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Rehabilitation of Disturbed Stream Frontages Using Natural Vegetation Templates - A Case Study on the Yarra River, Victoria

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SUMMARY
Revegetation of stream frontages is an important element of attaining return of stream health for many degraded waterways. Many revegetation programs are conducted without a lot of research and design. In particular the need to be aware of appropriate species and their preferred niche across the wetted perimeter of a stream is key to the successful recruitment of plants in a sustainable low maintenance riparian area. Placement and selection can be based upon natural templates of remnant vegetation communities and an understanding of prior disturbance regimes. The paper discusses these issues in the context of experiences along the Yarra River in Victoria. Here areas are being rehabilitated as part of a Stream Frontage Management Program run by Melbourne Water Corporation

THE MAIN POINTS OF THIS PAPER
The key to success in resetting disturbed or depauperate riparian vegetation communities is to first understand the disturbance sequence and its temporal evolution respective to that which would have existed in pre-disturbed conditions. Many streams, including the Yarra River, have had over a hundred years of human intervention based on subjective management understanding. Along with stock grazing, channelisation and successive stream desnagging created a disturbance regime favoring a limited suite of species (including weeds), or resulted in the total decline of community quality. This has led to a serious decline in waterway values.

Too many well-intentioned planting programs involve inappropriate species and inappropriate or unsuitable locations of species. These planting programs invariably prove to be ineffective in the longer term.

Central to the planting of riparian zone rehabilitation is the use of natural templates (or models) derived from representative remnant vegetation communities. Understanding disturbance, succession processes and the physical stream processes, allows appraisal of the target site and establishment of an appropriate planting program.

1. INTRODUCTION

The majority of Australia's stream systems have experienced a suite of ongoing disturbances since European settlement. Much of this disturbance occurred through inappropriate management and ignorance of Australian land systems, climate, and vegetation communities and ecological processes.

The Yarra River in south central Victoria exemplifies these disturbance regimes, with over 65 % of stream reaches now in a highly modified state (Melbourne Water 1997.). Whilst the physical stability of the river is regarded as being fair to moderately good, there is a significant problem in that overall stream health is impaired by the poor condition of the bank and verge vegetation community. In particular much of the riparian community is narrow, it has a highly reduced species diversity, recruitment in indigenous plant species is rare or lacking, and weed infestations are extensive.

This degraded condition has arisen from a multitude of poor river and land management practices which has left the river in a state of decline; its intrinsic and human-derived values are thus threatened.

This paper outlines a method for vegetation rehabilitation, to ensure that the physical condition of the river is sustained and improved. This is achievable through re-establishment of a robust riparian vegetation corridor that will be resilient to current degradation pressures.

Such revegetation will also have a critical role in the conservation of biodiversity in highly fragmented landscapes, and a major role in enhancement of visually degraded landscapes.

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It is recognised that it is unnecessary, undesirable and financially impossible to contemplate physical or structural stabilisation works along all streams that display moderate or fair degrees of erosion. Furthermore, for responsible waterway management revegetation provides a tool for tackling low rates of bank erosion and is the most appropriate option as opposed to physical or structural stabilisation works. In the use of these engineering solutions, costs ranging from $100,000 to $300,000 per kilometre could be expected. These are only appropriate where extreme erosion exists or where there is a critical threat to assets and the presence of an unsustainable process due to gross disturbance.

To ensure successful revegetation, the art is in developing a program that is well directed, utilises a strong understanding of fluvial geomorphic and instream ecological processes, and critically, an understanding of the vegetation communities and the ecology and biology of plant species for appropriate plant selection and vegetation design. This will ensure the program is effective and cost efficient.

2. THE ROLE OF BANK AND VERGE VEGETATION IN RIVER HEALTH

It is not proposed to extensively revisit the science behind the role of revegetation in stream ecology in this paper. This is well documented by Hynes (1970), Townsend (1980) and Phillipson (1966).
However, there are four significant ways that vegetation contributes to river health, as summarised below.

- Contributing to the maintenance of physical stability of banks and verges
- The provision of microclimate control and physical habitat
- The provision of large woody debris
- The provision of allochthonous organic material into the food chain of the stream

3.0 CURRENT MANAGEMENT PRACTICES AND THE NEED TO CHANGE - GETTING THE STRATEGY RIGHT

Currently, rural streams are the target for the majority of Melbourne Water revegetation programs. This has come about from analysis that shows that considerable lengths of degraded waterways are rural (Melbourne Water 1997). Degradation is predominantly due to weeds, lack of riparian vegetation and stock access.

Through the use of stream condition data and an application of the Strahler stream ordering system(Hills 1975), we are able to effectively target critical stream segments for maximum benefit to stream health. This results in a focus on establishing connectiveness of instream processes of foothill and forest edge streams to downstream segments.

However, in the reinstatement of this riparian vegetation corridor, lack of recognition of the constraints to implementing successful revegetation can result in failure.

Common failings include:

- **Failure to recognise physical stream processes and misuse of revegetation as a primary response to stream problem.** Too often we observe revegetation being used as the primary erosion control response when in fact some structural attention is first required. Analysing the site conditions through an understanding of geomorphological processes is a critical step in selecting the appropriate response. Whilst revegetation may be seen as a cheap alternative it can become expensive in circumstances where it fails to address erosion.
- **Failure to understand the condition, level of disturbance or successional stage that the vegetation is in.** In particular it is important to recognise the dominance of post disturbance or opportunistic species and age classes. A classic example would be a dominance of short lived and strongly competitive species such as wattles (Acacia Spp) which can prevent the establishment of more desirable species.
- **Failure to select the right species for the desired function and location across the wetted perimeter of the stream.** Plant species selection and revegetation design are keys to success. In particular the recognition of the biological and ecological characteristics species, and their ability to function as robust colonisers is crucial. It is quite common to find that revegetators try to recreate a full community floristic composition and structure without knowledge of what should be planted where and at what densities , and for what purpose.
- **Failure to plant the species in appropriate locations.** Placing the plant in the wrong place is a frequent error and is probably the greatest cause for failure and low recruitment. All plant species have an optimum niche and usually show very strong establishment when correctly sited.
- **Failure to prepare the site and conduct quality planting.** Thorough weed control is the key to successful plant establishment. If dominance of an out-of-balance or a non-preferred species, or an excessively weedy situation exists, some remediation must be undertaken to give the new plantings a competitive edge for establishment. More often than not stream bank vegetation has lost its natural groundcover and is dominated by aggressive, often stoloniferous, weed species, particularly grasses. Lack of effective control of these weeds will compromise the plantings. Ongoing weed control is also critical, especially for 18 -24 months post planting. This is assisted by the provision of a jute-based weed mat which provides some weed suppression, and retains moisture but which breaks down over the establishment period

leaving no residues. The use of treeguards is also recommended mainly because of grazing pressures from rabbits and wombats.

- **Selection of the wrong planting design**. Selection of the appropriate method for planting is dependent on the site. Having one overall recipe is impractical due to varying site conditions, variations in the natural plant vegetation community and the presence of remnant vegetation. Consequently a planting may comprise of solely overstorey;
  middlestorey; groundstorey
  or macrophyte species used exclusively
  or in a variety of combinations
- **Failure to maintain the plantings and manage the threats to successful establishment.** Simple maintenance of key threats such as grazing, weed control and drought (critical watering in adverse times), particularly in the first three years will increase the establishment rate substantially
- **Lack of a strategic approach to planting programs such that connectivity is rarely established**.

Through targeting forest edge through to rural stream segments the effects of improved riparian environments and hence stream system health continuity can be passed on downstream to middle and lower catchment areas. In many ways, it is a pre-condition for their rehabilitation.

- **Lack of technical support and guidance to individuals and community groups from experts and funding agencies**. The majority of plantings are conducted by volunteers or private landowners who have little technical training. Funding agencies often only supply funding for materials but none for planting support or education. The successful establishment rate will increase if people's understanding is enhanced.

4.0 A WAY FORWARD - SETTING THE KEY STEPS

A methodology developed by Melbourne Water (MW 1998) in its stream management program and by Carr and Lane (1996), Carr, Craigie et al (1996) and Carr, Peake et al (1996)involves the following phases to address the common mistakes discussed above:

Research to develop natural vegetation templates (models) that determine appropriate species and their environments

This vegetation reconstruction deals with vegetation structure and floristic (species) composition and considers the ecology of plant species. In determination of natural vegetation templates, field inspection and data collection and a review of literature (e.g. vegetation studies) is essential.

Important sources of information on the distribution, floristic composition, structure and ecology of riparian vegetation on the floodplains of the Yarra River and major tributaries include Rosengren et al. (1983), McMahon et al. (1989), McMahon and Carr (1991), McMahon et al. (1991) and Brown (1993).

Natural resource management authorities, consultants, local councils and community groups are sources of expertise or information. From these data a template is developed which is essentially a simplified structural and floristic model of the original vegetation of a site.

Other considerations in a wider or site-specific context used in developing vegetation templates include**:**

- Understanding the bioregions, associated vegetation types and relationship to the geomorphic tracts;
- A knowledge of the exotic as well as the indigenous flora and plant species biology and ecology;
- Understanding the physiography and geomorphic reaches, associated soils or substrates in relationship to the vegetation transitions down the valley;
- Understanding seasonal rainfall patterns and stream flow dynamics
- Understanding the local groundwater dynamics;
- Competitive ability (or lack thereof) of some indigenous species with weed species;
- The functional characteristics and life forms of species; and
- Availability and ready propagation of certain species (or lack thereof). Some species, while desirable for revegetation, are very difficult to propagate (e.g. Cherry Ballart, *Exocarpos cupressiformis*).

Site analysis to understand elements that will contribute to revegetation success

The design and style of planting will be influenced by the physical and biological nature of the site and the constraints these place on revegetation. Some site constraints include:

- the nature of the catchment, its soils and catchment generated inputs;
- slope or aspect of the site - this is a major determinant of species selection for revegetation. Natural plant communities are influenced or determined by the soil characteristics, aspect, exposure and moisture retention capacity of features such as escarpments and natural depressions;
- the proximity of the site to critical culverts (bridges, pipes, etc.) as this will influence the plant life-forms used in revegetation. Emphasis should be placed on using low-growing shrubs, grasses, sedges and clean-boled trees immediately upstream and downstream of critical culverts. This minimises the restriction placed upon the already compromised hydraulic capacity of streams upstream and downstream of culverts.

- Level of previous disturbance. In highly disturbed areas soil modification (eg. dredging spoil dumps or man made levees.) or re-contouring may be required, especially when the floodplain has been modified.
- Extent and severity of bank erosion.

Undertaking good site preparation in conjunction with education of the land owner and or community group to optimise success

Riparian vegetation communities are particularly prone to weed invasion and of all broad vegetation formations in Victoria, Carr et al. (1992) found riparian vegetation to have the greatest number of very seriously invasive weed species. This is because riparian environments are subject to a natural regime of disturbance through the regular raising and lowering of stream flows, periodic flooding and high nutrient levels which enhance weed growth.

These conditions allow the survival and abundant recruitment of weeds, while stock preferentially graze and disturb riparian environments, and weed seed and other propagules are dispersed by water.

Critical to the success of any revegetation program is the thorough and stringent management of weeds. Lead-times for weed management are critical with the level of preparation being site dependent. For example, sites dominated by summer-growing grasses such as Couch (*Cynodon dactylon*) will require herbicide application during active growth. In many cases, in the absence of persistent weeds, a single spray application may be all that is required, as rapid growth rates and appropriate planting densities will quickly out compete aggressive weed species. This has been the case for many sites in the Yarra Valley [see examples below].

For more detailed plantings at least 12 months lead time is desirable where problematic weeds occur. These especially include geophytic and stoloniferous or rhizomatous plant life forms (see Carr et al. 1992). Such a level of site preparation is not always practical in rural environments and is often not required. However this must be carefully evaluated in planning for revegetation

Invest in quality plants and planting materials enhance establishment and survival

Quality control of plants is achieved through the selection of suppliers who can deliver indigenous plant stock of local provenance and manage lead times through careful scheduling. This ensures juvenility of plant stock and more acceptable root to shoot ratios critical to establishment success. Too often we observe moribund stock being planted.

The use of indigenous plant species of local-provenance stock is critical in replicating original vegetation communities because of intrinsic values, but also because of:

- **cost effectiveness** - original plant types (genotypes) are generally better adapted to local conditions, establish well and have high survival rates;
- **preservation of local gene pools** - through revegetation using plant material sourced from local remnants;
- **retention of local landscape character** - revegetation with indigenous plant communities maintains the integrity and visual character of a place; and
- **establishing new sources of propagating material** - plantings provide a source of propagation material thereby lessening demands on remnant vegetation.

Invest in adequate protection of plantings with good-quality fencing

Quality fencing is crucial to ensure protection of the riparian frontage and to allow establishment of a robust riparian vegetation corridor. Fencing requirements should be compatible with farm use. For example, a 3-plain and 2-barbed wire fence is solid enough for cattle. In horticultural cropping land, such a fence is not required but definition of a riparian boundary with a less robust fence is. Boundary definition avoids incremental losses caused by inappropriate practices such as rubbish dumping and use of riparian frontage for “turn around” areas as well as longer term protection through the negative effects of a change in land ownership.

Selecting the right plant for the right place

As previously discussed the establishment of templates for revegetation is based on modified models (structure and floristic composition) of the original vegetation community. Variations within these plant communities often occur across the waterway as it passes through different geomorphic tracts and bioregions. For instance the Yarra River passes through various geomorphic tracts including upland valleys, lowland valleys and floodplains and coastal plains Thus the plant species planted at the head of the catchment will in many cases be different to those planted on a floodplain, especially if it crosses different bioregions. For example Paperbark (*Melaleuca Spp*) are components of Swamp Scrub communities often associated with upland and floodplain segments of the Yarra River and its tributaries. In some vegetation segments of Devonian geology, granitic soils more commonly support Scented Paperbark (*Melaleuca squarrosa*), whereas on Silurian geologies, sedimentary soils more commonly support Swamp Paperbark (*M. ericifolia).*

Knowing the species and its biological and ecological characteristics

Planting sites along a waterway can generally be divided into four planting zones based on soil-water relations and hydrological tolerances. (Table 1 & Figure 1) Riparian species should obviously show some degree of tolerance to wetted soils (waterlogging), although there are subtle variations down the profile of a river bank where saturation levels vary and top of bank and verge which are generally freely draining. Plant species must be planted in their appropriate niches.

Table 1. Waterways Planting Zones

Zone	Stream location	Suitable plants
Zone 1	Zone of inundation at or just below waterline (normal flow level).	Aquatic macrophytes and aquatic or amphibious herbs.
Zone 2	Zone immediately at and above Zone 1 and extending along the wetted gradient, ie. to the annual year flood level. Width of Zone 1 is determined by the wetted margin (visual assessment required).	Species tolerant of inundation and especially tolerant of high flows, ie. fibrous rooted shrubs (*Melaleuca, Leptospermum*) and rhizomatous or tufted grasses, sedges and rushes. Some localised occurrence of *Eucalyptus* species.
Zone 3	Zone immediately at and above Zone 2 or the annual flood level, extending to the top of bank and just beyond until grades changes, eg. natural levees alter soil hydrology and increase wetness of the floodplain.	Eucalypts species, *E. viminalis, E. radiata, E. camaldulensis. Acacia spp., Hymenanthera dentata, Gynatrix pulchella, Pomaderris spp., Leptospermum spp. Kunzea ericoides, Lomandra longifolia, Poa spp.* and *Dianella tasmanica*.
Zone 4	Floodplain zone which may be periodically inundated.	Species similar to Zone 2. Floodplain communities will vary considerably, eg. Woodlands, grassy wetlands. *Eucalyptus* species common to these floodplains may include *Eucalyptus viminalis, E. camaldulensis* (very restricted in Eastern Highlands and Midlands), *E. ovata, E. camphora, E yarraensis* (the latter two limited to Upper Yarra catchments).

* Eastern Highlands and Midlands – natural biophysical regions as defined by Conn (1993).

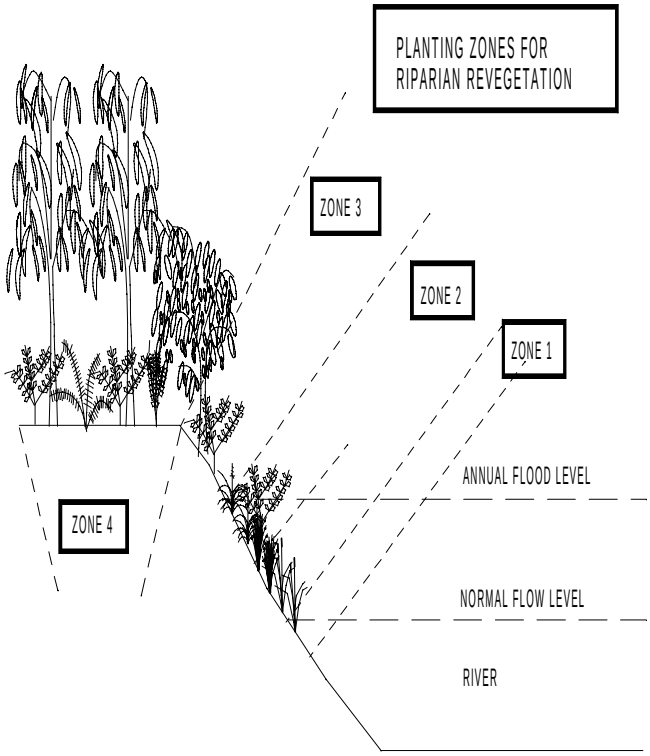

Figure 1 - Zonation across riparian environments**.**

Understanding the seasonal rainfall and stream-flow dynamics

Timing of planting is also critical for establishment success. Depending on the catchment and local climate, optimum planting times will vary. The Yarra Valley, under normal conditions, is subject to wet spring periods coinciding with periods of high flow and overbank activity. Late spring planting times are the most effective for quick establishment to avoid "wash out" and planting in excessively wet soils which may compromise plant establishment. Late spring plantings ensure sufficient soil moisture and warmth for plant growth. Autumn establishment periods are less reliable as rainfall is less consistent and frosts are likely.

5.0 SOME YARRA EXAMPLES

The Stream Frontage Management Program initiated by Melbourne Water has been running for the last 3 years. The program targets particular rural catchments based on the importance of the stream in terms of process, the level of degradation, the opportunity for restoration and the ability to work with Landcare or community-based groups. The program commenced in 1996 and some of the first properties targeted for revegetation are described below.

The first property belonged to **Maurie Pyle**. Two sites within Maurie's property were selected after an inspection of the river frontage. These sites totalled approximately 400 metres of frontage. Sites were selected on the basis of low risk for bank erosion and minimal threat from stream processes such as toe of

bank cutting. Both sites were dominated by Silver Wattle (*Acacia dealbata*) and some selective thinning was undertaken by MW contractors to remove competition. This also ensures successful plant establishment, encouraging a more diverse and robust suite of species which would otherwise be compromised by the intense competition provided by Silver Wattles.

The sites were prepared in October 1996 following a late wet spring. Glyphosate was applied over the site by a contractor 3 weeks prior to planting. Soon after application and prior to planting, the site was fenced by the landowner.

Plants had previously been ordered from a local indigenous nursery who had grown a suitable range of species as requested by Melbourne Water. Materials such as weed mats and treeguards were ordered by the landowner. Planting was undertaken in late spring by the Yarra Valley Tree Group comprising local landowners and interested volunteers. Over 3000 plants were planted over the 2 sites, including 2000 grasses and sedges grown as 'speedlings' (cells rather than tubes). These were "plugged" into exposed banks in relatively weed free areas. This allowed for establishment without competition from weeds. Tree and shrub species were laid out across the site to ensure correct placement across the river bank.

Within 10 months the plant were above the treeguards which had to be removed. At 2 years the plants were well established and eucalypt species were over 4 metres tall. The planting was close to 100% successful. There was some follow-up weed control of Blackberry (*Rubus fruticosus* spp. agg.) and Silver Wattle regrowth

The cost of the exercise equated to approximately $17.00/m (includes fencing, site preparation, plants, revegetation materials) with the labour component for planting provided by volunteers. Labours costs for planting would increase these costs to approximately $24.00/m.

Bruce Nixon was the second property owner. A total frontage of one kilometre was selected for fencing and revegetation. Planting on this site was undertaken in late autumn 1997 and the growth rates were considerably less than those at the above property. Dry conditions checked the growth of plants until the early spring. In the interim they provided food for rabbits and wombats. The plantings have been 70% successful and follow-up planting was required. The length of frontage necessitated the use of contractor support for planting with a portion undertaken by the Yarra Valley Tree Group. Eighteen months later the plantings have established but have been checked by considerable dry periods due to the driest year on record.
Both landowners were funded by the Stream Frontage management Program which provided $4.00/m for fencing and funds for the purchase of plants, treeguards and weedmats.

The above examples indicate that plant selection is critical and that the time of planting is paramount for effective establishment.

6.0 SUMMARY AND CONCLUSIONS

- Indigenous riparian vegetation performs crucial roles in maintaining and/or supplying physical stability of banks and verges, microclimate control of riparian environment, substrates for instream fauna and flora, energy for instream food chains and other conservation and landscape functions.
- In the catchment of the Yarra River, land-use and stream management practices have caused the destruction or gross modification of most indigenous riparian vegetation.
- Many riparian revegetation programs are or have been prone to failure because of a lack of understanding of the biophysical environments, natural and artificial disturbances, hydrological and ecological processes, and inadequate species selection, site preparation and ongoing management.
- A methodology and protocols developed by Melbourne Water Corporation and Ecology Australia for revegetation of riparian environments has been implemented through the Stream Frontage Management Program. Several cooperative revegetation programs have been implemented since 1996 with private landowners, the community and Melbourne Water. Several case studies are reported here.
- Key steps in planning and implementing riparian revegetation are:
- documentation of the floristic composition and structure of the indigenous pre-European vegetation of the revegetation site and the weed flora to enable design of revegetation (site selection, vegetation structure and species composition) and site preparation.
- developing an understanding of the site's physical characteristics and processes eg. geomorphology, stream processes, groundwater influence, soil characteristics, climatic variable, the need for stream works to repair serious erosion, and the location of critical culverts.

- developing an understanding of vegetation dynamics and the ecology of key plant species.
- good site preparation, notably for weed control.
- investment in good quality planting stock utilising local-provenance material of indigenous species.
- provision of good-quality fencing of revegetated areas.
- implementing effective and timely post-planting management, notably for weed control.
- Four waterway planting zones (down the riparian profile) are identified in relation to normal flow levels, annual flood levels, banks and verges. Indicative plant species lists are provided which illustrate the range of species and plant life-forms available for revegetation.

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