Managing Rabbits in Canberra Nature Park

A report to the Commissioner for Sustainability and the Environment

Dr Kent Williams
Formerly Principal Research Scientist
CSIRO Sustainable Ecosystems
20/01/2011

Acknowledgements

I thank the many staff of Parks, Conservation and Lands for generously providing the data and information on which this report is based, particularly Drs Nicola Webb and Daniel Iglesias, and Dr Adrian Manning of the Australian National University for information on the Mulligans Flat-Goorooyaroo Woodland Experiment. I am solely responsible for the manner in which the data and information are used and interpreted.

I thank The Commissioner and staff of the Office of the Commissioner for Sustainability and the Environment for the opportunity to engage in this task, for hospitality during the undertaking, and for access to documents and use of facilities.

I thank Dr Lyn Hinds, Dr David Shorthouse, Professor Tony Peacock and Mrs Narelle Sargent for improvements to the manuscript.

Contents

Managing Rabbits in Canberra Nature Park

1. Summary

Rabbits are a prime cause of degradation of Canberra Nature Park (CNP). Their evident impact is augmented by more subtle effects which include interactions with grazing by other herbivores and the stringencies from drought and burning, and by sustaining populations of predatory foxes and cats. The long-term outcome is attrition of perennial vegetation, loss of trees and shrubs and their replacement by weedy annual forbs and grasses, loss of native fauna and their ecosystem services, loss of nutrients, and denudation and erosion of soil.

The ACT Government accepts its duty of care in constraining the impact of rabbits and conserving the natural values in CNP. Actions appropriate to that duty include identifying lost or impacted values for purposes of conserving or restoring them, excluding or minimising stock, monitoring and controlling rabbits and over-abundant kangaroos, controlling foxes and feral cats, and employing fire regimes that promote plant communities that are inimical to rabbits and other pests and are beneficial to desirable native flora and fauna that help to sustain landscape function.

The management of the CNP targets many of these objectives. Collaborative studies using the grazing-predation exclosure in the Mulligans Flat-Goorooyaroo Woodlands Experiment will help to identify conservation values and elucidate interactions leading to degradation and the requirements for recovery and restoration. Burning prescriptions have been established with priority of protecting life and property near habitation, and elsewhere protecting various vegetation assemblages on the basis of life history of particular tree species, and promoting mosaics of staged regeneration.

Knowledge of the impact of rabbits on the conservation values of CNP is important but difficult to document. Monitoring indices of rabbit abundance using spotlight transects or counts of *active entrances* to warrens is used as a guide to the likely level of damage caused by rabbits. Systematic monitoring of rabbit abundance in CNP was begun recently to prioritise and manage control operations economically. Systematic regular monitoring of rabbits in Namadgi National Park since 1993 shows that rabbits may be developing resistance to rabbit calicivirus, giving a timely warning of likely resurgence of rabbits and their damage.

The most cost-effective way of controlling rabbits in CNP comprises an initial *Primary control* by poisoning, warren-ripping and fumigation, followed by peri-annual *Maintenance control* by fumigation. This best-practice methodology is characterised by more costly *Primary control* and cheaper *Maintenance control* that sequentially declines exponentially in effort and cost to very low levels. At present *Primary control* of rabbits and two sequences of *Maintenance control* have been

implemented and monitored strategically on Ainslie/Majura, while five more CNPs have received *Primary control*. Monitored outcomes conform to expectations for strategic rabbit control. However, of the 38 CNPs, strategic rabbit control has been implemented on only six, because of resourcing inadequacies that also generate managerial and operational problems[1]. An example is that the funding uncertainties discourage potential rabbit control contractors from training for accreditation and establishing viable businesses; the availability of contractors is a limiting factor.

These multiple constraints prevent implementation of rabbit control on further CNPs and they jeopardise the gains made on those previously treated. Rabbits rapidly recolonise *Primary control* -treated areas where *Maintenance control* is not sustained. The foundation of these constraints is that funding is inconsistent and generally insufficient. Only few CNPs can be treated in any funding period, and rabbits recolonise and resurge where previously they have been reduced and *Maintenance control* is not sustained. Consequently prioritisation of CNPs for rabbit control is difficult; limited inconsistent funding impedes prioritisation on a rational conservation basis. The inappropriate funding causes unavoidable operational inefficiencies that confound cost-effective control of rabbits, irrespective of efforts of skilled staff to compensate and deal with the situation strategically.

Provision of adequate funds on a consistent basis would enable correction of consequent problems, some of which are identified and addressed in the following recommendations, and others that would correct automatically. The current inconsistent and inadequate funding fails to prevent rabbits degrading CNP, and sustains the large shortfall in the required expenditure. Conversely, consistent provision of adequate funding for rabbit control would assist in halting degradation, enable pursuit of potential recovery and restoration, and would begin the progressive and rapid exponential decline in the required expenditure to an economical level. In the medium term, strategic funding is much cheaper than inconsistent funding and gives the best conservation outcome.

The following recommendations address several audiences:

- Recommendations-A focus on resourcing issues and are most pertinent to Government;
- Recommendations-B address issues relevant to management of the resources including Staff and are relevant to Departmental management;
- Recommendations-C deal with issues of necessary knowledge and research for management of rabbit impact and related conservation issues;
- Recommendations-D address management of operational issues in managing rabbit impact and issues that affect conservation values.

[1] See Appendix 3 for details on rabbit control on the individual CNPs

Recommendations

Recommendations-A: Resourcing strategic rabbit control

1. The ACT Government can demonstrate a firm commitment to suppressing the impact of rabbits on the conservation values of CNP by committing secure on-going funding to enable control of rabbits using the proven most cost-effective best-practice strategy and methods that makes best use of available personnel: staff, contractors and volunteers.
   Importance: Very high. Cost: Medium but rapidly declining. Payoff: Very High
2. Steps should be taken to emphasise in the budget process the need to enable a strategic approach to managing pest animals, noting their propensity to resurge when control pressure is eased, and the economy achieved by consistent control pressure, and the wastage incurred by inconsistent resourcing.
   Importance: Very high. Cost: Very low. Payoff: Very High
3. The number of ranger and research staff should be increased, or resources re-prioritised, to deal appropriately with the conservation management of CNP, Googong Foreshores and Namadgi National Park, including the rabbit control component.
   Importance: High. Cost: Nil or Medium. Payoff: High.
4. The Ranger staff should include a senior 'Specialist Ranger' whose specific duty is to drive and manage the rabbit control program across the entire ACT Nature Park system, including Molonglo River corridor, Googong Foreshores, and Namadgi NP, and coordinate it with programs managing other threatening processes and conservation initiatives.
   Importance: Very high. Cost: Nil or Medium. Payoff: Very high

Recommendations-B: Managing resources for strategic rabbit control

1. An ACT Rabbit Pest Management Strategy (RPMS) should be developed using advice from rabbit control experts, consistent with the ACT Pest Animal Management Strategy (ACT 2002 as revised) and the Pest Plants and Animals Act 2005 (Section 25).
   Importance: High. Cost: Low. Payoff: High.
2. Consistent with, and subordinate to the prospective RPMS, the 'Specialist Ranger' should develop a Rabbit Pest Plan of Management (RPPoM) for each CNP, Molonglo River Corridor and Googong Foreshores where rabbits are a problem[2]. Neighbours should be consulted, or involved if appropriate, in developing these plans.
   Importance: High. Cost: Low. Payoff: High.
3. There is a need for a review of opportunities for delegating further responsibilities and tasks to selected representatives of Park Care, and any impediments, and

[2] The RPPoMs should coordinate with the proposed Operational Plans (Sharp 2010) for the relevant CNPs.

whether appropriate formal training and accreditation would enable greater participation of Park Care Volunteers in specific aspects of rabbit control in CNP. The outcome of that review should direct appropriate changes to administration and practices, and institution of appropriate training and accreditation.
Importance: High. Cost: Low. Payoff: Very High.

4. Namadgi National Park is very high value conservation estate that retains many of the conservation values that have gone from the CNP. Being funded from ACT revenue, it effectively competes with CNP for funding. Funding sources for rabbit control in Namadgi NP (and Googong Foreshores) should be sought on the basis that their different characteristics and purposes might qualify them for different funding, additional to those of the CNPs.
Importance: Medium. Cost: Low. Payoff: High.

Recommendations-C: Research for strategic rabbit control

1. The prioritisation process for rabbit control treatments on CNPs should be formalised as far as possible to optimise use of available resources to ensure strategic protection of conservation values, protect the benefits of past expenditure, and to preclude any influence of external pressures. The effort and costs of rabbit monitoring and control should be monitored operationally to assess performance and cost-effectiveness and for use in prioritisation. A proposed prioritisation tool is shown in Appendix 4. The prioritisation process should take account of the recommended role for volunteers.
Importance: Very high. Cost: Low. Payoff: High.

2. Prescriptions for burning CNPs (excluding Asset Protection Zones) should be reviewed with an aim to depress habitat favouring rabbits[3], kangaroos and foxes, to retain population refugia for flora and fauna such as in damp creek lines, to promote complex woodland structures, and to retain ground litter and logs as habitat and shelter for terrestrial fauna, microhabitat for flora, protection of soil, and traps for mobile soil and nutrients, thereby promoting landscape function.
Importance: Very High. Cost: Low. Payoff: Very High.

3. The review of burning prescriptions should direct the design and implementation of long-term adaptive management burning trials that compare existing prescriptions with those designed on the basis of habitat requirements of fauna as well as floral life history. The trials should examine the responses of representative flora and vertebrate and invertebrate fauna, and habitat structure. Special funding and collaborations may be required to achieve such trials.
Importance: Very High. Cost: Medium. Payoff: Very High.

[3] Rabbits, Eastern Grey kangaroos, foxes, feral cats, and exotic rats and mice are favoured by similar habitat structure (Catling 1991).

4. **Recommendation: Grazing of CNPs by stock needs to be reviewed with a view to minimising the practice or replacing it with practical alternatives. Use of stock grazing should be restricted to only where and when it is essential for asset protection or achieving particular conservation objectives.**

   Importance: High. Cost: Low. Payoff: High.

5. On the basis of knowledge obtained in exclosures studies, such as those at Mulligans Flat, consideration should be given to establishing exclosures in other parts of CNP to promote recovery or restoration of suppressed species of plant and animal. Such exclosures may qualify as biodiversity offsets.
   Importance: Medium. Cost: Low. Payoff: Medium.

6. Continuing current policy, and similar to past achievements, knowledge of conservation values of CNP and the effects of management action in conserving them can be enhanced by seeking further student collaborations. Such benefits are being obtained currently from student studies of the exclosures and predation barriers at Mulligans Flat-Goorooyaroo, and the recommended long-term fire studies would provide further opportunities.
   Importance: High. Cost: Low. Payoff: High.

7. Continuing current policy, and similar to past achievements, further grants of operating funds should be provided for student-higher-degree projects where particular research issues, if amenable to statistical analysis, are identified as salutary to effective management of rabbits in CNP. Staff members should be committee advisors to student supervisors.
   Importance: High. Cost: Low. Payoff: High.

Recommendations-D: Managing operations for strategic rabbit control

1. Rabbits in CNP should be controlled strategically using *Primary control* followed peri-annually by *Maintenance control* over as large an area as is feasible, and in the appropriate seasons, as specified in the prospective RPMS.
   Importance: Very high. Cost: Medium but declining exponentially. Payoff: Very High.

2. The duties of managing degradation by rabbits and other threatening processes in the CNP should be separated from those of the Urban Wildlife Program which are temporally unpredictable, demand urgent attention and are time-consuming, but unlike rabbit management, are of little conservation value. This may require recruitment or deployment of staff members less senior than skilled Rangers specifically to the Urban Wildlife Program.
   Importance: High. Cost: Low. Payoff: High.

3. The current policy of high priority for standardised monitoring of rabbit abundance before and after control operations should be continued and extended where appropriate. This would enable comparisons over time to identify long-term trends and effectiveness of treatments and strategies, and enable rabbit management to adapt economically to changes and responses (viz. ACT 2002).
   Importance: Very High. Cost: Low. Payoff: Very High.

4. Rabbit numbers should be managed to minimal levels prior to prescription burns, or very soon after, to prevent them exploiting and suppressing post-fire regeneration.
   Importance: Very High. Cost: Low-Medium Payoff: High.

5. Rabbits should be managed to minimal levels prior to any scheduled kangaroo culling to prevent rabbits from exploiting and responding to the resources released by the reduction in kangaroo abundance and impact.
   Importance: High. Cost: Low-Medium. Payoff: Medium.

6. For best cost-effectiveness, that is, least cost for best conservation outcome, schedules developed in the prioritisation and planning processes should maximise the implementation of rabbit control in the appropriate seasons, summer and autumn and in dry conditions such as drought, as specified in the prospective RPMS.
   Importance: High. Cost: Nil. Payoff: High.

7. Counts of active entrances should be considered as a means of assessing effectiveness of control operations in areas where spotlight counting is problematic. With appropriate training, this measure can be implemented readily by volunteers.
   Importance: Medium. Cost: Nil-Low. Payoff: Medium.

3. Scope of this report

This report focuses on rabbits, their impact and management in Canberra Nature Park (nature reserves), the Molonglo River Corridor (MRC) and the Googong Foreshores (GF). Herein these reserves will be referred to collectively as CNP, although CNP (nature reserves) sometimes are specified separately (as CNPs) as well as MRC and GF. The report addresses aspects of the Terms of Reference (TOR) 1 to 6 inclusive and 8 of the investigation by the Commissioner for Sustainability and the Environment (OCSE) into CNP (nature reserves), MRC and GF.

4. The role of rabbits in Australian landscapes

Common knowledge, aided by a large body of research (Williams *et al.* 1995), contends that rabbits are environmentally destructive, conferring no apparent conservation benefit to the Australian landscape. This appears true for the wide range of environments that the rabbit occupies in Australia, although the rates of degradation probably depend on rabbit density and environmental traits. Unfortunately rabbits degrade environments even when their densities are very low, approaching undetectability. While CNPs generally do not carry extreme densities of rabbits, often they are abundant and widespread through the nature reserves, and degrade them by means that are obvious, but also, and especially, in subtle ways. Rabbits can be seen to affect the CNP by:

- Grazing, browsing, and ringbarking, thereby removing soil cover.
- Disturbing soil by burrowing and digging, thereby promoting erosion.
- Undermining buildings and built items of heritage value in CNP.

Rabbits' more subtle impacts on Australian environments (and CNP) include:

- Preferential selection of nutritious and palatable species and life forms
- Elimination of germinated perennials, causing failure of regeneration and progressing senescence of populations of tree and shrub
- Creating, by disturbance and dietary selection, microhabitats and niches amenable to invasion by annuals and exotics
- Degradation of species composition of swards towards domination by annuals and unpalatable species
- Eventual loss of palatable perennial species from local communities
- Exposure of soil as a consequence of disturbance and the phenology of dominating annuals
- Erosion of exposed soil, loss of nutrients and decline in landscape function.

Another unfortunate aspect of the degradation that rabbits cause is that the subtle effects may be masked by the regular seasonal changes and seasonal variability, and they occur over a long time span, so they progress unnoticed, and unmanaged.

The actual process of degradation is worse than the above. Rabbits degrade the environment in concert with other disturbing factors, interacting in ways whereby their damage together is greater than the sum of their separate impacts. Disturbing interactions include:

- Grazing and disturbance by rabbits, kangaroos and stock, with likely effects of competing, complementing and broadening grazing patterns of each
- Burning of vegetation and rabbit's selective grazing of pulsed post-fire germination and resprouting, and digging for plant remnants
- Drought and its effect on rabbit's grazing, browsing and soil disturbance.

These impacts have deleterious consequences for the biota and thereby for landscape function, again in interaction with another disturbing factor, namely the European Red Fox. The rabbit, being is its prime food source, augments and sustains the fox population in the CNP and surrounds. The impacts of rabbits on the vegetation, in interaction with the other disturbing factors, removes cover and habitat for other biota, small mammals, lizards, insects and other invertebrates, which then exposes them to the very effective predation of foxes and cats (Catling 1988; Saunders *et al.* 1995). The ecosystems thereby lose the services provided by this biota (for example, creation of soil micro-tubules, and dispersal of hypogeofungi), and so the landscape becomes less functional and degrades further.

While the processes of degradation of Australian environments by rabbits have been identified elsewhere, it is reasonable and economical to presume that processes are similar in the CNP, perhaps differing mainly in rates according to a suite of ecological factors. Sharp (2010) assessed rabbit-disturbed ground in the CNPs as having 'dysfunctional' landscape function.

The following sketch graphs summarise these concepts, integrating rabbit ecology (Williams *et al.* 1995) and landscape function (Sharp 2010).

Figure 1.

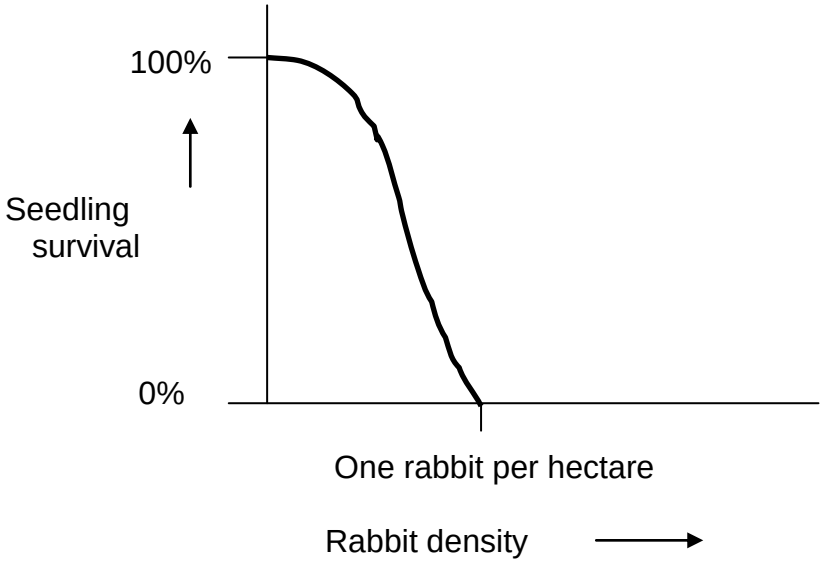


Figure 1. Rabbits at extremely low densities remove germinated palatable perennials and prevent regeneration of their populations.

Figure 2.

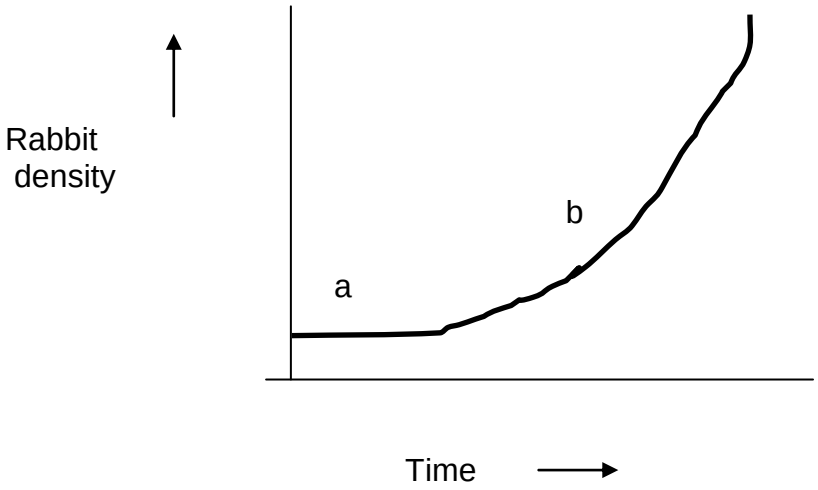


Figure 2. Rabbits at extremely low density prevent regeneration of palatable perennial plants (a), while at higher rabbit densities vegetation biomass is reduced with deleterious effects on the biota and landscape function (b).

Figure 3.

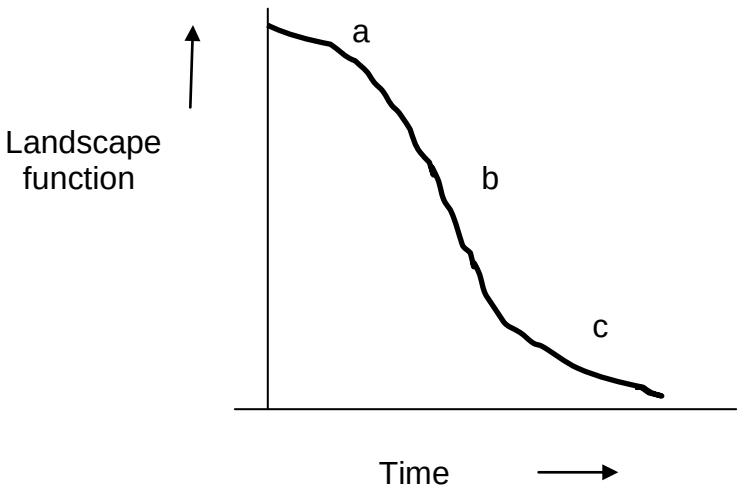


Figure 3. Landscape function declines over time as regeneration of perennials fails (a), perennial populations senesce and decline to local extinction and are replaced by annuals, dependent biota decline (b), and landscape function declines with loss of nutrients and erosion of soil (c).

Figure 4.

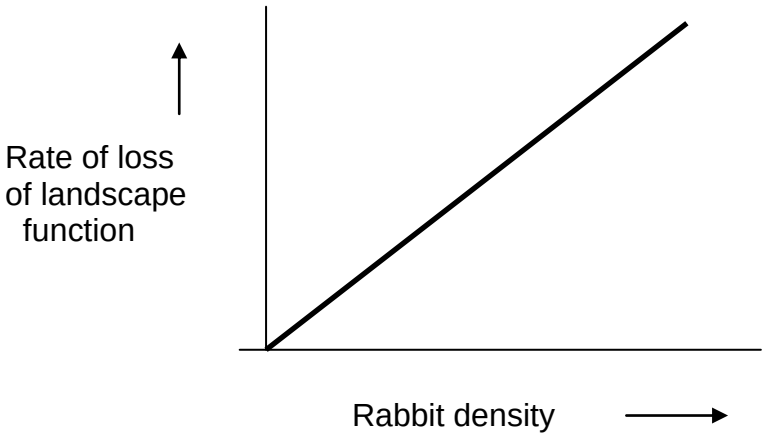


Figure 4. A conclusion drawn from the above is that the rate of loss of landscape function is proportional to the abundance of rabbits. While this is a reasonable conclusion, low densities of rabbits cause serious loss of landscape function over extended time.

Figure 5.

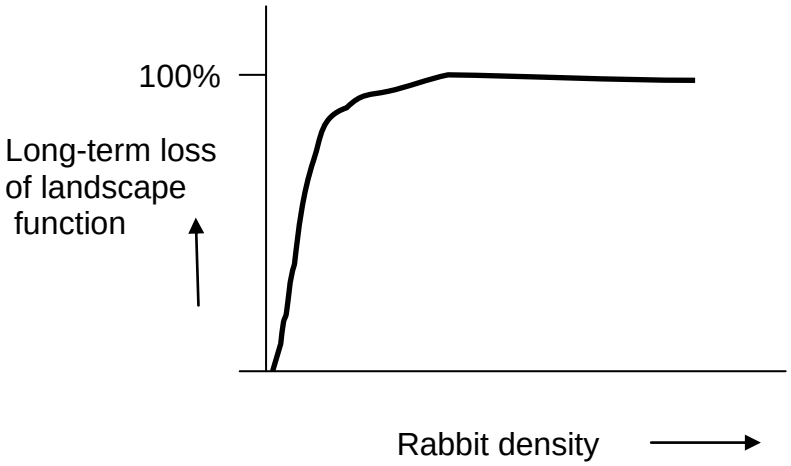


Figure 5. Very low densities of rabbits cause a loss of landscape function in the long-term through preventing regeneration of perennials and the consequential cascade of losses of the native biota and loss of their ecosystem services.

5. Canberra Nature Park as habitat for rabbits

The task of managing rabbits in the CNP has many impediments compared to most other Australian environments and places. CNPs are fragmented and numerous, relatively small (except GF), and surrounded by either rural land or suburban or urban development. This provides a large perimeter, relative to area, that is prone to invasion from land occupied by other landholders or jurisdictions. This disposition also complicates control operations, such as poisoning and warren-ripping, and exposes the treated areas to re-invasion by rabbits residing or sheltering in neighbouring land. The proximity of the CNP to urban and suburban environments and the presence of the public and their animals require numerous modifications to optimally cost-effective control procedures.

The CNPs generally comprise the steeper slopes and ridges with a smaller area of lower slopes. The upper slopes have skeletal soils that generally support shrubby woodland, while the lower slopes have deeper soils that support open grassy woodland. The hilltops and slopes are well drained and, in this respect, favourable to rabbits. On the other hand, soils mostly are thin, heavy, hard and stony and not favourable for digging burrows and warrens, except in accumulations of alluvium in lower slopes. Nevertheless, once dug, the warrens and burrows tend to retain their integrity and persist over time, especially among boulders. The rockiness and slope of the land creates difficulties for movement of equipment and machinery and effective control action, such as warren-ripping, and risks down-slope loss of soil, seed, and nutrients that may be disturbed by operations.

In the CNP, the combination of trees and shrubs adjacent to more open areas provides rabbits with a favourable mix of shelter and herbaceous food. That woodland structure probably derives from many factors including past and existing fire regimes.

Weeds, including woody weeds, are common in CNP areas infested by rabbits and offer protective cover as well as making warrens and burrow entrances difficult to find. Woody weeds also create difficulties for warren destruction and fumigation. Valued native trees also make warren ripping problematic for both access and avoiding damaging tree roots during ripping operations.

Managing rabbits in the CNP therefore requires attention to these complications and, “to conserve the environment”, mandates acceptance of lower cost-effectiveness (higher cost per level of reduction of rabbits) than is achievable in many other Australian landscapes.

Appendix 1 lists the constraints mentioned here, plus others encountered during this review, and some that are specific to particular CNPs.

6. The role of ACT Government in managing rabbits

The ACT Government acknowledges its duty of care in controlling rabbits in the CNP (Gibbons 2010). The rabbit is a declared pest in the ACT (Pest Plants and Animals (Pest Animals) Declaration 2005 (No 1)). Landholders may be obliged to suppress rabbits on their land if the Chief Executive of the Department of Territory and Municipal Services so directs and issues to them a written *Pest Management Direction* (Pest Plants and Animals ACT 2005). However, the *Pest Management Direction* must be consistent with the pest management plan for the rabbit[4]; presently there is no such plan and *Pest Management Directions* cannot be issued to landholders to deal with rabbit infestations including those on land adjoining CNP. The ACT Government (ACT Parks, Conservation and Lands) is the landholder of CNP. Consequently, any suppression of rabbits in the CNP, and other lands in the ACT, is undertaken for reasons other than legal.

Rabbits are adept at rapidly re-invading land cleared of rabbits (Parer and Milkovits 1994). While the CNPs adjoin other landholdings (NCA jurisdiction, the Australian War Memorial, property of the Defence Department, Actewagl service land, rural and urban leases, NSW rural properties), the ACT Government is politically and morally obliged to suppress rabbits in the CNP, although some adjoining properties contain substantial populations of rabbits that compromise efforts in the CNP. This obligation applies irrespective of any demonstration of the impact of the rabbit in the CNP or any demonstration of the benefit of rabbit suppression in the CNP.

In the Canberra Nature Park Management Plan (1999) two of the overall management objectives relate directly to rabbits: “(a) conserve and improve native plant and animal communities and maintain biodiversity and ecological processes .....”, and “(c) protect CNP and adjacent areas from the damaging effects of fire, erosion, pollution, pest plants and animals or other disturbances”. In order to attain these objectives and sustain the ecological integrity of the CNP, in view of the rabbit’s known interactive ecological role, and its foundational role in degrading landscape (above), it is essential to suppress rabbits together with suitable management of burning and grazing by kangaroos and stock, and management of the dominant exotic predators.

Recommendation: An ACT Rabbit Pest Management Strategy (RPMS) should be developed using advice from rabbit control experts, consistent with the ACT Pest Animal Management Strategy (ACT (2002) as revised) and the Pest Plants and Animals Act 2005 (Section 25).

Importance: High. Cost: Low. Payoff: High.

[4] Development of a pest management plan for the rabbit is proposed as an ACT Rabbit Pest Management Strategy (RPMS)

7. Inferred impact of rabbits in Canberra Nature Park

With the extensive knowledge of rabbit impacts in a variety of Australian environments, and where resources are limited, it is perhaps prudent to minimise the inferred direct and interactive impacts in preference to locally identifying specific impacts. On the basis of the existing knowledge, measured indices of abundance of rabbits in CNP are an economical surrogate for locally demonstrated knowledge of its impact. Nevertheless, assessment of the rabbit's impact in the CNP is desirable for justifying expenditure, may reveal unknown impacts, and would help in setting priorities for management action to protect the CNP values apparently threatened by the direct and interacting disturbances.

There does not seem to be any special feature of rabbits in CNP that would discount the known impacts of rabbits described above. However, it is useful to consider further some or the inferred interactions of rabbits with other threatening processes. Stock, kangaroos, fire and drought can threaten conservation values when at or above some minimum levels in the CNP. Each factor would hardly ever exist in isolation from one or more of the others, and in all cases rabbits can be expected to exacerbate the impact of the others.

Stock

With the abundance of kangaroos and the occasional need for culling, and the presence of rabbits and the need for their control, the strategy of adding further grazing pressure on particular CNPs by stock needs to be considered in terms of the conservation benefit/cost to the CNP. Stock grazing can assist in protecting assets from fire and can assist in achieving some specific conservation objectives. Their use also can impose negative effects on the values intended to be conserved in the CNP, such as some grazing and browsing off-take, introduction of weeds, focusing nutrients, damage to shrubbery and young trees, trampling and disturbance of litter, litter fauna and soil cryptogram fungi, and soil erosion. As a minimum, this damage by stock is additional to that of rabbits, and for some damage, to that of kangaroos. Conversely, excluding grazing tends to increase diversity of native flora in grasslands, woodlands and forests where soils are infertile, shallow or skeletal (Lunt 2005), as in much of CNP.

The macro and micro flora and fauna of the CNP, and the soils, evolved in the absence of large hard-hoofed herbivores and their grazing patterns. The disturbance of soil surfaces and cryptograms by stock, and the generally sloping profile of CNP, are significant risk factors for retention of soils and sustaining landscape function. Consequently it would be salutary to minimise use of stock where conservation objectives can be achieved by other means that have less negative impact. For example, Aboriginal burning practices probably have influenced the co-evolution and nature of the CNP biota and landscape over

thousands of years, and in some cases, some appropriate and precise burning regimes may achieve the desired conservation objectives with little negative effect.

Burning in precise regimes may be labour-intensive, but may compare favourably with effort involved in grazing stock for conservation purposes. Stock need to be transported, managed, supervised and constrained to only the appropriate vegetation associations in the CNP where, generally, there is no internal fencing separating landscape units.

Recommendation: Grazing of CNPs by stock needs to be reviewed with a view to minimising the practice or replacing it with practical alternatives. Use of stock grazing should be restricted to only where and when it is essential for asset protection or achieving particular conservation objectives.
Importance: High. Cost: Low. Payoff: High.

Kangaroos

Grazing pressure in many areas of CNP is applied mainly by kangaroos and rabbits. The abundant presence of kangaroos imparts an impression of their grazing pressure, whereas rabbits' impact can be more subtle, as described above, and less apparent to the untrained observer, but nevertheless extremely damaging to conservation values. While there is a management plan for kangaroos in the ACT (TAMS 2010), no rabbit pest management plan exists.

Rabbits are implicated with kangaroos in deleterious effects of intensive grazing on a variety of threatened animal species in ACT Native Grassy Ecosystems (Striped legless lizard *Delma impar*; Hooded robin *Melanodryas cucullata*; Brown treecreeper *Climacteris picumnis*; White-winged triller *Lalage sueurii*; Superb parrot *Polytelis swainsonii*) (TAMS 2010).

At the present time, kangaroos will continue to be culled where it is deemed necessary (TAMS 2010), undoubtedly with continuing public contention. Concurrently, there are few funds for rabbit control, and rabbits will respond to rainfall, as usual, by recolonising and resurging in treated CNPs, and burgeoning in untreated areas. The ability of rabbits to breed up quickly will mean that their increasing number will consume the regenerating vegetation that is responding to reduction in kangaroo grazing and rainfall. Consequently, with rabbits' attrition of the conservation benefit of kangaroo culling, it appears that failure to adequately fund rabbit control wastes the potential conservation benefits of kangaroo control. More importantly, it would represent a loss of opportunity for advancing conservation in the CNP. Evidently, precautionary rabbit control should precede kangaroo culling. It is clear also that all grazing impacts should be considered before control strategies are determined for any species.

Recommendation: Rabbits should be managed to minimal levels prior to any scheduled kangaroo culling to prevent rabbits from exploiting and

responding to the resources released by the reduction in kangaroo abundance and impact.

Importance: High. Cost: Low-Medium. Payoff: Medium.

Burning

The emphasis in prescribed burning in the urban and suburban areas of the ACT is on protection of life and property. To achieve this in CNP some areas near habitation are designated 'Asset Protection Zones'. Vegetation in these may be slashed, burned or grazed by stock. These areas are likely to offer little value for nature conservation.

Other areas in CNP are managed differently, with some variation. These areas have different requirements for fuel reduction and a different zoning classification. . In the 'Strategic Firefighting Advantage Zone' there is emphasis again on not allowing fuel to build up to high levels. In the 'Landscape Fire Management Zones' the common prescription is low-intensity burns in mosaic patterns during autumn, although there are some cases of no burning, or burning in spring to achieve some diversity of pattern, and a few burns of higher intensity for particular botanical purposes. Choices or flexibility in fire management practices in CNP area are influenced by urban and suburban proximity, although multiple values are taken into account when planning treatments. In some locations the ability to design burning prescriptions to achieve best conservation outcomes for desirable flora and fauna can be compromised (TAMS 2009).

One of the main priorities of controlled hazard reduction burning is to remove fine fuels from the litter layer. Burning removes living and dead ground biomass, stimulates germination of some stored seed, and can induce sprouting from rhizomes and epicormic buds on living perennials. Subsequent rainfall also induces germination of some perennials and some annuals, and the fresh green growth stimulates rabbits to breed (Myers and Poole 1962). This combination of events sets the scene for rabbits to concentrate their grazing on the sprouting and new generation of forbs and perennials. While burning may initiate perennial regeneration, in the presence of rabbits it is likely that the regeneration of palatable species would fail and the reproductive stores of the perennial plants would deplete (Leigh *et al.* 1987; Wimbush and Forrester 1988, and for post-fire grazing by mainly wombats with few rabbits, Leigh and Holgate 1979). Burning, if frequent, repeats the process without re-establishment of perennial flora, leading to local loss of the species. Annual flora then may dominate (Leigh *et al.* 1987), providing only short-term ground cover which also may be burned subsequently. The loss of ground cover exposes fauna to weather and predation, and the soil to erosion, thereby eluting nutrients and reducing landscape function. Controlling rabbits before undertaking controlled burns would seem a prudent precaution, although the task may be more easily achieved soon after burns.

Responses to burning depend on the season, frequency, intensity and extent of the burns as well as vegetation type. Variation in these factors of fire regimes can promote a range of conditions for flora and fauna. Catling (1991) studied

southeastern Australian forests and concluded that frequent, low-intensity burns in autumn reduce ground litter and shrubbery, increase forbs and grasses, reduce vegetation in gullies and creek lines, and reduce forest structure. These conditions suit some native mammals including eastern grey kangaroos and common wombats, rabbits, foxes, feral cats, rats, mice and other exotic species, and disadvantage many other species of native mammals, including swamp wallabies, *Antechinus* spp and native *Rattus*. Less frequent burns of higher intensity in spring promote growth of shrub understory and accumulation of ground litter, and tend to miss gullies and creek lines. These are conditions that promote the diversity and abundance of small native mammals, birds, medium-sized and large mammals and, as above, are unfavourable for rabbits (Catling 1991)[5].

Similarly, for southeastern Australian sub-alpine areas, Leigh *et al.* (1987) concluded that "the effects of high- frequency low-intensity fires were many and varied. They included (i) a reduction in shrub cover; (ii) a reduction in total biomass of shrubby and herbaceous species; (iii) exposure of bare soil; (iv) invasion by alien species; and (v) stimulation of grass-seed production."

Prescribed fuel reduction burns in CNP usually are lit in autumn, generally they are of low intensity, and they are intended to be patchy at small scale. It is important to know whether such fire regimes in the long-term would favour rabbits and the other undesirable herbivorous and predatory pest species and whether some different burning prescriptions would promote communities that include diverse native faunal components on the urban fringe of Canberra.

Invertebrates that live in ground-litter are intimately connected with the recycling of nutrients into the soil. Frequent (3 years) low-intensity autumn fires in dry coastal forests of south eastern Australia depressed the diversity and abundance of ground-litter invertebrates (York 1999)[6]. The fire regime that depressed the abundance and diversity of these important faunal elements is similar to the conditions that Catling (1991) showed as disadvantaging native mammals and birds and favouring the undesirable species. It is important to know whether the common burning regime in CNP would reduce the diversity and abundance of invertebrate fauna also.

The frequency of fires in CNP is related to proximity to the urban edge, and is high relative to reserves in nearby NSW (Buckmaster *et al.* 2010). The prescribed frequencies now are guided by specific vegetation phenology but not faunal responses. Frequent fires is a likely cause of the loss of ground litter and logs in CNP, and among other factors, apparently is a factor contributing to the observed decline and local extinction of most species of native terrestrial small mammal in the large CNPs (Buckmaster *et al.* 2010). These authors did not include rabbits as a contributing factor, although that could be inferred from the interaction of rabbits with responses of vegetation to burning and rainfall.

[5] Rabbits frequently live in shrubby areas, mainly using them for shelter if associated with adjacent open grassy areas that are the main feed source.

[6] Litter invertebrates are highly variable, temporally, seasonally and annually, and laborious to study, but their responses to perturbation are identified readily by appropriate balanced experimental designs.

The season, frequency, intensity and extent of hazard reduction burns in the CNP is important for retention of ground cover for persistence and recovery of conservation values and preventing erosion. It is therefore important that the effect of present burning regimes on abundance of rabbits, kangaroos, exotics, and on the diversity and abundance of valued native fauna is quantified, and should be a focus of future monitoring and research.

Recommendation: Prescriptions for burning CNPs (excluding Asset Protection Zones) should be reviewed with an aim to depress habitat favouring rabbits[7], kangaroos and foxes, to retain population refugia for flora and fauna such as in damp creek lines, to promote complex woodland structures, and to retain ground litter and logs as habitat and shelter for terrestrial vertebrate and invertebrate fauna, microhabitat for flora, protection of soil, and traps for mobile soil and nutrients, thereby promoting landscape function.
Importance: Very High. Cost: Low. Payoff: Very High.

Recommendation: The review of burning prescriptions should direct the design and implementation of long-term adaptive management burning trials that compare existing prescriptions with those designed on the basis of habitat requirements of fauna as well as floral life history. The trials should examine the responses of representative flora and vertebrate and invertebrate fauna, and habitat structure. Special funding and collaborations may be required to achieve such trials.
Importance: Very High. Cost: Medium. Payoff: Very High.

Drought

Failure of rainfall, combined with grazing by kangaroos and rabbits, and perhaps controlled burns, diminishes ground biomass, generally in the absence of replenishment by germination. Such conditions decrease dietary choice and may result in rabbits grazing less palatable perennials and gnawing bark and ring-barking shrubs. During dry seasons, before conditions become extreme, such as these mentioned, conditions are optimal for rabbit control operations; there are few young present, if any, having either died or matured, and the rabbits are avid for food and take bait readily. The reduced herbage means that warrens and burrows are more evident and more easily found for ripping or fumigation. In some, but not all types of soil, the soil may be dry and the burrows more amenable to digging or collapsing.

In the short-term, removal or paucity of ground biomass will affect the survival and local persistence of ground-dwelling species such as some birds, small mammals,

[7] Rabbits, Eastern Grey kangaroos, foxes, feral cats, and exotic rats and mice are favoured by similar habitat structure (Catling 1991).

reptiles and invertebrates (ACT 2004). In the long-term, grazing by rabbits will reduce the vertical structure of woodland habitat and impoverish further the fauna dependent on shrubs and trees for habitat, food or shelter, including wallabies, some birds, bats, possums, lizards and invertebrates. In the short and long term, rabbits probably contribute to the impoverishment of the fauna by being a persistent but fluctuating staple in the diet of foxes (see Robley *et al.* (2004). Similarly, feral cats supported by rabbits, and domestic cats, probably contribute to this degradation (ACT 2004; Barratt 1997, 1998).

Recommendation: For best cost-effectiveness, that is, least cost for best conservation outcome, schedules developed in the prioritisation and planning processes should maximise the implementation of rabbit control in the appropriate seasons, summer and autumn and in dry conditions such as drought, as specified in the prospective RPMS.
Importance: High. Cost: Nil. Payoff: High.

8. Identifying specific impacts

Historical records, in combination with current species lists, can indicate species lost over time. For example, Buckmaster *et al.* (2010) surveyed terrestrial small mammal fauna in three CNPs, compared their survey with two earlier studies, and documented the local extinctions between 1975 and 2005.

Plant losses might be recoverable by re-introduction and sufficient protection from grazing and fire, or they might be recoverable from persisting soil seed or phytoplasm, provided fire is managed appropriately and kangaroo grazing is controlled and rabbit grazing excluded.

Faunal re-introductions would require appropriate habitat and protection from predators. These remedial actions may require knowledge of the limiting factors and habitat requirements; in some cases research may be required, while others may be undertaken opportunistically or with little input. Buckmaster *et al.* (2010) identified a need for substantial ground litter and logs near smooth-barked trees as pre-requisites for re-introducing terrestrial small mammals to CNP. Mulligans Flat predator and grazing exclosure and Goorooyaroo can be expected to offer enlightenment on re-introduction in this region.

Comparison of sites with differing grazed intensities or differing fire histories may be of value in helping to identify values that are threatened in the current management regimes. Once identified, these values can be assessed for their potential for recovery by suitable management.

Exclosures offer the opportunity to observe the outcome of germination events that otherwise would be eliminated by grazing. Appropriate designs may enable attribution of grazing consequences to rabbits or kangaroos or stock, for particular fire regimes. Ainslie/Majura Park Care Group has small unreplicated demonstration exclosures for kangaroo and kangaroo plus rabbit at the base of Mt Majura. These

show that grazing has significant impact on vegetation in that area. The effect of kangaroo grazing has been demonstrated using large exclosures at Mulligans Flat in Goorooyaroo as part of the research partnership between the ACT Government and the Australian National University, known as the Mulligans Flat – Goorooyaroo Woodland Experiment.

PCL has Kangaroo exclosures at Jerrabomberra Grasslands East (14ha) and West (40 ha). These have been monitored by students at University of Canberra, and PCL has monitored them photographically. Apparently grass biomass has increased significantly within the exclosures relative to the outside. However, with the focus on biomass of tussock grasses for habitat for the Earless dragon, it appears that the opportunity to include rabbit exclosures within the kangaroo exclosures has not been taken.

Gibbons (2010) suggests that small localised exclusion fencing that protects localised populations of threatened flora from grazing by rabbits (and kangaroos) is above the existing duty of care involving rabbit control by poisoning, fumigation and warren-ripping, and thereby is a potential biodiversity offset. This applies also to predator-proof fencing for protection of threatened native fauna. However, the high level of duty of care in CNP may disqualify this potential in some instances in CNP, and CNPs may not be the preferred offset sites.

The feral animal-proof fence, established in 2009 at Mulligans Flat, excludes kangaroos, rabbits (a few remain), hares (some still present), dogs, foxes, and cats. Exclusion fences established within and as part of the Mulligans Flat – Goorooyarroo Woodland Experiment will allow also comparison between areas with high and low kangaroo grazing density. The intensive, designed, experimental study can be expected to yield much information on processes involved in degradation, recovery and restoration in CNP. Another important aspect of this program is the very extensive collaboration among ACT government researchers, and staff and students of ANU and other universities. The Sanctuary is an expensive long-term program and funding for it is distinct from the general funding of CNP management, and the ultimate intention is to seek sponsorship funding. This commendable program was developed by PCL staff with support from the Chief Minister, the community, and University expertise.

With respect to managing rabbits, while resources are so limited, PCL directs them to controlling rabbits rather than identifying and quantifying the rabbit's impacts. This strategy benefits existing flora and dependent fauna, although these may be only the less vulnerable components of the biota. However, in time, opportunity may be lost for identifying species that may be in a state of high suppression by rabbits and presently not recognised as being present in the CNP. In time, any preferentially grazed but persisting phytoplasm can be expected to senesce and die. However, observations in the Mulligans Flat – Goorooyaroo Woodland Experiment will offer clues about persisting values and their potential for recovery, although rabbit grazing is not being examined explicitly.

Recommendation: On the basis of knowledge obtained in exclosures studies, such as those at Mulligans Flat, consideration should be given to establishing exclosures in other parts of CNP to promote recovery or restoration of suppressed species of plant and animal. Such exclosures may qualify as biodiversity offsets.
Importance: Medium. Cost: Low. Payoff: Medium.

Recommendation: Continuing current policy, and similar to past achievements, knowledge of conservation values of CNP and the effects of management action in conserving them can be enhanced by seeking further student collaborations. Such benefits are being obtained currently from student studies of the exclosures and predation barriers at Mulligans Flat-Goorooyaroo, and the recommended long-term fire studies would provide further opportunities.
Importance: High. Cost: Low. Payoff: High.

Recommendation: Continuing current policy, and similar to past achievements, further grants of operating funds should be provided for student-higher-degree projects where particular research issues, if amenable to statistical analysis, are identified as salutary to effective management of rabbits in CNP. Staff members should be committee advisors to student supervisors.
Importance: High. Cost: Low. Payoff: High.

9. Monitoring rabbits

As discussed above, rabbit abundance is generally used as an approximate surrogate for measurements of rabbit impact on valued resources, and this is the case in the CNP. Spotlight counting of rabbits is an accepted method of monitoring rabbit populations and enables infestations to be assessed over large distances and areas. This is the main method that PCL uses, and it has been standardised in recent years enabling comparisons before and after control operations and between years. An index of rabbit abundance that may not have been used extensively is counts of active entrances (Parer 1982; Parer and Wood 1986). A benefit of this method is that it is employed during daylight hours. It has been used previously and economically in the ACT (e.g. Williams and Moore 1995) and some Volunteer groups use it. PCL may find it useful in particular situations where spotlight counting is problematic. However, it is imperative that the methods used remain standardised and systematic and as consistent as possible for long-term comparisons.

Recommendation: The current policy of high priority for standardised monitoring of rabbit abundance before and after control operations should be continued and extended where appropriate. This would enable comparisons over time to identify long-term trends and effectiveness of

treatments and strategies, and enable rabbit management to adapt economically to changes and responses (viz. ACT 2002).
Importance: Very High. Cost: Low. Payoff: Very High.

10. Strategic cost-effective rabbit control

The term 'cost-effectiveness' is used here as in common usage, denoting the reverse of 'cost per level of reduction in rabbit abundance or impact', that is, '*reduction in* rabbit *abundance or impact per cost'*. High cost-effectiveness implies good value for money.

Recent trials conducted by PCL suggested that there is little value in releasing rabbit calicivirus into rabbit populations. This outcome is similar to earlier research trials using myxoma virus (Merchant and Robinson 2003). Field strains of calici viruses, some of which may be protective (Robinson *et al. 2002*), are present naturally in the environment and infect rabbits as soon as conditions are suitable for contagion. Timing of release is problematic and it is difficult to determine which viruses are responsible for any subsequent epizootic. PCL correctly recognises that active control methods are necessary.

Several research studies on active control methods are pertinent to controlling rabbits in the CNP. Following the study of Cooke (1981) in semi-arid agricultural land, Williams and Moore (1995) identified the best use of rabbit control methods to control rabbits in grazing land in the ACT and adjacent NSW. Recognising that funding is limiting they determined a hierarchy of cost-effectiveness of combinations of treatments as *Primary control*, with peri-annual *Maintenance control* of low effort and high convenience.

Consistent with the findings of Cooke's study, the most cost-effective *Primary* control included initial poisoning followed by warren-ripping with dogs present, and fumigating those unable to be ripped. The mechanism of this combination is to kill most rabbits by poisoning, leaving fewer to re-open the ripped or fumigated warrens and little cover from weather and predators for any survivors and immigrants. These operations are most effective and cost-effective during summer and autumn when rabbit numbers are naturally at a minimum and most rabbits are vulnerable to the treatments.

Maintenance control followed the *Primary control*, protecting the investment from resurgence of rabbits. Rabbits have a propensity to migrate and are competent colonisers (Stodart and Parer 1988; Parer and Milkovits 1994). The annual low-effort *Maintenance* treatment, comprising fumigation using aluminium phosphide pellets, was an essential part of the cost-effective combination, reducing the resulting numbers of rabbits by about half at each successive treatment. Consequently, after the third *Maintenance control* the rabbit population indices had declined

exponentially so that only very small cost and effort were required to suppress the rabbits (Figure 6). Even lower inputs can be anticipated in following years provided *Maintenance control* continues.

Figure 6.

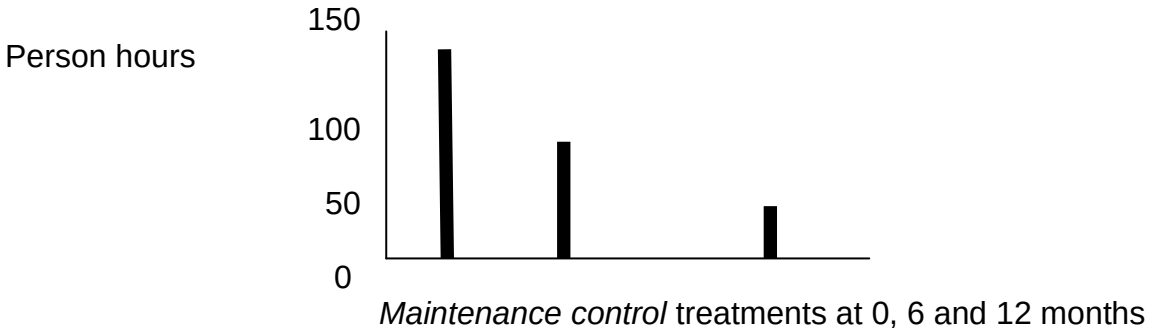


Figure 6. Declining costs of *Maintenance control* treatments (from Williams and Moore 1995)

The situation in the CNP differs from that in ACT grazing land. In areas of CNP close to suburbs, poisoning requires Pindone instead of 1080, and caged bait stations must be used instead of trail baiting. These differences add inefficiencies unavoidably. Also in the CNP warren-ripping can be more difficult because of the high preponderance of slope, rocks, trees and tree-roots. While lower parts of the grazing land can be treated using a tractor with multiple ripping tines, in much of the CNP the efficiency of the ripping operation is reduced by the need to use a back-hoe with bucket or single ripping tine. In very difficult situations warrens can be fumigated and then destroyed by crowbar or, in inaccessible rock crevices, blocked by balls of wire netting.

Nevertheless, the principles established in the research studies apply also in the CNP. The most likely cost-effective *Primary* control comprises poisoning then destroying warrens, fumigating unripped warrens, and then treating peri-annually with fumigation. Treatments such as these contribute to the ACT Government duty of care of CNP (Gibbons 2010).

A most important principle established in these studies is that continuation of the *Maintenance control* treatments greatly reduces the on-going costs of rabbit control, and, conversely, failure to continue *Maintenance control* operations risks rapid resurgence of rabbit numbers, and wastage of the substantial investment in the *Primary* control. In terms of impact on the CNPs, on-going *Maintenance* operations would enable regeneration and establishment of palatable perennials, whereas intermittent or no on-going *Maintenance control* could result in the young plants being grazed out of existence. Currently in the ACT, lack of resources is determining that the latter scenario will apply in many CNPs. The declining cost and accruing benefit of peri-annual *Maintenance control* operations should be noted.

A corollary of the propensity of rabbits to migrate and re-colonise treated areas is that treatment of larger areas is beneficial. For the CNP, this implies treatment of the CNP and as much of the neighbouring land as is possible, at the same time. This in turn implies a need for cooperative programs with neighbouring landholders, ideally on a sub-catchment and tenure-blind basis. Cooperation with neighbours of the CNP is complicated by the CNP having many neighbours including freehold and leasehold landholders, many suburban households, and various Commonwealth and Statutory bodies. Coercion, if required, is not possible while there is no Rabbit Pest Management Plan.

Recommendation: Rabbits in CNP should be controlled strategically in the appropriate seasons using *Primary control* followed peri-annually by *Maintenance control* over as large an area as is feasible, and in the appropriate seasons, as specified in the prospective RPMS.

Importance: Very high. Cost: Medium but declining exponentially. Payoff: Very High.

Recommendation: Steps should be taken to emphasise in the budget process the need to enable a strategic approach to managing pest animals, noting their propensity to resurge when control pressure is eased, and the economy achieved by consistent control pressure, and the wastage incurred by inconsistent resourcing.

Importance: Very high. Cost: Very low. Payoff: Very High

11. Resources for strategic cost-effective rabbit control

Staff

Rabbit control is deceptive in appearing to be simply unskilled field labour, while actually requiring also, *inter alia*, planning and organisation, coordination with neighbours, volunteers and contractors, a long-term view, cerebration and decision-making in its implementation, mechanical capabilities, physical capability, diligence, persistence, and an ability to endure sustained discomfort. Lack of any of these abilities reduces the cost-efficiency of rabbit control programs, wastes money and increases the chances of failure to achieve the desired conservation objectives. Managing rabbit infestation in difficult situations such as CNP is a specialised task needing appropriate training of people with suitable qualities. These people are an investment in expertise, cost-efficiency and conservation achievement. Protection of that investment requires their retention long-term and efficient use of their expertise. That investment includes Staff Rangers who mainly plan and oversee the operations, some Contractors who undertake the major operations, and some Volunteers who assist with limited but time-consuming tasks. This seems to be an efficient use of expertise and available time.

For Staff Rangers the main challenge specifically is matching Staff availability to the needs of the task. A related challenge is the efficient use of their expertise. Presently their duties managing threatening processes overlap with those of the Urban Wildlife Program and dog control, and other duties, particularly in Namadgi NP. While being managed centrally, the Rangers are located Northside, Southside and at Namadgi and tend to operate separately.

Similarly, Research Staff increasingly are required to deal with informing administrative proposals and actions, such as offsets for development proposals. While this is an appropriate use of Research Staff, other important research duties are queued with lower priority and deferred. This situation is an indication of insufficient staff for the burgeoning demand of tasks.

Recommendation: The number of ranger staff and research staff should be increased, or resources re-prioritised, to deal appropriately with the conservation management of CNP, Googong Foreshores and Namadgi National Park, including among other duties, the rabbit control component.
Importance: High. Cost: Nil or Medium. Payoff: High.

Recommendation: The ranger staff should include a senior 'Specialist Ranger' whose specific duty is to drive and manage the rabbit control program across the entire ACT Nature Park system, including Molonglo River corridor, Googong Foreshores, and Namadgi NP, and coordinate it with programs managing other threatening processes and conservation initiatives.
Importance: Very high. Cost: Nil or Medium. Payoff: Very high

Recommendation: Consistent with, and subordinate to the prospective RPMS, the 'Specialist Ranger' should develop a Rabbit Pest Plan of Management (RPPoM) for each CNP, Molonglo River Corridor and Googong Foreshores where rabbits are a problem[8]. Neighbours should be consulted, or involved if appropriate, in developing these plans.
Importance: High. Cost: Low. Payoff: High.

Recommendation: The duties of managing degradation by rabbits and other threatening processes in the CNP should be separated from those of the Urban Wildlife Program which are temporally unpredictable, demand urgent attention and are time-consuming, but unlike rabbit management, are of little conservation value. This may require recruitment or deployment of staff members less senior than skilled Rangers specifically to the Urban Wildlife Program.
Importance: High. Cost: Low. Payoff: High.

[8] The RPPoMs should coordinate with the proposed Operational Plans (Sharp 2010) for the relevant CNPs.

Volunteers

PCL supports Park Care Groups for some, but not all CNPs, partly because funding is limited. The ACT is well off for willing Park Care Volunteers and some are knowledgeable in rabbit management. Currently, they are a valuable workforce for specific limited tasks in rabbit control operations, mainly finding and marking rabbit warrens and burrows. Staff Rangers train them for a limited range of tasks, and organise their operations. Disadvantages in their use include that they are not always accurate, their availability may be intermittent or short-term, and some Volunteers may be physically limited. Their Staff coordinator needs to dedicate time and effort to retaining their enthusiasm, while on the other hand, their enthusiasm may help to augment and sustain motivation of Staff. Their interest and participation is to be encouraged.

The Volunteers of the Park Care program appear to be an underutilised resource. There is a perception among them that PCL prevents them from doing tasks that they know would be valuable in controlling rabbits. On the other hand the Staff of PCL are frustrated that they themselves cannot undertake or complete some of these tasks. There may be reasons, such as accident indemnity, that prevent some clearly-beneficial further cooperation. These obstacles might be overcome by specific formal training of selected Park Care Volunteer leaders and delegating particular authorities to them. An administrative review could identify further opportunities and determine any impediments preventing beneficial cooperation, with a view to greater participation of suitable Park Care representatives, after appropriate training and accreditation where required. The various options should be explored. Greater involvement of Volunteers in managing rabbits in the CNP may substantially improve the resourcing situation and prove satisfying to the Volunteers.

Recommendation: There is a need for a review to identify opportunities for delegating further responsibilities and tasks to selected representatives of Park Care, and any impediments, and whether appropriate formal training and accreditation would enable greater participation of Park Care Volunteers in specific aspects of rabbit control in CNP. The outcome of that review should direct appropriate changes to administration and practices, and identify any necessary appropriate training and accreditation.
Importance: High. Cost: Low. Payoff: Very High.

Contractors

A challenge for PCL is obtaining sufficient accredited Contractors with competency. A second challenge is attracting further potential contractors who are prepared to invest in the necessary training for accreditation and the expensive equipment required. Before they would make the investment these potential contractors need assurance that the ACT Government has made a long-term commitment to strategic control of rabbits. This applies also to retention of the existing Contractors so that they are not attracted elsewhere by contracts of longer tenure. It is anticipated that the supply of Contractors would adjust in response to the level of funding commitment that the Government demonstrates over several years, with appropriate

Departmental guidance by actions such as advertising and providing advice on training and accreditation and assisting with obtaining places in training courses.

Funding

Funding needs to be matched to the needs of the program of controlling rabbits; this is linked with the challenge of providing sufficient Staff time and obtaining sufficient Contractors, and making best use of the potential efforts of Volunteers. Lack of funds prevents initiation of large or complex operations that otherwise Staff would plan, coordinate and supervise, and Contractors would undertake. Also Maintenance operations that would protect and build upon earlier investments in rabbit control sometimes cannot be undertaken, even though these are assigned high priority. While staff resources and supply of contractors are limiting, it is important that these be considered in tandem with funding; large injections of extra funding alone without extra Staff availability could be problematic.

Recommendation: The ACT Government can demonstrate a firm commitment to suppressing the impact of rabbits on the conservation values of CNP by committing secure on-going funding to enable control of rabbits using the proven most cost-effective best-practice strategy and methods that makes best use of available personnel: staff, contractors and volunteers.
Importance: Very high. Cost: Medium but rapidly declining. Payoff: Very High

12. Achievements

A salutary step has been taken in the establishment of the grazing-predation exclosure with factorial treatments in the Mulligans Flat-Goorooyaroo Woodland Experiment. The extensive collaborations and student studies will contribute to identifying conservation values, understanding the interactions involved in degradation, and the requirements for recovery of conservation values.

Conserving values in CNP requires appropriate and various fire regimes that take account of threatening processes and interactions. The necessity for life and asset protection from fire imposes considerable pressures for prescribed burning regimes in CNP that can, in particular places, over-ride protection of conservation values. Under these circumstances PCL is progressing with developing practices that are based on phenology of vegetation types and burn to achieve mosaics of staged regeneration. While compromise is inevitable, present achievements should be recognised and further experimentation encouraged, including taking account of faunal increases or decreases, both desirable and undesirable, to vegetation responses to differing fire regimes.

PCL Staff are well aware of the constraints to controlling rabbits in the CNP and have instituted a program that is systematic wherever possible, but nevertheless would be improved considerably if the main constraints were removed.
Monitoring rabbit abundance in particular CNPs before and after control actions was systematised in 2009-10 using spotlight counts. This salutary development will enable assessment of benefits and cost-effectiveness of current and future rabbit

control programs and enable management efforts to adapt to outcomes and changing circumstances.

In Namadgi NP, PCL has monitored rabbit abundance using spotlight counting regularly since 1993 to the present. This has provided an excellent record of trends since before the advent of rabbit calicivirus and documents a recent recovery of rabbit populations, imparting a warning that resistance to the disease may be developing and that active rabbit control is essential. Such regular and long-term monitoring has become part of the culture of the Namadgi NP PCL unit, and is a salutary development in other PCL sections. It is important that PCL be able to respond with strategic control operations to such signals in the monitoring data.

A desirable situation of low effort *Maintenance control* of rabbits seems to be emerging or achieved in the exclosure at Mulligans Flat. Rabbits have been reduced to very low levels, and rabbits and hares are monitored and reduced regularly by spotlighting and shooting. Shooting normally is ineffective as a control measure for rabbits, but in this situation is appropriate where rabbit numbers are extremely low, warrens apparently are absent, and hares are present.

Where rabbit abundance is monitored, the records enable continuous monitoring of performance of control efforts. Combined with records of effort and costs, it is possible to determine cost-effectiveness. Such records would assist in future prioritisation of control effort (see next section and Appendix 4).

Properties of the CNPs relevant to conservation values, rabbit management and protective action are shown for North side in Appendix 3(a) and for South side in Appendix 3 (b). These data indicate recognised impacts of heavy grazing and significant weed infestations on the CNPs (Sharp 2010); rabbits are known to cause such impacts, but in the CNP stock, kangaroos and other factors would contribute also.

It is evident in these data that many CNPs impacted by grazing and weeds are not treated for rabbit infestation, although in some of these cases, rabbits may not be the cause of the impacts. Red Hill was treated by warren-ripping in 2007-8[9] and Sharp (2010) did not indicate signs of heavy grazing or significant weed infestation, and rabbit numbers were low in 2009-10, although interpretation is equivocal in the absence of monitoring prior to treatment in 2007-8.

Currently the best data available[10] is from Mt Ainslie / Mt Majura which were monitored *before/after* and treated in 2008-9 and 2009-10. In the first year rabbit control operations reduced rabbits, on a spotlight-kilometre basis, from 23/km to

[9] Information supplied by TAMS Land and Management Planning

[10] Data supplied by PCL

11/km, and in the second year from 4.2/km to 2.9/km. This decline is consistent with expectations of strategic control.

Less extensive *before/after* data are available for 2009-10: Mt Painter where control operations reduced rabbit numbers from 29/km to 1.5/km; The Pinnacle (from 12/km to 6/km); Callum Brae (from 12/km to 4/km); Jerrabomberra Wetlands (from 76/km to 17/km) and Red Hill (from 3.3/km to 2.2/km). These outcomes reflect the variable nature of the habitats in the respective CNPs, the effectiveness of the separate operations, and the fact that they were *Primary* control treatments, that is, the initial reductions of rabbits. The outcomes suggest that the control operations undertaken were appropriate for the CNPs and reasonably effective and that strategic control would have the desired effects provided *Maintenance control* treatments follow and continue.

13. Prioritisation of rabbit control in Canberra Nature Park

The recent records of rabbit control in the Northside and Southside CNPs (Appendices 3a and 3b) demonstrate that limited resources mandate choices on which CNPs are treated for rabbits. Criteria used variously by PCL to assign priority include:

- The necessary size of the control operation
- Available funds, Staff and other resources
- High value conservation areas
- Protecting earlier investments in rabbit control
- Maintaining areas of low rabbit population
- Worst affected areas
- The potential to involve neighbouring properties
- The provision of funds specified for particular CNPs
- Local public pressure.

PCL seems to exercise flexibility in these decisions, there being a great number of variables impinging on the situations and potential operations in the CNPs.

While rabbit control funding is inadequate, few CNPs can receive *Primary* rabbit control. Prioritisation generally comprises *Primary* treatment for the worst infested CNPs with some *Maintenance control* of high value CNPs. These decisions are made ACT-wide, but are managed separately by Staff of Northside and Southside and Namadgi, MRC and GF. Revised prioritisation should consider all CNPs, MRC and GF together with Namadgi NP[11], in the interests of conservation. Practical considerations in implementation may require some distinction of the CNPs from Namadgi, MRC and GF. Prioritisation should include those CNPs that need *Primary* control treatment and those in need of *Maintenance control*. It should not respond to public pressure which may be parochial or variably resourceful, instead prioritising for best protection of conservation values across the whole estate, including sites and items of cultural heritage that may be threatened by rabbits.

[11] Namadgi NP is not part of the review of the Commissioner for Sustainability and the Environment

If reasonable funding were to be provided for rabbit control, it may be possible to rationalise the prioritisation process. A priority listing for CNPs to receive the scheduled *Primary* control treatment or *Maintenance control* treatment might be analysed from two sequential regressions. The first regression, of Rabbit Density (or Impact) on assigned values of Conservation Value would give an ordination of relative risk to conservation values, and the second regression, of Estimated Cost (or Time, depending on the limiting factor) for rabbit control treatment on the relative risk to conservation values, would provide an ordination of provisional priority of CNPs for rabbit control. Compared against available resources, the provisional list would identify and prioritise those CNPs that would be assigned for rabbit control treatment or none (or assigned to Park Care, see Recommendations-B 3). Thereafter the outcome should be reviewed with respect to any other impinging factors, to achieve a final priority listing of control actions. Appendix 4 shows a protocol and explanation for this process.

Recommendation: The prioritisation process for rabbit control treatments on CNPs should be formalised as far as possible to optimise use of available resources to ensure strategic protection of conservation values, protect the benefits of past expenditure, and to preclude any influence of external pressures. The effort and costs of rabbit monitoring and control should be monitored operationally to assess performance and cost-effectiveness and for use in prioritisation. A proposed prioritisation tool is shown in Appendix 4. The prioritisation process should take account of the recommended role for volunteers.

Importance: Very high. Cost: Low. Payoff: High.

Recommendation: Namadgi National Park is very high value conservation estate that retains many of the conservation values that have gone from the CNP. Being funded from ACT revenue, it effectively competes with CNP for funding. Funding sources for rabbit control in Namadgi NP (and Googong Foreshores) should be sought on the basis that their different characteristics and purposes might qualify them for different funding, additional to those of the CNPs.

Importance: Medium. Cost: Low. Payoff: High.

14. References

A.C.T. (1997). Kangaroo Advisory Committee (October 1997).
Living with Eastern Grey Kangaroos in the A.C.T. – Public land
Third report to the Minister for the Environment, Land and Planning (1997)

ACT (1999). Canberra Nature Park Management Plan. October 1999. Australian Capital Territory, Canberra 1999.

ACT (2002). ACT Vertebrate Pest Management Strategy. Environment ACT Conservation Series No. 19. Australian Capital Territory, Canberra 2002.

ACT (2004). Woodlands for Wildlife: ACT Lowland Woodland conservation Strategy. Action Plan No. 27. Environment ACT, Canberra, 2004.

Barratt, D.G. (1997). Predation by house cats *Felis catus* (L.), in Canberra, Australia. I. Prey composition and preference. Wildlife Research 24,263-277.

Barratt, D.G. (1998). Predation by house cats *Felis catus* (L.), in Canberra, Australia. II Factors affecting the amount of prey caught and estimates of impacts on wildlife. Wildlife Research 25, 475-487.

Buckmaster, A.J., Osborne, W. S. and Webb, N. (2010). The loss of native terrestrial small mammals in large urban reserves in the Australian Capital Territory. Pacific Conservation Biology 16, 36-45.

Catling, P.C. (1988). Similarities and contrasts in the diet of foxes, *Vulpes vulpes*, and cats, *Felis catus*, relative to fluctuating prey populations and drought. Australian Wildlife Research 15, 307-17.

Catling, P.C. (1991). Ecological effects of prescribed burning practices on the mammals of southeastern Australia. Pp 353-363 *in* Conservation of Australia's Forest Fauna (ed Daniel Lunney). Royal Zoological Society of NSW, Mosman.

Cooke, B.D. (1981). Rabbit control and the conservation of native mallee vegetation on the roadsides in South Australia. Australian Wildlife Research 8, 627-36.

Gibbons, P. (2010). Potential biodiversity offset actions and sites for the Australian Capital Territory. Advice for the ACT Office of the Commissioner for Sustainability and the Environment. The Fenner School of Environment and Society, The Australian National University. August 2010.

Leigh, J.H. and Holgate, M.D. (1979). The responses of the understory of forests and woodlands of the Southern Tablelands to grazing and burning. Australian Journal of Ecology 4, 25-45.

Leigh, J.H., Wimbush, D.J., Wood, D.H., Holgate, M.D., Slee, A.V., Stanger, M.G. and Forrester, R.I. (1987). Effects of rabbit grazing and fire on a subalpine environment. I. Herbage and shrubby vegetation. Australian Journal of Botany 35, 433-464.

Lunt, I.D. (2005). Technical Report 18. Effects of stock grazing on biodiversity values in temperate native grasslands and grassy woodlands in SE Australia: a literature review. Environment ACT.

Merchant, J.C., Kerr, P.J., Simms, N.G., Hood, G.M., Pech, R.P., and Robinson, A.J. (2003). Monitoring the spread of myxoma virus in rabbit *Oryctolagus cuniculus* populations on the southern tablelands of New South Wales, Australia. III. Release, persistence and rate of spread of an identifiable strain of myxoma virus. Epidemiology and Infection 130: 135-147

Myers, K. and Poole, W.E. (1962). A study of the biology of the sild rabbit *Oryctolagus cuniculus* (L.) in confined populations. III. The effects of rabbit grazing on sown pastures. Australian Journal of Zoology 10, 225-267.

Parer, I. (1982). European rabbit (Australia). In 'CRC Handbook of Census Methods for Terrestrial Vertebrates'. (Ed. D.E. Davis.) pp136-8. (CRC Press: Boca Raton, Florida.)

Parer, I., and Wood, D.H. (1986). Further observations on the use of warren entrances as an index of the number of rabbits, *Oryctolagus cuniculus*. Australian Wildlife Research 13, 331-2.

Parer, I, and Milkovits, G (1994). Recolonisation by rabbits after warren ripping or warren fumigation. Australian Rangeland Journal 16: 51-63.

Robinson, A.J., Kirkland, P.D., Forrester, R.I., Capucci, L., Cooke. B.D., and Philbey, A.W. (2002). Serological evidence for the presence of a calicivirus in Australian wild rabbits, *Oryctolagus cuniculus*, before the introduction of rabbit haemorrhagic disease virus (RHDV): its potential influence on the specificity of a competitive ELISA for RHDV. Wildlife Research 29(6), 655 – 662.

Robley, A., Reddiex, B., Arthur T., Pech R., and Forsyth, D., (2004). Interactions between feral cats, foxes, native carnivores, and rabbits in Australia. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Melbourne.

Saunders, G, Coman, B, Kinnear, J and Braysher, ML (1995). Managing Vertebrate Pests: Foxes. Bureau of Resource Sciences, Australian Government Publishing Service, Canberra.

Sharp, S. (2010). Report to Commissioner for Sustainability and the Environment.

Stodart, E., and Parer, I. (1988). Colonisation of Australia by the rabbit. CSIRO Division of Wildlife and Ecology Project Report No. 6.

TAMS (2009). Strategic Bushfire Management Plan for the ACT [Draft]. Territory and Municipal Services, Australian Capital Territory, Canberra 2009.
TAMS (2010). ACT Kangaroos Management Plan. Territory and Municipal Services, Australian Capital Territory, Canberra 2010.

Williams, C.K., and Moore, R. J. (1995). Effectiveness and cost-efficiency of control of the wild rabbit, *Oryctolagus cuniculus* (L.), by combinations of poisoning, ripping, fumigation and maintenance fumigation. Wildlife Research 22, 253-69.

Williams, C.K., Parer, I., Coman, B.J., Burley, J., and Braysher, M.L. (1995). Managing Vertebrate Pests: Rabbits. Bureau of Resource Sciences/CSIRO Division of Wildlife and Ecology, Australian Government Publishing Service, Canberra.

Wimbush, D.J., and Forrester, R.I. (1988). Effects of rabbit grazing and fire on a subalpine environment. II. Tree vegetation. Australian Journal of Botany 36, 287-298.

York, A. (1999). Long-term effects of frequent low-intensity burning on the abundance of litter-dwelling invertebrates in coastal blackbutt forests of southeastern Australia. Journal of Insect Conservation 3, 191-199.

Appendix 1

Constraints to strategic cost-effective rabbit control in CNP

a) Limited staff and too many other demands on their time. A particular problem is the diversion of experienced expert staff from conservation management to localised and short-term issues arising in the Urban Wildlife Program. Research personnel commonly are diverted to pressing issues to detriment of attention to research issues.
b) Shortage of Contractors and limited places in few training courses.
c) Lack of certainty of on-going funding deterring potential contractors.
d) Possible conservative use of volunteers.
e) Shortage of funding prevents rabbit control implementation where and when strategic and economic. This would become more acute if more Contractors became available.
f) Inability to pursue identification of impact of rabbits on conservation values constrains budgetary case for sufficient resources (staff and funding).
g) The lack of a rabbit pest plan of management is a legal impediment to coercion and enforcement of rabbit control action by uncooperative landholders. Existing staff are painfully aware of the need for this Plan. They have the competency to prepare it but are pre-occupied with other duties that they judge to be of higher urgency and therefore higher priority, but not necessarily higher importance. This situation indicates insufficient staff or personnel for necessary tasks.
h) Competing requirements for rabbit control in Namadgi National Park. The limited resources will continue to mandate decisions on priorities with detriment to management, implementation and conservation in either or both sets of reserves.
i) Fire prescriptions for conservation purposes in CNP must be compromised in favour of strategies that protect life and property.
j) Inability to use poisons near places frequented by the public.
k) Use of Pindone near urban areas, which has an antidote but is less effective and has secondary poisoning constraints, instead of 1080 for which there is no antidote.
l) Bait stations are used instead of trail baiting in order to prevent valued wildlife from taking poison.
m) Ripping warrens is constrained by steepness, tree roots, and, on the slopes of Mount Pleasant, woody weeds.
n) Many diverse neighbours.
o) Inflexibility of NCA to requests to replace the woody shrubs at Kings Ave Bridge that provide dense rabbit harbour
p) Lack of response from the Australian War Memorial to requests to remove woody garden shrubs that provide dense rabbit harbour.
q) Asbestos and unmarked buried cables are present in the soil at Jerrabomberra Wetlands impeding fumigation and ripping.

Appendix 2
Key points of rabbit management in CNP

a) TAMS recognises that rabbits threaten conservation values in the CNP estate and require active management.
b) The lack of a rabbit pest plan of management legally impedes the Chief Executive of TAMS from issuing directions to landholders to suppress rabbits.
c) Suppressing rabbits in the CNP presents an opportunity to impede degradation and enhance the value of the natural estate.
d) The recent pattern of funding for managing the threat of rabbits to conservation values in CNP is contrary to the prerequisites of strategic best-practice management of rabbit impact, and precludes its proper implementation. This results in resurgence of rabbits, low cost-effectiveness, and wastage of earlier expenditure, with cost to the conservation values of the CNP.
e) Strategic rabbit control includes a *Primary control* program initially to reduce high numbers of rabbits, warrens and burrows, followed by peri-annual *Maintenance control*. While initial expenditure may be high, costs and required effort decline exponentially in subsequent sequential applications of *Maintenance control*, to minimal levels.
f) The CNP is a difficult environment for controlling rabbits and unavoidably makes relatively high demand on resources.
g) While there is insufficient research into the conservation cost of rabbits in the CNP and the potentials for recovery or rehabilitation, the recent development of the Mulligans Flat-Goorooyaroo Woodlands Experiment can be expected to make a significant contribution to that required knowledge.
h) Research by PCL into values, threats and management of CNP is impeded by many demands on few Staff.
i) PCL Staff commendably and effectively have sought, promoted and used collaborations and student projects where possible to provide the necessary information.
j) The main impediments to addressing the rabbit problem are limitations on, and inconsistent application, of resources. Insufficient funds are provided, they are provided inconsistently, there are administrative impediments to sufficient application of time of skilled staff, there are too few available contractors and funding deters their availability, and there may be unused opportunities for better use of the many willing volunteers.
k) The above impediments in the difficult environment cause inefficiencies in the use of the limited resources, often unavoidably. Examples include application of *Primary control* in the wrong seasons, and an inability to apply *Maintenance control* treatments to CNPs previously treated with *Primary control*.
l) Within the limitations of inadequate resources, PCL Staff use a strategic approach to rabbit control.
m) The limited data available on monitored control operations on six CNPs suggests that the operations were appropriate and effective, and continued application of strategic control would yield a high level of cost-effectiveness and suppression of rabbits in the long-term.

n) Long-term monitoring in Namadgi NP offers a timely and ominous warning that rabbits there (and in CNP) might be developing resistance to rabbit calicivirus.
o) While future funding can be expected to constrain rabbit control below optimal effort, increased consistent funding and some procedural modifications can be expected to enable improved strategic planning, improved prioritisation, and better implementation of rabbit control, with continuing protection of investments and benefit to conservation.

Present practices of hazard-reduction burning for conservation in CNP are designed on multiple criteria including phenology of specific tree species and might be improved with inclusion of faunal habitat values. Adaptive management experimentation on varied burning regimes may identify prescriptions that tend to suppress rabbits and other undesirable fauna and promote conservation of native biota.

Appendix 3(a) North side CNPs: conservation and rabbit management.

CNP name	Area Ha	R-I	B V	M-A	Rabbits treated	Action Needed	Main constraints
Aranda Bushland	93	G	H	?	07,09	Annual observation	
Black Mountain	452		V			Assess	
Bruce Ridge	199		M			Assess	
Crace Grassland	540					Assess	
Dunlop Grassland	100	G W	H^			Assess	
Goorooyarroo		G	V	07,08,09	07,08,09	Annual observation	None
Gossan Hill	45		M			Assess	
Gungahlin Hill	11		H			Assess	
Gungaderra		G	H^			Assess	
Harcourt Hill			L			Assess	
Kama		G	V	09	09	F ri & fu	Funds
Kinlyside			V			Assess	
Mount Ainslie	[1179]	G	V	08,09	08,09	F ri & fu	Funds Contractor
Mount Majura	[1179]	G	V	08,09	08,09	F ri & fu	Funds Contractor
Mount Painter	24	G W	L	09	09	F ri & fu	Funds
Mount Pleasant	57	G*	M	?		Full *Primary* treatment	Funds Contractor Weeds, Access
Mulligans Flat	765	G	V	07,08,09	07,08,09	Annual observation	None
Mulanggari Grassland						Assess	
O'Connor Ridge	9		M			Assess	
Percival Hill			M			Assess	
The Pinnacle	126	G	M	09	07,?,09	F ri & fu	Funds Contractor
Lower Molonglo			V			Assess	
Molonglo Gorge		W	V			Assess	

Ha=Area (hectares) [ ] =combined; R-I= recognised impact (Sharp 2010; * PCL Rangers) (G=grazing , W=weeds); BV=Biodiversity value (Sharp 2010) (V,H,M,L = very high, high, moderate, low; ^=woodland only); M-A = monitoring of rabbit abundance (07,08,09 = financial years beginning with these dates; Rabbits treated (07,08,09=financial years); Action needed (F=*Maintenance control*; ri=rip warrens; fu=fumigate warrens; Assess = assess rabbit abundance and treat).

Appendix 3(b) South side CNPs: conservation and rabbit management.

CNP name	Area Ha	R-I	BV	M-A	Rabbits treated	Action Needed	Main constraints
Callum Brae		G	V	09	09	F ri & fu	Funds, Contractor
Coolemon Ridge	188		M			Assess	
Farrer Ridge		G	H			Assess	
Issacs Ridge East^{e} & West^{w}	34		M^{e} H^{w}			Assess	
Jerrabomberra Wetlands		G*	V	09	08^,09^,09	F fu & ri	Funds, contractor, ri access, asbestos
West Jerrabomberra		G	V			Assess	
Mount Mugga Mugga		G W	H			Assess	
McQuoids Hill	59		M			Assess	
Mount Taylor	295		H			Assess	
Oakey Hill	59		M			Assess	
Red Hill	245		V	07?,09	07,09	F ri & fu	Funds, Contractor
Rob Roy e = East	616	W e	V			Assess	
Tuggeranong Hill	275	W	H			Assess	
Urambi Hills	182	G W	M			Assess	
Wanniassa Hills	217	G	H			Assess	
Googong Foreshores	5089	G	H			Assess	

Ha=Area (hectares);); R-I= recognised impact (Sharp 2010; * PCL Rangers) (G=grazing , W=weeds); BV=Biodiversity value (Sharp 2010) (V,H,M,L = very high, high, moderate, low); M-A = monitoring of rabbit abundance (07,08,09 = financial years beginning with these dates; Rabbits treated (07,08,09=financial years (^= east grasslands only); Action needed (F=*Maintenance control*; ri=rip warrens; fu=fumigate warrens; Assess = assess rabbit abundance and treat).

Appendix 4

Protocol for a possible prioritisation tool for rabbit control in CNP

Note that this protocol has not been tested and is proposed for investigation.

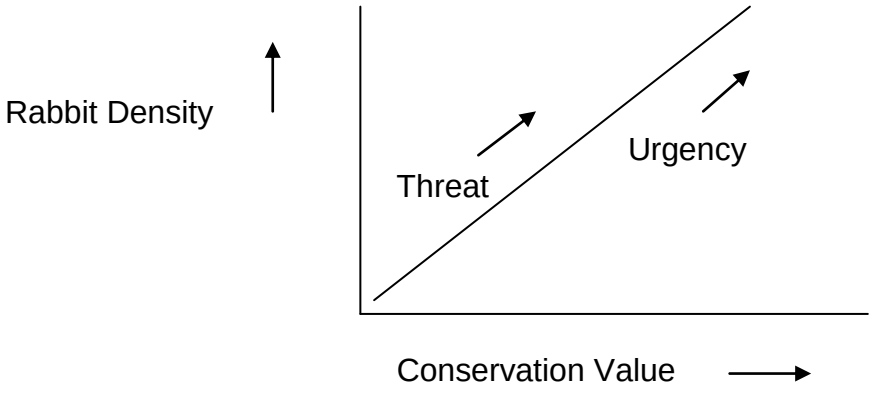
Data required for each relevant CNP:

a) An estimate of Rabbit Density, e.g. number per spotlight kilometre, or number of active entrances per area.
b) An estimate of Conservation Value based on multiple variable criteria and/or intuitive judgements of knowledgeable personnel. Assign best CNP to ordinal 100, worst CNP to 1, interpolating the remainder.
c) An Estimated Cost of Control Action, or if the main limiting factor is available personnel, an estimate of the expected time for completion.

Assumption

This analysis assumes that the level of threat rabbits pose to the conservation values of the CNP is greater when rabbits are in higher densities. A corollary of this assumption is that the need for control treatment of rabbits is more urgent in CNPs where they are in higher densities (Figure A4-1).

Figure A4-1. Assumption of prioritisation strategy



Protocol

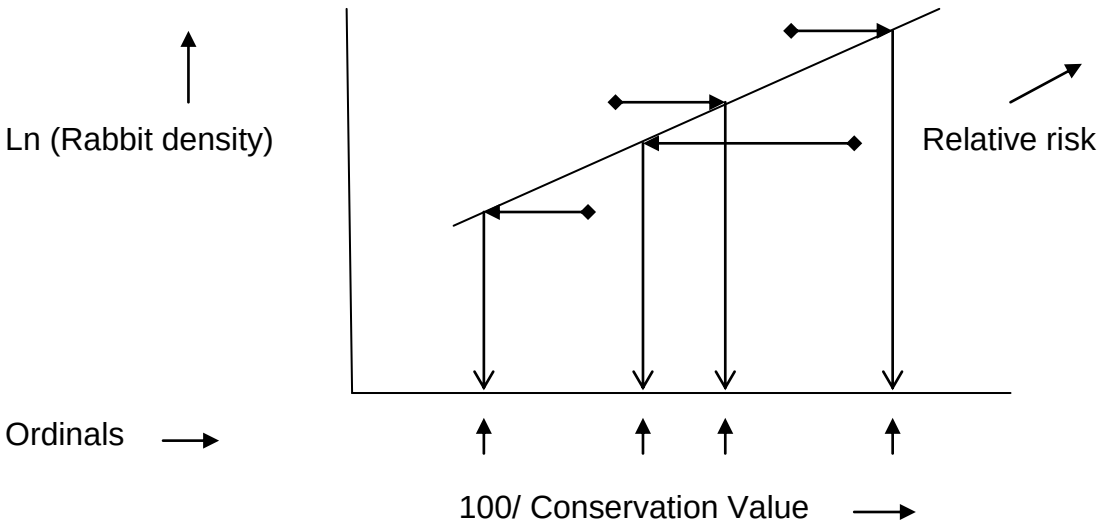
1. Depending on the variation of the data, above, decide whether to use logarithms for the estimates of Rabbit Density.
2. The data of Conservation Value may be transformed to 100/conservation Value, or some other appropriate transformation.
3. Regress Rabbit Density on the transformed conservation Value as the independent variable.

Regression 1

It is expected that the regression will have a significant slope, based on the expectation that the density of rabbits in a CNP will depend on the suitability of the habitat for occupation by rabbits, and that the higher densities of rabbits will have greater impact on the conservation values of the CNP. Nevertheless, previous treatments of rabbits may influence the density of rabbits, and this should be considered when examining the resulting regression (Figure A4-2). In exploring the regression it may be helpful to exclude such cases for separate treatment (see possible rule later). In any case, the spread of the data and significant regression or randomness should be examined for possible causes.

Assuming a significant regression is found, the relative conservation risk or jeopardy for each included CNP can be obtained from the predicted transformed Conservation Value. This is obtained by solving the regression equation for the transformed Rabbit density of each CNP. Graphically this equates to extension of the transformed Rabbit Density of each CNP to the regression line, and then extending from the intersection to the axis of transformed Conservation Value (Figure A4-2). The sequence of intersections, ordinals, describes the relative risk to the Conservation Value of each CNP. The ordinals are read from the left, with the relative conservation risk increasing to the right. Any change of sequence between conservation value and relative risk for the CNPs will accord with the regression residuals of rabbit density.

Figure A4-2.



Protocol (continued)

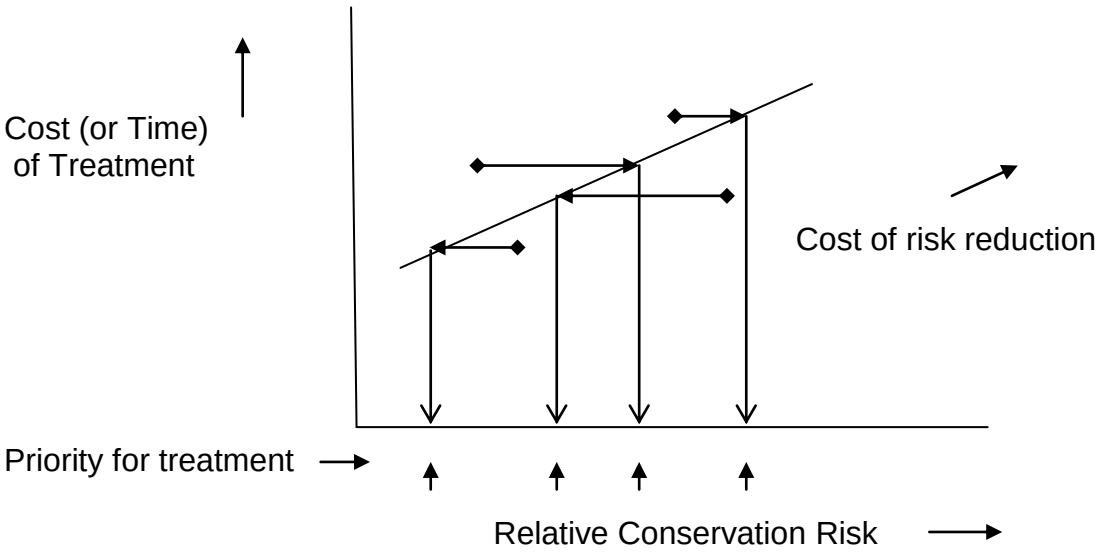
4. Regress the Estimated Cost (or Time) of Control Action on the predicted Relative Conservation Risk as the independent variable (Figure A4-3).

Regression 2

It is anticipated that the Cost (or Time) of treatment will regress significantly on the Relative conservation risk because of the influence of rabbit density on the costs or time for treatment. Again this may be modified by the influence of previous rabbit control treatment of a CNP. The regression should be explored for such effects and the relevant cases could be culled for separate analysis (see possible rule later).

By the same procedures used for Regression 1, assuming a regression is found, the regression of Cost (or Time) of Treatment on Relative Conservation Risk indicates the relative expense of dealing with the risk that rabbits pose to conservation in the CNPs. A priority for rabbit control in the CNPs can be obtained by solving the regression equation for the Relative Conservation Risk for each CNP. Similarly, graphical extension of the Cost of treatment for each CNP to the regression and thence to the axis for Relative Conservation Risk provides the ordinals for priority for rabbit control treatment. Again the ordinals are read from left to right, with priority decreasing sequentially.

Figure A4-3.



Protocol

5. Sum the cost of treatment in each CNP in priority order to the limit of available resources.
6. Recognising this outcome as provisional only, review the full priority sequence and determine whether changes should be made in view of other criteria not used in the analysis.

Possible rule

CNPs that have received the *Primary* control treatment and perhaps one (or more) *Maintenance control* treatments could be removed from the analysis and given top priority, in order to protect the large earlier investment. (If Recommendations-B 3 were effected, the continuing annual *Maintenance control* treatments could be implemented by the Park Care accredited personnel, for example crow-bar demolition of re-opened burrows after the second or third implementation.) These could be replaced in the analysis if a year (or more) of *Maintenance control* treatment is missed. As the program progresses the accumulating CNPs subject to *Maintenance control* treatments could be assessed in the same way as the above. At that stage costs should be low and it should be possible to treat all CNPs with *Maintenance control* treatments.