. Records on growth, ease of management, costs and species configurations are being kept. Standard forestry techniques are used to maintain the plants.

* Senior Extension Officer Forests, Resource Management Business Group, Queensland Department of Primary Industries, Gympie, Queensland.
Tel: (074)821522 Fax: (074)821529 Email:ODonneS@DPI.QLD.GOV.au.

Rutherfurd, I.D. & Walker, M. (1996). Proceedings of the 1st National Conference on Stream Management in Australia, 19 – 23 February, 1996, Merrijig, Australia.

3. VEGETATION SURVEY RESULTS

One hundred and ninety-seven species were recorded, excluding grasses and sedges. Twenty-nine of these were woody or vine-type weeds. A small number of common species dominated most sites (Table 1).

TABLE 1
The most common species of the Mary River mainstream.

Aquatic species	**(upper stratum cont.)**
Cyperus spp.	_Castanospermum australe_
other sedges	_Casuarina cunninghamiana_
Avicennia marina	_Eucalyptus tereticornis_
Aegiceras corniculatum	_Melaleuca linariifolia_
Excoecaria agallocha	_Syzygium australe_
Ground layer	_Syzygium francisii_
Adiantum sp.	_Waterhousea floribunda_
Commelina cyanea	**Vines (native)**
Doodia sp.	_Geitonoplesium cymosum_
Lomandra hystrix	_Malaisia scandens_
Lomandra longifolia	**Vines (introduced)***
Oplismenus aemulus	_Asparagus plumosus_*
Pseuderanthemum variabile	_Cardiospermum halicacabum_*
Shrub stratum	_Macfadyena unguis-cati_*
Cleistanthus cunninghamii	_Passiflora subpeltata_*
Lower tree stratum	**Weeds***
Acacia aulacocarpa	_Duranta erecta_*
Aphananthe philippinensis	_Eugenia uniflora_*
Casuarina glauca	_Lantana camara_*
Cryptocarya triplinervis	_Leucaena leucocephala_*
Ficus coronata	_Maclura cochinchinensis_*
Ficus opposita	_Psidium guajava_*
Hibiscus tiliaceus	_Ricinus communis_*
Mallotus claoxyloides	_Schinus terebinthifolia_*
Mallotus philippensis	_Solanum mauritianum_*
Streblus brunonianus	_Solanum torvum_*
Upper tree stratum	
Argyrodendron trifoliolatum	
Callistemon viminalis	

* (naturalised since European settlement.)

On the mainstream, species associations varied from the headwaters south of Conondale to the reaches near the town of Maryborough in the north.

Vegetation structure types along the tributaries to the north-west of the catchment were predominantly classifiable as dry sclerophyll river forests of *Eucalyptus, Callistemon, Melaleuca* and *Casuarina*. Those on the tributaries to the south and east and on the mainstream were predominantly subtropical rainforest associations. Species varied significantly from the toe of the river bank to the top of the bank. The greatest species diversity occurred along the face of the bank. Natural regeneration of dry sclerophyll forest species occurred on degraded rainforest areas. Some rainforest species had established themselves on, and stabilised several severe slips near Maryborough.

An interesting feature was the seed dispersal characteristics of the plants, many of which are dispersed by birds. This is seen as an important factor in the stability of some forests (Catterall & Kingston, 1993). Only a few of the plant species are water-dispersed, with *Waterhousea floribunda* (weeping lilly pilly) being the most common species. Sun-intolerant species such as *Cryptocarya triplinervis* (three-veined cryptocarya) and *Neolitsea dealbata* (white bolly gum) were common in dense healthy remnants. Few of these species occurred close to the margins of the remnants, which are open to sunlight and wind, and adjoin cleared areas.

It was evident that a loss of species from significant associations affected bank stability at the toe, defined by Anon. (1993) as from the water mark to the lower bank, and that this had an adverse effect on the entire riparian vegetation ecosystem (Arthington *et al.*, 1992). The most diverse remnants had up to 60 species whereas degraded remnants had as few as 15 species. Few remnants are not grazed but floodplain remnants still had up to 90 native species (Smith, 1987).

Genetic diversity and species survival is threatened when remnants are devoid of species. Regeneration and planting projects are also made more difficult due to loss of the seed bank.

4. STRUCTURAL CLASSIFICATION

4.1 Flood and Cattle Damage

Investigations indicated that cattle damage such as plant stripping, grazed leaves, broken branches and trampled plants was very common. The species diversity of the vegetation was in fact seriously diminished in many places due to the effects of grazing. The damage from cattle was particularly severe in the case of the ground flora, but tree seedlings and the shrubby component were also severely depleted.

Signs of flood damage such as injuries to trees from logs, dumping of litter and silt over plants, and lodging of plants were recorded. In addition, once a remnant was opened up, the impact of flood damage became increasingly severe and hastened the decline of the remnant as rushing waters gouged out terraces

Rutherfurd, I.D. & Walker, M. (1996). Proceedings of the 1st National Conference on Stream Management in Australia, 19 – 23 February, 1996, Merrijig, Australia.

once protected by shrubs, ferns, creepers and stooled plants like *Lomandra spp.*

One species, *Cleistanthus cunninghamii* (cleistanthus), occurred only in a band a few metres wide along the toe banks and in places which are inaccessible to cattle. Cleistanthus is a significant species in that it occurs in mallee-like form and in populations in excess of 5 000 trees per hectare.

An interim condition assessment was established using the attributes identified in the species surveys and in the measurements from the remnant plots. Comparisons between degraded remnants and healthy remnants were made and information from ungrazed remnants was used to establish criteria for a presumed "healthy stable state".

4.2 Degraded Remnants

Some of the characteristic features of degraded remnants are:

- The loss of many species and a great number of plants, particularly shrubs and seedlings, from cattle damage and the multiplication of robust species that are rough-leaved and presumably less palatable.
- Greater flood damage; flood damage becomes greater than cattle damage as the remnants are opened up or long stretches of the bank are denuded of vegetation.
- The loss of key species, e.g. *Cleistanthus cunninghamii*, *Lomandra hystrix*, that stabilise the toe.
- An increase in vine weeds and woody weeds.
- An increase in ground weeds and herbs which inhibit regeneration and compete with native seedlings.
- The deposition of massive logs and litter.
- An increase in some dry-forest species which may dominate if the area regenerates.

4.3 Healthy Remnants

The characteristic features of healthy remnants are:

- that the structural integrity of the forest remains in order (see 4.4.1 below),
- that there are no gaps in the vegetation,
- that there is no erosion,
- that the plants in the remnant grow vigorously with an abundance of new growth at appropriate times of the year,
- that there is a high density of plants - *c.*10 000 trees of all ages per hectare - and a species diversity of greater than 60 species,
- that there are reasonable populations of large rainforest trees to provide seed, food and habitat, especially for animals which disseminate seed,
- that the rainforest community should be dense and difficult to walk through,
- that there are few exotics.

4.4 Condition Assessment of the Riparian Forest

Healthy and sound riparian rainforests contributes to the stability of river banks. These forests are layered and each layer plays a role in maintaining ecological stability, by ameliorating floods, filtering pollution, catching silt by reducing stream velocity and by preventing the erosion of river banks,.(Arthington *et al.*, 1992).

In an endeavour to understand the dynamics of change in remnants I have identified five phases of condition of rainforest remnants in south-east Queensland as shown in Figure 1. These phases are dynamic and their definition is open to discussion, but they are designed to stimulate ideas.

4.4.1 Healthy Phase

Complete structural integrity with plant populations in excess of 5 000 and possibly more than 10 000 trees per hectare.

- Upper tree stratum: tall and very tall trees, providing deep-rooted trees for bank stability and shelter for the understorey, and which have emergent trees that overshadow the canopy. Included here are several species of vines.
- Lower tree stratum: tall shrubs and small trees, contributing to water filtering and subsoil stability and providing a high degree of cover.
- Shrub stratum: small shrubs and large seedlings, provide ground cover, stability. and filtering.
- Ground layer: ferns, herbs, grasses and seedlings, all of which protect the floor of the forest from sheet erosion caused by water runoff.

4.4.2 Surface Erosion Phase

- Cattle damage trees and graze out the shrub stratum, seedlings of lower and upper stratum species and ground covers.
- Greater sheet erosion occurs on the forest floor after depletion of ground cover, caused by local water runoff from the steeper parts of the forest or from floodplain torrents.
- Greater light and wind penetration then occurs from the top of the bank.
- There is a loss of organic matter and a reduction in collection of silt which once provided seed-beds for germination, especially for *Cryptocarya* and *Cleistanthus* species.
- Gradual infiltration of creepers, vines, herbs and woody weeds.
- A reduction in plant numbers to 2 000-5 000 plants per hectare, patchy in occurrence.

Rutherfurd, I.D. & Walker, M. (1996). Proceedings of the 1st National Conference on Stream Management in Australia, 19 – 23 February, 1996, Merrijig, Australia.

4.4.3 Flood Erosion Phase

The loss of canopy creates gaps which allow higher velocity flows of floodwater, creating a vicious circle of increasing degradation.

- There is an increase in sunlight and wind, limiting some species and dehydrating seedlings.
- There is a reduction in plant density to fewer than 2 000 trees and shrubs per hectare, very patchy in occurrence.
- Terraces develop as a result of soil loss, slipping or slumping.
- There is an increase in exotic tropical pasture grasses.
- The end result is the creation of a plant community composed of large- or rough leaved plants and vigorous growers in inaccessible positions and an increased infestation of weeds

4.4.4 Bank Failure Phase

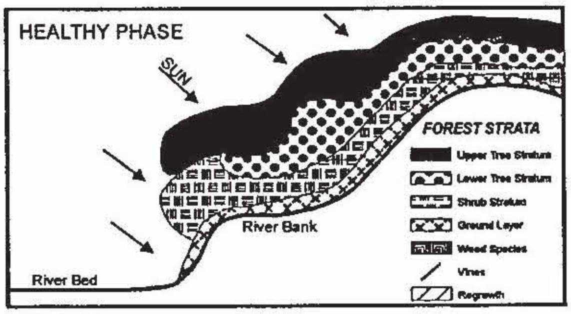
- There is a weakening of the toe of the bank.
- The occasional tree remains on the bank, sometimes causing erosion from scouring at the roots.
- Weeds are now dominant and pasture grasses severely inhibit the regeneration of native riparian species.
- Mass bank failure occurs.

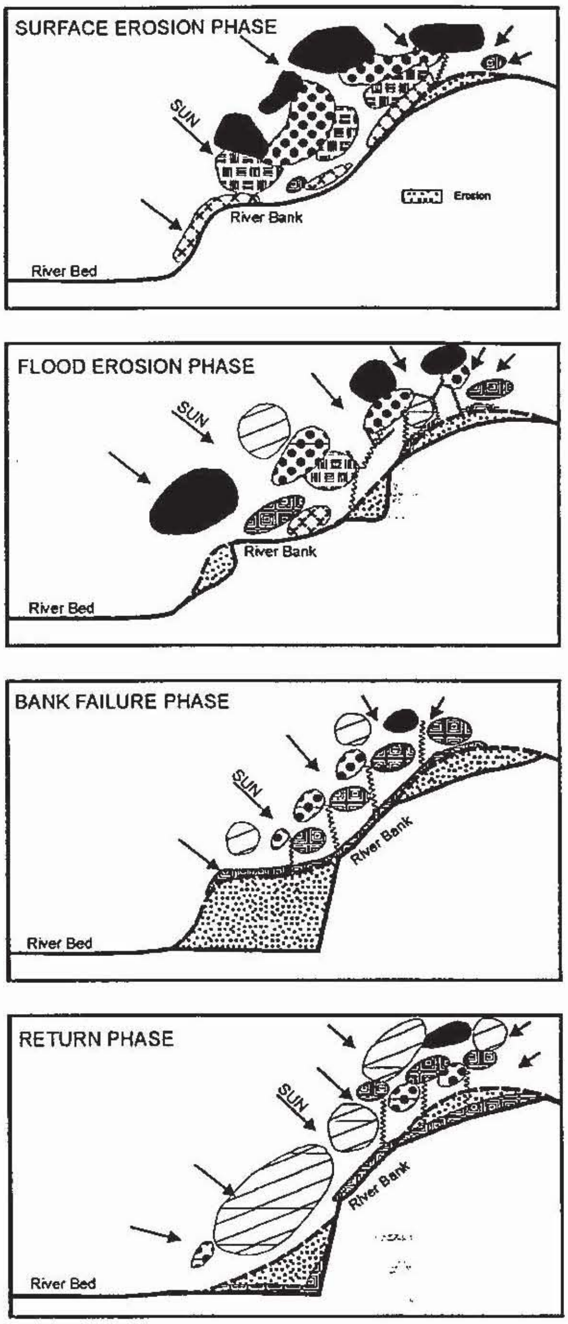
4.4.5 Return Phase

This can occur at any of the bank phases 4.4.2 to 4.4.4 above by natural regeneration if conditions permit.

- The establishment of fast-growing natives not necessarily indigenous to the site occurs, for example *Eucalyptus tereticornis*, *Callistemon viminalis* and *Casuarina cunninghamiana*. There is a lack of species diversity and the construction of a completely new ecosystem, for example *Casuarina* forest.
- Woody weeds, vine weeds and tropical pasture weeds can become completely dominant.

Figure 1: Condition assessment of riparian rainforest.





5. PLANTING SITES

To be able to establish plants on riparian zones an understanding of the limitations to plant growth in this demanding habitat is required. Good growth performance is dependent on the manager being able to overcome these limitations.

5.1 Frost Damage

Frost is a significant limitation that rainforest trees have to contend with. In the first two winters of this project severe frosts defoliated most plants at the Conondale and Gympie sites. Damage by frost was found to be dependent on three main factors: position on the bank, severity of frost, and time of planting.

Rutherfurd, I.D. & Walker, M. (1996). Proceedings of the 1st National Conference on Stream Management in Australia, 19 – 23 February, 1996, Merrijig, Australia.

5.1.1 Position on Bank

On steep banks frost damage varies throughout the site, with plants at the toe suffering less damage than those on top of the exposed bank and those in open situations.

5.1.2 Severity of Frost

Most plants were completely defoliated by severe frosts. Species responses varied greatly to lighter frosts.

5.1.3 Time of Planting

Young seedlings suffer more and die from frost damage if planted close to winter before they have become properly established. Time of planting seemed to significantly affect survival, especially for rainforest plants. Plantings made just prior to winter suffered severe mortalities from frost, especially of *Ficus coronata* (creek sandpaper fig), *Elaeocarpus grandis* (blue quandong) and *Streblus brunonianus* (whalebone tree).

5.1.4 Shelter

Frost proved to be less of a problem in protected areas such as cliff faces with overhanging vegetation and where large trees sheltered seedlings. Pioneer plantings of plants with a good frost recovery potential may need to be established on severe frost sites before planting climax rainforest species, although pioneer plantings may affect the growth and vigour of underplantings.

5.2 Recovery from Frost

Recovery from frost was influenced by the health and growing conditions of the plant.

5.2.1 Health

Recovery from frost was satisfactory for plants that were in good condition at the time of planting, but was also dependent on the plants being healthy when the frost struck. Healthy plants have the vigour to reshoot regularly after defoliation. Nevertheless a loss of growth does occur, this loss varying considerably between species. Plants such as *Mallotus claoxyloides* (green kamala), *Mallotus philippensis* (red kamala), *Grevillea robusta* (silky oak), *Pararchidendron pruinosum* (snow wood), all recovered after 100 per cent defoliation from frost. Some plants such as *Ficus racemosa* (cluster fig) were reshooting as soon as two weeks after frost.

5.2.2 Growing Conditions

Few rainforest plants were completely unaffected by frost but established plants of most species, if given reasonable growing conditions, soon recovered. Good growing conditions - warmth and adequate moisture - influence the recovery of plants by permitting vigorous growth. Should drought occur after frost, the mortality rates in certain more sensitive species are likely to be higher, or alternatively growth is severely reduced. Irrigation through dry periods may aid recovery after frosts.

5.3 Species Tolerance

Species selection is critical for successful plantings. Frost reduced vigour of some species such as *Syzygium francisii* (giant water gum). *Elaeocarpus grandis* (blue quandong) suffered severely from frost with 100 per cent mortality. *Melia azedarach* (white cedar) fared very well under frost conditions and this may be a consequence of the deciduous nature of this species. *Syzygium australe* (brush cherry) showed the best tolerance of all the rainforest plant species studied.

The non-rainforest species such as *Casuarina cunninghamiana* (river she oak), *Melaleuca linariifolia* (snow in summer), *Melaleuca bracteata* (black tea tree), and *Callistemon viminalis* (weeping bottlebrush) showed good tolerance to frost. We are investigating the use of these species as pioneer plants for establishing rainforest plantings. The fast-growing plants naturally also provide faster rehabilitation.

5.4 Other Limitations to Plant Growth

Nutrition and Flooding impact on the growth of plants.

5.4.1 Nutrition

Nutrition of river banks is generally poor and severe deficiencies do occur. Elements such as nitrogen, sulphur, phosphorus, potassium and zinc were recorded in low to very low levels. NPK fertilisers were used along with some special mixes containing other elements such as zinc and boron. Up to 550 grams of fertilisers were applied in split applications. Research on nutritional requirements will certainly provide information that will help to improve the performance of trees.

5.4.2 Flooding

Like frost, flooding severely affects plants. However, little is known of the impact of flooding on different species of plants. Several factors need to be considered with flooding:

- Submersion of foliage. Prolonged submersion can cause rotting leaves or dieback of leaves. This was found to be particularly so with the creek sandpaper fig, *Ficus coronata*, and the white cedar *Melia azedarach*, which defoliated severely after inundation. Tolerant plants, especially the hard-, smooth-leaved plants such as *Waterhousea floribunda* (weeping lilly pilly) and *Syzygium australe* (brush cherry), seemed to suffer little initial flood damage.

- Siltation. Plants are covered or partially buried in silt, inhibiting photosynthesis, reducing plant vigour and perhaps eventually causing death; for example *Diploglottis australis* (native tamarind) tended to die after a prolonged period covered in silt.
- Lodging. Small plants with shrubby habit, e.g. *Melaleuca linariifolia* (snow in summer), lodged less than tall thin trees such as *Cupaniopsis parvifolia* (small-leaved tuckeroo). Some species such as *Melia azedarach* (white cedar) completely bent over. *Glochidion sumatranum* (umbrella cheese tree) reshot very quickly at the roots after being lodged and having its roots exposed by floods. Another impact of lodging may be from the subsequent erosion from turbulence around the exposed roots and the plant being washed away. Lodged trees are also much more difficult to maintain.

5.5 Erosion Hazard

Active erosion needs to be addressed prior to planting by means of engineering works as well as cover cropping. Strategic application of cover crops proved to be a useful tool in the protection of small erosion-prone areas on site. The young trees were planted in the cover crop in patches previously sprayed with herbicide, the dead cover crop plants serving as an erosion-control measure. Months later, when the dead plant material had rotted, more ground cover seed was sown around the base of the plants. After a further three weeks the new crops of young cover plants were sprayed in their turn with herbicide to renew the dead mat of erosion-control mulch at the base of each tree.

5.6 Topography, Geography and Site Condition

There were significant differences in performance of similar species on the different sites. Extreme differences also occurred on steep banks of the same site. Growth was much better for species at the lower bank positions even with the impact of the floods. In summer the tops of the banks and the floodplain were exposed to wind and heat, and we had considerable trouble establishing some species in these situations. Windbreaks may have to be provided on these sites well before the establishment of the riparian species.

6. OVERCOMING LIMITATIONS

In overcoming the limitations to growing plants on riparian sites close consideration must be given to the level of inputs required for success. On sites of high soil erosion potential, with banks that are unstable from active inundation and high-velocity floods, inputs from management will obviously need to be higher than for, say, a bank in a sheltered area that would not suffer the same severe climatic and hydrological perturbations. The selection of species would also vary depending on the site conditions. Obviously fast-growing plants are needed for severely degraded sites for fast stabilisation. In this context species selection is not only a factor of the growth potential of the plant but also the type of site.

The growth of the plants also influences costs. Fast-growing plants need a shorter period of management for establishment than the slower growing plants.

7. CONCLUSION

Plants at the demonstration project sites are proving successful in stabilising severely eroded banks with minimal delay and under severe climatic growing conditions. It is probable that landowners with eroding banks will not have the resources for engineering works and will need to rely on planting as the most cost-effective method for rehabilitation.

Reafforestation programmes on sheltered un-degraded sites will achieve greater survival rates, plants are generally most successful when planted in moist sites in good growing conditions, after frosts and with good weed control and fertilising practices. Floods will impact greatly on plants and erosion-control methods are required to reduce loss of plants by floods.

Standard forest management techniques allow the establishment of riparian plantings through good site and plant maintenance.

On remnants close attention needs to be paid to the control of woody weeds. Windbreaks could be used to protect remnants as well as plantings from severe environmental conditions, especially from direct sunlight and wind caused by clearing at the top side of the banks. Timber plots could be used for this purpose. In plantings a canopy of plants may need to be planted two years in advance before sun-sensitive plants are brought to the site.

Where limitations are severe the choices of species is critical. On severely limited sites few rainforest species are available to stabilise the site quickly. If the site can be made stable using strategic engineering works and cover crops the chances of survival of rainforest plants is greatly improved. These severely limited sites may need to be

Rutherfurd, I.D. & Walker, M. (1996). Proceedings of the 1st National Conference on Stream Management in Australia, 19 – 23 February, 1996, Merrijig, Australia.

established with the faster-growing forest riparian species, perhaps mixed with some of the more hardy rainforest species (whose fruit may encourage birds in due course). Plantings of rainforest plants can be commenced at a later date when the situation becomes stable.

On stable protected sites species selection is relatively unlimited with choices between slow growing plants and fast growing plants possible. On sites like this greater attention can be made to creating the original riparian rainforest habitat.

8. ACKNOWLEDGEMENTS

The assistance of Diana O'Donnell Queensland Department of Primary Industries, Resource Management in helping to prepare the original draft of this paper is gratefully acknowledged, as is that of Lyn Otto and Tony Reason Queensland Department of Primary Industries, Resource Management who produced the diagrams. Thanks are also due to John Comrie Greig of the Queensland Forest Research Institute who edited the final text.

9. REFERENCES

Anon. (1993). State of the Rivers Project: Training Manual. (Prepared by Environmental Studies Section, Water Resources, in consultation with Dr. J.R. Anderson.) Water Resources Division, Queensland Department of Primary Industries, Brisbane.

Arthington, A.H., Bunn, S.E. and Catterall, C.P. (1992)., The Ecological Roles Of Riparian Vegetation. "The role of buffer strips in the management of waterway pollution from diffuse urban and rural sources". Woodfull, J., Finlayson, B. and McMahon, T. (eds.). *in* (Proceedings of a Workshop held at International House, University of Melbourne, 9 October, 1992.) Land and Water Resources Research and Development Corporation, and Centre for Environmental Applied Hydrology, University of Melbourne. pp. 93-102

Catterall, C.P. and Kingston, M. (1993). Remnant bushland of south east Queensland in the 1990's: its distribution, loss, ecological consequences, and future prospects. Institute of Applied Environmental Research, Griffith University : Brisbane City Council, Brisbane.

Smith, I.R. (1987). A study of a remnant of riverine rainforest on the Mary River, south-eastern Queensland. M.Litt. thesis, University of New England, Armidale.