Threatened Species and Farming

South-eastern Red-tailed Black Cockatoo:

Management of Buloke feeding habitat in the Southern Wimmera

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SUMMARY

This study was funded by the *Ecologically Sustainable Agriculture Initiative* (ESAI) of the Department of Primary Industries. It is one of seven case studies investigating management techniques for threatened species in the context of improvements in agricultural production that are ecologically sustainable over the long-term. The focus of this study is the nationally endangered South-eastern Red-tailed Black-Cockatoo (RtBC).

The RtBC population is thought to be limited by food availability, and the most depleted of its food sources is the seeds of the Buloke tree. Almost all remaining mature Buloke trees within the range of the RtBC occur on private agricultural land, and conservation of these is essential to the future of the RtBC population. However, losses of these trees continue, and recruitment of new Bulokes is largely prevented by the major land uses in the area.

This study comprised three components. The first component involved an experimental trial of stock-proof fencing around paddock trees. This component aimed to a) identify the degree to which bark damage and canopy senescence could be reduced by the use of stock-proof fencing, and b) determine whether fruit production and/or quality were impacted, either positively or negatively, by protection from livestock.

Stock damage to the bark of unfenced control trees was found to be severe compared to fenced trees. There was an increase in mean bark damage scores of control trees of 53%, compared with a decrease of 25% for fenced experimental trees (due to previous damage becoming less evident). Damage due to cattle, particularly bulls, was more severe than that caused by sheep. Despite this difference in the degree of bark damage, there was no significant difference in canopy health, cone density, seed weight per cone, or ratio of seed to cone mass between fenced and unfenced trees. However, a slight non-significant trend towards lower ratios of seed to cone mass (less profitable foraging trees) in more damaged trees suggests that further monitoring to identify longer-term influences of fencing would be desirable. Fencing of even individual trees or small groups appears to be a successful strategy to minimize bark damage and does not appear to depress fruit production, at least in the short term.

The second component of the study involved an aerial photograph analysis to assess the rate of loss of paddock Buloke trees within the RtBC's range. The aims of this component were to a) determine the rate at which Buloke trees, an important food source of the endangered Red-tailed Black-Cockatoo (RtBC), are being lost from within the cockatoo's range, b) assess the amount of Buloke revegetation occurring in the area, and c) to provide advice relating to revegetation and protection of existing Buloke trees in order to minimise the impact of current and future food limitation on the cockatoo population.

Analysis of aerial photographs revealed an average 25% loss of Buloke trees per focal area over a period of just 15 years. Losses in three of the five areas studied were above 33%, with trees in one area being reduced by nearly 39%. These losses are likely to be attributable largely to deliberate and accidental tree removal rather than natural tree decline, as losses in one area were just 4.4% over the 15-year period. Regeneration of Buloke was only evident on roadsides in the focal areas. Discussions with local residents identified that the major barriers to Buloke revegetation included the cost of and time and effort required for successful establishment.

In order to minimise the impact of Buloke tree losses on the RtBC, efforts must be made to a) protect existing mature trees, b) manage areas of regeneration appropriately, and c) offer incentives for revegetation of Buloke on private land along with the support necessary to achieve successful establishment. This analysis resulted in suggested action relating to management of existing Buloke feeding habitat as well as creation of future habitat, which will be further developed with other stakeholders.

Promotion of suckering may be a useful method of Buloke regeneration as it produces stronger, faster growing plants, is low cost, and requires lower levels of maintenance than planting seedlings. However, identification of the distance from parent plants at which sucker production can be initiated is required in order to determine the extent to which this method is useful. The final component of the study focused on a trial of soil disturbance at different distances from mature Buloke trees. Soil disturbance due to ripping at different distances from trees was employed at four sites to determine the maximum distance of reliable sucker production. Only one sucker was identified during the course of this study, at a distance of seven meters from the parent tree. Personal observations from the study area suggest that suckering is common within 12 m from a parent Buloke. Longer-term monitoring of the suckering trials would be valuable in identifying the maximum distance of reliable sucker production.

1. INTRODUCTION

1.1 Ecologically Sustainable Agriculture Initiative (ESAI)

"Threatened Species and Farming" is a sub-project of the ESAI. This project will identify how agricultural practices might be modified to help conserve selected threatened species as part of working toward ecological sustainability. The project will document case studies of selected threatened species in four bioregions: the Victorian Riverina, Wimmera, Victorian Volcanic Plain and Gippsland Plain. The farms considered include examples from the meat, wool, dairy and grains industries. This case study focuses on the south-eastern Red-tailed Black-Cockatoo *Calyptorhynchus banksii graptogyne* (RtBC).

1.2 The South-eastern Red-tailed Black-Cockatoo

The RtBC occurs only in south-western Victoria and adjoining far south eastern South Australia. The population is thought to consist of fewer than 1000 individuals (Hill 2000, Burnard and Hill 2002) and is listed as a threatened taxon under Schedule 1 of the Flora and Fauna Guarantee Act (1988) and the Environment Protection and Biodiversity Conservation Act (1999). The distribution of the RtBC in Victoria is limited to parts of the Wimmera, Victorian Volcanic Plain and Glenelg Plain Bioregions. In this area, the primary land uses are sheep grazing for wool and meat production, cattle grazing for beef, dryland cropping of cereal, legume and oilseed crops, and irrigated cropping of white clover for seed.

The RtBC is a specialised arboreal feeder and consumes only the seeds of three tree species: Brown Stringybark *Eucalyptus baxteri,* Desert Stringybark *E. arenacea* and Buloke *Allocasuarina leuhmannii* (Joseph 1982, Joseph *et al*. 1991, Maron 2000, Burnard and Hill 2002). Seed of Brown or Desert Stringybark is patchily available year-round (Burnard and Hill 2002, P. Koch, unpublished data) while Buloke seed is available during summer and early autumn (Joseph 1982, Maron 2000). Availability of food of sufficient quality is thought to be the primary factor limiting the RtBC's population size (Burnard and Hill 2002). A population increase, required to upgrade the status of the RtBC to Vulnerable, is therefore not likely without a corresponding increase in food availability. Indeed, continued removal of feeding habitat is likely to be driving a slow decline in numbers (Burnard and Hill 2002). This continuing loss of feeding habitat is a major hurdle to increasing the population size of the RtBC.

1.3 Buloke feeding habitat

Buloke woodland, which occurs in the northern third of the cockatoo's range, is by far the most depleted of the RtBC's feeding habitat types (Maron 2000, Maron and Lill 2004.) and is now listed as an endangered vegetation community under the EPBC Act (1999). Approximately 97% of original Buloke woodland has been removed (DNRE 1997). The vast majority of remnant Buloke woodland occurs on private land that is used for agriculture, and no significant area of it is reserved within the range of the RtBC. Most remnant Buloke occurs as scattered trees in grazed or cultivated paddocks (practices which prevent regeneration), or as thick regrowth of young trees on roadsides that are widely believed to be suckers (L. Morcom, unpubl. data). All remaining Buloke trees within the range of the RtBC have been mapped as habitat critical to its survival (Hill, unpublished data). Although stringybark habitat is more common and occurs throughout the cockatoo's range, Buloke is thought to provide a particularly nutritious food source, and may be of great importance to newly fledged birds, as the period of seed production coincides with fledging of young (Maron and Lill 2004).

1.4 Threats to Buloke

Ongoing loss of feeding habitat, through deliberate removal of vegetation and attrition of paddock trees, is the main threat to the RtBC (Burnard and Hill 2000). This threat is most pronounced in the case of Buloke, as almost all remaining mature Buloke occurs on private land rather than public parks and reserves. In particular, the recent trend toward the installation of centre pivot irrigation systems has resulted in numerous planning permit applications to remove mature Buloke trees. Centre pivots are used in spray-type irrigation. The spray arm pivots from a central point, so this type of system requires the removal of all trees within the reach of the arm for a full-circle paddock. Loss of Buloke trees, especially mature paddock trees, is of particular concern due to the difficulty involved in establishing young Buloke trees to replace them. Buloke regenerates both by production of seedlings and through vegetative suckers from roots near the surface. Successful regeneration by either method requires exclusion of grazing, and is then very slow. It may take as long as 100 years for young trees to gain a trunk diameter of 19 cm (Morcom in prep.), the size of the smallest Buloke in which a RtBC has been observed feeding (Maron 2000).

1.5 Research objectives

This project comprised three components, addressing the following questions:

1. To what degree can protection of paddock trees from livestock (e.g. with fencing) prolong their lives and/or improve their fruit production?

Buloke seedlings and suckers are extremely slow-growing, and take longer than 90 years before they are of a size which Red-tailed Black-Cockatoos will utilise. Additionally, large, old trees are favoured by the cockatoos when foraging (Maron and Lill 2004). If large old trees in paddocks suffer accelerated senescence due to livestock damage, it is likely that cockatoo numbers will also be affected. While efforts need urgently to be put toward revegetation and facilitation of regeneration in order to attempt to at least offset this loss, it is likely to be some time before resulting young Bulokes are available as a food source to cockatoos. In order to minimise the impact of this lag period, methods must be explored which will prolong the life of existing paddock trees. Fencing of individual trees in grazed and/or cropped paddocks may provide a compromise situation whereby farmers may continue current land use practices around existing trees while prolonging the trees' productive lives. Such protection may also affect cone production, either positively or negatively, through prevention of both bark damage and further soil compaction, and removal of other stock impacts from the area immediately surrounding the tree.

This component of the project aimed to identify changes in tree health and cone production related to the protection of individual trees and small clumps with stock-proof fencing.

2. What are appropriate revegetation/regeneration goals for Buloke in the range of the cockatoo, and how much Buloke regeneration/revegetation must occur annually in order to at least maintain the status quo?

Due to the apparently high rate of loss of mature Buloke trees, and the extremely long period before they are able to be fed in by Red-tailed Black-Cockatoos, a plan for protection of existing Bulokes and revegetation with Buloke within the cockatoo's range is urgently required. In order to set appropriate targets for revegetation, regeneration and protection of paddock trees, the net rate of loss of Buloke trees from the range of the south-eastern Red-tailed Black-Cockatoo must be determined. A comparison of the respective rates of loss from scattered trees on private land, and stands of trees on both public and private land, as well as from different land use areas, will provide valuable information which will assist in determining where protection, revegetation and regeneration effots need to be focussed.

The aims of this component were to a) determine the rate at which Buloke trees are being lost from within the cockatoo's range, b) assess the amount of Buloke revegetation occurring in the area, and c) provide advice relating to Buloke revegetation and protection of existing Buloke trees in order to minimise the impact of current and future food limitation on the cockatoo population.

3. What distance from a parent Buloke can sucker production be induced?

Buloke is a difficult species to revegetate with as it is highly palatable to introduced herbivores and livestock and extremely slow growing, and therefore susceptible to competition with weeds.

While some revegetation is essential in order to establish new individuals that are genetically diverse and in areas where no mature Bulokes remain, encouraging development of suckers by disturbing the root systems of existing trees may be a useful method of more quickly providing a food source for the cockatoos. Suckers are faster growing, and more resilient to grazing pressure by rabbits and hares, as they have access to effectively unlimited resources from the parent plant until they are established. However, the usefulness of this method is limited by the distance from the parent tree at which sucker production can be induced.

This component involved a series of trials where roots were disturbed at varying distances from trees in order to yield information to assist in artificially encouraging regeneration of Buloke feeding habitat for the south-eastern Red-tailed Black-Cockatoo.

2. METHODS

2.1 Tree protection

2.1.1 *Study sites*

The study sites for this component consisted of three properties with scattered Buloke trees, in Bringalbert South and Patyah. A total of 35 female Buloke trees in paddocks were selected at random at the study sites, with the majority (30) located on the Bringalbert South property. Stock proof fencing (either electrified or with five lines of plain wire and two of barb) were erected around the trees in April 2003, at approximately the distance of the outer drip line of the canopy (Figure 1). Gripple devices were used on plain wires to allow for ease of maintenance. In some instances small groups of trees were fenced in this way. For each experimental (fenced) tree, a nearby control (unfenced) tree was selected (Figure 1). This was typically the nearest female tree in the same paddock, although on six occasions, control trees were not available from within the same paddock and so controls were located in a nearby paddock subject to the same grazing regime.

Figure 1. Fenced Buloke tree in a grazed paddock (left) and a matched pair of trees, the left one unfenced and the right fenced (right).

2.1.2 *Monitoring of tree characteristics*

Tree characteristics were recorded for each tree immediately prior to fencing in April 2003, and subsequently in February of 2004 and 2005. The degree of bark damage due to stock (on the trunk below 2m) was estimated on a scale of 0 to 10, with 0 being no visible damage, and 10 being more than 80% ringbarked (Fig. 2). The apparent health of the canopy was also scored visually on a scale of 1 to 10, with trees with very little photosynthetic material scoring 1 and the healthiest trees with the densest foliage scoring 10 (see Fig. 3). All canopy health and bark damage estimates were carried out by the same observer in order to minimize observer variability. Cone production was also monitored. In 2004, no cones matured on the trees, a phenomenon which was apparent across the Wimmera. In 2005, cones matured as normal and scores of fruit density were estimated for each tree on a scale of 1-5, using the system of Maron (2000), with 1 being < 50 cones per branch (of approx. 15cm diameter at base) and 5 representing > 200 cones per branch. Ten cone samples were taken from each tree. These samples were stored in paper bags and allowed to dry at room temperature for three weeks before being subjected to 20 h in an oven at 38°C to speed dessication. Once the valves were open the seeds were removed from the cones and both seeds and cones were weighed separately for each tree.

Figure 2. Buloke trunk with no visible bark damage, scoring 0/10 for bark damage score (left) and Buloke trunk with severe damage and bare heartwood, scoring 9/10 for bark damage.

Figure 3. Buloke with dense, healthy canopy, scoring 9/10 for canopy health (left) and Buloke showing severe dieback, scoring 2/10 for canopy health (right).

2.1.3 *Data analysis*

Bark damage scores and canopy health scores from 2003, 2004 and 2005 were compared between fenced and unfenced trees using paired-sample t-tests. Fruit density, seed mass per cone and the ratio of seed to cone mass (seed ratio) in 2005 was compared between the two treatments using paired-sample t-tests. The seed ratio gives an index of the potential foraging profitability of trees (Maron and Lill 2004). Linear regression was used to identify relationships between the degree of bark damage and canopy health, and the degree of bark damage and the ratio of seed to cone mass.

2.2 Tree loss and revegetation targets

2.2.1 *Aerial photograph analysis*

Areas where Buloke occurs within the range of the RtBC were identified and five focal areas were selected on the basis of information on past sightings of foraging RtBCs (Fig. 4). The five areas covered land under both grazing and cropping regimes. The two most recent aerial photography runs that produced images at 1:25 000, the scale at which individual trees could be distinguished, were undertaken in 1997 (color digital) and 1981/82 (black-and-white conventional). Images centred on each of the five focal areas were obtained from each run.

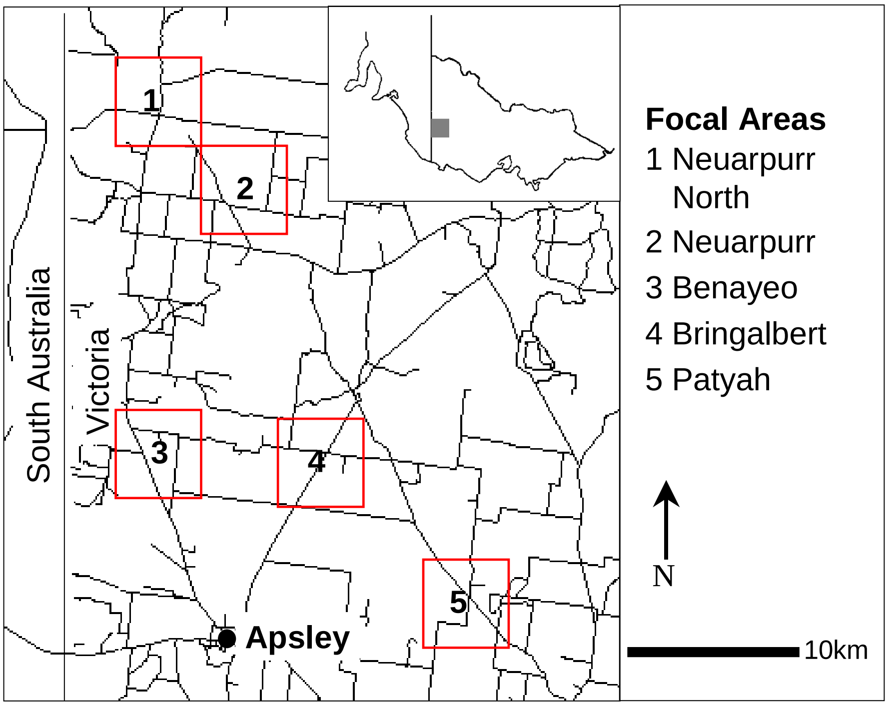

Figure 4. Map of the study area depicting the locations of focal areas.

Regions of each image where tree species other than Buloke (i.e. *Eucalyptus* species) predominated were identified on the basis of visual characters evident from the images. A field survey was then undertaken in order to ground-truth the identifications, during which focal areas were surveyed from a slow-moving vehicle. The ground-truthing revealed that Bulokes were able to be distinguished from other tree species with high accuracy on the aerial photographs. The regions identified as being dominated by species other than Bulokes were excluded from the analysis.

The remaining area was partitioned on the basis of land-use as identified from the 1997 images and confirmed during the field survey. Paddocks were categorised as either 'pasture' or 'cultivated'. Paddocks were categorised as cultivated if they either appeared to hold a crop or crop stubble in the 1997 image or if they showed signs of recent cultivation (i.e. if regular sowing lines were visible). All individual Buloke trees in paddocks were counted, as were Bulokes in stands that were at densities low enough that individual trees could be distinguished. Five stands of Buloke were too dense for individual trees to be counted. In these cases, tree number was estimated on the basis of vegetation area, and it was assumed that no tree loss had occurred as all stands occupied a similar area in each year. Bulokes growing along roadsides adjoining private land were also considered in this study, as they can be affected by adjacent land uses. Additionally, roadside Bulokes were the only examples growing on non-agricultural private land in the focal areas studied and thus provided a comparison between the fate of Bulokes on public land and those on private agricultural land. The length of roadsides along which Bulokes were visible was measured for all images, as individual tree identification on roadsides was not possible due to the high density of vegetation. The figures for number of trees and length of roadside Buloke woodland for each focal area were compared between 1981/82 and 1997.

2.1.2 *Revegetation information*
In order to obtain some estimates of Buloke revegetation, information was compiled from interviews of individuals who have been involved with revegetation in the district in various capacities, including staff from the regional Department of Sustainability and Environment office, the Wimmera Catchment Management Authority, and Greening Australia, as well as the Kowree Farm Tree Group and local farmers.

2.3 Sucker encouragement

Three experimental plots were set up at two properties in order to determine maximum distance from a parent tree at which suckers can be produced following root disturbance. Each plot was protected with stock-proof fencing. At each site, a 15-m ripline (to a depth of aprrox. 20 cm) was created at various distances (5-25 m) from mature Bulokes (both male and female). Ripping was conducted on one side of each tree only in order to minimise risk of negative impacts on the tree. A total of 40 riplines were made and marked for later identification. Monitoring of ripped areas and measurement of any suckers produced was undertaken in February of 2004 and 2005, once surrounding annual grass residue had dried out, in order to allow easier visual detection of the green suckers.

3. RESULTS

3.1 Tree protection

The fences erected around the experimental trees effectively excluded the majority of stock with only one breach evident (i.e. one top wire was broken by bulls in 2004). The most cost-effective method of fencing was a single electrified wire. This type of fencing was inexpensive and quick to erect, and it is possible that in rotational grazing situations where electric fencing is used, temporary electric protection could be erected around particular trees in paddocks while stock are present.

Two of the three properties involved either switched from grazing of sheep to cattle, or intensified the rate of stocking of cattle, within six months of the initiation of the experiment. Partially as a result of these changes in farming practices, the impacts on control (unfenced) trees were substantial. Severe loss of bark and fresh partial ringbarking became visible on the majority of control trees within the first year. There was no significant difference in mean bark damage scores between fenced and unfenced trees in 2003, but damage scores were significantly higher for unfenced trees in 2004 and in 2005 (Figure 5, Table 1).

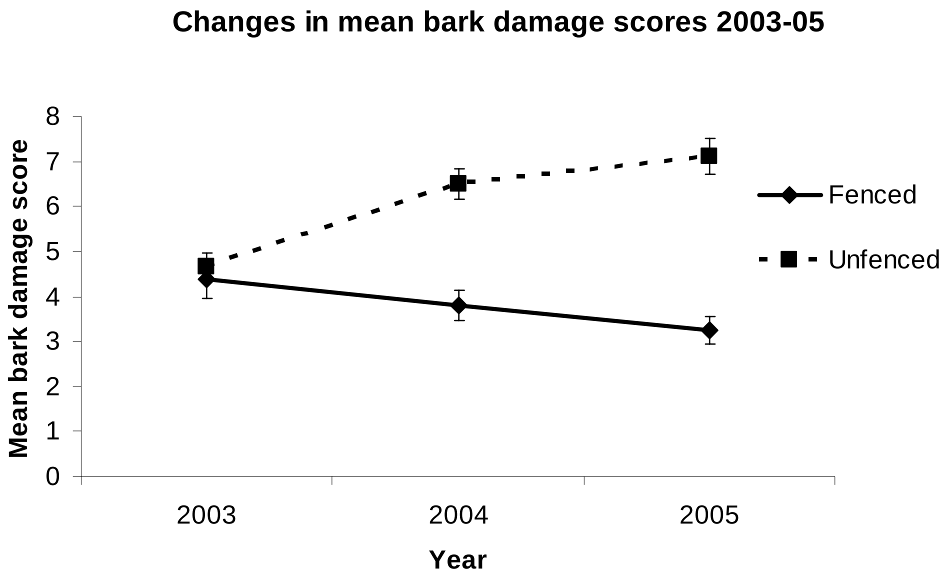

Figure 5. Changes in the mean bark damage score (±1 s.e.) of fenced and unfenced trees between 2003 and 2005.

Mean canopy health did not vary substantially over the course of the experiment. There were no significant differences in mean canopy health between fenced and unfenced trees in any year (Table 1, Figure 6), and canopy health was not significantly related to the degree of bark damage in 2005 (r^2 = 0.034, P = 0.125).

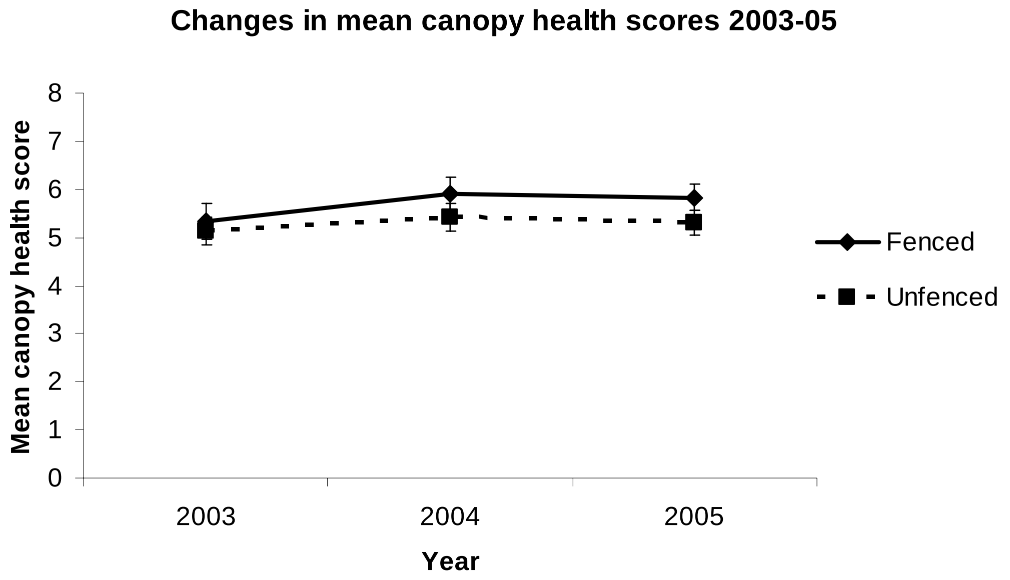

Figure 6. Mean canopy health scores (±1 s.e.) for fenced and unfenced trees in 2003, 2004 and 2005.

There was no significant difference in fruit density of fenced and unfenced trees in 2005 (Figure 7) (3.5±0.2 fenced vs 3.9±0.2 unfenced, t_{34} = 1.43, $P > 0.05$). Fruit from some trees could not be reached for sampling, and some samples were subject to insect attack following collection. These factors led to seed and cone data from seven pairs of trees being unavailable for analysis. Neither the total weight of seeds per cone nor seed ratio (the ratio of seed to cone mass) differed between fenced and non-fenced trees (Table 2). Although there was no significant relationship between the degree of bark damage and seed ratio (r^2 = 0.056, P = 0.074) the scatterplot suggested a slight negative relationship (Figure 8). be careful here, pretty much any line could be out through that scatter plot.

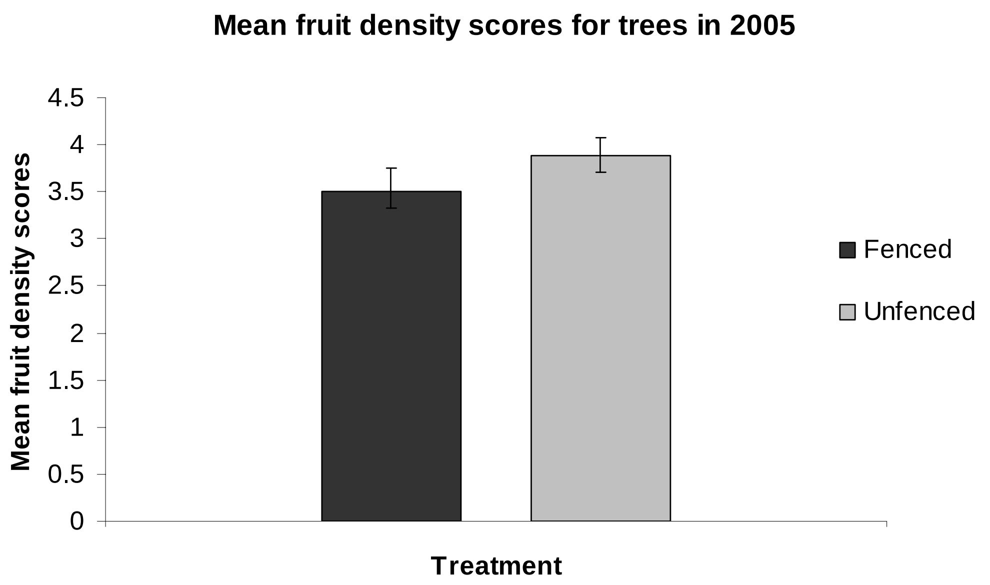

Figure 7. Mean fruit density score (±1 s.e.) for fenced and unfenced trees in 2005.

Table 1. Mean seed ratio and seed mass per cone and results of paired-sample t-tests for 2005 data. N = 56 in both cases.

	Mean			
	Fenced trees	Unfenced trees	*t*	*P*
Seed mass per cone (g)	0.056±0.004	0.055±0.005	0.102	0.919
Seed ratio	0.078±0.004	0.076±0.004	0.257	0.799

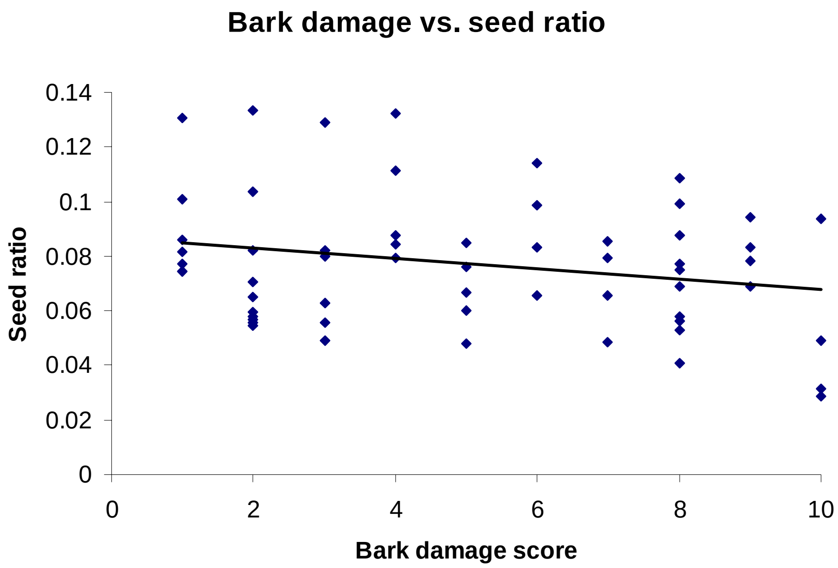

Figure 8. Relationship between bark damage score and the ratio of seed to cone mass (seed ratio) in 2005 (both fenced and unfenced trees included).

3.2 Tree loss and revegetation targets

3.2.1 *Paddock tree loss*

A total of 7850 ha of land supporting Buloke trees Buloke country was identified for the analysis. Nine thousand four hundred and seventy individual Buloke trees were counted from the 1981/82 aerial images, compared with 6967 from the 1997 images (Table 3), which equates to a total loss of 26.4% of trees from the five focal areas since 1981/82. The mean density of Buloke trees decreased from 1.25 trees/ha in 1981/82, to 0.96 trees/ha in 1997. The highest tree density was evident in the Bringalbert focal area (2.96/ha in 1982 and 2.41/ha in 1997) and the lowest was in the Neuarpurr focal area (0.068/ha in 1981 and 0.42/ha in 1997). The Neuarpurr area recorded the highest percentage loss of Buloke trees, but the greatest number was lost from the Bringalbert area (784 trees). The fewest trees and the lowest percentage of trees were lost from the Patyah area (18 trees, 4.4% loss).

Table 2. Loss of Buloke trees from focal areas in the southern Wimmera over the 15-year period 1981/82 to 1997.

		No. Buloke trees			
Focal area name	**Area (ha)**	**1981/82**	**1997**	**No. lost**	**% loss**
Neuarpurr	2320	1586	969	617	**38.9**
Neuarpurr North	2060	1662	1116	546	**32.9**
Bringalbert	1440	4257	3473	784	**18.4**
Benayeo	1500	1554	1016	538	**34.6**
Patyah	530	411	393	18	**4.4**
Mean	**1570**	**1894**	**1393**	**501**	**25.8**
Total	**7850**	**9470**	**6967**	**2503**	**—**

Sixty-three percent of the total area studied was identified as being recently cultivated at the time the 1997 image was taken. Buloke tree loss was 58% greater from these cultivated areas than from pasture (Table 4).

Table 3. Loss of Buloke trees from cultivated land and pasture between 1981/82 and 1997.

		No. Buloke trees			
Land use	**Area (ha)**	**1981/82**	**1997**	**No. lost**	**% loss**
Cultivation	4957	4645	3135	1510	**32.5**
Pasture	2893	4825	3832	993	**20.6**

The land-use practice that appeared to be the greatest factor in tree loss was centre pivot irrigation. No such irrigation was present in 1981/82 but in 1997, a total of 13 centre pivot circles were evident across two of the focal areas. Tree losses from these locations contributed disproportionately to total tree loss from each of these focal areas. Three times as many trees were lost per unit area from locations where pivot circles were present in 1997 compared to non-pivot areas in Neuarpurr North, and twice as many from pivot areas in Neuarpurr (Table 5).

Table 4. Loss of Buloke trees from areas where centre pivot paddocks were visible in 1997 as a percentage of total tree losses.

Focal area name	**No. pivot circles**	**Total pivot area**	**% of total area under pivots**	**% lost trees from pivot areas**
Neuarpurr	7	446.6	19.25	42.3
Neuarpurr North	6	459.0	22.28	63.6

3.2.2 *Roadside vegetation*
Buloke regeneration was evident along a total of 28.0 km of roadside in the five focal areas in 1981/82, and 30.2 km in 1997 (Table 5). Ground-truthing revealed that the majority of these roadsides currently consist of dense sucker regeneration with a few mature trees. Increases in the total length of roadside vegetation were visible for three focal areas: Neuarpurr, Bringalbert, and Benayeo (Table 6).

Table 5. Changes in length of roadside where Buloke-dominated vegetation was visible between 1981/82 and 1997.

	Length of roadside (m)			
Focal area name	**1981/82**	**1997**	**Difference (m)**	**% difference**
Neuarpurr	6550	6675	125	**1.9**
Neuarpurr North	5525	5525	0	**0**
Bringalbert	8125	9325	1200	**14.8**
Benayeo	4200	5050	850	**20.2**
Patyah	3575	3575	0	**0**
Average	**5595**	**6030**	**435**	**7.4**
Total	**27975**	**30150**	**2155**	**—**

3.2.3 *Revegetation/regeneration originating from the period 1981/82-1997*

The only revegetation/regeneration evident from the 1997 images that had not been visible in 1981/82 was roadside regeneration and a small area of revegetation (<1 ha) adjoining a centre pivot irrigation circle. However, the identity of the species present in the revegetated area is not known, and is unlikely to be Buloke as the trees had attained a large size by 1997.

Interviews with the following individuals took place:

<u>Interviewee</u>	<u>Organisation/occupation</u>
Allyson Lardner	Department of Sustainability and Environment
Andrew Bradey	Kowree Farm Tree Group & grazier
Max Skene	Wimmera Catchment Management Authority
Bill Wallace	Grazier (beef cattle)
Sue Close	Grazier (beef cattle)
Ron Dodds	Greening Australia
Dean Robertson	Wimmera Catchment Management Authority
Monica Kealy	Grazier (sheep)

Native Vegetation Retention (NVR) controls came into force in 1989. Prior to this time, there were no consistent statewide controls on the removal of native vegetation and so revegetation options were not routinely considered as part of a planning permit process. Since NVR controls were introduced, applications to remove native vegetation are generally referred to the relevant State Government department, now the Department of Sustainability and Environment. Such permits may be granted provided specific revegation recommendations or recommendations relating to the protection of existing vegetation, are met. Information gathered from interviews with A. Lardner of the Department of Sustainability and Environment and M. Skene of the Wimmera Catchment Management Authority, indicated that the recommendation specifically to replace Buloke trees with Buloke seedling revegetation (as opposed to direct-seeding, from which Buloke will not grow) was not commonly imposed until the early- to mid-1990's, and M. Skene notes that there was evidence of widespread lack of compliance with such permit conditions at least until the mid 1990's. Therefore, Buloke revegetation as a condition of permits for removal of trees would only have applied widely in approximately the last two years of the study period. Neither A. Bradey (Kowree Farm Tree Group & grazier) nor S. Close (beef cattle grazier)were aware of any Buloke revegetation occurring in the shire prior to the late 1990s. It is likely that some regeneration did occur during this period in areas other than roadsides, as a few landholders may have fenced off areas containing Buloke, but such fencing was not widespread. The author is aware of a site of several hectares near Patyah which was fenced approximately 12 years ago, and which contains some natural Buloke regeneration. However, the period during which tree loss was investigated appears to have been a time of substantial net loss of Buloke trees.

3.2.4 *Current revegetation efforts*

Several community projects and private landholders have attempted revegetation with Buloke during the past 4 years. A. Bradey established a plantation of 3000 Bulokes on a roadside near Neuarpurr in 1999 and believes that approximately 90% are still alive. However, these trees are at a density of 650 ha^{-1}, and so are at a much higher than estimated natural density for Buloke woodland (30–50 stems ha^{-1}, Morcom, in prep.). A. Bradey has planted a further 250 Bulokes recently on his own property. S. Close is aware of a laneway near Edenhope where 300 Bulokes were planted two years ago and the area was actively managed for weeds. She estimates that 100–150 are still alive. She has recently planted 50 seedlings on her own property. She is also aware of two small fenced sites of a few hectares each where natural regeneration is occurring. M. Kealy (sheep grazier) raised her own Buloke seedlings for 18 months to a height of approximately 40cm before planting them out, and she now believes the three-year old plantation consists of 80–120 Bulokes approximately 1.2–1.5 m in height. She is also aware of areas of Buloke being fenced on other properties between 6–10 y ago, but no natural regeneration has occurred within these areas. B. Wallace (beef cattle grazier) planted approximately 1200 Buloke seedlings in late 2002, and estimates that survival is approximately 60-70%, with losses partially attributable to dry conditions in 2002–03. Discussions with R. Dodds (Greening Australia) revealed that ten fencing projects funded under the Bushcare Remnant Vegetation Fencing Assistance scheme from 1998–2001 were located within the West Wimmera Shire, several of which included fencing of some Buloke woodland.

All individuals interviewed who had been involved in Buloke revegetation emphasised the difficulties involved. A. Bradey said that he is frequently approached by landholders interested in establishing Buloke, but that they lose interest when made aware that it must be planted rather then direct-seeded, and of the stringent, time-consuming and expensive requirements for maintenance. He believed that intensive weed control was required for at least 2–2.5 years. The trees he established in Neuarpurr have required fencing, four sprays with herbicide, fertiliser tablets and guarding of individual trees with landcare sleeves. M. Kealy stressed the difficulty in nursing Bulokes through the first summer and protecting them from European Rabbits *Oryctolagus cuniculus* and Brown Hares *Lepus capensis*. She says that her plantation required hand-watering several times throughout the first summer, and that weed control continues to be a major difficulty requiring frequent spraying.

The past two years have seen an increase in the number of planning permit applications for the removal of Buloke trees. Applications for permits to remove at least 446 Buloke from within the range of the RtBC were advertised over the 12-month period to 20 Feb 2003, and a further 14 applications were advertised which referred only to removal of 'trees' or 'native vegetation'. These permits typically would have required the planting of 15-20 Bulokes for each removed, although not all stipulated that Buloke be replaced. However, A. Bradey estimates that survival of Buloke revegetation is typically less than 5% due to the difficulties involved in successful establishment of such a slow-growing species.

3.3 Sucker encouragement

Only one sucker was produced from a ripline during this experiment, so no statistical tests were possible. The sucker was located in a ripline 7 m from the nearest mature Buloke. It was 13 cm high when recorded in February 2004.

Incidental observations within the study area recorded suckers being produced up to 15 m from the nearest mature Buloke, although most were between 5–12 m from the nearest mature Buloke (Figure 8).

Figure 8. Buloke suckers 6m from several adult Bulokes along a fenceline, near one of the study sites.

4. DISCUSSION

4.1 Tree protection

The monitoring of fenced and unfenced trees revealed a substantial and rapid increase in damage to the bark of unfenced trees during the three years of this study. Such a large increase in bark damage within this short period was unexpected, as all the case study properties had been subject to grazing by livestock for at least the last 60 years. The cause of the rapid increase in damage is likely to be due at least in part to the fact that two of the properties, including the one where the majority of the trees were located, changed from being stocked predominantly with sheep and some steers to being stocked with young Friesian bulls within one year of tree fencing. Bulls often do more damage than sheep or steers to both fences and trees due to their tendency towards active social behaviour (B. Wallace, pers. comm.) Bark is usually rubbed from trees when bulls congregate around them, rather than chewed. Several properties in the West Wimmera Shire, which encompasses the majority of the overlap between the distribution of Buloke and the range of the RtBC, have recently begun stocking Friesian bulls, which are mainly exported.

A further change that is occurring on many grazing properties in the region is the switch towards more intensively managed rotational grazing regimes, such as cell grazing and techno grazing. These regimes involve the use of electric fencing, sometimes portable, which divides large paddocks into smaller ones – in some cases as small as 1 ha. Stock are then moved among these smaller enclosures in herds, remaining in one enclosure for a relatively short period of time. There are both potential benefits and drawbacks to these types of grazing regimes from the perspective of paddock tree health. If stock are frequently moved among paddocks, this reduces the incidence and intensity of stock camping behaviour, which can substantially alter the soil properties underneath and around paddock trees. However, the risk of stock running out of adequate feed before they are moved also increases, and this tends to increase the incidence of boisterous behaviour, particularly in bulls, which can damage trees and fences (B. Wallace, pers. comm.).

These relatively subtle changes in land use therefore have the potential to exacerbate declines in tree health and increase tree mortality. Such increases in tree mortality are often associated with a change in land use from grazing to cropping, but this study has suggested that less obvious agricultural intensification may also be a factor in paddock tree decline. However, despite the substantial bark damage recorded on unfenced trees, these trees were no more likely to have an unhealthy canopy than fenced trees. As the degree of ringbarking recorded is highly likely to be placing these trees under water and/or nutrient stress, the three-year monitoring period may have been too short for such flow-on effects to become apparent. The study also did not record the death of any focal trees during the three-year monitoring period. However, a longer period of monitoring may reveal any differences in mortality rates between fenced and unfenced trees.

Foraging RtBC have been shown to exhibit consistent selectivity among trees, preferring those with characteristics that make them potentially more profitable food sources; i.e. maximising calorie intake while minimising searching and handling time (Maron 2000; Maron and Lill 2004). Fruit density, seed production per cone and seed ratio are all factors related to RtBC choice of feeding trees, and none differed significantly between fenced and unfenced trees (Maron 2000; Maron and Lill 2004). Seed ratio is of particular interest as it gives an indication of the amount of work a foraging RtBC must do for each gram of food it extracts (Maron and Lill 2004). Again, the period of monitoring for this study was relatively short compared to expected response times of mature trees to environmental changes. Another reason why seed ratio and seed production did not decline despite the bark damage is that plants can respond to stress by directing more resources into reproductive efforts. This can mean either an increase in fruit and seed production, an increase in provisioning of endosperm per seed, or both. Such an effect may have masked any negative impacts on tree health, but continued monitoring would help to elucidate longer-term trends in fruit production.

One potential side-effect of removing stock from the vicinity of trees is the potential for nutrient levels to decline within the root zone, due to a reduction in deposits of nitrogen-rich animal wastes. This may lead to a reduction in nutrients available to the plant to use for reproduction. Although the long-term goal of tree health and survival is of most critical importance, the RtBC is highly sensitive to seed ratio, and fruit crops with a reduced seed ratio may not provide an adequately profitable food source. In the short-term, at least, it does not appear that any reduction in nutrient inputs from stock and fertilisers within the root zone had negatively impacted on cone and seed production by paddock Bulokes. As Bulokes have a symbiotic relationship with nitrogen-fixing bacteria, it is likely that nitrogen availability is not limiting. However, it is possible that over time, the reduced phosphorus inputs from the cessation of fertiliser application within the root zone may influence cone and seed production.

On the basis of the recorded bark damage alone, it appears that high intensity-grazing, particularly of bulls, is a threat to maximising the persistence of paddock Buloke trees in the West Wimmera. However, the more intensive level of management that such grazing systems require also provides opportunities to reduce stock impacts on trees, both fenced and unfenced. Firstly, rotational grazing properties frequently have a relatively high density of electrical fencing. This fencing can be accessed to provide temporary electrical fencing around trees in paddocks when stock are present. When trees are near to a fence, it is inexpensive and quick to extend the electrical fencing to surround and protect the tree.

In some paddocks, there are too many trees for all to be protected while preserving the productivity of the paddock. Landholders could consider stocking such paddocks with steers or sheep, rather than bulls; indeed, this initiative was suggested by one landholder involved in this study who has now permanently removed bulls from one paddock which contains a large number of Bulokes.

4.2 Tree loss and revegetation targets

4.2.1 *Methodology*

There are limitations to identifying objects on the ground from aerial photographs, and this is why extensive ground-truthing was carried out. Buloke trees were generally easily identified from the images due to their small canopy size and paler appearance compared to eucalypts. However, one limitation of this analysis was that aerial images taken in 1981/82 were black-and-white conventional photography, and the 1997 images were colour digital images. The digital images were of a higher quality and trees were more clearly visible, particularly in areas where tree density was higher. Counts of trees from the digital images therefore may have been more accurate than those from the older images. This may lead to underestimates of the rates of tree loss, as some Bulokes may not have been detected on the 1981/82 images.

4.2.2 *Causes of decline*

Notwithstanding the potential for underestimation of tree loss, the losses detected were substantial. The Neuarpurr North focal area displayed an alarmingly high rate of tree loss (38.9%) compared with the Patyah area, which lost only 4.4% of trees over the fifteen years. The considerable differential in the rates of tree loss indicates that factors other than natural senescence are driving the very high rates of loss from some areas.

The most significant factor in the loss of trees appears to be the installation of centre pivot irrigation systems. The highest rate of tree loss was from areas where these irrigators had been installed by 1997. Tree losses from this land use do not appear to be slowing, as evidenced by the large number of recent removals of Buloke trees for this purpose. Although all water licences for the area have been issued, the continuing clearing is driven by the fact that the pivots are moved every few years, and there is disagreement as to what period must elapse before previously irrigated areas can be irrigated again. There are very few remaining that are free of trees and large enough to accommodate a centre pivot.

Cropping generally appeared to result in more tree losses than did grazing, a result consistent with the findings of Ozolins *et al.* (2001) in central New South Wales. There is perhaps a greater incentive to remove trees from land to which access with large machinery is regularly required. Tree death may also be accelerated by soil cultivation close to the roots, which may cause root damage and alter soil structure (Cutten and Hodder 2002). Aerial spraying of crops also occurs in the area (pers. obs.) and herbicide spray is likely to adversely affect trees in the crop. A major factor threatening trees in cropped land is the burning of grain stubbles, a common practice in the area. Stubble fires frequently result in tree deaths when trees catch alight or the canopy is severely scorched (pers. obs.), and over several years the cumulative impact of these losses is likely to be substantial. The creation of adequate firebreaks around paddock trees through the slashing of stubbles close to the ground and removal of fallen branches would most likely alleviate these losses considerably.

Grazing appears to be the land use type most sympathetic with the retention of paddock Buloke trees. Although deliberate removal of trees occurred in grazed paddocks in the past, remnant trees may now be seen as beneficial as they provide shade trees for stock (Ozolins et al. 2001, Cutten and Hodder 2002). However, grazing may still accelerate the rate of decline of trees in paddocks due to altered nutrient impacts, ringbarking, and soil compaction especially under trees where stock camp (Cutten and Hodder 2002). The impact of these factors appears to be considerably less than that of cropping practices, because the rate of tree loss was substantially lower for trees on grazed land. Further investigation of the causes of tree loss on grazed land may elucidate the reasons for the very low rate of tree loss from the Patyah region (4.4%) compared with other grazing areas. It is likely that deliberate removal of trees during the 15-year period contributed to the higher average rate of loss from pasture of 20.6%. It is also possible that some of the areas identified as pasture in 1997 from the aerial images had in fact been cropped in the preceding years, and were thus also subject to impacts from that land use type.

4.2.3 *Roadside regeneration and revegetation*

The changes in the length of Buloke woodland visible along roadsides contrast with the fate of trees on agricultural land. While agricultural land suffered a substantial net loss of Buloke trees, some apparent gains were evident on roadside areas. A total of 2155 m of Buloke roadside was visible across the 1997 images that had not been visible on the 1981/82 images. This revegetation is now at most 20 years old, and comprises the next cohort of young trees with the potential to provide food for the RtBC. If properly managed, these trees will be available as RtBC foraging habitat within about 80 years. Therefore, appropriate management of these roadside areas is essential. However, during field surveys of the area, it was noted that most of these roadside areas consisted of thick (probably sucker) regeneration. Widespread fires which may have historically produced the open nature of Buloke woodland (Morcom, in prep.) no longer occur in the area, so active management of these areas is necessary for appropriate tree densities to be attained on these roadsides. At current densities, the growth of trees in most of these roadside areas is likely to be constrained by competition for nutrients and water (Morcom in prep.). A suggestion of this report is that research be undertaken into efficient and effective means of managing these roadside areas in order that the young trees are able to reach maturity and achieve close to natural stem densities, and that such management then proceed as a priority.

Roadside areas also present opportunities for active revegetation efforts. There is a considerable distance of unvegetated roadside in the area, which would once have been suitable for Buloke woodland. Linear plantings such as these can be a low priority in areas historically dominated by vegetation of an open woodland structure, as connectivity may be less of an issue and such plantings can result in vegetation which contains no ‘interior’ habitat area, a requirement of some bird species. However, these issues are less critical to the conservation of the RtBC, as the taxon does not appear to be sensitive to the landscape configuration of habitat (Maron 2000). In addition, even small, linear and degraded areas of Buloke woodland appear to provide habitat for numerous woodland bird species, several of which are thought to be declining across southern Australia (Maron unpub. data). This may be partially attributable to the fact that Noisy Miners *Manorina melanocephala* generally do not maintain colonies in Buloke woodland unless eucalypts are also present (Watson *et al.* 2000). Therefore, such roadside planting (as long as inclusion of eucalypts is restricted to small numbers) may be a desirable strategy that will benefit other bird species. A further recommendation is that appropriate roadside areas for Buloke revegetation be identified and such revegetation proceeds immediately. However, roadside revegetation should not be relied upon to offset entirely the current rate of losses from private land. A potential negative aspect of roadside plantings is that they may increase the likelihood of cockatoo deaths by collisions with vehicles should the birds' feeding areas be concentrated along roadsides. Part of a long-term habitat management and revegetation strategy should therefore also include plantings away from roadside areas, which may mean encouraging farmers to incorporate areas of Buloke revegetation on their properties as part of a sustainable farming strategy.

Loss of Buloke woodland is of particular concern due to the difficulty involved in establishing young Buloke trees. Buloke regenerates both by production of seedlings and through vegetative suckers from roots near the surface. Successful regeneration by either method requires exclusion of grazing, and is then very slow. The smallest Buloke in which a Red-tailed Black-Cockatoo has been recorded feeding is 19 cm in trunk diameter (Maron 2000). A tree of this size is estimated at approximately 100 years (Morcom in prep). This slow growth rate, coupled with the fact that it is currently unable to be grown successfully when direct seeded, results in Buloke often being omitted from revegetation projects. Successful Buloke revegetation requires raising and planting of seedlings, secure guarding from stock, rabbits and hares, and stringent weed control for several years (A. Bradey, pers. comm.).

4.2.4 *Implications for conservation of the RtBC*

The RtBC is a highly mobile species and flocks are known to move large distances within their range, probably in response to local and regional changes in availability and profitability of food resources (Joseph 1982b; Burnard and Hill 2002). Individual trees appear to vary in terms of their profitability from year to year, so it is likely that only a relatively small proportion of the RtBC's potential foraging habitat supplies food of sufficient quality at any one time. Therefore, relatively small areas of feeding habitat can assume critical importance at certain times, and protection of all remaining food resources is essential for the recovery of the RtBC (Hill *et al.* 2003).

Although RtBCs can move great distances, during breeding they require feeding habitat in relatively close proximity to nest sites. Saunders (1977, 1980) found that Short-billed Black-Cockatoos *Calyptorhynchus latirostris* in Western Australia had lower breeding success in an area where feeding habitat was scarce and highly fragmented compared with larger tracts of continuous habitat. Although R. Hill (unpubl. data) found no significant difference in nesting success of RtBCs between an area with 40% vegetation cover and one with 8% cover, he reported that the birds in the more sparsely vegetated region relied heavily on scattered trees for foraging, and noted that such habitat was under threat.

The loss of mature paddock trees is a major threatening factor to the RtBC population. At the current rate of tree loss, the population faces a prolonged period (perhaps 70 years) with extremely low Buloke feeding habitat availability before current revegetation efforts begin to address the situation. Therefore, protection of existing habitat must be a priority in order to minimise this lag time.

The successful replacement of approximately 2500 Bulokes on appropriate soils and at an appropriate stem density is required simply to offset losses from the focal areas over the 15-year period. At the estimated natural density, this equates to approximately 50–65 ha of Buloke woodland. At a loss over 100 years of 90%, 25 000 Bulokes would need to be planted initially. Such a plantation may not provide a food source for ca 100 years, and would not approximate the value of the removed trees as feeding habitat for considerably longer. Although these time-frames seem daunting, they are typical of the period over which land managers must plan landscape restoration. The trees would also be likely to provide habitat benefits to other organisms in a much shorter time-frame.

It is important to note that the percentage of trees lost during the 15-year period relates *only to trees that were present in 1981/82*. The number of trees remaining at this time reflects a very small proportion of the Buloke feeding habitat that was historically available to the RtBC. Therefore, the goals of revegetation efforts must not be simply to replace trees lost since the early 1980's, but to attempt to make some significant gains beyond the habitat present at that time. Assuming losses of mature trees are minimised, a goal of successfully establishing at least 5000 Bulokes per year over the next 10 years throughout the distribution of Buloke within the range of the RtBC would be an appropriate first step toward re-establishing Buloke feeding habitat. Such revegetation must be on appropriate soil types, of local provenance, and with the aim of achieving appropriate stem densities at maturity (30–50 stems/ha, Morcom in prep.) to maximise the probability that it will provide food of sufficient quality for RtBCs. However, it is important to factor in the likely high mortality of Buloke seedlings over a 100-year period when determining initial planting densities.

4.3 Sucker encouragement

Unfortunately the time frame of this study was too short to observe sufficient suckering activity for conclusions to be made regarding optimal and maximum suckering distance. A single sucker was produced at 7 m from a parent tree, a distance at which suckers are often observed from large trees on roadsides and other ungrazed areas. Anecdotal reports have suckers being produced approximately 25 m from the nearest Buloke. Personal observations made during this study suggest that suckers often occur up to a distance of 10-14 m from a parent plant.

While further monitoring of the disturbed sites is necessary for conclusions to be drawn, the implications of personal observations and the majority of anecdotal accounts encountered in discussions with landholders during the course of this project suggest that when planning restoration of Buloke habitat based on sucker production, the total area to be regenerated will typically be limited to less than 15 m from a parent Buloke. It is also critical to bear in mind that suckers are genetically identical to the parent plant, and so the encouragement of a large number of suckers from male trees will not contribute directly to the food resource available to the RtBC. When sucker production does occur, it tends to be in very dense stands, and growth of individuals is arrested. Without appropriate management, these stands will take a much longer period before attaining a size sufficient to support foraging cockatoos. Further research into the management of dense regrowth is required.

5. CONCLUSIONS

This study has quantified the loss of mature Buloke trees in five focal areas in the Victorian Wimmera. This loss is associated with cropping generally and specifically with the deliberate clearing of trees for the installation of centre pivot irrigators. Investigation into bark damage caused by stock grazing suggests that damage caused by bulls may also contribute to tree decline in the longer term.

Mature Buloke trees are known to be important feeding habitat for the RtBC (Maron 2000, Burnard and Hill 2002, Maron and Lill in press). The loss of these trees has been identified as a significant factor threatening the RtBC population in the RtBC Recovery Plan (Burnard and Hill 2002).

Evidence on Buloke growth rates and RtBC feeding observations suggests that it is unlikely that replacement plantings or natural seedling regeneration of Buloke will provide feeding habitat for the RtBC for approximately 100 years (Maron 2000, Hill et al. 2003, Morcom in prep.).

If the loss of mature Buloke trees continues, it is likely to lead to a further reduction in the population of RtBC in Victoria and a corresponding increase in its risk of extinction in Victoria. In order to reduce the risk of extinction, responsible planning authorities, conservation and primary industry agencies and landholders need urgently to address the loss of mature Bulokes and develop measures to arrest this trend.

The following suggested management actions will be developed in conjunction with key stakeholders. Adoption of these management practices will assist agriculture in becoming more ecologically sustainable, by conserving Buloke habitat for the RtBC.

In order that Buloke feeding habitat continue to be available to the RtBC, protection of existing mature trees is essential, as revegetation or regeneration will not provide a food source for approximately 100 years, and will not be of the size preferred by the RtBC for considerably longer. The cessation of deliberate tree removal is vital in reducing tree loss. The protection of trees from stubble fires and cultivation should substantially reduce the rate of tree loss. Encouragement of tree protection by fencing is likely to prolong tree life and may allow for recruitment in the fenced areas. The fencing of individual trees to avoid further damage by livestock is a measure that may be advisable wherever possible, such as where electric fencing can be quickly erected. Temporary electric fencing of individual trees or small clumps of trees may be desirable where rotational grazing is being practised. In situations where such fencing is not feasible due to large numbers of Bulokes in a particular paddock, stocking of the paddock with sheep or steers rather than bulls may reduce the potential for damage to the trees.

Revegetation of Buloke is difficult and time-consuming to achieve, with the result that it is often avoided or unsuccessful. Experienced community groups and specialist contractors have a much higher success rate and should be at least consulted for all proposed Buloke revegetation. Ongoing management of weeds and herbivores is essential for success. Revegetation efforts should be focussed in northern parts of the study area where cropping is the major land use as these areas have suffered the greatest loss of Buloke trees. Use of incentives may be appropriate for tree protection and revegetation. The encouragement of landholders in Buloke areas to plant a small number of Bulokes each year as part of an ongoing effort may be a way to reduce the burden of time and cost involved in establishing and managing Buloke revegetation.

Revegetation on roadsides and roadside woodland management provide opportunities to achieve gains in Buloke numbers in areas where they can be protected from most impacts of agricultural practices. However, further research is required in order to determine the best strategy for managing roadside woodland. One issue is managing areas of unnaturally dense roadside regeneration in order that the trees may mature and ultimately achieve natural stem densities.

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APPENDIX

Appendix 1. Mean bark damage and canopy health scores (±1 s.e.) for fenced and unfenced trees in 2003, 2004 and 2005, and results of paired-sample *t*-tests. *N* = 70 for all tests.

	Bark damage score				Canopy health score			
Year	fenced	unfenced	*T*	*P*	Fenced	unfenced	*t*	*P*
2003	4.7±0.4	4.4±0.3	0.586	0.561	5.3±0.4	5.1±0.3	-0.468	0.643
2004	3.8±0.3	6.5±0.3	5.41	<0.0001	5.9±0.3	5.4±0.3	-1.29	0.206
2005	3.2±0.3	7.1±0.4	8.31	<0.0001	5.8±0.3	5.3±0.3	-1.29	0.205