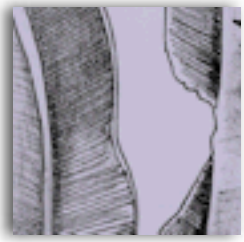

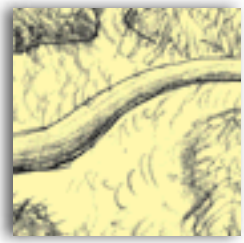

Bringing the Bush Back to Western Sydney

Best Practice Guidelines for Bush Regeneration on the Cumberland Plain

Department of
Infrastructure, Planning and Natural Resources

AABR
AUSTRALIAN ASSOCIATION OF BUSH REGENERATORS

CAVEAT

This document recommends a range of methods and techniques that have been successfully used to regenerate bushland on the Cumberland Plain.

Applying these methods and techniques may require licensing or permitting through local or State authorities under a range of State or local government regulations.

Before these methods and techniques are used in any situation, the proponent should contact their local council, the NSW National Parks and Wildlife Service, the NSW Department of Infrastructure, Planning and Natural Resources and the NSW Environment Protection Authority.

Department of
Infrastructure, Planning and Natural Resources

First published June 2003
Department of Infrastructure, Planning and Natural Resources
10 Valentine Avenue
Parramatta NSW 2124

Bringing the Bush Back to Western Sydney
ISBN 0 7347 5374 8
Designed and printed by ClickMedia, Penrith

Botanical illustrations by Cherie Parmenter

A number of organisations also generously assisted with provision of photographs for this publication including:

Hawkesbury City Council
National Trust of Australia (NSW)

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PREFACE

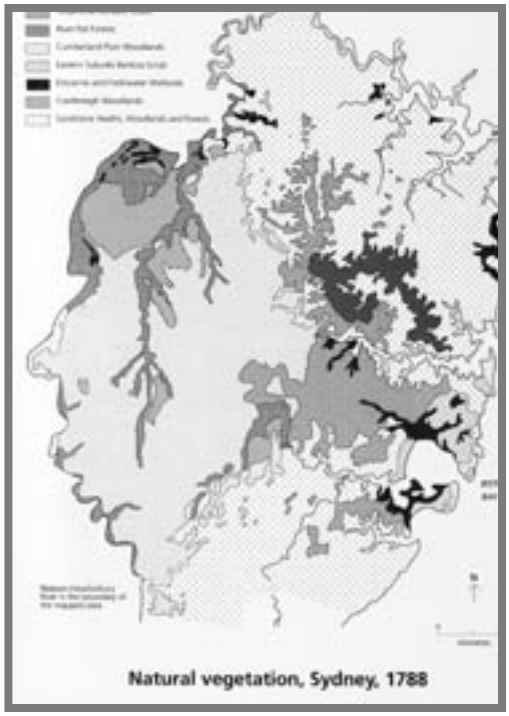
Much of the vegetation of the Cumberland Plain in western Sydney has been cleared for farming, housing and industry. In June 1997, Cumberland Plain Woodland (CPW), the dominant vegetation community, was listed as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995*. Since the listing of CPW, most of the other vegetation communities on the Cumberland Plain have also been listed as endangered (a table of the listed communities is attached at Appendix A).

In late 1997 the South Creek Catchment Management Committee (SCCMC), in partnership with the Hawkesbury Nepean Catchment Management Trust (HNCMT) launched the Cumberland Plain Woodland Project. The purpose of the project was to facilitate effective action across the catchment community with an integrated response to its conservation and management. With the listing of other vegetation communities the project evolved to become the Cumberland Plain Vegetation and Habitat Initiative.

These Best Practice Management Guidelines have been developed as one of a number of specific projects under the initiative. Other projects have included holding forums for community and government, Interim Planning Guidelines for Cumberland Plain Woodland and a number of education and awareness projects including a Cumberland Plain Woodland Poster and a schools education package, "Bringing the Bush Back to Western Sydney".

The Guidelines are based on the best current practice and knowledge. Along with bush regeneration techniques they deal with relevant legislative requirements and management planning. They are not prescriptive, in that there is often no one "right" way to do things. Rather there are a variety of different techniques discussed which can be applied depending on specific circumstances.

As more knowledge and experience is gained in bush regeneration on the Cumberland Plain the guidelines will need revisiting and revision. It is envisaged that a review will be undertaken in 2005.



Maps courtesy of - Taken for Granted, Kangaroo Press 1990

For more detailed maps see Appendix E

INTRODUCTION

These guidelines are based on the documented experience of sixteen key people with practical and/or managerial experience of bush regeneration/restoration projects on the Cumberland Plain, plus the experience of the principal author, Debra Little. The participants were extensively interviewed in late 1998 and early 1999. They included bush regenerator operators and supervisors, managers/directors of bush regeneration/ restoration companies, and Council Bushland Management Officers. Background material and additional information can be found in a broader report (Little 1999).

The operating assumption has been that what most experienced practitioners and managers in the field are doing is current best practice. The guidelines also draw on existing literature. However, they would not exist without the generosity of all those interviewed in giving freely of their time and sharing what they have learned.

Current best practice in bush regeneration attempts to achieve restoration of an ecosystem to what can be termed the "highest practicable extent". Some participants put this in terms of a 'certain level of pragmatism' applied to some decisions and choices as to courses of action. These choices reflected particularly technical, but also social limitations. The guidelines are perceived best practice while recognising that every site involves constraints that will limit what is practicable.

The guidelines are intended to provide a practical tool for all those managing, undertaking or assisting with restoration works on the Cumberland Plain (as opposed to the more frequently discussed sandstone areas). They do not set out to provide, for example, detailed technical information or instruction about specific techniques, herbicide ratios, or deal with all the broader issues of bushland or natural area management. For these readers are referred to existing texts and handbooks such as Buchanan (1989) and National Trust (1999).

Historical Context

The practice of restoring damaged ecological communities is a relatively new activity within Australia, as well as internationally. In Australia, the earliest recorded restoration project occurred in the mid-1930s at Broken Hill (McDonald 1998).

In the Sydney urban context, the process of assisted natural regeneration that became known as 'bush regeneration' began to be undertaken in the 1970's, in urban conservation reserves. These reserves were largely in the Hawkesbury Sandstone areas of Sydney. Since that time this field of endeavour has expanded greatly to include other soil and vegetation types, within and outside Sydney, and formal study in the area has been offered for some years, via a TAFE bush regeneration course.

Expansion of work in this field has seen a significant level of knowledge develop from the experience of restoration/bush regeneration practitioners, and a corresponding development in the methods or techniques available. The knowledge base, practices, teaching and management expertise still reflect to a large degree their origins in and the dominance of the sandstone experience.

Restoration work on the shale soils of the Cumberland Plain is a more recent phenomenon, with work of this nature really only commencing in the last 8 to 10 years. In some instances, the guidelines reflect differences that arise on the Cumberland Plain compared to sandstone regions.

Terminology

- ***Bush regeneration*** is defined by the Australian Association of Bush Regenerators (AABR) as: "the practice of restoring bushland by focussing on reinstating and reinforcing the systems' ongoing natural regeneration processes".

  It is a term known and used popularly within Australia by its practitioners (and to an extent by the wider community) and corresponds most closely to the approach known as ***assisted natural regeneration,*** one of the main practical approaches within the broader (international) philosophy and practice of ***ecological restoration.***

- ***Ecological restoration*** aims to restore pre-existing indigenous ecosystems and ecological processes, maintaining and developing the capacity of a natural ecosystem to self-perpetuate (Perkins 1999).

'Assisted natural regeneration' and 'reconstruction through revegetation' are two conceptually different approaches to ecological restoration that are sometimes applied in combination.

- ***Assisted natural regeneration*** aims to stimulate or "trigger" the growth of native plant propagules (such as seed, tubers or rhizomes etc) already present on site or having the ability to migrate onto the site, and aided by suitable management, to allow natural regeneration processes to occur.

- ***Reconstruction through revegetation*** involves the introduction of locally indigenous plant species, modelled on the diversity and structural characteristics of the original vegetation community. It is carried out by planting or by re-introducing propagules.

The two restoration approaches are dealt with separately in this document, in recognition of their conceptual difference. However, in theory and practice, it is recognised that on any particular site requiring restoration intervention, a combination of both approaches may be required (Perkins 1994, Buchanan 1989; National Trust of Australia (NSW) 1991; McDonald 1998). This may be the case for certain areas within the site, or in relation to certain plant species. It particularly applies to remnant vegetation areas of intermediate quality that have been highly disturbed and impacted upon by agricultural activities, resulting in degraded plant communities over large site areas (McDonald 1994,1996). The Cumberland Plain contains a number of such sites.

- ***Site*** The term 'site' is used loosely to refer to both the whole of an area of relevant vegetation (such as a reserve) and to a specific part that is the subject of a restoration process.

- ***Resilience*** refers to the manifested recovery of a plant community, species or ecosystem following disturbance, as well as the potential of the plant community, species or ecosystem to recover after disturbance (McDonald 1996).

Comparison with Sandstone Contexts

Until a few years ago, bush regeneration in the Sydney region centred largely around sandstone areas, and much of the training and experience for bush regenerators in the area still occurs in these areas. It is thus important to note that a number of key differences are found in Cumberland Plain areas as opposed to sandstone. While many management approaches and techniques are common to both, differences noted by those working in the field are summarised below.

Differing distribution of degrading impacts

The gentler topography and richer soils of the Cumberland Plain resulted in a broader range of past disturbance and impacts, both in type and area of disturbance. Large areas were subject to cattle grazing or cultivation, or mown for parkland.

Sandstone areas were less suitable for traditional European uses in the past, and such activities were generally limited to the flatter land on the ridges, with the bushland on steep slopes left intact. In sandstone areas impacts (ie.-increased moisture, nutrients and weeds) are typically concentrated in particular areas. For example, along edges, behind or down slope of houses, and in gullies and along watercourses, from where they spread over time into the rest of the remnant. A mosaic of good bush alongside or amongst more degraded areas has resulted.

Managers don't find the same range of good pockets of bush on the Cumberland Plain. They are more often dealing with bigger areas of semi-degraded bushland. Areas classed as 'good' Cumberland Plain bush are more likely to still exhibit some level of impact and weed growth as compared to good areas of sandstone bush.

Differences in history of land use

Past patterns and history of land use in sandstone areas has resulted in impacts on vegetation which are generally major but limited in area. Levels of resilience are more readily defined, and patterns of disturbance and weed invasion are similar in different areas of the same vegetation type.

The Cumberland Plain was developed for agricultural purposes under early European settlement. As a result, native plant populations have been depleted under repeated and sustained clearing and grazing. This has also skewed the species available for recovery from disturbance. Patterns of disturbance have differed over time. Earlier small allotments and intensive landuses have since fallen into neglect since the 1970's.

Cumberland Plain communities exhibit a great level of natural resilience in their tolerance to a dramatic range of environmental conditions, and their ability to survive the degrading impacts that have occurred on the Cumberland Plain.

These land use patterns and history have resulted in an irregular landscape of variable resilience with consequent implications for management.

Differences in vegetation structure and dynamics

On the Cumberland Plain, native floral diversity and density is most pronounced in the ground storey of grasses and forbs. This is characteristic of the Cumberland Plain Woodland. In this more open-structured community, the groundlayer is also where problem weed species are most prolific – as has been found in other grazed woodlands throughout Australia. In comparison, in sandstone areas, the mid-storey or shrub layer is the most frequently impacted, and by woody weeds. Woody weeds occur and impact upon the Cumberland Plain as a whole to a much lesser extent. However, they can be a major problem in moister gullies, river flat and riparian areas.

Successional processes are also different. For example in sandstone woodland and forest communities, shrubs will often come up in great numbers following disturbance events, then thin out and die as the canopy develops dominance. The shrub layer in Cumberland Plain Woodland is sparse but persistent, reflecting the more open canopy.

However, there are similarities in the vine infestations which frequently affect River Flat and Riparian areas on the Cumberland Plain much as they do in areas along creeks and elsewhere in sandstone forest and woodland communities.

Impact of increased nutrients

Soil in sandstone areas is low in nutrients. Where impacts result in higher nutrient levels in the soil, weed growth is favoured and native species decline. These higher nutrient levels tend to occur in particular locations related to the topography of the sandstone and the pattern of ridge top development that has occurred.

Increases in soil nutrient levels do not appear to be as critical or 'devastating' for Cumberland Plain native plants as they are for many of the sandstone species. Overall, the Cumberland Plain soils are more fertile, and nutrient levels tend to effect the intensity and possible persistence of weed competition.

Impact of topography and soil

The sandstone areas with their typical deep gully areas and slopes are more vulnerable to degradation on drainage lines. Nutrient enriched stormwater, sometimes augmented by sewage overflows, can pour down into and through the bushland from many sources, and bush regeneration practitioners can find themselves involved in ameliorating stormwater flows.

Drainage problems are much less significant on the Cumberland Plain where stormwater management is at a much larger engineering level. Salinity on the Cumberland Plain is an emerging problem and addressed in Section 1.3.

The clay soils of the Cumberland Plain, including alluvial ones, are finer and more dispersive. They are particularly susceptible to compaction due to past land uses and management regimes and to soil erosion along watercourses. Soil erosion and compaction problems are not so critical or evident in sandstone areas.

Community use and abuse

Problems of use and abuse, such as access for inappropriate activities, repeated fire starting, dumping etc, are similar between Cumberland Plain and Sandstone communities. However, the scale and frequency of these impacts appears to be greater and more difficult to manage on the Cumberland Plain.

This is due to a number of factors. The flatter topography, more open vegetation, the larger size and roadside location of some areas make access easy. The

lack of natural or other boundaries, and the prevailing perceptions about the nature and value of the Cumberland Plain bush also contribute to this problem.

In the sandstone regions there appears to be more widespread understanding and acceptance and favourable attitudes towards the local bush, and living in proximity to it has often been a very active (and expensive) choice. However, these problems still persist.

Challenges and opportunities facing practitioners on the Cumberland Plain

Bush regenerators on the Cumberland Plain confront different challenges to their counterparts working in other vegetation types, both in terms of constraints and possibilities.

Indigenous Cultural Heritage

The Cumberland Plain is characterised by a wide range of Aboriginal cultural heritage. This includes open campsites, some dating to more than 10,000 years ago, scarred trees, grinding grooves, stone quarries, rock engravings and other places of social and religious life. There are also a number of historical sites such as the Native Institute at Blacktown.

- The presence of a large number of Aboriginal sites on the Cumberland Plain means that bushland restoration projects must incorporate Aboriginal heritage requirements under the National Parks and Wildlife Act 1974.

Restricted knowledge base

Knowledge of the original diversity and relative frequency of species in the Cumberland Plain is limited, particularly in relation to the understorey (Benson & Howell 1990). Historical descriptions are too limited to provide guidance and few if any areas of unimpacted bush remain for analysis and comparison (only 6% remains uncleared). In sum "there is no baseline from which to determine a characteristic native understorey nor a near natural structure" (NPWS 1977, p.4). The balance among the surviving flora

of the Cumberland Plain is probably tilted towards those that discouraged grazing or penetration, such as Bursaria, and those with underground regeneration elements (bulbs, tubers, tuberous rootstocks) and grasses.

- The challenge for practitioners – in the face of this uncertainty - is to decide what vegetation community structure to adopt as a management target.

The amount of time spent observing, researching, working on, and understanding the Cumberland Plain communities has been much lower than for other communities. As a result there is much less confidence about or detailed understanding of community structure and dynamics; the associated ecological requirements and processes; and how these might interact with other site factors. In particular, past land use patterns such as grazing, cultivation and/or mowing, often unknown in detail for any given site, have led to a variety of successional (ie. re-growth) stages. These are still evolving, as is knowledge about them.

- The challenge for practitioners - despite this limited knowledge - is to prevent further degradation and to identify meaningful and non-prejudicial restoration work.

Scale and focus

Bush regenerators on Cumberland Plain sites are sometimes managing quite large areas of semi-degraded bush with major expanses of weeds. In the open, grass-dominated areas there are often no stands of good bush serving as buffers and few clear internal boundaries to provide a framework and direction for work. Further, the sparseness of the shrub layer means that managers have to wait for native grasses to recruit and become a weed barrier.

In riparian sites, although more definite boundaries might exist, the sheer length of areas and the extensive edge effects, provide other challenges. These are exacerbated by the intensity of weed infestation and continuing disturbance through flooding events.

A 'big picture' approach is essential. For example, benefit can be gained from an emphasis on a target approach to weed management over wide areas (at least in the shorter term), rather than on a comprehensive approach applied to a smaller area. Given the greater persistence of weed growth this often continues into the medium term. Much work on the Cumberland Plain at present is often a situation of 'clearing the decks' by reducing or controlling populations of key weeds.

- The challenge for practitioners is to identify and maintain a level of focus appropriate to the scale of the site and the intensity of weed infestation.

Modifying practices

The particular conditions of the Cumberland Plain have an effect on patterns of work and techniques. However, the principles involved in maximising the ecological potential or response of the native community remain similar.

Standard bush regeneration methods and techniques are applicable and skills gained elsewhere are transferable. However, some modifications are required in the choice, effective use and emphasis given to one or other techniques, and the extent of their application to site situations.

Notable among the changes are:

- **The different proportions of time devoted to the various types of work.** For example, a large proportion of time overall is spent treating weeds affecting the ground layer, because of the pattern and nature of weed invasion.
- **A high level of flexibility of work patterns is required.** Advantage has to be taken of opportune seasonal conditions, such as better soil moisture, to remove certain well-rooted weeds such as Paddy's Lucerne.
- **Other tasks also offer narrow windows of opportunity.** For example, spraying is of limited effectiveness in hot, dry conditions when translocation is poor. Waiting for these opportunities can hold work back and planning must allow for rapid changes in work schedules.
- **The constrained use of fire as a regeneration technique.** Opportunities for planned and controlled burning are restricted on the Cumberland Plain because frequent unplanned fires (arson and accident) and the rapid build up of (grassy) fuel load can result in repeated burning of areas. The use of fire is also difficult to manage because of the disparity between people's perception of threat from essentially grass fires, and the actual level of risk to them.
- **The need to identify many small herbaceous plants.** Managing the native ground flora in the face of exotic grass and other weed competition provides a major challenge. It needs to be faced with good working skills in identifying the diverse native grasses and other ground covers that occur on the Cumberland Plain, many of which may be vulnerable, and some possibly rare.
- **The reduced emphasis on hand removal of weeds.** Hand removal techniques are frequently difficult to apply when faced with hard, dry, compacted soils and the scale of some sites and the intensity and nature of ground layer weed infestation. Some participants remarked that rougher, or grosser techniques and tools (mattocks, and peter levers rather than trowels or knives) need to be more often used on the Cumberland Plain than on sandstone areas. Other methods and combinations of methods also have to be employed. For example, greater use of herbicides, including more use of selective herbicides is often necessary.
- **The option to use larger-scale equipment.** The ease of access into sites, while having the disadvantages outlined earlier, also provide easier working access for removal of weed materials, and other practical management tasks. This may include access occasionally for the use of equipment larger in scale than usually possible as a necessary part of a particular strategy, such as ripping a compacted track.

The challenge is to adapt standard practices to a new context while making innovative use of the opportunities it presents.

1. Planning and Site Assessment

1.1 Plans of Management

A Plan of Management for the site is important. This will clarify the goals and objectives of management and restoration of the site and clearly set out the proposed actions and their general sequence. These actions may not all be directly associated with restoration of the vegetation. The plan is to be the vehicle for agreement among stakeholders. The plan also ensures appropriate direction of practice and its continuity across the different personnel involved in restoration work.

A supplementary strategy or action plan, is also necessary. This differs from a Plan of Management in that it details specific restoration actions and techniques - as opposed to overall guiding goals and actions in the Plan of Management. The supplementary strategy or action plan can be in a separate follow-on document, or possibly form part of a tender proposal process. Such strategies are for a short period only and need to be revisited as work progresses.

When developing Plans of Management and Action Plans the following needs to be considered:

- The development of management and action plans and revisions to them should be undertaken by those with significant experience and understanding of restoration philosophy and practice as it relates to Cumberland Plain situations.
- A plan should provide a basis for restoration to the highest extent presently practicable. It should include a realistic assessment of 'that which can be done', based on available resources and technical knowledge as well as ecological potential. However, the plan should reflect a preferred, or even a somewhat ideal approach to restoring the community. This provides a point of reference to which to return should resources or technology improve.
- Although plans are guides to action, it is also necessary to maintain a flexible approach to implementation so that strategies can be changed as work proceeds and it becomes apparent that planned actions are no longer required. Plans should be revisited frequently and revised as necessary.
- Requirements under the *Threatened Species Conservation Act (1995)*, the *National Parks &Wildlife Act 1974* (relating to Aboriginal Heritage), the *Native Vegetation Conservation Act (1997)* and relevant Recovery Plans, notably the Cumberland Plain Endangered Communities Recovery Plan, need to be incorporated into Plans of Management and site strategies.
- The landowner needs to be identified. Plans of Management for council-owned "community land" are to be prepared in accordance with the *Local Government Act 1993* and the Community *Lands Amendment to the Act 1998*. Requirements under other land ownership need to be fulfilled.
- A thorough site assessment that has identified and documented the level of restoration intervention needed, and why is the best basis on which to develop an effective management plan.

1.2 Assessment of resilience for Cumberland Plain sites

As part of the Plan of Management and prior to commencement of a bushland restoration project, an assessment of the site and its potential to regenerate naturally is

required. This assessment is then used to guide the work program, and type of work required for restoration.

- Site assessment should be carried out by personnel who have experience, knowledge and understanding of the plant community and its structure, especially the range and nature of native ground layer components.
- Site assessment should err on the side of optimism, as vegetation on the Cumberland Plain has surprising resilience. Underestimating this resilience can result in inappropriate and unnecessary interventions that may compromise recovery.
- Native ground cover species, in particular the presence of certain disturbance-sensitive species, are strong indicators of the quality of resilience. Such species include certain native grasses, other herbs and forbs, which are less common and slower growing (non-opportunistic or non-colonising) species. These are indicative of an undisturbed soil profile. Examples include, *Dianella* spp, *Aristida* spp, *Lomandra filiformis*).
- Thorough documentation of the assessment procedures and the associated reasoning will enable outcomes over time to be used to refine the process and the judgement of those involved.

Case 1: The Hoxton Park Olympic shooting centre site had a history of intensive grazing for 10 to 15 years, and presented with few scattered canopy trees and only bare, though natural, soil present. Natural regeneration was occurring within 12 months of simply fencing to exclude grazing and other impacts. (Interview: I. Perkins)

Case 2: City of Bankstown: Mowing was withdrawn from several parkland areas, which had been mown for between 15 and 25 years, and in some cases grazed prior to that. Many additional native species to those observed before mowing was withdrawn, were found to be regenerating within 2 to 3 years, including species from all levels of strata. (D.Little)

Case 3: Rouse Hill; The site had been reduced to bare soil and canopy trees only; native understorey including many native grass species returned, as anticipated, following a change in management regime (Interview: E. Freimanis)

There are a number of site features and variables which can assist in predicting the likely resilience of a site, and consequently in guiding the appropriate levels of intervention. Key ones are:

- the nature and quality of existing native vegetation (identifies ongoing sources of propagules).
- the extent, nature, condition and diversity of structural elements present (indicates whether representatives of all principal elements of structure are likely to regenerate).
- the individual native species present (indicates the minimum range of diversity to be expected). The presence of certain disturbance-sensitive ground cover species (eg *Aristida* spp. *Dianella* spp. *Lomandra filiformis*) can be particularly good indicators of general resilience.
- nature of their reproductive habit, and dispersal mechanisms (indicates the persistence and ease of spread).

- observed recruitment and regeneration occurring
- remnant size and connectivity (proximity to other native vegetation).
- land use, and disturbance history, including fire history (may suggest the likely size and viability of the native propagule bank in the soil).
- soil conditions - degree of 'naturalness', extent of alteration and filling (also may point to the likely native propagule bank in the soil).
- nature of current and ongoing level of disturbance (including adjacent land use) and whether this can be controlled or not (indicates the type and level of threat to regeneration).
- types of weed infestation and their extent and density (suggests the type and extent of weed management likely to be required).

1.3 Salinity

Salinity can be a significant threatening process for vegetation communities, however vegetation management can be a major tool in amelioration of salinity problems.

To effectively control or manage salinity a catchment or regional plan is required, as salinity issues are rarely confined to a single property. Vegetation management or other treatment works generally need be implemented at both the recharge and discharge sites. Salinity plans usually consider a range of salinity management tools such as: drainage management, water use, grazing techniques and vegetation management.

> The importance of a plan can be highlighted by a salinity program in the Central West. Considerable effort was put into fencing off remnants and revegetation works. The project had little or no impact on the spread of salt scalds and tree decline. It was not until a plan was developed that it was recognised the main cause of the salinity was a road impeding the natural drainage. Once drains were placed under the road, the site slowly recovered.

Retention & Regeneration of Remnants

The retention and regeneration of remnants is often the most important vegetation management tool used to ameliorate salinity in both recharge and discharge areas. In addition to amelioration of salinity, there are many biodiversity and conservation benefits of these techniques.

Implementing salinity management strategies from a salinity management plan, is the key to retention or regeneration in saline areas. An important component will be minimising soil disturbance, as salinity impedes vegetation. Consequently fencing along with, the control of feral animals and recreational vehicles is essential.

Traditional low disturbance regeneration techniques generally apply in saline areas. However retention of vegetation cover should be seen as a priority.

Revegetation

While retention or regeneration is clearly the best option for biodiversity it may not be possible due to the level of disturbance or lack of viable propagules. As with any revegetation projects, clear objectives need to be established. For this document the objectives are assumed to be for conservation or conservation and salinity amelioration.

1.4 Habitat for Fauna

Site Assessment and Strategies need to take account of the existence and needs of faunal populations. Maintenance and enhancement of faunal habitat values must be an integral part of restoration aims and actions. Without these, faunal habitat may be inadvertently destroyed in the course of restoration treatments; and processes of recovery may be halted or stalled due to the absence of key fauna (eg pollinators and/or dispersers of vegetation material).

Native fauna is dependent on vegetation and other elements for its survival; and this may include exotic vegetation. In turn the role that fauna play in the pollination and dispersal of native vegetation may be crucial to the long-term regeneration and recovery of indigenous plant communities.

Wherever possible, the extent and nature of faunal populations and current habitat uses of a site needs to be assessed prior to undertaking restoration activities.

Site Assessment and Action Plans should include actions which maintain and increase habitat.

Actions to be considered include: (after D. Ondinea 1997,1998)

- consider the habitat potential of
  - weeds
  - rubbish/debris (such as old pipes, tiles, sheets of tin, and particularly when long established and away from public view) and work towards their replacement by more natural components before removal, allowing time for fauna to adopt the new sites.
- retention, and possible re-introduction of logs, bark, dead brush/natural debris etc.
- adoption of a staged or mosaic pattern of weed removal on degraded sites, involving areas no larger than 20m x 20m, or no more than one third of the total area at any one time.
- attempting to remove areas of dense weed infestations only outside peak bird breeding times (see eg Simpson and Day 1996) and when they are not providing a major food source.
- protection of mature trees by removal of weed vines smothering canopy, and weed competition from around their bases.
- in the absence of mature indigenous trees, selective retention of mature weed trees until mature sized indigenous canopy trees are established.
- consideration of the potential impacts of herbicides on amphibians.
- ensuring that a diversity of habitats are retained and integrated into regeneration and reconstruction projects. For example, in revegetation projects, on the Cumberland Plain, aiming to enhance habitat by:
  - planting dense shrub habitat, by using spiky species (such as Bursaria and Dillwynia) and insect attracting species (eg. Acacias and other Fabaceae), and by planting in patches or clumps.
  - attempting to introduce some diversity of ground covers (native grasses and forbs) in dense clumps to provide shelter/protection for ground dwelling native fauna.

1.5 Goals of Ecological Restoration

The long-term goal of ecological restoration, (which can include both 'assisted natural regeneration', and 'reconstruction through revegetation') is ultimately the self-perpetuation of a plant community, in this case one which approximates the available understanding of the pre-1788 structure.

In determining goals, the following should be taken into account.

- The intent is to carry our restoration to the highest extent practicable, recognising that there are significant constraints to be faced in practice.
- The principle of minimum intervention should be adopted, ie the intervention should only be that necessary to deal with the degree of damage on the site, and to achieve restoration goals.
- As a general rule, an accent on efforts involving minimal intervention over a significant period is warranted before revegetation is considered.

1.6 Implementation of Ecological Restoration

Assessment of site resilience when combined with the goals of ecological restoration will enable the appropriate approach to be identified.

A hierarchy of action will guide the choice of the appropriate approach.

1. **Retain** remnant indigenous vegetation
2. **Regenerate** where site resilience indicates potential for natural regeneration (assisted natural regeneration)
3. **Revegetate** where there is no regeneration potential (reconstruction through revegetation)

These actions start from minimal intervention building up to high levels of intervention. Minimal intervention methods are more efficient and cost effective.

Current practice for assisted natural regeneration and reconstruction through revegetation are detailed in Section 2. Generally a combination of the two approaches is required on any one site, where certain zones recover with minimal intervention and reconstruction is required in very degraded sections.

2. ECOLOGICAL RESTORATION CURRENT PRACTICE

2.1 Assisted Natural Regeneration

Assisted natural regeneration involves improving the conditions and promoting opportunities for the natural regeneration and recruitment of native species. Taking specific physical actions known to trigger response may also be called for.

The principle of adopting the minimum intervention necessary should be applied when choosing techniques to restore vegetation on a site. A combination of techniques is frequently needed and all implications of their use, both joint and mutual, need to be taken into account. The combination used depends upon the particular site conditions, degree of degradation and the likelihood of weed invasion or re-establishment; the minimum intervention necessary will vary from site to site.

Effectiveness is increased and risks reduced if techniques are varied and combined in response to site and location characteristics (rather than one or two applied uncritically over wide areas). Given the endangered status of a number of Cumberland Plain plants and communities, this is especially so.

Action to improve conditions for regeneration can include:

1. Reducing or eliminating degrading disturbances.
2. Creating regeneration niches.
3. Managing weeds.
4. Using 'triggers' to encourage regeneration.

2.1.1 Reducing or eliminating degrading disturbances

The disturbances most readily addressed are usually human or human-induced. Actions in this area may be the single, most cost-effective technique available to the bush regenerator.

Withdrawal of mowing and associated maintenance practices ("passive regeneration")

- The removal of mowing from areas assessed as retaining resilience and having good recovery potential has been a particularly effective strategy. Success has been sufficiently widespread to warrant wider adoption of this practice.

> The removal of mowing from areas assessed as having resilience and good recovery potential has been a particularly effective strategy in a number of Local Government areas on the Cumberland Plain (eg Bankstown, Holroyd, Parramatta, Blacktown, and Hawkesbury). Many species have survived on site, because of a combination of mowing tolerance at the prior level of frequency of mowing, or regenerated because of the presence in the soil of a good native seed bank.
>
> At Bankstown City Council, around 20 Public Reserves have had mowing withdrawn from areas within them, resulting in good regeneration of both Woodland and River Flat Forest community species (Interview: R. Corby). A reduction in the herbicide spraying regimes often associated with park management practices has also contributed to recovery of native species, for example at tree bases.

- Knowledge of the duration and frequency of prior mowing is valuable in judging the likelihood of regeneration success, but close observation of the mown area at different times can also reveal regeneration occurring.

- If recovery is to be sustained, changes to mowing and maintenance practices need to be supported in the following ways by the land manager.
  - Follow-up weed control is necessary to protect regeneration. The extent, location and staging of withdrawal need to be considered in the light of likely resources required and available for follow-up weed management.
  - Liaison with and education of maintenance staff, as well as clear boundary definition, will help to avoid the reintroduction of the withdrawn practice and prevent problems arising from the management of adjacent areas.
  - Addressing issues of continued use and access (eg via education, interpretation, signage, access tracks) can promote public acceptability. Together with weed control, these can demonstrate a continued, though changed, 'caretaker' role in relation to public open space.

Exclusion of grazing animals

Fencing to exclude grazing has been carried out at some sites (Interviews: G. Limburg, E. Freimanis, I. Perkins). As with the withdrawal of mowing this has provided the opportunity for recovery and regeneration of native species.

- Grazing can be by native animals (kangaroos, wallabies, possums), by stock (horses, cattle, goats) or by feral animals (rabbits and hares). The type of animal posing a threat dictates the measures taken. Feral animal eradication programs such as rabbit baiting may be required to economically reduce the grazing impact prior to planting or regeneration programs. Rabbits can cause extensive damage to trees up to several years old in some situations, as they readily chew bark, and of course groundcover and understorey species are threatened at all ages.
- The extent, location and staging of withdrawing of grazing animals should be considered in the light of resources available for follow-up weed management. This is particularly important for the moister river flat or riparian areas, where vine and other weed growth such as Privet can rapidly occur following the cessation of stock grazing.

Exclusion of human disturbances

Installing barriers (eg bollards, poles) to exclude vehicles, diverting pedestrian and other access, and other measures to reduce and re-direct usage are valuable measures to maximise regeneration potential. Such physical methods can be even more effective when combined with education and interpretation initiatives. These access measures can also assist efforts to :

- reduce the frequency of unplanned fires, which often result from dumped and burnt vehicles.
- limit the removal for firewood of timber, dead logs etc, important as habitat.

Controlling erosion

The soils of the Cumberland Plain are naturally very dispersive and therefore easily eroded. Sheet and wind erosion of soil and seed banks from slopes can be slowed or prevented by the use of logs, jute mesh, and debris/brush. The diversion of steep tracks can also assist.

2.1.2 Encouraging or simulating niches for regeneration

Niches for propagule capture and protection are often a by-product of other restoration actions that create disturbance but can also be used as a deliberate strategy.

Techniques include:

- laying of debris/brush (eg. sticks, branches, logs) on the ground.
- scarifying the soil in barer areas by raking of the soil to produce a rough surface.
- a combination where scarifying the soil is carried out prior to laying of brush/ debris.

2.1.3 Weed management

Weed management aims to free up resources (light availability, soil moisture, nutrients) for native plant regeneration. Under the Noxious Weed Act (1993) there are statutory requirements that must be met by land owners/managers with regard to certain weed species. It is important for practitioners to be familiar with the requirements of the Act. A copy of the noxious weeds for each Local Government Area is available from the local weed control authority, which may be the council or a county council, or through the New South Wales Agriculture website (www.agric.nsw.gov.au/noxweed/). It should be noted, however, that weeds posing a problem in bushland areas are not always on the noxious weeds schedule, and the term 'environmental weed' is often used. A list of environmental weeds can be found on the Australian Association of Bush Regenerators (AABR) website (www.zip.com.au/~aabr). Management of bushland areas requires that all weed species be considered for control.

Weed management works require technical knowledge and skills, including secure identification of Cumberland Plain weed and native species, particularly grasses and groundcovers. It also needs a commitment to ensure that longer-term follow up weed control can be and is carried out. If not, strategies adopted for controlling weeds may be ineffective, at worst leading to increased weed proliferation and decreased resilience.

There are a range of factors to be considered when setting weed management priorities (deciding what to take out and when). These include:

- the size of the site.
- the condition of the site and the stage of regeneration.
- the quantity and nature of weed occurrence on the site.
- the level of threat to native species posed by particular weeds and the stability of the regeneration so far evident.
- the objectives established for the site.
- the level of weed control needed to achieve the site objectives.
- the stage of the reproductive cycle of the weeds involved and their status as annual or perennial.
- the ease or difficulty of controlling specific weed species (this is influenced by external constraints eg uncontrolled upstream weed sources, the weed's biology eg its means of spread and persistence, and the soil and weather conditions).
- the resources realistically available, and the time constraints operating.
- the degree of public profile of the site or area.
- the ecological function of the weeds - they may, for example, act as habitat for fauna (including insects having a role in initiating ecological processes), or assist in controlling erosion, or provide a protective, microclimate for young native species (This 'nurse' role may outweigh the significance of any competition from the weeds). The habitat value of weeds should not be underestimated, and weed control measures may need to be staggered in time and space to accommodate faunal needs.

- the role some weeds may play in site management by providing a barrier to other weed invasion or expansion or further disturbance.

In a site where mowing has been withdrawn and Sida (Paddy's Lucerne) occurs amongst patches of Microlaena (Native Weeping Grass), the Sida is temporarily tolerated because in the absence of any shrub layer the Sida is protective cover providing possible nesting habitat for Blue Wrens (Interview: S. Cook).

At a site where Privets occur but are not a major weed, and seedling growth is slow, Privets below a road edge are being selectively retained as they act as a positive weed barrier and a brake on other weed invasion (Interview: J. Diamond). A similar role is planned at another site where stock have been withdrawn. It is anticipated that some male Pittosporum undulatum will be selectively retained to act as a positive weed barrier on edges (Interview: G. Limburg).

The removal of Tradescantia from River Flat Forest areas needs to be considered and staged carefully because of its soil stabilising and (other) weed-suppressing role. If too much is cleared too quickly it is difficult to keep up with the inevitable subsequent herbaceous weed growth that follows its removal, and loss of soil can occur, especially from bank edges during flooding events (Interviews: M. Birmingham, F. Gasparre, J. Stannard).

Where Couch is not treated as a weed problem (it is not listed in Flora of NSW as an exotic), it can be useful in controlling erosion (Interviews: G. Limburg, E. Freimanis)

- On the Cumberland Plain the extent and diversity of weed problems is high and some sites can be large (80 hectares or more). An approach of 'tipping the balance' towards greater native diversity through the progressive targeting of weeds over time is likely to be more effective overall, than, for example, trying to comprehensively remove every bit of ground layer weed. In the better pockets of bush and towards the latter stages of restoration works, a more comprehensive approach to the removal of weeds may be possible.
- An effective approach involves monitoring changes as work proceeds, with the flexibility to re-order priorities frequently as the behaviour and apparent impacts of weeds are better noted and understood and changes in site conditions (eg through wet weather induced weed flushes) are evaluated.
- Generally, the aim is to use a combination of techniques that achieve the agreed objectives with the least intervention practicable.

Weed Removal Techniques

Major weeds currently affecting Cumberland Plain sites are tabulated in Appendix A.

Methods for tackling some of the major weeds of the Cumberland Plain are tabulated in Appendix D.

The methods and techniques applied in the management of weed infestations on the Cumberland Plain include:

- hand removal,
- use of selective and non-selective herbicides,
- weed biomass reduction (ie use of slashing/mowing, or cutting back, or fire)
- matting, mulching, and
- scraping back weed infested material.

An integrated approach involving combinations of these is usually necessary.

Hand removal of weeds

Hand removal is carried out on all sites across the Cumberland Plain at varying levels and frequency. The extent of its use (whether used to target species, and/or as a more comprehensive approach), may be limited by the nature of overall weed and other site impacts, the scale of the site, and the particular objectives and priorities established.

However, biophysical conditions on the Cumberland Plain can place resource and ecological limitations on hand removal of weeds. The frequent hard, dry and compacted nature of soil conditions, means that digging to remove some weeds in hard, dry soil is time consuming, and can result in an unacceptable level of disturbance and removal of soil and seed bank. Timing is important; wherever possible take advantage of favourable seasonal conditions, eg work after good rain when soil moisture conditions allow easier removal.

Use of herbicides

Given the scale of many Cumberland Plain sites, the nature and extent of weed infestations across them and the limitations that can be associated with hand removal, herbicides are important tools. Herbicides are applied by spraying; by painting following cutting or scraping; by stem injection involving drilling or chiselling; or, less often, by wick wiping of weeds.

A range of selective and non-selective herbicides is currently being used to address particular weed problems across the Cumberland Plain. This is reflected in Appendix B, which indicates successful approaches to the management of key weed species by regenerators. It is also worth noting some distinctive practices that have not yet become widespread, and permits are required to use herbicides in the manner described.

While herbicides are valuable aids in weed management, they will destroy native vegetation if used indiscriminately. To avoid outcomes counter-productive for regeneration:

- only choose a herbicide on the basis of a clear understanding of:
  - the purpose behind the use of the herbicide.
  - the effectiveness of the herbicide on the targeted species.
  - the correct concentration of herbicide identified for the weed species.
  - the possible deleterious effect on any off target native species, including fauna, amphibians, insects etc.
- use herbicides strictly in accordance with the manufacturers' labelling and ensure that any permits, orders or other 'off-label' use requirements are obtained and complied with.
- where direct injection, or cut/scrape and paint methods using concentrated solutions of non-selective herbicides is being carried out in herbaceous native areas, exercise great care so that applicators or other equipment do not inadvertently drip onto or touch native plants.
- limit the use of non-selective herbicides in grassy/woodland situations. Control by herbicide should follow prior assessment to ensure no endangered or vulnerable species are on site. Work should be limited to cautious, targeted spot spraying only, carried out by experienced operators with a good knowledge of native ground storey flora (i.e. no broad-scale spraying of these herbicides).
- only use selective herbicides where spraying in grassy woodland situations is needed to control woody or other weed infestations, or where the level/extent of weed occurrence requires a more extensive approach.
- avoid spraying to such an extent that it leaves the naturally dispersive soils bare and easily susceptible to erosion, and/or open to hardening or 'baking' which will make natural regeneration difficult.
- time the application of herbicides so that maximum effectiveness is achieved. Application should be in accordance with:
  - the identified peak period of susceptibility for the weed concerned.
  - the limitations posed by climatic conditions, eg hot, dry weather, slows herbicide translocation; wet weather may wash it off or render it ineffective.
  - the seeding times of native grasses as an additional precaution to minimise the potential for loss of native species (in cases where there is no suitable selective herbicide).

Weed biomass reduction

Reducing weed biomass by selective use of fire or slashing/mowing may be useful as an interim measure to provide access and to allow more targeted and effective weed control. This is especially so in native grassy woodlands, where herbaceous weed growth can be difficult to selectively control. Opportunistic use can be made of unplanned fire for biomass reduction.

An example is the cutting back of Blackberry to improve access, reduce bulk, and stimulate vigorous re-shooting for subsequent herbicide treatment has been found to be particularly effective.

- Careful assessment of the specific area is called for to avoid damage to native plants (especially endangered/vulnerable species) that are not tolerant to mowing/ slashing, or damage from repeated burning of an area.
- Slashing or mowing has had more limited application, but can be a useful interim measure to reduce biomass in other weed situations, such as in grassy native areas:
  - as a holding measure (eg. in relation to tall annuals),
  - to allow discrete treatment of faster recovering weeds within the native ground storey (eg the management of Watsonia or similar bulb species in areas of native grassland).
- It should not be used as an ongoing treatment or driven by resource or time-based constraints. It should not be used if endangered or vulnerable species may be present or where there are shrubs. Timing and the height of cut also need to be considered as it may be possible to allow some native grasses to run to seed despite the mowing.
- The deliberate use of fire to reduce biomass is not seen as a repeatable technique because frequent, repeated burning in any particular area is known to reduce structural diversity and abundance of native species. Further caution is therefore needed in areas where unplanned fires may also occur.
- Stimulation of native regeneration may also result as a response to the use of fire. An integrated management approach is desirable, with weed treatment both before and after burning planned for and timed carefully (see also the section on fire as a trigger below for precautions about the use of fire).

Mulching and matting as weed suppressants

These are generally inappropriate treatments in areas where native regeneration is predicted. (see Section on Reconstruction through Revegetation).

- Matting such as degradable jute matting may be considered in areas where erosion is a significant issue. Mulching may be useful on edges to delineate the limits to mowing zones, and to suppress the encroachment of exotic lawn grasses.

Distinctive weed management practices

The following practices demonstrate how a combination of methodologies is used to achieve maximum weed control and survival of native species in particular situations. Once experience has been gained at a particular site and vegetation responses known, be prepared to experiment on a small scale with different innovative weed control techniques.

- Use of the selective herbicide Fusilade® to control exotic grasses in areas of no or few native grasses so that native herbs survive (Interview: S. Cook).
- Use of Garlon® at low concentrations to control small Privets and Sida (Paddy's Lucerne), and other similar small, more woody species in native grasslands (Interview: A. Parkes).
- Achieving effective treatment of bulbs (eg. Watsonia) in grassy native areas (eg *Themeda australis*) by a process of firstly whipper snipping back the grasses and bulbs. Subsequent re-growth of the bulbs is at a faster rate than the native grasses, allowing discrete herbicide treatment of bulb leaves - the technique does need to be carried out during times of active bulb growth (Interview: L. Brodie).
- Preventing seed drop from grasses and herbaceous weeds (eg. *Bidens pilosa, Ehrharta erecta)* in areas of native understorey by targeted burning of the aerial parts using a hand held flame-thrower to consume the plant and scorch seed (Interview: S. Cook).
- Using a wick wiper to apply herbicide to tall annual weeds

  (Interview: E. Freimanis).
- After spraying of Wandering Jew (*Tradescantia fluminensis)*, subsequent scraping back and removal of the top layers of accumulated sediment has helped control residual plant re-growth (Interview: F. Gasparre).

"Recalcitrant" or problematic weeds and weed situations

There remain some weeds and associated situations for which those working in the field feel current practices are not able to achieve the desired results in an efficient way.

Exotic grasses intermingled with grassy native understorey

Hand removal can be too time consuming, especially on larger sites with extensive growth of exotic grasses. Hand removal is also difficult due to frequently hard, dry soil conditions, especially for grasses with a creeping habit (stoloniferous). Herbicide control is also problematic. Even with careful spot spraying, the non-selective herbicide Roundup® has definite limitations because of the dangers to adjacent natives. Hand application is generally too time-consuming.

Cestrum: Treatment remains slow because of the time resources involved in treating it, and its tendency to re-shoot, necessitating follow-up treatment.

Tradescantia fluminensis: Control is complicated because this weed has a valuable role in stabilising the banks of watercourses and other areas. In addition, its spread is

aided by flooding which also deposits sediment over it. Limiting its growth to specific boundaries is currently the most feasible approach given these circumstances.

*Asparagus asparagoides (*syn. *Myrsiphyllum asparagoides*) – Bridal creeper: Although some promise is now being shown with the use of the non selective herbicide Brushoff®, the narrow window of opportunity for its use (during flowering), and the susceptibility of some non target natives (eg, Bursaria), suggests that a mix of hand removal and herbicide control is necessary. However, its matted habit can lead to major disturbance in the process of hand removal.

2.1.4 Using 'triggers' to stimulate recovery and regeneration

Certain ecological disturbances such as fire are essential to the regeneration or re-invigoration of some native plant species. Due to changes in land management these may now be missing. Re-introducing them or similar disturbances can trigger recovery.

The use of 'triggering' techniques needs to be integrated or combined with weed management and control to protect regeneration, as flushes of weed germination or growth are also frequently triggered.

Fire as a trigger

The deliberate introduction of fire to stimulate regeneration has mainly been carried out via strategically placed pile burns, often using weed debris from the site. In this way, regeneration methods have been integrated with weed management. In many cases, native species not previously recorded on sites have regenerated following pile burns.

Fire has also been used less often, via broader area patch burns. Here too, burning has been integrated with prior particular weed management. For example, herbicide spraying or wiping of weeds has occurred to control areas of standing weed populations (eg. patches of *Pennisetum clandestinum* (Kikuyu) or *Eragrostis curvula* (African Lovegrass), and provide fuel prior to burning (Interviews: J. Rawling, F. Gasparre, S. Cook).

Periodic fire is considered necessary to maintain the Cumberland Plain Woodland (NPWS, 1997 p.4). A fire-free interval of between 5 years and 10 years is recommended for Cumberland Plain Woodland, to avoid reduction in species richness and abundance and the decline of particular shrub species (Interview: I. Perkins and information supplied in Perkins (1999), quoting Thomas (1994) and D. Benson, Senior Plant Ecologist, RBG).

Thus, repeated burnings at intervals of less than 5-10 years will result in the loss of many native species. On the Cumberland Plain accidental and arson fires are not infrequent and their occurrence constrains the use of fire as a deliberate strategy, particularly on any broad scale.

This underlines the importance of experience and careful consideration of areas to be burnt, and the need to consider the vulnerability of sites to unplanned fire frequency. In practice, planned pile burns are considered a more cautious option in more vulnerable situations.

The following guidelines should be adopted:

- In doubtful cases, or where the presence of rare species rules out the use of fire, trialing the use of smoke water is a safer option as smoke elements are often the actual trigger.
- The use of fire requires authorised personnel, usually working within the framework of an approved fire management plan that has included the assessment of a site's vulnerability to unplanned fires as well as other suitability factors.
- If fire is to be used, minimal intervention is best served by using strategically placed pile burns of dried and stacked weeds removed from sites, or, where essential, material brought to the site to serve as fuel. These are a suitably cautious option in most cases, but they should generally be kept small (below about 10 m^2) to avoid 'sterilising' large sectors within the pile area.
- Post-fire weed control is essential and needs to be timed to avoid damage to regenerating natives. Skilled staff are needed, particularly those able to identify the range of young native understorey plants.
- The timing of burns to coincide with the summer thunderstorm season is thought to provide conditions resembling natural fire regimes but requires the close cooperation of the fire authorities.
- Harrowing of the ground prior to burning (Interview: J. Rawling) may further assist regeneration.

Use of smoke water and smoked mulch as triggers

Studies in West Australia have shown that for some native species it is elements in smoke that trigger regeneration, rather than fire itself. The application of water or mulch through which smoke has passed can provide a trigger for the regeneration of these species.

These are currently being trialed at Duck River Reserve, Auburn (Interview: J. Stannard). Some see the use of smoke water as a potential tool in certain areas, where burning is more difficult or not possible (eg River Flat Forest areas, or areas where there are habitat concerns, rare species etc). It may be an alternative where high unplanned fire frequencies prohibit the use of fire as a trigger. Others see the role of fire in relation to Cumberland Plain grassy woodland elements as important and so do not see a big role for smoke water on the Cumberland Plain, except perhaps in very small remnants and where there are the sorts of difficulties with fire identified above. More research is needed on its potential for the plant communities on the Cumberland Plain.

Soil disturbance as a trigger

Deliberate soil disturbance can be used to relieve the often severe compaction problems arising from past management regimes on the Cumberland Plain, releasing soil-stored seed banks and to create niches for regeneration.

Soil disturbance via tillage and ripping can be undertaken with hand tools, such as mattocks, forks and rakes, but larger-scale machinery, such as rotary hoes, tractors and graders also have a place. Bare, compacted areas, such as former car parks, old tracks etc, provide good locations for its use. (Note that deep ripping is not recommended in saline or waterlogged areas).

- Where there is a gradient, soil loss is best prevented by following contours.
- Ripped areas need to be protected from further degrading disturbances, such as human access of various sorts.

Success in achieving regeneration may vary from excellent, to poor if subsequent control of public access is ineffective. However, systematic documentation and monitoring has generally not been carried out. One exception is an ex-grazing area at Horsley Park (McDonald, 1996) where tillage and burning singly and in combination were carried out.

Soil disturbance has been carried out at a range of sites, usually in barer compacted areas such as along tracks, old roads, in bare compacted parts of Reserves, and in former car parking areas. Examples include Duck River Reserve, Auburn; Bogabilla, Lansdowne and Carysfield Reserves at Bass Hill; Reynolds Reserve, Toongabbie and Plumpton Park, Plumpton.

Note that a degree of disturbance occurs in the process of hand removing weeds, particularly as larger scale hand tools such as peter levers and mattocks are often needed. The process of raking *Tradescantia fluminensis* creates soil disturbance, and when this occurs amongst patches of the grass *Microlaena stipoides* it can create a good seedbed for speedy *Microlaena stipoides* regeneration. Occasionally machinery eg. the use of machinery to remove large Boxthorn (pers. com. R. Davies, J. Diamond) can be advantageous in the right location.

Root disturbance as a trigger

Some species may sucker from their root system when it is disturbed.

Root disturbance for regeneration has most often been successful in relation to *Casuarina glauca*, where suckering from the root system has been achieved by mechanical disturbance, using either a mattock, whipper snipper or mower (Interviews: M. Birmingham, L. Brodie, S. Cook, W. Jack).

Some suckering of Acacia species, such as *Acacia parramattensis*, and *A. implexa*, has been observed in the course of hand digging to remove weeds (Interview: E. Freimanis). Root suckering of *Acacia pubescens* has also been observed following surrounding soil disturbance (Interview: I. Perkins).

Distinctive 'trigger' practices

- Irrigation: At one agricultural/farm site along the Nepean River, sustained use of a sprinkler over a 2 to 4 week period has triggered recovery (Interview: G. Limburg).
- Recruiting and using wildlife: Sticks placed in mud on the edge of the Nepean River, encouraged birds to perch and drop seed. *Elaeocharis* sp. was recruited to the area in this way (Interview: G. Limburg).

2.2 Reconstruction Through Revegetation

Revegetation measures should generally only come under consideration when:

- regeneration potential has been wholly or severely depleted,
- attempts to trigger regeneration of soil stored seed by a range of techniques have failed, and
- it is assessed that key missing species are not able to be naturally recruited to an area.

Re-vegetation in or immediately adjacent to remnants, and other areas where there is regeneration potential is not generally thought to be an appropriate practice. Resilience on any Cumberland Plain site can be surprisingly strong and persistent in or adjacent to remnants, even in extremely degraded and altered areas not likely to be formally classified as woodland. Bare, compacted areas within previously mown parkland can respond well given time and/or soil disturbance. Even areas of fill adjacent to good bush may get effective recruitment with time and suitable management.

Many remnant and re-growth areas on the Cumberland Plain have an endangered ecological status and revegetation in or immediately adjacent to them requires NPWS approval.

In undertaking revegetation the aim is to use the minimum intervention necessary to re-establish natural regeneration processes. This is sound from both a resource and ecological perspective. It is important to resist the tendency for ecological considerations and principles to be compromised by concerns for community involvement, aesthetics etc.

For areas where highly disturbing and large-scale alterations have occurred, such as in areas subjected to extraction or mining activities (as has occurred along parts of the river systems within the Cumberland Plain) a revegetation approach is more clearly indicated.

2.2.1 Planning revegetation works

Revegetation needs clear goals and objectives and a realistic long planning horizon. The objectives of revegetation should take into account both what is needed and the potential of the site. In the absence of this, actions based on aesthetic or public relations considerations may predominate, and adhoc processes can result. An unplanned approach usually results in the use of a limited range of easily grown and quickly available species, with a low species diversity and the skewing of vegetation towards some perhaps non-existent community.

Planning should identify the ideal or preferred range of species to be included. As much time as possible (two years would be a good minimum) should be allowed so that local provenance seed collection and propagation can be carried out, and planting be staged, so that as many species as is practicable from the range identified can be included. This is particularly important in relation to key component species of the community.

Sufficient resources for implementing the revegetation; for prior weed control; and for ongoing maintenance, (particularly in terms of follow-up weed management) also need to be allocated if efforts are not to be wasted.

2.2.2 Species selection and representation

It is thought that quite a large percentage of Cumberland Plain species are difficult to include in revegetation programs because of lack of knowledge regarding their collection and propagation requirements. This includes difficulty of propagation;

difficulties regarding availability and quantities of material; and the time and resources needed to overcome these limitations. This is particularly the case for ground storey species (the various herbs and forbs) as well as a number of riparian vegetation species. However, some have found that with specialist application a wider range of species can be propagated (Interviews: G. Limburg; E. Freimanis; J. Rawling; A. Parkes; R. Davies).

In practice, it is generally the more easily obtained/collected and propagated species that tend to be used in revegetation projects, and these are typically canopy trees (eg Eucalyptus spp.) and certain pioneer shrub species (eg Fabaceae species). Ground covers, particularly in any quantity or representative diversity, are used less often if at all.

There is also a lack of detailed knowledge of what should go where, and in what amounts. In planning the distribution and abundance of species, practitioners are guided by their observation of existing remnants and by the available literature. The operation of technical and resource constraints makes the achievement of revegetation 'to the highest practicable extent' a continuing challenge.

- Guidance on the appropriate distribution and abundance of species can be sought from the available literature (eg Benson and Howell 1990, Benson, Howell and McDougall 1996, 2nd Ed 1999) and from the observation of existing remnants. Knowledge of the original vegetation is not extensive.
- The availability of desired species may be limited in both variety and quantity, but the temptation to overuse the more readily obtainable and propagated ones should be resisted to avoid further skewing.
- These knowledge and availability constraints on restoration by revegetation underline the importance of the retention and regeneration of existing vegetation.

2.2.3 Methods and techniques for propagule introduction

- *Direct seeding* – has often been limited to a small range of suitable species, (such as large seeded species, eg Acacias). But, given the right conditions and timing, areas of native grasses may be established or extended on a small scale using this technique. Favourable environmental conditions - particularly soil moisture and minimal weed competition - are crucial to success of direct seeding and to minimising seed wastage (as sources of sufficient seed can be limited). Direct seeding on the Cumberland Plain has usually, but not always been on a small scale. Native grass seed, for example, has been hand scattered.
    - Hand scattering of seed represents a minimum intervention approach and is generally favoured over mechanical distribution; hydromulching is seldom used.
    - It may be possible to spread seed-bearing hay harvested from native grass stands where available.
    - Direct seeding can be carried out in combination with planting, but is usually carried out to a much more limited extent than planting.
- Planting of tubestock is the most commonly used method to reintroduce vegetation, and most frequently this occurs along very degraded edges and boundaries (especially river or creek edges), to create links, establish connectivity, and to create buffer zones. Less frequently, it is carried out more widely across sites, depending on the degree and location of degradation that has occurred. It is resource intensive, but can allow for community participation.

- Use of *seed-laden brush* is restricted in its application because material is scarce and its relocation may deplete its original area. It may be possible to obtain material from areas about to be cleared.
- The endangered ecological community status of many sites requires that any *translocation planting* or other transfer of propagules only be carried out as a last resort and within the framework of an approved reinstatement plan. In other sites and under good weather conditions, limited amounts of suitable common species (eg *Commelina cyanea, Dichondra repens*) can be translocated. Larger scale transfer of soil seed bank between sites (eg covering areas of 100-300m^2) has occurred in the past. The Australian Network for Plant Conservation has produced guidelines for Translocation.

2.2.4 Pattern and sequence of revegetation

- To decide what species are introduced and the timing of their introduction, consideration should be given to:
  - the goals and objectives established for sites.
  - the plant community desired, and achievable.
  - practical constraints relating to species availability.
  - practical management and maintenance issues.
  - the level of competition posed by weed growth on sites.
  - the best route to achieve a workable ecological succession.
- One approach to revegetation projects is to introduce all layers, including a range of grasses and groundcovers at the outset. This approach has been applied where:
  - sites are smaller,
  - a high degree of weed control has been achieved,
  - resources for follow-up maintenance are high, and
  - a sufficient quantity of material is available.
- Introduction of all layers is especially appropriate where there are erosion problems in order to provide cover and ensure diversity in root depth.
- Ground covers are important in the structure of Cumberland Plain Woodland and a diverse ground cover layer is important for biodiversity and a functioning ecosystem. One way of introducing ground covers in significant but manageable quantities is to plant them very densely in clusters (eg using cost-effective Virocells®) to achieve solid patches of ground cover quickly, and to facilitate weed management. These 'islands' or mosaic patches of densely planted ground covers can then be managed to facilitate their expansion to replace areas of exotic grass and other weeds.
- In both Cumberland Plain Woodland and River Flat Forest/Riparian situations, particularly where shade-loving weed ground covers are likely, canopy species and fast growing, nitrogen-fixing pioneer shrubs are introduced first, with the introduction of groundcovers deferred for 6-12 months or longer.

  This is because of one or more of the following:
  - difficulties associated with the level of post-planting weed control needed, particularly for herbaceous ground cover weeds, very disturbed sites and RFF/ Riparian situations.

- problems associated with maintenance practices of Council or other personnel eg. slashing and spraying.
- lack of sufficient ground cover material to make any significant impact upon a site at this level, and/or resources to carry out the labour-intensive process.
- the need to establish a framework first to serve as a protective structure for more shade dependent or vulnerable species (such as some ground covers), particularly in locations exposed to hot, dry conditions.
- as upper strata establish, they can provide protective structure and niche areas for the regeneration and recruitment of ground cover which will occur over time
- full biodiversity is only intended to be achieved in stages over time because of limitations of resources and technical knowledge.

Distinctive practices

- Tubestock planting as a multi-species introduction process. A number of species, including colonisers, are planted in each tube, so that at planting out, somewhat of an 'instant' community is introduced (Interview: S. Cook).
- Canopy trees and ground covers are the focus of initial plantings, with shrubs added later when available. It is considered that shrubs are more incidental to woodland situations, and it is important that the grassland component is not filled with shrubs (Interview: A. Parkes).

2.2.5 Site preparation and maintenance

Staging of works to avoid leaving bare areas, particularly in erosion prone river flat/ riparian areas, is important, as is the strategic retention of larger, bank stabilising woody weeds.

Site preparation and follow-up maintenance procedures include:

- erosion control measures - possibly weed/erosion control matting, mulching or simply logs. (Matting is not advised where control of bulbs or other plants with underground structures has not been achieved, but jute matting can be very useful in assisting with the establishment of native grasses, which are in turn very useful in erosion control.)
- ripping to relieve soil compaction and improve moisture retention. For example a rip line 20 to 50 cm deep, followed by a period to allow soil to settle - ensuring contour ripping when slopes are involved to avoid soil loss. (Note that deep ripping is not recommended in saline or waterlogged soils as it can create further problems.)
- weed control for some period of time prior to planting - usually up to 2 months - but ideally over six months or longer - to deplete as much weed seed bank as possible prior to revegetation.
- In some situations, control of rabbits may be judicious in the site preparation phase.
- mulching of areas when mulch is available, or mulching around individual plants (in areas not subject to flooding); both to conserve moisture and to delineate revegetation areas clearly for those undertaking adjacent maintenance practices. A 'living' mulch comprised of a sterile nurse crop is another possible option, suppressing weed growth by the occupation of available niches.
- pre-watering of holes, and watering following planting. Follow-up watering is

often difficult and factors to be considered include site characteristics, resources available, weather conditions, the degree of 'investment' in the planting and the level of risk of plant loss.

- protective fencing or other barriers to protect and delineate areas.
- individual plant protection with tree guards where feral animal predation or maintenance practices are a problem.
- follow-up weed control, after planting - the frequency and duration dependent on resources.

Distinctive practices

- The use of water retaining granules (Interviews: J. Rawling; G. Hudson). These are also used in conjunction with low phosphorous tree fertiliser tablets (pers. com. J. Rawling).
- The use of a CSIRO supplied mycorrhizal solution at planting - results not yet evaluated (Interview: S. Cook). The introduction of mycorrhiza at propagation (Interview: J. Rawling). Others question the value of mycorrhizal introductions because of the advice of mycologists that Cumberland Plain species may have a lower dependence on mycorrhiza (Interview: G. Limburg).

2.2.6 Seed collection and genetic integrity and diversity

Material for propagation is best found on site, or close to it, i.e. local provenance. The use of site-adapted local genotypes for propagation is best for restoring pre-existing plant communities and conserving local (and potentially unique) biodiversity. It is also more likely to lead to a self-perpetuating plant community.

The collection of suitable propagation material of local provenance is constrained when small, isolated remnants are involved, and where the plant community is restricted in occurrence. The limited availability of source material creates pressures for collection from the remaining sources of material and could lead to over collection of seed, and at worst to the placing of remnant populations of plants at risk. The resultant plantings are not necessarily an adequate genetic replacement for the remnant population from which the seed was taken.

It is also important to leave seed on site as it often plays an important role as a food source for fauna that may in turn be involved in pollination or other interrelationships with plants, a fact not always recognised by collectors.

The *Threatened Species Conservation Act (1995)* includes the requirement of a licence to collect seed from areas listed as Endangered Ecological Communities. This provides one mechanism for addressing the dangers of over-collection by allowing some limitation and co-ordination of seed collection to be achieved. In conjunction with the various available seed collection policies and codes of conduct, the Act also provides a framework for addressing the issues relating to genetic integrity.

The issue remains of how 'local' local provenance should be, and how far afield collection may appropriately be carried out. Currently, it is being interpreted to mean either as close as possible to a site, or within a local catchment - which may be based on a local creek, or wider river catchment - or within a 3 to 5 kilometre radius of a site. Many add the proviso that similar underlying geology and soil, aspect and other relevant site features or conditions must apply. Establishing consistent criteria for this is difficult and the question is dealt with on a case by case basis.

The former Hawkesbury Nepean Catchment Management Trust, with others produced protocols to guide decision making in relation to provenance issues. This is available on the AABR website www.zip.com.au/~aabr

Practitioners believe that collection should be project based, with quantities of material collected based on the requirements of the specific project. However, the limited time frames often imposed on revegetation works can lead to difficulties in obtaining sufficient and sufficiently varied material. This creates a temptation to stockpile seed.

Current concerns regarding seed collection on the Cumberland Plain include:

- possible inbreeding, given the small, isolated nature of some sites, or on other sites, the restricted amount of native vegetation.
- seed being collected in the absence of good knowledge and skills regarding effective propagation.
- possible over-collection of seed on the Cumberland Plain, given the limited availability of material, the difficulty of co-ordinating collection in the market place and a certain level of social/institutional bias to landscaping and revegetation approaches.

Planning for seed collections should consider the following:

- A self-perpetuating plant community is promoted by the use of site-adapted endemic genotypes in propagation material. Such material is best found on site, or close to it, i.e. that is of local provenance. This is also crucial for restoring pre-existing plant communities and conserving endemic biodiversity.
- The practice of seed collection on the Cumberland Plain is best carried out within the framework of a formal, documented seed collection policy or code of practice. A range of policies, guidelines and codes of conduct exist.

  The *Model Code of Practice -for Community Based Collectors and Suppliers of Native Plant Seed* (1999) by FloraBank is the most recent. This can be found on the FloraBank website (www.florabank.org.au).

- Others include:
  - The Native Seed Savers Network Code of Conduct.
  - Greening Australia (NSW) Code of Practice for Seed Collection.
  - Hawkesbury City Council Native Vegetation Seed Collection Policy.
  - National Trust of Australia (NSW) Seed Collection from Bushland Reserves.
  - Urban Bushland Management Consultants General Guide to Indigenous Vegetation Restoration - Collecting, Processing and Storing Native Plant Seed.
  - CSIRO guidelines for the collection of Eucalyptus spp.
- Requirements under the Threatened Species Conservation Act (1995), need to be met. Generally, those seeking to collect seed from a plant community scheduled under the Act need to apply for a Section 91 licence from the NSW National Parks and Wildlife Service.
- Seed should be collected on a specific project by project basis, where the amounts of seed to be collected are based on the requirements of that project (not by a desire to establish a stockpile).
- Collectors require a clear understanding of the provenance range that may be appropriate for the specific site and vegetation community involved.
- Collection should be carried out as far as possible in co-ordination with others carrying out seed collection in the general area. Refer to local government and Greening Australia bushcare networks.
- Collectors need to be aware that some species are protected under the National Parks and Wildlife Act (1974), and it is an offence to pick or have parts of these plants in your possession. These plants are listed under Schedule 13 of the Act, and the offence described in part 8, Section 117.

2.2.7 Species Selection and revegetation in saline areas

There is considerable debate over species selection for saline discharge sites. There are many non-local natives and exotic species that have a high degree of salt tolerance, which may be useful for addressing salinity and non-biodiversity objectives, such as agroforestry. Fortunately, many plants on the Cumberland Plain have a degree of salt tolerance. There are two common techniques for species selection for biodiversity in saline areas:

1. Use species that previously occur on the site, with propagules selected from as close as possible. This is the preferred option; however the greater the change in salinity and water balance the less likely it is to be effective. This technique has been proven in many areas.

2. Use species that occur in naturally saline or water logged sites in the vicinity. There is far less risk with this technique and results often reflect the natural succession on a landscape scale.

Planting and site preparation should be carried out as described in the rest of the document. However, particular attention needs to be placed on water logging and deep ripping. Deep ripping of water logged soils is generally not required and can cause problems. If deep ripping is being considered in water logged soils, it should be discussed with a Department of Infrastructure, Planning and Natural Resources' Soil Conservation Officer.

Never just plant within the scalded area; plant the surrounding areas as well. In severely affected areas it may be necessary to progressively plant from the surrounding

areas towards the centre of the scald over many years. Remember, revegetation of recharge areas alone is unlikely to be a long-term solution and if salinity levels are very high may not be feasible at all.

Where water logging is a problem, mounding has proven a useful technique to establish seedlings. Salt tends to accumulate at the highest point of the mounds due to evaporation of the rising water table. Consequently, seedlings should be placed in a dip at the top of the mound or on the side of the mound.

Direct seeding of saline sites, with or without mounding, has been successful out side of Sydney. However, salt inhibits the germination of some species. Further research is needed for direct seeding to be a reliable revegetation technique on the Cumberland Plain.

2.3 Management of Edges

Typically on the Cumberland Plain many weeds are not just edge related or edge occupying but spread extensively across the whole of the bushland on the site. Long, narrow sites are effectively all edge. In sandstone areas specific edge treatments are generally carried out. In comparison, on the Cumberland Plain, the specific treatment of edges may be carried out to a lesser extent. For smaller reserves, particularly near more dense urban settlement, the focus on edge or interface areas may be higher.

On the Cumberland Plain site edges vary considerably. They include:

- narrow River Flat Forest/riparian sites with long, river, agricultural or parkland edges.
- sites with long, arable, pastoral or roadside boundaries.
- sites within and bordering mown parkland areas.
- sites on the rural residential interface.
- sites with more urban, residential or industrial boundaries.

Acceptable options for managing edges include:-

- undertaking buffer plantings of canopy and/or other elements (especially along long riparian sites) to extend areas and to compete with and shade out encroaching weeds. Note that planting as an edge treatment will require NPWS approval under the *Threatened Species Conservation Act (1995)* if adjacent to remnants which are Endangered Ecological Communities or contain endangered species. It is good practice to leave a gap of several metres as an expansion zone for other remnant areas.
- spot spraying to control encroaching grassy/herbaceous weeds.
- installing of physical barriers such as logs or bollards, especially where delineation is required in the face of adjacent land maintenance practices e.g. mowing or where there are access problems.
- mulching (either alone or in combination with physical barriers) to delineate different land uses and maintenance regimes, especially mowing. This also helps with public acceptability of areas. Some planting on the edge may also occur in conjunction with mulching.
- liaising with and education of maintenance personnel and adjacent landowners.
- targeting hand weeding of selected weeds.

- tolerating some weed growth to inhibit other weed incursion, e.g. short-term retention of certain woody weeds or Tradescantia where this may provide an effective weed barrier or "biological fence".

- enlarging a buffer zone by removing mowing further away from an edge and tolerating certain weeds within this.

- slashing a fixed edge width between bushland and parkland areas.

These options need to be flexibly deployed according to the site specific impacts from adjacent areas and the practicability of treatment. A combination of approaches is often more effective than a single approach. What happens over time on the edge needs to be monitored and management practices modified as necessary.

3. DOCUMENTATION, MONITORING and EVALUATION

A balance between documentation and actual restoration work needs to be maintained. However, the better the documentation, the more likely it is that appropriate courses of action will be identified and pursued. Documentation needs to be sufficient to monitor progress and change, assess the effectiveness of approaches and techniques, and justify past and future funding.

Documentation and subsequent monitoring and evaluation can be problematic due to a number of factors:

- many interacting variables are involved in dynamic ecosystems; natural or modified.
- objectives for work rarely specify which variables are seen as significant, so that it is unclear exactly what should be being looked at or measured.
- consistency in observation and recording is hampered by the short-term and discontinuous pattern of works and the resultant changes in personnel.
- the expertise, time and resources for sound, scientific monitoring are generally not available.

Sampling methods using for example long-term quadrats and/or transects are accurate and give high resolution results. They are a useful methodology for recording changes in native vegetation, weeds and other components and to provide a quantified account of what is happening on a site. However, their use in a scientific and statistically sound way requires skills and time generally lacking in practical restoration works and not currently allowed for in project specifications. Long-term management of the data can also be a problem and how the data is kept and disseminated needs to be determined.

Qualitative methods are quicker and inexpensive, but it may be difficult to show change using these.

The following guidelines apply:

- Clear specification of desired ecological outcomes and good prior and ongoing documentation of works and ecological variables provides the best basis for monitoring progress, correcting practices and evaluating success in the achievement of restoration.

- Specification of ecological outcomes in measurable terms is difficult, but valuable elements of documentation include:
  - annotation of photographs which are repeatable in respect of both location and angle of execution.
  - vegetation maps showing boundaries of weed infestation and the assessed

condition class of areas, based on weed densities and/or the ratio of weeds to natives.

- the collection or preparation of species lists for natives and weeds, noting where possible their occurrence as rare, occasional or common, and the date of identification.
- the collection of lists of fauna species and any other available baseline data.
- establishing permanent quadrats and/or transects to enable quantitative recording of factors such as:
  - species densities and diversity and extent of cover.
  - weed and native responses to particular techniques.
  - recording qualitative observations and accounts of relevant site phenomena e.g. fauna, disturbance events, and apparent site responses.
- recording of any new techniques or approaches being used or trialed, noting methodology and all relevant conditions and requirements under which treatment is occurring.
- recording hours and categories of work, including techniques used and areas involved.

- The compilation at suitable intervals (e.g. every month, half-year and year) of reports which summarise work activity and note and analyse changes in the various variables recorded provides the most useful basis at present for evaluating performance.

  Ongoing progress can be documented through:

  1. daily records indicating:
     - hours of work.
     - category of work (whether primary, secondary, maintenance or target etc).
     - nature of weeds and weed management techniques used.
     - extent of site worked, e.g. square metres covered.
     - any faunal observations, including feral animals.
  2. monthly, half yearly and annual reports, including maps and 'before and after' photographs and quadrat descriptions which:
     - summarise works showing for example total hours worked, which type or category of work, weeds involved and where.
     - describe the current treatment level, work category, or condition class for areas.
     - identify current ratios of weeds to natives.
     - include updates to species lists (new native species) to indicate changes in species diversity.
     - provide descriptive accounts, including visual observation about (for example):
     - weed successions observed
     - fauna
     - observed changes to community structure
     - rate of recruitment and growth of native species

Measures of performance should relate back to the desired ecological outcomes. It may take several years before the changes to be achieved are significant.

Measures currently in use or under consideration include:

- changes over time in hours required for different treatment levels in defined areas.
- changes in the ratios of weeds to natives in defined areas.
- changes to the condition class of areas.
- changes in the number of hectares or square metres considered to be on a maintenance (ie. lowest) level of treatment.
- changes to species diversity as indicated by species list updates. Include fauna, feral animals, evidence of use as habitat.
- changes to observed community structural integrity and structure, whether structural re-formation or degradation is occurring, for example.
- the rate of native recruitment and growth.

The CRAM project (produced by the former DLWC) is a series of protocols for assessing and monitoring ecological and environmental quality of works. These are available through the AABR web site at www.zip.com.au/~aabr

4. COMMITMENT TO LONG TERM PROCESSES

4.1 Who should be working in Cumberland Plain vegetation?

Those who work in bushland areas of the Cumberland Plain will include professionals and community volunteers. The following gives an indication of the expected qualifications and experience.

Currently TAFE has a Certificate II and a Certificate III in Natural Area Restoration and a Diploma in Conservation and Land Management (Natural Area Restoration). At the most basic level, everyone employed to work in bushland areas should have attained or be in the process of completing the Certificate II, or an equivalent qualification which has strong practical application of the principles of natural regeneration. This would apply to any staff considered to be "Horticultural " staff or involved in Noxious Weed Control.

Team leaders or supervisors should have completed or be in the process of completing the Certificate III in Natural Area Restoration or equivalent. In addition, the supervisor should have 2 years experience in the bush regeneration industry.

The Australian Association of Bush Regenerators (AABR) NSW has criteria for full membership. This requires that the applicant completes an AABR-approved bush regeneration course (Currently the TAFE Certificate II), and at least 200 hours field experience over a two year period, under the supervision of an AABR member. It is recommended that team leaders/supervisors have the equivalent qualifications and experience, with the addition of completing the Certificate III.

Community Bushcare groups work at a different level. Currently, two day Introductory Bushcare Training is made available to most community group members by their local council and Landcare. This training covers the Introductory Course developed by the National Trust. It is recommended that all group's members complete this course.

Professional supervision of community groups is necessary in bushland on the Cumberland Plain, and this supervision should include further training, advice and site planning for the group. The professional supervisor should have the same qualifications and experience as shown above for team leaders/supervisors.

Consultants providing advice and recommendations for bushland restoration should be experienced in this field. Experience in Ecology, Landscaping or Horticulture is useful but not enough to allow correct interpretation of an ecosystem's ability to regenerate and what inputs are needed to encourage that regeneration. It should be noted that this is a specialist field and consultants should be required to demonstrate their specialist knowledge. Many bushland consultants have completed the TAFE courses, have worked as regenerators in the field or have extensive experience in the development of bush regeneration site strategies.

4.2 Community Involvement in Restoration

The process of achieving the restoration of sites can be considerably smoother and more successful if the local community is supportive. This usually means that the community needs to be considered, informed, and, where possible and appropriate, involved. The right of the community to have its views taken into account should be acknowledged. An ideal first step would be to assess local community perceptions and use of the bush through surveys, or discussion with representatives of different sectors of it.

It is important that the community is aware of the issues relating to bushland

in their area, or have access to correct information, so they can become involved in an informed way. As far as possible actions to address likely perceptions should be undertaken prior to commencing works. Failure to do so can result in a 'backlash' which is much harder to deal with as attitudes have already been formed. The bush itself is often perceived by many in the community as containing threats (eg fire, snakes, humans). For others, restoration activity may threaten the existing use of and relationships with the bush. Taking the time early on to anticipate such responses is helpful.

Actions that have been effective in gaining community support include the following:

- consultative or explanatory site meetings, open days, tours to which the local community is invited.
- explanatory and interpretive signage (particularly when used in conjunction with physical barriers to delineate or exclude access, or in areas of changed mowing regimes).
- letter box leaflet or brochure drops - reporting and explaining restoration works demonstrates continued active management of sites, which is especially important in areas where mowing or other maintenance regimes have been withdrawn. Providing information about times when works are being carried out can give people the opportunity to visit, observe and engage in informal discussion.
- emphasising in discussions and information provision:
  - fauna habitat issues as they relate to particularly the 'charismatic' fauna, eg the importance of dense shrub vegetation for small birds such as Blue Wrens, and grassland for parrots, and
  - the endangered ecological status of Cumberland Plain plant communities, and species within them.
- erection of a community noticeboard at appropriate sites (vandalism is a problem).
- articles in local newspapers, eg. ongoing press releases highlighting positive discoveries.

- photographic and other displays at community events, festivals etc.
- community awareness-raising training courses/workshops, or forums. These can be precursors to establishing voluntary bushcare or other support groups.
- in areas where mowing has been withdrawn, recognising and accommodating existing access and uses as far as practicable, eg by ensuring access tracks which guide access and usage.
- where revegetation areas are involved, involvement of individuals, community groups and schools in planting of indigenous species.

4.3 Commitment to Restoration by the Land Manager/Owner

The major land owner, manager and funding provider for Cumberland Plain restoration projects is Local Government. Other projects may be part of developments under the guidance of Council. Understanding of and commitment to restoration philosophy and actions can make or break restoration 'to the highest practicable extent'. Overall, the levels of awareness amongst council and other project managers, or support amongst managerial staff, or at the political level are not high. Council staff structures and processes often mean that the input of bushland technical staff (where present) is not always sought for decisions which affect remnant vegetation.

Prevailing ideas and perspectives are often inconsistent with bushland restoration philosophy and practices, and this is manifested in a tendency within some Councils to focus on planting and landscaping approaches, rather than focusing on the regeneration potential and resilience that is so often there.

Often too much, too soon is expected of regeneration and revegetation projects alike. This is particularly reflected in the time frames allowed for the planning, implementation and achievement of results for reconstruction/revegetation projects. A mix of political considerations, impatience and a lack of understanding appear to underlie these unrealistically high expectations.

The Commonwealth is a major funding provider especially via grant programs, with the State also providing some funding. The development of funding programs requires the need for long term commitment and awareness of restoration processes to be understood and supported.

The effectiveness of bush restoration efforts is enhanced if the overall management and funding arrangements for projects:

- ensure that the overall planning, management and supervision of restoration projects at the land manager level is entrusted to personnel who have understanding and basic expertise in the field of restoration work with particular understanding of the Cumberland Plain context. Expertise may be augmented by the creation of a bushland advisory committee or similar, to advise and assist with management issues.
- extend planning and funding contract periods (a minimum of 3-5 years is desirable) so that works may be more soundly planned, objectives more effectively pursued, and achievements monitored and assessed over a longer time frame, more in accord with the natural processes involved. Short term funding under grants needs to be supported by longer term funding from Council.
- establish in contract or project specifications or at the outset of works, the nature and frequency of communication expected during the course of each project. Otherwise, feedback may be patchy or lacking, and expectations can remain unclear and, consequently, may not be met.

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APPENDIX A. Listed Endangered Ecological Communities of the Cumberland Plain

Endangered Ecological Communities
Cumberland Plain Woodland
Shale/Sandstone Transition Forest
Sydney Coastal River-Flat Forest
Elderslie Banksia Scrub
Blue Gum High Forest
Sydney Turpentine Ironbark Forest
Western Sydney Dry Rainforest
Castlereagh Swamp Woodland
Agnes Banks Woodland
Cooks River/Castlereagh Ironbark Forest
Moist Shale Woodland
Shale Gravel Transition Forest

(cited from National Parks and Wildlife Service website for Threatened Species)

APPENDIX B. Project Participants

Megan Birmingham	Bush Regeneration Practitioner, and Cumberland Plain Woodland Project Officer (South Creek Catchment Management Committee)
Louise Brodie	Bush Management Officer, National Trust of Australia (NSW)
Simon Cook	Toongabbie "WHAT Bushcare"
Rob Corby	Bushland Management Officer, Bankstown City Council
Richard Davies	Corridors project Co-ordinator, Greening Australia (NSW)
John Diamond	Bush Regeneration Practitioner
Michelle Engelhard	Land Management Officer, Hawkesbury City Council
Edgar Freimanis	Partner/Project Manager, Ecohort
Frank Gasparre	Upper Parramatta Catchment Management Trust
Geoff Hudson	Bushland Management Officer, Hawkesbury City Council
Warren Jack	Sydney Bush Regeneration Company
Gordon Limburg	Bushland Management Consultant
Anne Parks	Manager, Hills Bushcare
Ian Perkins	Parks and Bushland Management Consultant
Judy Rawling	Executive Director, Urban Bushland Management Consultants Pty Ltd.
Jeanette Stannard	Bushland Management Co-ordinator, Parramatta City Council

Cumberland Plain
Weedlist May 2003

APPENDIX C. Major Weeds of the Cumberland Plain

Genus	Species	Common Name	Risk	Cumberland Plain Woodland	Sydney Coastal River Flat Forest and Riparian	Cooks River/ Castlereagh Ironbark Forest	Sydney Turpentine Ironbark Forest
Bulbs							
Alium	*triquetrum*	Angled onion				X	
Freesia	*refracta*	Freesia	High	X		X	
Lilium	*formosum*	Formosan Lilly		X		X	
Northosocordum	*borbonicum*	Onion Weed		X	X	X	
Romulea	*rosea var australis*	Guilford Grass		X	X	X	
Watsonia	*bulbillifera*	Wild Watsonia	High	X		X	
Zantedeschia	*aethiopica*	White Arum Lily			X		
Grasses							
Agrostis	*capillaris*	Bent Grass				X	
Andropogon	*virginicus*	Whisky Grass	High	X	X	X	
Arundo	*donax*	Giant Reed			X	X	
Avena	*fatua*	Wild Oats		X	X		X

Genus	Species	Common Name	Risk	CPW	SCRFFR	CR/CIF	STIF
Axonopus	*affinis*	Narrowleafed Carpet Grass		X	X	X	
Briza	*maxima*	Quaking Grass		X	X	X	
Briza	*minor*	Shivery Grass		X	X	X	
Briza	*subaristata*			X			
Bromus	*catharticus*	Prairie Grass		X	X	X	X
Chloris	*gayana*	Rhodes Grass	High	X	X	X	X
Cortaderia	*selloana*	Pampas Grass		X	X	X	
Cynodon	*dactylon*	Couch		X	X	X	
Dactylis	*glomerata*	Cocksfoot			X		
Digitaria	*sanguinalis*	Summer Grass		X	X	X	
Echinochloa	*crus-gulli*	Barnyard Grass			X	X	
Ehrharta	*erecta*	Ehrharta	High	X	X	X	
Ehrharta	*longiflora*	Ehrharta	High	X	X	X	
Eleusine	*indica*	Crowsfoot		X	X		
Eleusine	*tristachya*	Goose grass/ crabgrass		X	X		
Eragrostis	*curvula*	African Love Grass	High	X	X	X	X
Lolium	spp.	Rye Grass	High	X	X		
Melinis	*repens*	Red Natal Grass	High	X	X	X	
Nassella	*neesiana*	Chilean Needlegrass	High	X	X		
Paspalum	*dilatatum*	Paspalum	High	X	X	X	X
Paspalum	*urvillei*	Giant Paspalum	High	X	X	X	
Pennisetum	*clandestinum*	Kikuyu	High	X	X		X
Phalaris	spp.	Canary Grass			X		
Poa	*annua*	Winter Grass			X	X	
Setaria	*gracilis*	Pidgeon Grass		X	X	X	X

Sorghum	*halepense*	Johnson Grass			X			
Sporobolus	*indicus*	Parramatta	High	X	X	X	X	
Stenotaphrum	*secundatum*	Buffalo Grass		X	X	X		
Vulpia	spp.	Fescue			X			
Ground covers								
Agapanthus	*praecox variety orie*	Agapanthus				X		
Hydrocotyle	*bonariensis*	Pennywort		X		X		
Nephrolepis	*cordifolia*	Fishbone Fern				X		
Persicaria	*capitata*	Japanese Knotweed			X	X		
Ranunculus	*repens*	Creeping Buttercup		X	X	X		
Rosa	*rubiginosa*	Sweet Brair		X	X	X		
Tradescantia	*fluminensis*	Wandering Jew	High	X	X	X	X	
Vicia	spp.	Vetch	High	X	X	X		
Herbs								
Agaves	spp.	Yukka/Century Plant			X			
Apium	*leptophyllum*	Slender Celery		X	X		X	
Alternanthera	*philoxeroides*	Alligator weed	High		X	X		
Anagalis	*arvensis*	scarlet pimpernal	High	X	X	X	X	
Aster	*subulatus*	Bushy Starwart		X	X			
Begonia	*x semperflorens-cult*	Begonia	High			X		
Bidens	*bipinnata*	Cobbler's Peg	High	X	X	X	X	
Bidens	*pilosa*	Cobbler's Peg	High	X	X	X	X	
Brassica	spp.	Wild Turnip		X	X	X		
Bryophyllum	*delagoense*	Mother of Millions	High	X	X	X		
Bryophyllum	*pinnatum*	Resurrection Plant		X	X			
Colocasia	*esculenta*	Taro	High	X		X		

Genus	Species	Common Name	Risk	CPW	SCRFFR	CR/CIF	STIF
Cambomba	*caroliniana*	Cambomba Fan wort				X	
Canna	*indica*	Canna lily			X	X	
Capsella	*bursapastoris*	Shepherd's Purse		X	X		X
Cardamine	*hirsuta*	Flickweed	High		X	X	
Cenytaurium	*erythraea*	Common Centuary		X			
Cerastium	*glomeratum*	Mouse-ear Chickweed		X	X	X	
Chenopodium	*album*	Fat Hen		X	X	X	X
Chlorophytum	*comosum*	Spider Plant		X	X	X	X
Chrysanthemoides	*monilifera*	Bitou Plant				X	
Cirsium	*vulgare*	Spear thistle		X	X		
Conyza	spp	Fleabane	High	X	X	X	
Coreopsis	*lanceolata*	Coreopsis	High		X	X	
Crassocephalum	*crepidioides*	ThickHeads		X	X		
Cyperus	*brevifolius*	Mullumbimby Couch			X		
Cyperus	*eragrostis*	Umbrella Sedge	High	X	X	X	
Cyperus	*rotundus*	Nutgrass			X	X	
Dietes	*grandiflora*	Wild iris					X
Echium	*plantagineum*	Paterson's curse/ Salvation			X		
Eichomia	*crassipes*	Water Hyacinth	High		X	X	
Euphorbia	*peplus*	Petty Spurge			X	X	
Foeniculum	*vulgare*	Fennel	High	X	X	X	
Fumaria	spp.	Fumitory		X	X		X
Galinsoga	*parviflora*	Potato Weed	High			X	
Galium	*aparine*	Cleavers			X	X	
Gnaphalium	*pennsylvanicum*	Cudweed		X	X		X

Hypericum	*perforatum*	St.John's wort	High		X		
Hypochaeris	*radicata*	Flatweed / Catsear	High	X	X	X	X
Isolepsis	*prolifera*	Sedge		X	X	X	
Latuca	*serriola*	Prickly Lettuce		X	X	X	
Linum	*trigynum*			X	X		X
Ludwigia	*peruviana*	Water Primrose			X		
Medico	*polymorpha*	Burr Medic		X	X		
Mirabilis	*jalapa*	Four O'Clock		X			
Modiola	*carolliniana*	Red Flower Mallow			X		
Myrsiphyllum	*asparagoides*	Baby smilax/Bridal Creeper	High	X	X	X	X
Myrsiphyllum	*scandens*	Asparagus Plant	High	X		X	X
Opuntia	*stricta*	Prickly Pear		X	X		
Oxalis	spp.	Oxalis	High	X	X	X	
Parietaria	*judaica*	Sticky Weed/Asthma Weed	High		X	X	
Petrorhagia	*nanteuilii*	Childing Pink		X			
Phyllanthus	*tenellus*			X		X	
Phyllostachys	spp.	Bamboo	High		X	X	
Phytolacca	*octandra*	Inkweed	High	X	X	X	
Plantago	*lanceolata*	Common Plantain		X	X	X	X
Polygonum	*aviculare*	Wire Weed		X	X		
Protasparagus	*aethiopicus*	Fern Asparagus	High		X	X	X
Protasparagus	*plumosus*	Climbing Asparagus Fern	High			X	
Rorippa	*nasturtium-aquaticum*	Watercress			X	X	
Rumex	spp.	Dock	High	X	X	X	
Salvinia	*molesta*	Salvinia	High		X	X	

Genus	Species	Common Name	Risk	CPW	SCRFFR	CR/CIF	STIF
Senecio	*madagascariensis*	Fireweed	High	X	X	X	X
Sida	*rhombifolia*	Paddy's Lucerne	High	X	X	X	X
Silene	*gallica var. quinquevulnera*	French Catchfly		X			
Solidago	*canadensis*	Canadian Goldenrod			X		
Sonchus	*oleraceus*	Common Sow Thistle		X	X	X	X
Stachys	*arvensis*	Stagger weed		X	X		
Steearia	*media*	Chickweed		X	X		X
Tagetes	*minuta*	Dandelion		X	X	X	X
Taraxacum	*officinale*	Dandelion		X	X	X	
Trapapogon	*porrifolius*	Oyster Plant		X	X		
Trapaeolum	*majus*	Nasturtium			X	X	
Trifolium	*repens*	White Clover			X		
Verbena	*bonariensis*	Purple Top	High		X	X	
Verbena	*rigida*	Veined Verbena		X	X		
Xanthium	spp.	Noogoora Burr			X	X	
Sedges							
Juncus	*acutus*	Spiny Rush		X	X		
Juncus	*articulatus*	Solmuvihvilä		X	X		
Shrubs							
Ageratina	*adenophora*	Crofton Weed	High	X	X	X	
Ageratina	*riparia*	Mist Flower	High		X	X	
Amaranthus	*hybrids*	Slim Amaranth		X	X		X
Caesalpinia	*decapetala*	Wait-a-while		X			
Cestrum	*nocturnum*	Night Cestrum			X		
Cestrum	*parqui*	Green Cestrum	High	X	X	X	X
Coprosma	*repens*	Mirror plant		X			

Cotoneaster	*glaucophyllus*	Cotoneaster		X	X			
Cotoneaster	*pannosus*	Cotoneaster		X				
Cytisus	*scoparius*	English Broom		X		X		
Datura	spp.	Thornapple		X	X			
Genista	*monspessulana*	Montpellier Broom				X		
Gomphocarpus	*fruiticosis*	Narrowleaf Cotton Bush		X	X			X
Impatiens	*walleriana*	Busy Lizzie / Impatiens			X	X		
Lantana	*camara*	Lantana	High	X	X	X		
Lycium	*ferocissimum*	African Boxhorn	High	X	X	X		
Melaleuca	*armillaris*	Bracelet Honeymyrtle				X		
Ochna	*serrulata*	Ochna / Mickey Mouse Plant	High	X	X	X		X
Pavonia	*hastata*	Pink Pavonia		X	X	X		X
Pyracantha	*augustifolia*	Hawthorn	High		X	X		
Rhapiolepis	*indica*	Indian Hawthorn			X			
Ricinus	*communis*	Castor Oil Plant	High	X	X	X		
Rubus	*fruiticosa*	Blackberry	High	X	X	X		
Senna	*floribunda*	Cassia	High	X		X		X
Senna	*pendula*	Cassia	High	X	X	X		
Solanum	*nigram*	Blackberry Nightshade	High	X	X	X		X
Solanum	*pseudocapsicum*	Madeira Winter Cherry		X	X			X
Ulex	*europaeus*	Gorse			X	X		
Trees								
Acacia	*baileyana*	Cootamundra Wattle	High	X		X		
Acacia	*cultriformis*	Knife Leaved Wattle		X	X			
Acacia	*podalyriifolia*	Queensland Silver Wattle	High	X	X	X		

Genus	Species	Common Name	Risk	CPW	SCRFFR	CR/CIF	STIF
Acacia	*saligna*	Golden Wattle	High	X	X	X	
Acer	*negundo*	Black Maple			X	X	
Ailanthus	*altissima*	Tree of Heaven	High		X	X	
Cinnamomum	*camphora*	Camphor Laurel	High	X	X	X	
Eriobotrya	*japonica*	Loquat			X	X	
Erythina	*crista-galli*	Cockspur Coral Tree	High	X	X	X	
Erythina	*x sykesii*	Coral Tree		X		X	
Eucalyptus	*citriodora*	Lemon-Scented Gum	High	X		X	
Gleditsia	*triacanthus*	HoneyLocust	High	X	X	X	
Grevillea	*robusta*	Silkyoak	High	X	X	X	X
Jacaranda	*mimosifolia*	Jacaranda				X	
Ligustrum	*lucidum*	Broad-Leaved Privet	High	X	X	X	X
Ligustrum	*sinense*	Small-leaved Privet	High	X	X	X	X
Lophostemon	*confertus*	Brushbox				X	
Melia	*azedarach*	White Cedar				X	
Morus	*alba*	Mulberry Tree		X	X	X	
Olea	*europaea* spp *africana*	Wild Olive/Afican Olive	High	X	X	X	X
Paraserianthes	*lophantha*	Crested Wattle/Albizia	High			X	
Phoenix	*canariensis*	Phoenix Palm/Date Palm		X	X	X	
Pinus	*radiata*	Pine Tree		X			
Pittosporum	*undulatum*	Sweet Pittosporum		X	X	X	X
Populus	*alba*	Poplar			X	X	
Robinia	*pseudo-acacia*	False Acacia/Black Locust	High		X	X	
Salix	spp.	Willow	High	X	X	X	

Sapium	*seberiferum*	Chinese Tallow Tree		X	X	X	X
Solanum	*mauritianum*	Wild Tobacco		X	X		
Toxicodendron	*succedaneum*	Rhus Tree	High		X		
Vines & creepers							
Acetosa	*sagittatus*	Turkey Rhubarb	High	X	X	X	
Anredera	*cordifolia*	Madeira Vine	High	X	X	X	
Araujia	*sericifolia*	Moth plant / Mothvine	High	X	X	X	X
Cardiospermum	*grandiflorum*	Balloon Vine	High	X	X	X	
Delairea	*odorata*	Cape Ivy			X	X	
Dipogon	*lignosis*	Dolichos Pea			X		
Ipomea	*indica*	Morning Glory	High	X	X	X	
Jasminum	*polyanthum*	Jasmine		X		X	X
Lonicera	*japonica*	Honeysuckle		X	X	X	X
Macfadyena	*unguis-cati*	Cat's Claw Creeper	High		X	X	
Passiflora	*edulus*	Passionfruit			X	X	
Solanum	*jasminoides*	Potatoe Vine/Jasmine Nights		X			
Thunbergia	*alata*	Black - eyed Susan		X	X		X
Vinca	*major*	Blue Periwinkle		X	X	X	X

Weed list courtesy of the Australian Association of Bush Regenerators Weed Committee and Maree Costigan and Mike Dine

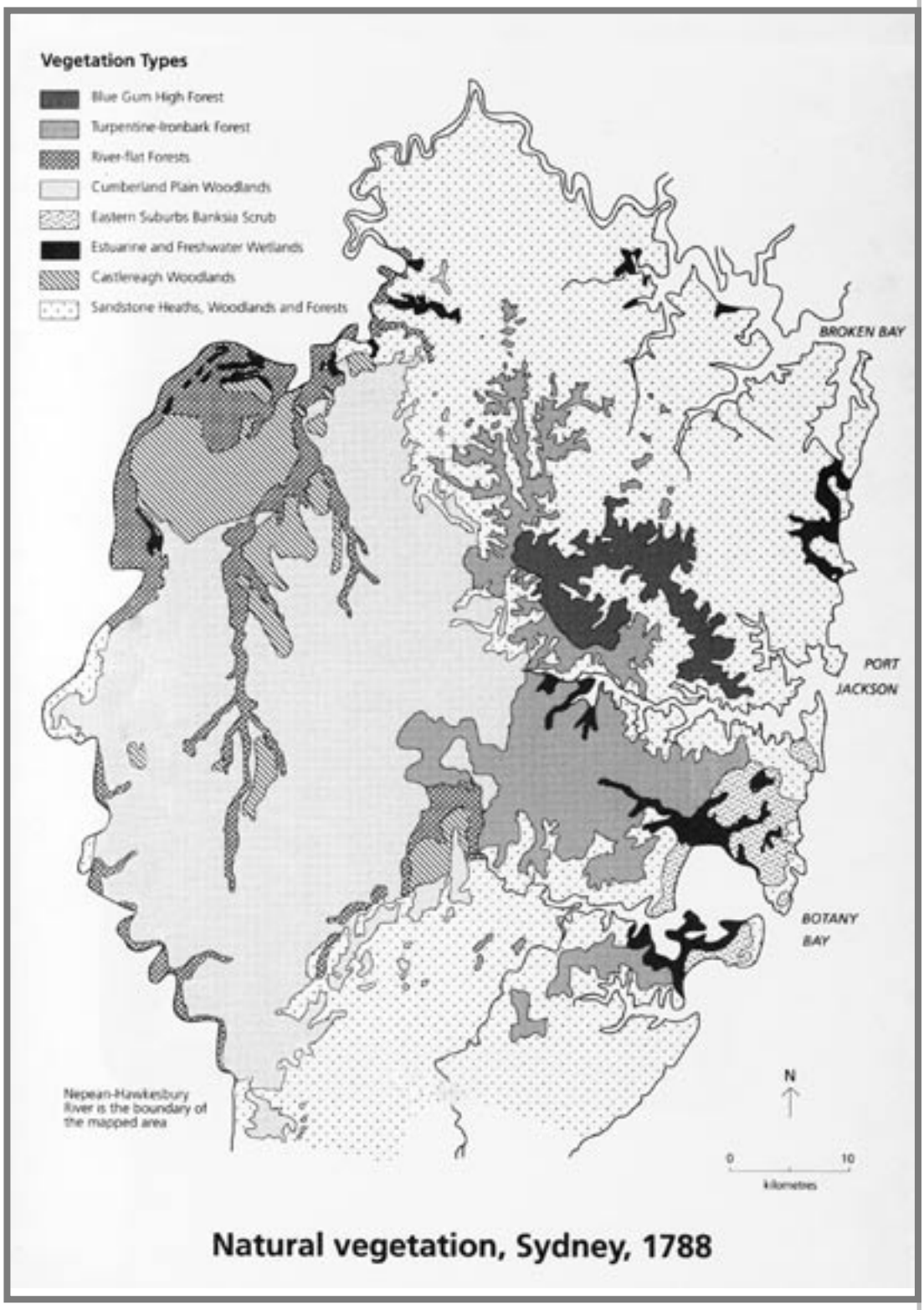
Updates of the Cumberland Plain weed list can be downloaded from the Australian Association of Bush Regenerators website: www.zip.com.au/~aabr

APPENDIX D.
Treatments for Cumberland Plain Weeds

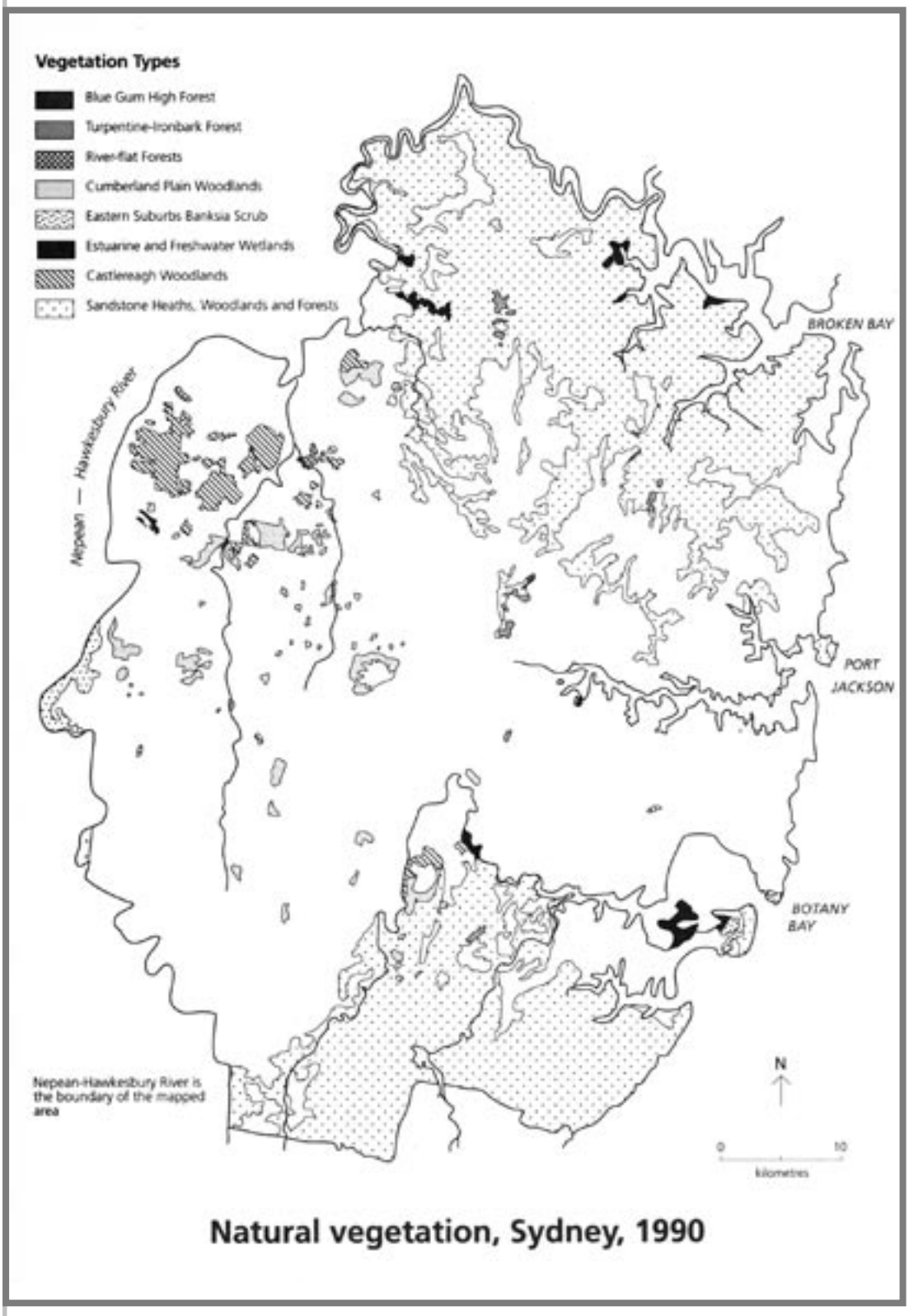
The table below summarises current methods found effective for tackling particular weeds of the Cumberland Plain.

Weed problem or situation	**Treatment/s being applied (***Please note all herbicides should be used strictly according to label**.)**
Woody weeds in native, grassy understorey:	
Blackberry (*Rubus fruticosus*)	Selective herbicides Garlon®, Grazon® or Brushoff® (provided away from water). Mechanical slashing or hand pruning to encourage new growth, prior to recommended spray period is quite effective - reducing biomass & facilitating access for treatment.
African Olive (*Olea europaea ssp africana)*	Cutting and painting with non selective herbicide Roundup® is effective. Frequently unresponsive to drilling and poisoning with Roundup®. Basal bark application of Garlon® and diesel can also be unreliable.
Bridal Veil Creeper (*Asparagus asparagoides*)	Selective herbicide Brushoff® used under permit being found to be effective. Narrow window of opportunity for effective herbicide treatment (at flowering). Some woody natives eg. Bursaria sensitive to Brushoff®. Hand removal also carried out in combination with spraying.
African Boxthorn (*Lycium ferocissimum*)	Cut and paint, or drill and inject with Roundup®. Care needed due to sharp spines. Mechanical removal has also been used in some suitable sites.
Herbaceous weeds in native, grassy understorey	
African Lovegrass (Eragrostis curvula)	Removal by mattock Slashing or mowing when possible to reduce biomass (clump size) followed by spraying of re-growth with Roundup®. Spot spraying also possible. Response to herbicide can be variable.
Other exotic grassy/ herbaceous weeds	Limited, cautious spot spraying with non-selective herbicide Roundup® timed when possible to coincide with seeding of native grasses. Use of fire to isolate weeds for discrete treatment with Roundup®. Also hand removal.
Other weeds	
Green cestrum (*Cestrum parqui)*	Scrape and paint with Roundup® (both sides of stem), or cut and paint with Roundup® can both be reasonably effective, although difficult to achieve 100% success. Some degree of re-shooting occurs with both methods, requiring re-treatment. If there is accumulated sediment around plant base, scrape and paint may be preferable. For large plants, cutting back stems to gain access to and expose the lignotuber, followed by drilling and injection of lignotuber can also be effective. Some success also with use of selective herbicide Grazon® at Fairfield City Farm.
Wandering Jew (*Tradescantia fluminensis)*	Spraying of non selective herbicide Roundup® is effective. Plant is photo-inhibited so reacts best when treated on overcast days after rain. Raking is also possible, including where there are areas of native grasses. Hand weeding of smaller or sparser amounts.
Tree of Heaven (*Ailanthus altissima)*	Basal bark application of Garlon ® and diesel. Caution advised due to possible allergic respiratory reaction to Tree of Heaven.
Honey Locust (*Gleditsia triacanthos)*	Stem injection from early spring well into Autumn. Care needed due to sharp spines.
Privet (*Ligustrum spp.)*	Cut and paint or drill/chisel and inject with Roundup®
Celtis australis	Drill and inject with Roundup®

APPENDIX E Map Detail



Natural vegetation, Sydney, 1788



Natural vegetation, Sydney, 1990

ACKNOWLEDGEMENTS

A great many people have contributed their time and expertise to the development of these guidelines. They were substantially written by Debra Little and based on her interviews with expert bush regeneration practitioners on the Cumberland Plain.

In finalising the guidelines the following people are gratefully acknowledged.

Peter Dixon	Department of Infrastructure, Planning and Natural Resources
Rebecca Coventry	NSW Agriculture
Tim Wilkinson	Department of Infrastructure, Planning and Natural Resources
Jo Ann Moore	Department of Infrastructure, Planning and Natural Resources
Peter O'Malley	Department of Infrastructure, Planning and Natural Resources
Louise Brodie	National Parks & Wildlife Service
Richard Davies	Greening Australia
Michael Druce	former Hawkesbury Nepean Catchment Management Trust

Most of the funds for the project were provided by the former Hawkesbury Nepean Catchment Management Trust. Additional funds were provided by the Department of Infrastructure, Planning and Natural Resources and from the National Bushcare Program to assist in the printing of the guidelines.

The project was also assisted by the Australian Association of Bush Regenerators, which acted as a referee and provided technical input. The Association also is happy to endorse the Guidelines.