Flora conservation issues at Kinchega National Park, western NSW

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Kinchega National Park reserves significant stands of *Eucalyptus largiflorens* open woodland on the Darling River floodplain, low open *Maireana pyramidata* shrubland and *Casuarina pauper/Alectryon oleifolius* open woodland on dune systems. We identify four key issues for the conservation of flora in Kinchega National Park, western NSW. These are:

1) There is an urgent need to initiate regeneration in a number of long-lived perennial trees and shrubs. Failure to do so will lead to local population declines and extinction in a number of species. Reduction in grazing impacts of rabbits and goats is needed. Some degree of rabbit control has been achieved over the last few years through a combination of the effects of the rabbit calicivirus disease (RCD) and an extensive rabbit control program for the reserve.

2) The need to initiate a water plan of management for the reserve to overcome the problem of changes in water flows, flood periodicity and flood magnitude that have occurred in response to water regulation activities on the Darling River.

3) Management of several threatened species and ecological communities on the reserve, in particular the nationally vulnerable species *Acacia carneorum* and *Solanum karsense*. Kinchega NP is the only conservation reserve containing populations of these species and these populations are significant for both species.

4) Management of weeds, in particular those with bird-dispersed fruits as these species have the potential to become severe problems on the park.

Other issues that are likely to be significant in the future are salinity impacts and the interaction between grazing pressure, regeneration and climate change.

Introduction

Management of formal conservation reserves needs to address a range of issues from biodiversity conservation, cultural heritage and recreation. In arid and semi-arid Australia, including far western NSW, the reserve system sits within a landscape that has only been partially cleared of native vegetation. However, much of the landscape has been modified by less dramatic changes, particularly by grazing pressure from stock and introduced feral pests (James et al. 1999). Management of a reserve in this context must consider a range of landscape factors impacting on both the reserve and the surrounding areas.

In arid landscapes throughout the world, grazing management is an important issue for the conservation of flora and fauna habitat (Benson 1991, Fuls 1992, Milton 1994, James et al. 1999). These areas receive little rainfall and plant recruitment is generally triggered by rainfall events (Robertson 1988, Milton 1995). Such recruitment may be tenuous if grazing alters this rainfall driven recruitment process. Changes in such landscapes may be rapid for fauna, for example the decline and extinction of medium size mammals in arid Australia (Morton 1990, Dickman et al. 1993), and for short-lived plants (ephemerals), for example the temporal changes in presence and abundance — (Robertson 1988). However, changes in populations of long-lived taxa such as perennial plants may occur very slowly, and it may be difficult to recognise the existence of a decline without some understanding of the dynamics of species and the processes that control recruitment and growth (Harper 1977, Watson et al. 1997).

With the recent release of the Kinchega National Park Plan of Management (NPWS 1999) and the recent vegetation map of the park (Westbrooke et al. 2001) it is timely to consider the key conservation issues facing the park in the context of its regional landscape. Plant nomenclature follows Harden (1990–1993).

Kinchega National Park

Kinchega National Park, 32°28'S 142°20'E, lies adjacent to the Darling River in western NSW, 113 km south-east of Broken Hill (Fig. 1). The climate at Kinchega NP, is one of low erratic rainfall with no predictable seasonality (average 236 mm per annum) combined with high summer temperatures in excess of 40°C (Robertson et al. 1987). The Park, covering 44 182 ha, was gazetted in 1967 and was the first national park declared in western NSW. The main biological reasons for the reservation of Kinchega NP were to protect samples of the major semi-arid and arid landscapes in western NSW, in particular the Darling River floodplain and large stands of low open shrublands of *Maireana pyramidata* (Black Bluebush). The two major lakes that are largely surrounded by the park (Lakes Menindee and Cawndilla) are not part of the national park.

The vegetation of Kinchega NP has been described in Westbrooke et al. (2001). The most widespread communities are *Eucalyptus largiflorens* open woodland on the floodplain near the Darling River and Tandou Creek; open woodlands of *Casuarina pauper* and *Alectryon oleifolius* on the dune system in the southwest of the park; and low open shrublands of *Maireana pyramidata* on ancient weathered dunes bordering the floodplain. Open shrublands of *Acacia* spp., *Eremophila sturtii*, *Dodonaea viscosa* subsp. *angustissima* and *Senna artemisioides* also occur in the reserve (Westbrooke et al. 2001).

Kinchega National Park has a rich and diverse ephemeral flora (annuals and short-lived perennials) (Robertson 1987, 1988, Kinchega NP plant list 2000, Westbrooke et al. 2001). This component of the flora is dynamic with the distribution and abundance of species across the landscape varying in response to seasonal rainfall and flooding (Robertson 1987, 1988). The Asteraceae (some 70 native and 20 introduced species), Chenopodiaceae (some 61 species) and Poaceae (some 39 native and 16 introduced species) are the dominant plant families on the reserve. The genera in these families

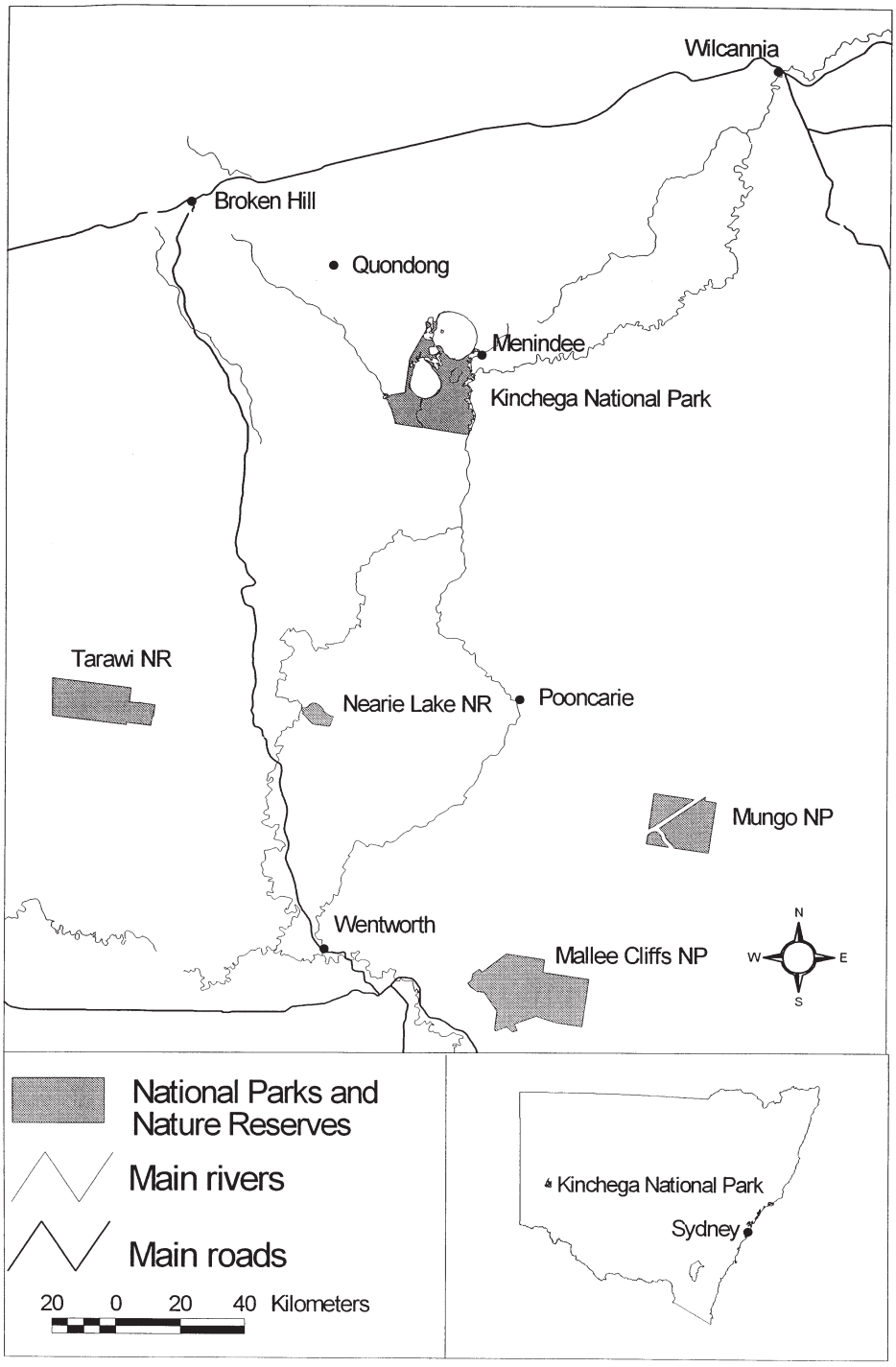

Fig. 1. Location of Kinchega National Park in western NSW.

with the largest number of species on Kinchega NP include *Atriplex* (13 spp.), *Brachycome* (8 spp.), *Calotis* (7 spp.), *Eragrostis* (6 spp.), *Maireana* (15 spp.), *Rhodanthe* (9 spp.), *Sclerolaena* (14 spp.) and *Senecio* (11 spp.). Whilst a few are long-lived perennials, most of these species are a component of the ephemeral flora and the variation in timing of rainfall can transform the landscape from a daisy dominated one to a chenopod dominated one or vice versa. Other genera with a number of species occurring on Kinchega NP include *Acacia* (12 spp.), *Eremophila* (8 spp.) and *Sida* (9 spp.).

Domestic stock grazed the area since the 1860s and the park has been fenced to exclude stock since its inception in 1967. Rabbits, *Oryctolagus cuniculatus*, first reached the area in about 1881 (Caughley 1987) and are now widespread. The major native mammalian grazers on the park are Red, *Macropus rufus*, and Western Grey, *Macropus fuliginosus*, Kangaroos. Euros, *Macropus robustus*, and Eastern Grey Kangaroos, *Macropus giganteus*, occur in small numbers. Goats are uncommon but variable in abundance while pigs are widespread.

Key Issues for Vegetation Conservation

Conservation of long-lived perennial tree species

In arid western NSW, the very high extinction rates for small to medium sized mammals since European settlement are well documented (Morton 1990, Dickman et al. 1993). In contrast, there have only been two extinctions of plant species (Leigh et al. 1984), one small shrub (*Acanthocladium dockeri* — recently rediscovered in South Australia) and a subshrub (*Senecio behrianus*). Grazing by stock and rabbits is thought to have been responsible for the loss of these two species (Leigh et al. 1984).

Many of the plant species and communities currently at risk of extinction or serious decline are large shrubs and small trees that are perennial and long-lived. There is now a large body of evidence from a range of species and locations that suggests that regeneration from seed in many dominant arid plant perennial trees/large shrubs has been eliminated over the last century across a broad area in far western NSW and arid South Australia (Crisp & Lange 1976, Crisp 1978, Chesterfield & Parsons 1985, Lange & Graham, 1983, Auld 1990, 1993, 1995a, 1995b, Woodell 1990, Tiver & Andrew 1997). The cause of this lack of regeneration is grazing by rabbits, goats and domestic stock. Consequently, given the longevity of the parent plants, we predict that we are on the verge of a major episode of decline and local extinction of many plant species and associated communities (including dependent fauna) in these areas. We argue that it is simply the longevity of the plants that were growing at the time of European settlement and the subsequent introduction of pest species, that has masked declines towards extinction in the area.

At Kinchega NP, in the dune country in the southwest of the park, the pattern is one that is typical for the landscape as a whole. There is evidence of a systematic failure of recruitment in the 20th Century in several species (see Table 1) and evidence of the retreat and decline of others that occur in the area. Key examples are *Acacia carneorum* (Purple-wood Wattle, a nationally vulnerable species, Auld 1993), *Acacia loderi* shrublands (an endangered ecological community in NSW, Auld 1995b), *Acacia aneura*

(Mulga), *Callitris gracilis* subsp. *murrayensis* (Murray Pine), *Casuarina pauper* (Belah) and *Alectryon oleifolius* (Western Rosewood). As Westbrooke et al. (2001) have shown, belah/rosewood is a major dominant community in southwestern Kinchega NP. *Acacia aneura* and *Callitris gracilis* subsp. *murrayensis* are highly restricted and scattered on Kinchega NP, but the patterns on the Park are typical of the widespread dying and declining stands of *Aacacia aneura* to the northwest of Kinchega NP and declining stands of *Callitris* to the south and east of Kinchega NP. Both species are retreating to wetter areas where the balance between recruitment success and grazing pressure is more in favour of the plants. Some species such as *Myoporum platycarpum* (Table 1) and *Acacia oswaldii* (Auld 1995a) have some regeneration occurring, but it may be insufficient to maintain populations in the long-term. For *Myoporum platycarpum*, regeneration appears spatially variable at Kinchega NP, with little regeneration on dune systems in the southwest of the Park.

Table 1. Species and Plant communities showing evidence of lack of regeneration on Kinchega National Park.

Species/community	Abundance on park and comments on decline
Acacia aneura	Rare, mostly scattered individuals with canopy dieback. No significant recruitment.
Acacia brachystachya	A few plants only with canopy dieback.
Acacia carneorum	Significant populations, all except one with no evidence of recruitment in past. Some vegetative recruitment recently initiated following rabbit control program.
Acacia ligulata	Several large populations. Several in serious decline, a few with evidence of good recruitment.
Acacia loderi	Several large occurrences. Seedling recruitment absent. General absence of regeneration except at one site where limited vegetative regeneration occurred following rabbit control.
Acacia oswaldii	Widespread as scattered individuals. Recruitment by seed only. Seedlings and some juveniles present but limited by rabbits. Highest recruitment under nurse plants such as *Maireana pyramidata.*
Alectryon oleifolius	Extensive stands. Young saplings from seed extremely rare. Some vegetative recruitment recently initiated following rabbit control program.
Callitris gracilis subsp. *murrayensis*	Rare, mostly scattered individuals with canopy dieback. No recruitment except at two individuals where caging has excluded grazers.
Casuarina pauper	Extensive stands. Seedling recruitment absent. Some recruitment of vegetative suckers to maintain stands. Some areas of extensive dieback.
Exocarpos aphyllus	Uncommon, associated with *Casuarina pauper* or *Eucalyptus largiflorens*. Small individuals absent suggesting a lack of regeneration.
Hakea leucoptera	Scattered stands or individuals. A few stands of mixed size classes, most occurrences with no regeneration and dieback of canopies. No seedling recruitment. Some vegetative recruitment recently initiated following rabbit control program.
Myoporum platycarpum	Common, scattered individuals and some denser stands. Recruitment by seed only. No regeneration in dunes in southwest, but mixed size stands in northwest.
Pittosporum phylliraeoides	Widespread, especially in west. Vegetative suckering widespread. Recruitment levels from seed unknown.
Santalum acuminatum	Rare. Vegetative regeneration prevented by grazing, some regeneration in rabbit proof exclosures.
Templetonia egena	Scattered individuals associated with *Casuarina pauper.* No regeneration.

On Kinchega NP there have been several attempts to control rabbits using biological control (myxomatosis) and local ripping of warrens. Following the accidental introduction of rabbit calicivirus disease into the area in 1996, at Kinchega NP there was an extensive program to rip rabbit warrens and poison rabbits where warrens could not be ripped due to the presence of long-lived perennials. This program was put in place to maximise the extent and scale of reduction in rabbit numbers and to reduce the future rate of population growth in rabbits. If regeneration is to be initiated in many of the perennial plants on the park, both rabbit and goat numbers must be kept low in the long-term. Whilst kangaroos will browse some seedlings and juvenile plants, as well as crushing seedlings sheltering under other shrubs through their habit of utilising hipholes in shady areas, there is no evidence that they eliminate recruitment at Kinchega NP (Auld 1993, 1995a, 1995b). Monitoring of regeneration on park in selective exclusion plots since 1996 has revealed some possible regeneration (Denham & Auld unpubl.), however, the first few years after the dramatic reduction in rabbit numbers from calicivirus and rabbit control, were dry and not conducive to regeneration. The key test for whether or not rabbit numbers are low enough to allow long-term regeneration will be in the next drought, when rabbits have little available food and can ringbark and kill young perennial plants.

Key conservation recommendations are:

a) continue control and monitoring of rabbit numbers;

b) reduce goat impacts through continual goat control;

c) continue monitoring of regeneration in key perennial plant species.

Wetland management and flooding regimes

A large component of the park is essentially an ephemeral wetland (Fig. 2) including:

a) the floodplain of the Darling River and associated Tandou Creek dominated by *Eucalyptus camaldulensis* along the Darling River and large areas of *Eucalyptus largiflorens* (Black Box) woodland, overlying grey cracking clays on the floodplains and along Tandou Creek;

b) the lakes including water storage Lakes Menindee, Cawndilla and Speculation (now more or less permanently filled), and remaining ephemeral lakes (e.g. Emu Lake, with extensive stands of lignum (*Muehlenbeckia florulenta*);

c) the numerous small depressions with *Eucalyptus largiflorens* (Black Box) or *Chenopodium nitrariaceum*. These fill from flooding of the Darling River or Tandou Creek, or in some cases only from heavy local rain.

There have been extensive changes to the historic flooding regime at Kinchega NP. Primarily these have resulted from the development of the Menindee Lakes scheme in 1960s, but they are also the result of water extraction all along the Darling River above the park. Flooding into the park from downstream along Tandou Creek, due to the presence of weirs below the reserve, is also affecting water flows.

The flora and fauna of the Darling River floodplain and associated wetlands and overflow lakes within Kinchega NP are dependent upon periodic flooding and

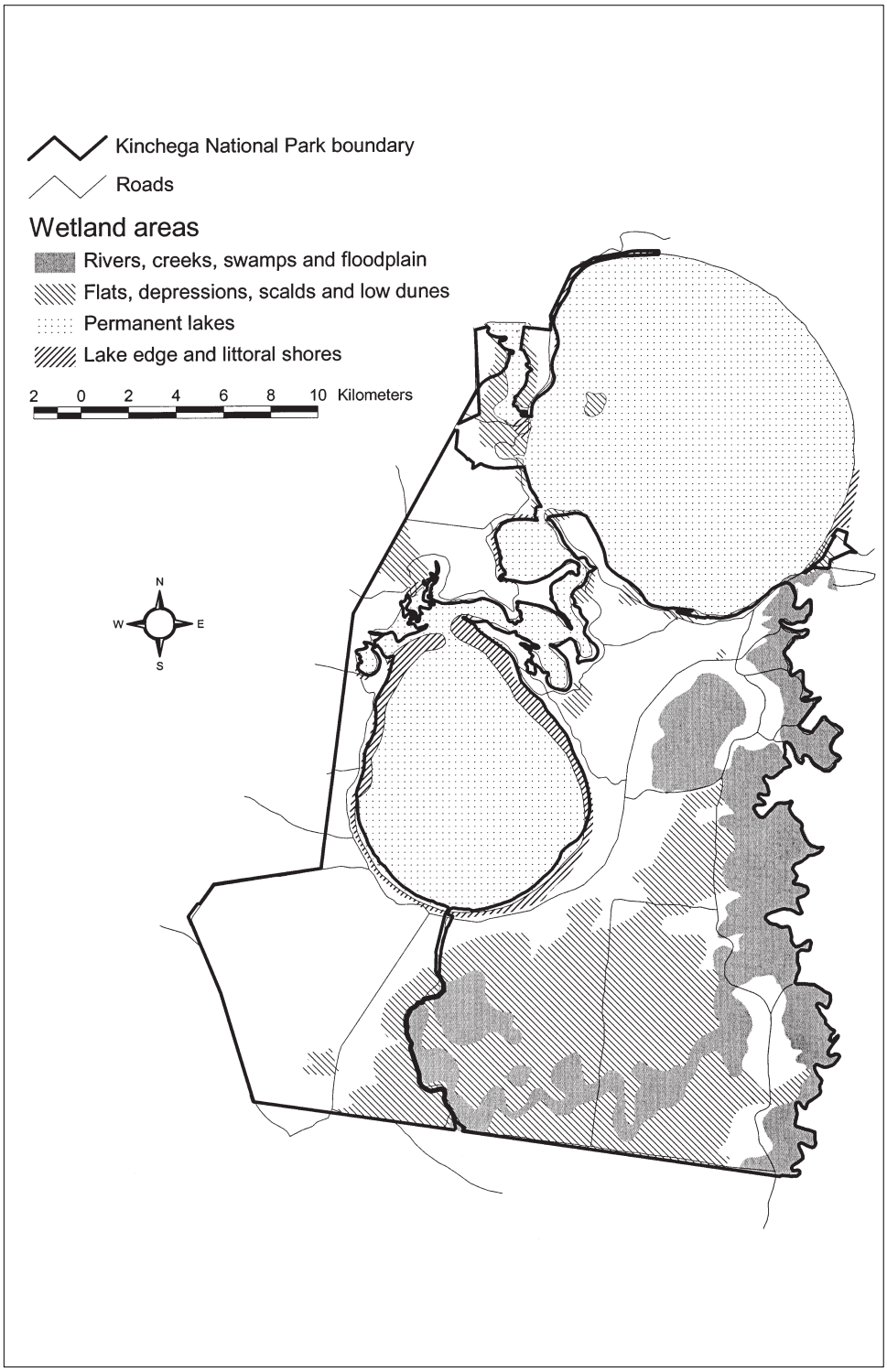

Fig. 2. Distribution of wetland habitat at Kinchega National Park. Some small ephemeral depressions that only fill from heavy local rain are not mapped.

subsequent drying for their continued survival, as are most wetland systems (Kingsford 2000). Key water requirements for flora and fauna concern the periodicity and magnitude of flooding and the length of time an area is flooded or left dry.

Water management issues for biodiversity conservation on Kinchega NP are:

a) Lakes Menindee, Cawndilla and Speculation are now more or less permanently filled and subsequently biologically depauperate in plant and animal species, including the loss of habitat for the vulnerable plant *Solanum karsense* and the loss of extensive stands of Black Box. The numbers of duck species and wading waterbirds, including Paleartic migrants, has also probably decreased (Auld & Kingsford 1992, Kingsford unpubl.).

b) a decline in flood frequency and intensity on major watercourses in NSW, including the Darling River and hence Kinchega NP (Kingsford 2000). This has particular consequences for the large remaining ephemeral lake (Emu Lake) which is habitat for the vulnerable plant *Solanum karsense*, as well as for the persistence of flora and fauna on the extensive floodplain areas;

c) flooding of non wetland habitat by over-filling of Menindee and Cawndilla lakes. This has resulted in loss of several stands of the endangered *Acacia loderi* shrubland community;

d) repeated long duration flooding of several small ephemeral lakes which fill off Lakes Menindee and Cawndilla when high lake levels are maintained. This reduces the productivity of these wetlands, making them less acceptable to diverse types of waterbirds as well as destroying the habitat of the vulnerable plant *Solanum karsense*;

e) serious disruption of the natural drainage patterns of several small ephemeral lakes and Black Box swamps through the construction of the Cawndilla channel which connects Lake Cawndilla to Tandou Creek to the south. These areas previously filled from floodwaters from Tandou Cereek, but now one ephemeral lake fills directly from the Cawndilla channel only, and others fill when water frequently backs up along Tandou creek from the south of the park or when Tandou creek itself floods from the Darling River. This has resulted in the loss of large areas of Black Box trees in two depressions and may impact on the long-term viability of this habitat for a number of wetland plants, including the vulnerable plant *Solanum karsense*, and waterbirds that breed in the trees during floods (cormorants, spoonbills, etc.).

Recommendations for water management

Water management is a key issue for the conservation of plant and animal biodiversity on the park (NPWS 1999). Recommendations for water management are:

a) wetlands require periodic drying to maintain their natural productivity (Briggs 1988, Brock 1999, Casanova 1999);

b) wetlands should not be flooded continuously or tree death and loss of biodiversity is likely to result (Kingsford 2000). Even flooding for two continuous summers has

led to the death of extensive stands of *Eucalyptus largiflorens* in depressions near Tandou Creek on Kinchega NP (Auld unpubl.); and

c) when flooded, wetlands should remain inundated continuously for a period of time, eg. four to six months, to ensure appropriate conditions for plant and invertebrate succession (Briggs 1988, Brock 1999, Boulton 1999). Waterbirds require at least this period to acquire necessary body reserves for egg laying, incubation and fledging of young.

d) There needs to be consideration of environmental water flows for maintaining wetland habitat on Kinchega NP.

Threatened species and species of conservation significance

Several plants or ecological communities that are listed as threatened on the *NSW Threatened Species Conservation Act 1995* (TSC Act) occur at or near Kinchega NP as do some rare or poorly known species (Briggs & Leigh 1996). For these species/communities, special management is required to maintain viable populations into the future.

Acacia loderi Shrubland — an endangered ecological community in NSW. This community is threatened by a lack of regeneration of the dominant tree species due to grazing pressure. It is only reserved in Kinchega and Mungo National Parks. In Kinchega NP, successful recruitment from seed has not been observed, and while a cohort of suckers in one area is extensive, overall it appears that the overstorey species is in decline (Auld 1995b). Reduction in rabbit grazing pressure and elimination of goats in Kinchega NP would help promote regeneration of *Acacia loderi*. Also on Kinchega NP, some small stands of the community have been destroyed by flooding as a result of over-filling Lake Menindee. This long-lived tree is killed by flooding and further artificial flooding of its habitat should be prevented.

Acacia carneorum (formerly *Acacia carnei*) — a nationally vulnerable species. This species occurs in arid western NSW and eastern South Australia (Auld 1993). Its only occurrence in a conservation reserve is at Kinchega NP. On Kinchega NP, there are a number of large and small stands and this reserve represents a significant long-term conservation area for *Acacia carneorum*. This species produces vegetative suckers up to twice a year, and is thought to be highly clonal at each known site. Vegetative suckers are readily eliminated by rabbits (Auld 1990, 1993). Rabbits occupy warrens in the sandy dunes where *Acacia carneorum* occurs. In Kinchega NP, in the early 1990s, one patch of *Acacia carneorum* showed signs of successful regeneration from suckers in the recent past, while the remaining locations showed no evidence of regeneration (Auld 1993) .

Estimates of plant age from five samples of wood taken from five different plants for carbon-14 dating indicate that *Acacia carneorum* standing plants may vary from 120 (± 52) to 330 (± 60) years old (ANU 7855–7859, 81 (± 52) BP to 290 (± 60) BP, where BP is before present =1950). This would suggest that it is likely that there has been little or no regeneration in the species since sheep and rabbits arrived in the area. Recent reductions in rabbit numbers across the park have led to some successful recruitment of vegetative suckers, but it is too early to tell if these will persist through the next dry

period (Denham and Auld unpubl.). Seed production in *Acacia carneorum* is extremely rare. Two sites that regularly produce seed are known from Middlecamp Station to the southwest of Kinchega NP. On Kinchega NP, there is one patch of *Acacia carneorum* plants that regularly initiates fruits following flowering (other sites flower but do not initiate fruits). However, successful seed production at this site is rare and limited in magnitude. These fruiting sites are very important in the long-term conservation of the species as it is only from dispersal of seeds from these sites (some seeds are dispersed by birds) that new sites can be initiated or old, now extinct sites, can be recolonised. Continued control of rabbits and goats is necessary to maintain *Acacia carneorum* on Kinchega NP and elsewhere.

Solanum karsense — a nationally vulnerable species. This species is endemic to NSW and is essentially confined to the floodplain lakes and depressions of the Darling (below Wilcannia) and Lachlan River systems. It is only known to be reserved in Kinchega NP. The distribution of *Solanum karsense* in Kinchega NP (Fig. 3) is essentially restricted to areas that are periodically flooded (i.e., ephemeral lake beds, Black Box swamps). A few plants have been found on the side of Old Pooncarie Rd but were probably moved there as seeds in soil during road maintenance. When the habitat of *Solanum karsense* is flooded the species survives as seed in the soil of the lake beds (Monaghan & Brownlee 1979). After these areas dry out seeds germinate and young plants emerge from the cracking grey clays. These juvenile plants require 3–6 months to mature, flower and set seed, after which the populations decline and eventually only the soil seedbank is left. The species may be clonal (Purdie et al. 1982) and has spreading lateral roots which can produce new shoots (Monaghan & Brownlee 1979). Germination will once again occur after the next flood cycle or possibly following high local rainfall events. Key water management requirements for *Solanum karsense* are:

i) After a flood recedes, a minimum period of 6 months is required to allow fruiting and replenishment of the soil seedbank. Repeated flooding at short intervals must be avoided; and

ii) long periods of continuous flooding should be avoided. The species has been known to survive for two years under continuous flooding, i.e. beyond the limit for mature Black Box, but it is not known for how much longer seeds can survive. Areas that are effectively permanently flooded are no longer suitable habitat for this species.

Swainsona adenophylla — a species endangered in NSW, not threatened nationally. This species has been recorded from Kinchega NP (Thompson 1993). The species has not been seen on the park since 1974, despite extensive plant collecting on the park. It is likely that this species is locally extinct in Kinchega NP, or if it still occurs on Kinchega NP, is very restricted and ephemeral in nature. Further searching in seasons favourable to the growth of *Swainsona* spp. and in the favoured habitat of the species, sandy flats near lake margins, is needed to try and relocate this species.

Swainsona pyrophila — a nationally vulnerable species, has been recorded for the park in 1973 (Bowen & Pressey 1993) and recently (Westbrooke et al. 2001). We believe that this species is not likely to occur on the park as the species is generally found in mallee

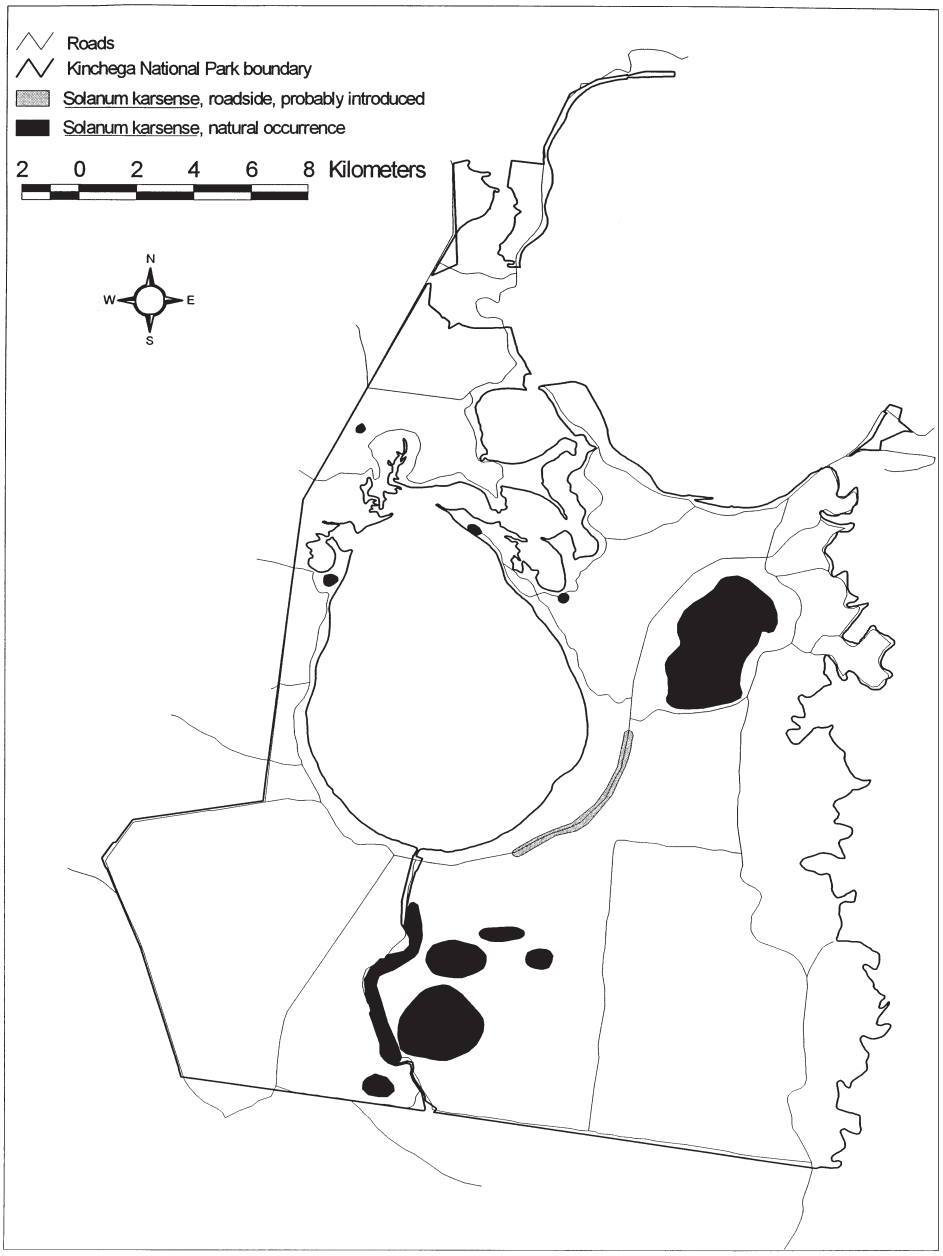

Fig. 3. The distribution of the vulnerable plant *Solanum karsense* on Kinchega National Park.

habitat far to the south and east of Kinchega NP. Records for *Swainsona pyrophila* at Kinchega NP are likely to be misidentifications with *Swainsona laxa*. *Swainsona laxa* was formerly known as *Swainsona rigida*, while *Swainsona pyrophila* was formerly known as *Swainsona laxa* (Thompson 1991, 1993). Taxonomic confirmation of the specimens from Kinchega NP is required.

Haloragis exalata — a nationally vulnerable species, has recently been recorded for Kinchega NP (Westbrooke et al. 2001). This is a major extension of range for this species and is also not in its usual habitat of damp riparian areas (Harden 1990–93, Walsh & Entwisle 1996). Since other *Haloragis* spp. occur in Kinchega NP, taxonomic confirmation of the specimens from Kinchega NP is required.

There are a number of species that are potentially threatened which have been recorded on Kinchega NP. Some of these are locally common, but have been rarely been collected in NSW, for example *Amaranthus grandiflorus*, *Phyllanthus lacunarius* and *Senecio murrayanus*. Given the abundance of these taxa on Kinchega NP, they are likely to be more widespread and are not likely to be threatened. *Echinochloa lacunaria* is a poorly known species (2K, Briggs and Leigh 1996), that is locally rare at Kinchega NP and has a limited distribution outside of Kinchega NP; while *Sida* sp. C (referred to as *Sida spodochroma* in, Walsh and Entwisle 1996) is infrequent where it is known to occur in far western NSW (Harden 1990–93), including at Kinchega NP. Further surveys of *Echinochloa lacunaria* and *Sida* sp. C in suitable habitat in western NSW are needed to determine whether they are threatened.

There are a number of species with distributions that include Kinchega NP as an outlier. Some examples include *Acacia tetragonophylla* (1 plant known), *Acacia colletioides* (2 plants known), *Acacia burkittii* (a few plants in a clump), *Eucalyptus socialis* (3 small clumps known), *Sarcostemma australe* (one diffuse clump on a lunette) and, Tri*odia scariosa* (one clump now thought to be locally extinct). These are all very old plants where future local recruitment is unlikely.

Three taxa of conservation significance occur near Kinchega NP. Despite extensive plant collecting in Kinchega NP over 30 years, there have been no recorded sightings of these species on the reserve.

*Acanthocladium docker*i was a nationally presumed extinct species from near Kinchega NP (Bowen & Pressey, 1993) that has been rediscovered in South Australia. Searches for this taxon have failed to relocate it near Kinchega NP.

Atriplex infrequens is a nationally vulnerable species where the type specimen (from 1860) is thought to come from Lake Pamamaroo, just to the north of the Park (Wilson 1984). It has not been recorded from the area since.

Atriplex morrisii is a poorly known species (Briggs & Leigh 1996) and is known from some 40 km NNE of Menindee.

Management of weeds

A number of weed species occur on the park, and while many currently occur in low numbers it is likely that without significant management action they will become a

conservation problem. The weeds that are of most concern, yet are most likely to respond to changes in management, are shrubs with seeds dispersed by birds and perennial herbs including *Lycium australe* (Australian Boxthorn), (Chr*ysanthemoides monilifera* (Boneseed) and *Arundo donax* (Giant Reed). Local infestations of the first two of these weeds respond favourably to simple management strategies such as cutting and painting with herbicide, while the last appears to require more effort to physically extract and remove rhizomes. Monitoring and mapping of these weeds should continue indefinitely to ensure that they do not become more widespread (NPWS 1999). Other, ephemeral, weeds which may have significant impacts include *Asphodelus fistulosus* (onion weed), *Echium plantagineum* (Paterson's Curse), *Carrichtera annua* (Ward's Weed), a range of grasses (*Bromus* spp., *Hordeum leporinum*, *Rostraria pumila*, *Schismus barbatus*, *Vulpia muralis*), *Ricinus communis* (Castor Oil Plant), *Xanthium occidentale* (Noogoora Burr), *Argemone ochroleuca* (Mexican Poppy), *Acetosa vesicaria* (Rosy Dock), *Emex australis* (Three-cornered Jacks), *Centaurea melitensis* (Maltese Cockspur) and *Nicotiana glauca* (Tree Tobacco). For a number of these ephemeral weeds, there can be extensive areas of the park where they dominate or co-occur with native species in some seasons. At other times they may not be obvious in a native dominated flora. Particular problems occur after winter rains and it may be that the weeds have competitively excluded a number of native winter growing forbs and grasses. Solutions to such widespread but temporal weed issues are not currently available and may depend on future biological control actions.

Other Issues

Two areas where biodiversity impacts may occur in the future are the impacts of salinity and climate change. Although there has not been extensive clearing of vegetation in the Kinchega NP area, the maintenance of permanent water in the Menindee Lakes Scheme may cause local uprisings in the water tables in adjacent dryland areas. Recently, within Kinchega NP an area of several hectares has developed extensive death and dieback of *Casuarina pauper*. This may be influenced by rising water tables and salt levels along with the lack of regeneration issue already discussed earlier. Rising salinity levels in the Darling River catchment generally may also influence the long-term survival of wetland/floodplain vegetation.

The impact of future climate change may be important in altering the balance between grazing and recruitment in perennial plants by influencing both the pattern and amount of rainfall and evapotranspiration. Current predictions for the area suggest a slight increase in temperatures (0.5–1.5°C) and a 2–10% decline in daily rainfall by 2030 (Environment Protection Agency 1997). Such predictions would imply a decline in recruiment success in perennial species (given constant grazing pressure) under future climate change.

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