5. Weed Management

Effective weed management strategy requires a large-scale, long-term weed control strategy (Moody & Mack 1988, Storrs 1996a and Storrs 1996b, Rea and Storrs 1999). Too often, insufficient attention is given to developing an effective strategy, with the emphasis on weed control tactics (i.e. the specifics of herbicides, and other control procedures) rather than focusing on the invaded ecosystem and its management (Hobbs & Humphries 1995). Moreover, many weed-control strategies are written without consideration for reducing the long-term costs of weed management or recommended follow-up weed control does not happen.

Strategic weed management requires detailed planning and needs to be fully integrated into all long-term management programs (Storrs and Lonsdale 1995, Storrs et. al. 1996). It must be recognised that weed management is inseparable from land management, and that weeds interact with fire, feral animals and other factors. Weeds are both a symptom and a cause of land management problems and cannot be seen separately from other land management activities.

The preliminary weed survey presented here shows that for effective management of weeds on Aboriginal land there needs to be a concentration of resources on the following:

- the prevention of introduction of new species
- the prevention of dispersal and establishment of existing weeds
- the reduction of human-induced disturbance

5.1 Effective prevention

> *Perhaps the most powerful tool against weed incursions is to prevent them in the first place (Storrs and Lonsdale 1995).*

Prevention is also the most cost-effective way to stop the establishment of weeds and consequent damage to the environment. Invasive weeds must be stopped from accidentally or intentionally entering clean areas. Around half of the noxious weeds in Australia were introduced intentionally (Panetta 1993). A total of 61% of weeds on Aboriginal land were introduced intentionally either as pasture or ornamental species (see Section 4.3).

While weed seeds are dispersed by a variety of agents, analysis of the dispersal syndromes of non-native noxious weeds around Australia revealed that humans contributed in some way to nearly 90% of cases, including 21% that were dispersed by humans alone (Panetta & Scanlan 1995). Lonsdale and Lane (1993) demonstrated in Kakadu that tourists' vehicles did carry weed seeds albeit in small densities. They did, however, note that the study may have missed the more adventurous 4WD tourist, so their figures may not be truly representative. Natural agents of dispersal (e.g. wind, water, birds and native animals) are also at work. Routine surveys can nip new "random" outbreaks in the bud, e.g. new mimosa outbreaks in Kakadu National Park.

It is vital to intercept invasive plants before they enter clean areas. A major way to minimise risk is to control the importation of plant matter including seed or vegetative reproductive parts, soil and construction materials into weed-free areas.

Common methods of introduction include:

- Contaminated seed, hay, straw, mulch, feed.
- Movement of unclean equipment into uncontaminated country. Vehicles such as recreational 4WDs, tour vehicles, road-building and maintenance equipment, grass-slashers, hay and stock transporters etc are likely to be major carriers of weed seeds and propagules.
- By animals on fur, skin, feathers, fleece, through ingestion and possibly in crops of birds[9]
- Spreading of contaminated gravel, roadfill, topsoil.
- Plants sold through nurseries or distributed through landcare programs. Cultivation of plants or introduction of live plants into any area can be a source of weeds.
- Intentional introductions as improved pasture species.

9. Landowners from Old Mapoon in North Queensland are concerned about the possible spread of mimosa seeds by magpie geese from the Northern Territory onto Cape York and are currently investigating the possibility of this happening. Birds are also implicated in the movement of *Hymenachne amplexicaulis* between catchments in north Queensland.

5.1.1 Control of imports

There is in some cases a need to develop a prohibited list (probably impractical) or a list of approved plants, such as the list developed for Kakadu National Park or permits which outline conditions for the transport of hay. For example, the issuing of permits by the NLC could help stop uncovered hay from entering relatively clean areas e.g. along the Bulman track and into Daly River Land Trust. Currently permits are required for any hay to be taken through Kakadu National Park[10] and certain conditions apply. Recently *Andropogon gayanus* (gamba grass) was discovered at Nhulunbuy in two locations. It was presumed that the small infestations arrived as a result of the importation of hay for horse feed or garden mulch. Stopping the uncontrolled movement of hay should be a priority for much of Arnhem land and other areas where *Andropogon gayanus* (gamba grass) and *Pennisetum pedicillatum* (mission grass) are absent. Minimum standards for transporting hay through any area should be adopted such as all hay must be covered and certified weed free[11] (see best practices outlined in Appendix 2). Currently hay is being transported into Nhulunbuy by road and by barge.

An education program would need to be developed to complement any permit system so residents in permit areas don't sneak hay in the back of vehicles. There have been unconfirmed reports of Ramingining and Maningrida residents bringing in hay to use as mulch through Kakadu National Park—even though restrictions apply with heavy penalties. Residents from these areas need to be informed on alternatives to the use of hay as mulch for gardens. A range of other suitable products from the local area should be identified and residents encouraged to use these. The NLC should liaise with ALEP to identify local sources of mulch and distribute this information as part of their education program.

Given the relatively high percentage of weed species on Aboriginal land that result from escaped ornamental or pasture species (61%), there is a strong case in some areas to develop a prohibited list or an approved list of plant species. Experience elsewhere would indicate that permitted plant lists may be more manageable than prohibited lists. The latter would be very difficult to form and would be excessively large. At present there are no restrictions on the importation of plants into north east Arnhem land. Consequently regional centres are heavily infested with such plants, particularly the area around Nhulunbuy. Unless some controls are enforced the weed situation in this area will undoubtedly get worse. It is recommended that the NLC investigate the feasibility and desire of landowners to implement such a system in all applicable areas e.g. Beswick, Manyallaluk, Daly River/Port Keats, Upper Daly River and the Arnhem land Aboriginal Land Trusts. Where possible all plants used in theses areas for amenity or rehabilitation purposes should be locally collected species. Alternatively seed should be collected from local areas and sent to nurseries outside for propagation. These can then be re-introduced as container plants when required.

Special consideration should also be given to the introduction of improved pasture species (see inset text below).

Ponded pastures: intentional introductions

Humphries et. al. (1991) states that perhaps the most insidious and uncontrolled threat to the native communities of northern Australia are introduced pasture grasses; which are implicated in causing major changes to ecosystems. The introduced semi-aquatic grasses of *Hymenachne amplexicaulis* (Olive Hymenachne), cultivars of *Echinochloa polystachia* (Aleman Grass) and *Urochloa mutica* (Para Grass) are used for wetland pastures in the NT and were until recently being promoted for this purpose by the NTDPIF. The effects of these species are potentially serious and include reduced biological diversity with structural and functional deterioration of the ecosystems and possible complete alteration/modification of entire ecosystems. Cook (1993) argues that given the high conservation value of the Northern Territory wetlands, and the value placed on waterfowl as a food resource by Aboriginal people, the sowing of improved pastures is inappropriate and techniques need to be developed to revegetate wetlands with native species. These species are included by Humphries et. al. 1991 as some of 'top' environmental

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10. The control of importation of plants into Kakadu National Park is governed by the Commonwealth's *National Parks and Wildlife Conservation Act* (1975) particularly regulations 16, 19 and 20.

11. Weed free should be taken in the broad sense to include all unwanted plant species such including *Andropogon gayanus* (Gamba Grass) a species from which hay is often made.

Ponded pastures: intentional introductions

weeds in Australia. While there is little rigorous scientific data about the impact of these species, there is evidence that they form monocultures and are, in certain situations, invasive (Wilson et. al. 1991). *Hymenachne amplexicaulis* (olive hymenachne) has been listed as a weed of national significance (WONS). If these species are planted on Aboriginal land there is a risk that they will spread from the planted area and by the time their impacts are known one way or the other it may be too late (Rae and Storrs 1999). It is imperative that landowners receive culturally appropriate information about the potential effects species so they can make informed choices about the use of these and other pasture species on their country.

Unfortunately there is also a great risk that ponded pasture species will spread onto Aboriginal land from habitats within the same and neighboring catchments[12]. An ecosystems approach to weed management would indicate it is dangerous to plant such species anywhere in any catchment. All government departments should consider a moratorium on the planting of species that have weed histories elsewhere until a thorough assessment of their potential risks. Such action would be consistent with the NT Weeds Management Strategy 1996-2005, a recent Memorandum of Understanding (MOU) between the NTDPIF and the PWCNT and the National Strategy for the Conservation of Australia's Biological Diversity.

An excellent manual for using Weed Risk Assessment (WRA) to assess plants has been developed by Walton et. al. (1998). It is also important that any assessment applies to species that cause both environmental as well economic losses.

5.1.2 Control of sale

The weed situation is also further complicated by invasive exotic plants that are sold through nurseries and seed suppliers for use in ornamental horticulture, landscaping, soil conservation and as crop plants. This included those already known to be invasive weeds here in the Northern Territory as well as those which have serious weed records interstate. With the increase in species that are now available through nurseries the problem can only become worse. One nursery inspected in Nhulunbuy had a good stock of known weeds for sale, many of which will ultimately be destined to be problem plants for the town lagoon area which is already heavily infested with escaped garden plants.

Weeds CRC and the NLC could offer support to NTDPIF to assist in seeking some cooperation from the Nursery Association in the NT or individual nurseries and industry members to stop selling known weeds. The NLC could also liaise with interested parties on this issue. Industry could also develop voluntary labelling systems that advises customers of any potential weed problems. This is already under way with Weeds CRC and the NLC should liaise with this organisation. ALEP and ILMF could possibly advise communities on suitable alternatives to weedy species and how they can be obtained.

5.1.3 Washdown facilities

Figure 2 shows the spread of weeds on NLC lands to be along major and minor arterial routes. It is appropriate then that washdown facilities be used to halt the spread of seeds by these avenues. Research has shown however that tourist vehicles entering Kakadu National Park carry a very low density of seeds and most carry no seeds, or only one seed (Lonsdale & Lane 1994). In Iron Range National Park on Cape York, vehicles are known to spread the seeds of *Senna obtusifolia* when they become entrapped in radiators, bumper bars and other parts of vehicles. Unfortunately there is a paucity of data available in other areas on the spread of seeds by vehicles. Nevertheless this does not negate the need for functional washdown facilities to be installed at strategic locations. Many people consulted in this survey indicated they thought vehicles, including passenger and heavy vehicles and machinery, were responsible for the spread of many weed seeds. Locations for the installation of washdown facilities should include entry points into some of the larger areas of relatively weed-free

12 Some Agriculturalists in the USA believe that migratory birds were responsible for the movement of Hymenachne amplexicaulis (Rudge) Nees (Olive Hymenachne) from the West Indies to Florida where it is now a rampant environmental weed.

land trusts e.g. Bulman, Kunbarllanjnja, Daly River Crossing. Extra washdown facilities at Nhulunbuy are also probably warranted to keep weeds from this area

of the rest of Arnhem land. The possibility of a washdown facility at Perkins Barge facilities in Darwin[13] should also be investigated so equipment can be cleaned before it is sent to other areas. In each of these cases funds could be sought from stakeholders in the area to contribute to the costs of installation and maintenance. For example, Nabalco could be approached to support the Bulman and Nhulunbuy washdown facilities while Parks North could liaise with the NLC and Kunbarllanjnja Town Council and the cost could be incorporated into freight costs.

While enforcement may prove impracticable for independent passenger vehicles, it would be essential for road maintenance and slashing equipment, tour operators whose itineraries include areas of major weed infestations, stock transporters, earthmoving equipment and especially for animal catching contractors to be made to pass through such facilities. Once washdown facilities were established it could be condition of entry on NLC issued permits that vehicles be washed down.

Although washdown facilities should be built primarily for the use of contractors and other operators it is recommended that all road users be encouraged to use the facilities—particularly muddy vehicles and vehicles that have visited sites of major weed infestation. Interpretive material (signs) on weed issues could be provided beside these facilities and when permits are issued by NLC printed interpretative materials could be included to encourage their use.

To be effective washdown facilities need to be theft and vandal proof. Strong portable washdown facilities are currently being manufactured out of old shipping containers by “Container Engineering” , P.O. Box 257 Virginia Qld 4014 Tel: (07) 3865 8251. Standard modules are around 8ft wide easily accommodating passenger and light commercial vehicles.

5.1.4 Early detection

The most important weapon against the threat of widespread weed invasion is early detection (Storrs and Lonsdale 1995). Hobbs and Humphries (1994) also argue early detection and treatment of invasions will prevent many future problems. Eradication is a cost-effective form of weed management when action is initiated during the early stages of invasion (Panetta and Scott 1995). Wherever weed populations have been allowed to build, control has generally been proven to be either extremely costly or ineffective. It is essential then to make sure that available resources are used for weeds well before their numbers increase. Many invasive species, when introduced into an area, undergo an ‘establishment phase’, a ‘lag phase’ and then an ‘explosion phase’ (Groves 1986). Although the lag phase may last for decades, in the explosion phase the population of the weed may grow exponentially. This is certainly the case with *Mimosa pigra* in the Northern Territory (Braithwaite et. al. 1989, Lonsdale 1993). Weeds should where possible be controlled before the explosive stage, after which it is often too late.

Early detection, then, relies on landowners and managers to notice something new and to call attention to new plants appearing on their country. Most landholders interviewed during this study identified the need for improved education material for plant identification (see Section 7 for more details) and easier access to training programs (see Section 6). Other needs included information on the process of what to do about weeds seen on country including culturally appropriate information on who to call or take weed specimens to for identification. The NLC could consider some form of interpretive material (such as posters or calendars that include contact information). Consideration should be given to presenting information in different languages. NLC should liaise with interested parties on this e.g. NTDPIF, Weeds CRC, ALEP, ILMF and AQIS.

5.1.5 Surveying susceptible areas

Certain types of ecosyst.ems are more prone to invasion by weeds than others (Storrs and Lonsdale 1995, Storrs et. al. 1996). For example, riparian systems are usually the most heavily weed-infested areas in most catchments in the Northern Territory. Further, most of the critical (often the most highly invasive) weed species identified by Humphries et. al. (1991) are either restricted to floodplain habitats or form their densest infestations along watercourses e.g. *Mimosa pigra* (mimosa).

13. This could be very important considering many of the ports and mine sites in Indonesia, Irian Jaya and PNG are infested with many weeds including the highly invasive *Chromolaena odorata*.

Weed Management

Given that we know the preferred habitats for this species and these can be roughly located using vegetation mapping data, it seems sensible that a proactive approach to seeking out populations of this species will in the long term be an extremely cost-effective form of weed control.

Once mimosa becomes established it is very expensive to control and virtually impossible to eradicate. Recent new sightings of populations of this species previously outside the known range highlights the urgent need to survey and control any as yet unknown infestations. Anecdotal evidence from landowners and pastoralists suggests that buffalo catchers in the 70s and early 80s were responsible for the spread of weed seed, in particular mimosa seeds. The NLC should look to secure funds, possibly from bodies such as the ILC to investigate buffalo catcher camps and to trace their movements across Aboriginal land. Methodologies for this work could include interviewing Aboriginal landowners, stock inspectors and the buffalo catchers themselves. The interrogation of NTDPIF stock inspector files would also be useful. This information will highlight potential mimosa infestations. Immediate surveys of these priority areas should then be undertaken before any mimosa populations reach a size where they become unmanageable[14]. There is also some urgency to carry out this work before buffalo catchers and NTDPIF stock inspectors from this era pass on or move to other areas.

Other areas that need to be surveyed include campsites used by Aboriginal people and tourists on the Bulman to Nhulunbuy track. This work needs to be carried out in conjunction with traditional owners whose country the road traverses. Yirrkala Business Enterprises (YBE) has responsibility for road maintenance for this section of the track and could get funds from the roadside weed program currently being administered by the NT Department of Transport and Works. The NLC could assist YBE in sourcing this money. Further potential investigative work that could lead to early detection of weeds includes surveying areas where widespread vegetation disturbance has occurred because of the installation of optic fibre cable lines, gas pipelines, Telstra lines etc.

The NLC needs to investigate the feasibility of sourcing funds to carryout appropriate weed surveys in conjunction with traditional owners for these areas.

5.2 Effective control

All weed management programs should consider a range of different control techniques that can be cost effectively incorporated into a flexible integrated control program suited to local conditions. Integrated weed management should ideally be undertaken on a catchment basis, bearing in mind that non-water transportation of weeds in and out of the catchment is also a major consideration. Shared catchments need to be managed in conjunction with adjacent landholders. The liaison with adjoining landholders should be an important part of the overall strategy. It should be recognised that cooperation is a very important part of integrated weed control because weeds know no boundaries. Further, all weed control work should be focused on strategically controlling weeds according to regional or catchment management plans. The basic concept of a regional weed management strategy are listed in the inset text.

Regional or Catchment Strategies

The aim of regional or catchment strategies are to increase the effectiveness of inputs into weed management by acknowledging the components necessary to undertake effective and efficient weed control by outlining strategic and coordinated approaches to their use. The production of weed strategies are the first step necessary in controlling weeds. They should address the following points:

1. Regional coordination: there will be increased efficiency and effectiveness of weed management through the coordination of all stakeholders in the catchment. For example landowners controlling *Senna alata* (candlebush) on Arafura floodplain areas will only achieve satisfactory results when adjoining landholders control infestations up-stream.
2. Acceptance of roles and responsibilities: successful weed management relies on the participation of all landholders and there needs to be a regional recognition that weeds affect

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14 The recently discovered mimosa infestation on the Phelps River, just north of Ngukurr in the Roper District, reached a size of 45 ha before detection. It was originally presumed this infestation began from seed dropped by buffalo catchers in the early eighties however magpie geese are also now considered to be a possible vector for this species by some Ngukurr residents.

Regional or Catchment Strategies

3. everyone. There is a need to maximise ownership of the weed program by stakeholders and to utilise the skills and experiences of every person in the local community.
4. Identification of resources: weed control needs considerable resources such as expert people, expensive equipment and funding: All these need to be identified.
5. Quarantine and hygiene: preventing spread of weeds to new areas is an important part of long-term planning.
6. Assessing the problem: collecting all available data on weed species, their distribution (mapping of weeds) and phenology. Information collected here helps in strategic planning and timing of weed control activities.
7. Identifying suitable control measures: weed control should form part of long-term land management programs. The various control methods available should be identified and integrated into these management programs.
8. Monitoring and evaluation: these are essential parts of the regional weed strategy enabling stakeholders to check on the progress and make appropriate changes. This may mean developing performance indicators for assessing the success of the strategy and to develop procedures for reviewing the strategy.

Effective weed control often relies on the combination of a number of technologies, the choice of which is generally determined by compatibility, effectiveness, cost, current land use, extent of weed problems and environmental effects. However in some cases, for example where early detection has been possible, simple handpulling of isolated seedlings may be adequate. Weed control should be integrated into other programs such as feral animal control, fire management and land rehabilitation. One of the major goals of the Northern Territory Weed Management Strategy (1996) is to ensure weed management is an integral part of land management.

Physical and chemical control methods can be appropriate especially when integrated with other methods such as biological control, manipulation of fire regimes and promoting the growth of indigenous plants. Because of the complexity of environmental, economic and land management concerns associated with weed management, programs that are based on a combination of technologies are likely to be more effective. No weed control technique used in isolation will succeed as well as the use of a range of techniques applied to the problem (Groves 1991). This is particularly so for large expansive infestations such as mimosa or gamba grass. Successful results from a weed control program will only be achieved over the long term.

There is a significant difference between weed control in conservation areas to that in agricultural or some pastoral areas. Control methods used in agricultural systems further simplify an already simplified ecosystem by attempting to remove the ‘weed’ component of the biodiversity. In contrast, the aim in natural systems is to maintain or even enhance biological diversity and thereby reduce the chance of weed invasion. Widespread use of herbicides in natural areas is generally not regarded as a sustainable long-term practice in weed control because reduced biological diversity is almost certain to result. Herbicides are also very expensive. However, in the short term it may be necessary to control particular highly invasive weed species with herbicides e.g. the control of mimosa at Kunbarllanjnja.

So far very few techniques have been developed specifically for weed management in conservation areas (Groves 1989) as there is limited ecological and environmental information on even the most common weeds with respect to natural systems. The Northern Territory Government (1977) recognises the consequences of herbicide use in natural ecosystems and has recommended that its effects be monitored, with this monitoring funded by both the government and chemical companies. It should be noted, however, that newer herbicides are often less toxic, have short residual times and are more specific than even a few years ago.

Land management remains the cheapest and most sustainable form of weed control available and also aims to promote the growth of desirable species which compete with weed species. Planned use of fire is a method that can be used to conserve natural plant communities and to control the growth of undesirable plants invading those communities (Christensen & Burrows 1986). In the past perhaps too much emphasis was placed on removing undesirable plants while re-introduction or encouragement of native species was neglected.

Whatever control method chosen, weed removal should be coordinated with a viable and achievable rehabilitation and revegetation strategy. Strategic re-establishment of vegetation is an important part of redressing the environmental problems associated with weeds.

5. 3 Control techniques

5.3.1 Physical control

Physical methods are one of the oldest forms of weed control and until recently were the only means available to control weeds. The advantages of physical means include that they can often be applied with machinery or equipment that is readily available, they can be cost-effective, they are often relatively non-polluting to the environment and non-toxic to the operator. The appropriate physical method can also help to retain ground cover and discourage the germination of weed seeds. The main disadvantage of physical means is the low cost-effectiveness when applied over large areas. Other disadvantages can be that some species are actually spread by seeds and the fragmentation of plant parts and the transfer of material to other areas e.g. slashers used for weed control in the Top End may have been responsible for the spread of *Pennisetum polystachion* (mission grass). The use of machinery may also cause a loss in stability of the ecosystem resulting in poor structure and erosion. In some instances, unless best practices suggested in Appendix 2 are adhered to, the disturbance of soil by this method can stimulate seed germination and growth.

Physical methods of control include the planned physical or manual cultivation of invaded land such as grubbing, hoeing, pulling, cultivation, chaining, nets, mulching and slashing. Physical removal of individual plants is a most effective method for woody shrub species particularly in areas where the population is sparse e.g. mimosa on floodplains. In such situations physical removal has the advantages of being immediately available and cheap. It does not usually affect non-target species.

5.3.2 Chemical control

Chemical control involves the use of herbicides. Herbicides are powerful management tools and must be used carefully and according to the advice or instructions available. The chemical control of weeds can be very expensive but, if used judiciously, can play an important role in an integrated weed management program. Only registered herbicides should be used. A control program that abandons herbicide altogether is likely to be tedious and risks becoming ineffective (Nazer 1994). Chemical control can be very effective in limiting newly discovered infestations which have yet to spread. For extensive or widespread populations herbicidal control is still seen as one of the most cost-effective methods of control for certain weed species. However on marginal grazing lands where productivity is low or where no income is derived from the land then herbicide may not be economically feasible. This may also be the case near human inhabitation or near recreation areas.

There are two types of herbicide:

- non-residual: these herbicides usually have a short life and only work on the plants that are sprayed (unless there has been drift or volatisation).
- residual: these herbicides have a longer life and remain active in the soil killing seedlings that may grow up in the area later after the parent infestation has been killed.

Some of the more common methods of application are:

- Foliar spray (high, low or ultra-low volume applications)
- Rope wick
- Basal bark
- Cut Stump
- Stem injection
- Soil application

Information on chemicals can be found in Material Safety Data Sheets (MSDS) which have information on toxicology etc. supplied by the producer of each herbicide. Also from Harden and Hamilton (1988), Howard (1991) and Parsons and Richardson (1992).

5.3.3 Biological control

Biological control is an attempt to restore the balance to systems that go out of kilter. It involves using natural predators or diseases to control certain weeds. The strategy is to reduce the weed population to an acceptable level which is sustained by continued attack of the predator. For plants invading nature reserves where low-cost control and minimal disturbance are important considerations, biological control methods have a considerable and continuing role to play (Groves 1989). Biological control of certain widespread invasive species e.g. mimosa, is probably the only feasible long-term management solution, however the effectiveness of this method for this species is yet unproven.

A biological control program has four main stages:

- Overseas exploration.
- Quarantine testing and host specificity testing.
- Mass rearing and release.
- Monitoring.

In the Northern Territory the weeds *Salvinia molesta* (salvinia) and *Sida acuta* (broom bush) are both effectively controlled by biological control agents. Eleven biological control agents have been introduced for the control of mimosa, four of these are widespread and abundant.

Once biological control agents are widespread they can be integrated with other forms of control to produce the most cost-effective integrated management program. How this integration will occur varies from situation to situation depending on the other control options available and the mode of action of the biological control agent. For example, leaf and stem feeding insects alter a plant's susceptibility to herbicides.

5.3.4 Land management

The following activities can be used in an integrated weed management plan as tools to help control weeds.

Reduce grazing: Weeds are generally opportunistic and will often germinate in bare areas denuded by overgrazing. The removal or reduction in grazing pressure is usually important to re-establish desirable species, thus assisting in weed control. In some rare situations more palatable weed species can be temporarily managed through judicious grazing.

Fire: Fire can be a very important tool in weed management; it is therefore important to integrate fire management with weed management programs. The different components of a fire regime—frequency, season and intensity—may be used effectively to retain the natural element and control the invasive element in the flora of the reserve (Groves 1989). However the effect of fire on the ecosystems of the Top End is poorly understood, let alone its effect on weed species. Frequent firing can favor aggressive introduced species (Christensen & Burrows 1986). Fire can aid in the germination of some species which can be an advantage if some form of follow-up control such as cultivation or spraying is carried out.

Hygiene: A lot of weeds enter clean areas via the importation of contaminated soil, garden refuse, machinery, stock feeds or pasture seeds. The aim is to stop movement of weed seeds in and out of any weed-free areas.

Revegetation: Wherever possible use native species of trees, shrubs and grasses. Choose native species that originally come from the area to be revegetated. The aim is to out-compete weeds and reduce their numbers. In particular, it is important to consider the benefits of revegetating with native grasses. Once native grasses have disappeared from ecosystems they become prone to invasion by other less desirable grasses such as *Cenchrus ciliaris* (buffel grass). Buffel can alter fire regimes and hence reduce the opportunity for re-establishment by native grass species. Further incursions of buffel then affect viability of shrub layers and the ecosystem becomes open to further exotic species invasion. Quick replacement of any displaced native grass layer in a vegetation community will create a healthy functioning ecosystem as well as protecting it from erosion.

5.4 Recommendations

Recommendation 13: Where possible NLC to assist in the development of controls on the importation of plant matter, soil and construction materials into weed-free areas. For example, a policy and list of acceptable species for introduction of needs to be developed for the Arnhem land area.

Recommendation 14: NLC to raise the profile of weed issues among landowners, local community residents, members of the public, tourism industry, contractors and government departments working on Aboriginal land. (Liaise with all those with an interest.)

Recommendation 15: NLC to consider the development of an approved list of species to guide landholders and residents to appropriate native species suited for their country.

Recommendation 16: NLC to facilitate the development of alternative lists of plant species that are suitable for plantings on Aboriginal land. The replacement of some crop trees and screening of shrubs are of paramount importance. Lists of species need to be developed for improved pasture areas, particularly ponded pastures, that don't include the current suite of highly invasive exotic plants. (Liaise with ALEP,ILMF.)

Recommendation 17: NLC to liaise with nurseries in rural and remote areas to suggest alternatives to selling weed species or Northern Territory plants out of their genetic range e.g. Nhulunbuy nurseries. (Liaise with ALEP, ILMF, NTDPIF PWCNT.) Possibility of including some sort of status category like Australian-made.

Recommendation 18: NLC to coordinate an education program designed for local community councils and resource centres to make them aware of the importance of not importing weed species. (Liase with ALEP, ILMF, NTDPIF.)

Recommendation 19: NLC to liaise with NTDPIF pastures re the assessment procedures used to determine release of pasture species.

Recommendation 20: NLC to investigate landholders' desire to install washdown facilities at strategic locations to prevent the entry of weeds onto relatively weed-free areas.

Recommendation 21: NLC to consider making permits that regulate the movement of hay through Aboriginal land compulsory, ensuring best codes of practice are conditions of entry to Aboriginal land. For example, sourcing hay from weed-free crops.