Condition of selected Natural Temperate Grassland sites in urban and peri-urban Canberra

Final report to the Commissioner for Sustainability and the Environment, ACT

Dr Kenneth C. Hodgkinson

7 March 2014

The condition of fourteen remnant sites of Natural Temperate Grassland in Canberra ranged from 0 to 40 in Floristic Value Score. This variation can be attributed to both past and current land management practices. Current management of these sites (the remnants of Australia's most threatened natural plant community) will not ensure their survival. The native plants and animals of these remnants of Natural Temperate Grassland in Canberra are threatened by overgrazing from kangaroos, animal pests and domestic herbivores, by excessive and untimely mowing regimes, by failure to eradicate weeds, and by failure to apply fire regimes essential for the survival of most of the native plant species. Many of the grassland patches are approaching critical thresholds, beyond which they will change to a different and less desirable state.

Executive Summary and Recommendations

1. The fourteen remnant sites of Natural Temperate Grassland (NTG) measured in this investigation ranged in Floristic Value Score from 0 to 40. Higher scores of 55 to 60 have been recorded elsewhere in the ACT and Southern Tablelands.
2. The generally poor condition of the remnants of Australia's most threatened natural plant community in Canberra is of concern and the ACT Government should allocate more resources, especially for weed and fire management, to secure a future for this natural capital and quintessential grassland of Canberra.
3. These grasslands are now at sub-marginal levels in the ACT and there should be no offsets of this threatened community in land development. The Lawson Commonwealth site (BE08b) should not be allocated to suburb development; the site is of such high floristic condition and is supporting populations of four threatened animal species, that it should be retained as a Nature Reserve or equivalent.
4. The method used by Conservation Research and Planning to derive a Floristic Value Score and other summary data for NTG and other grassy woodland sites, is widely accepted in the scientific community and commonly used by plant ecologists globally. There is a need to add to these measurements the determination of an Evenness Score for the plant community, necessary to calculate the score for plant diversity. This is done by line transects. The point-to-nearest plant measurement using the point-centred quarter method is recommended.
5. The documentation for the Floristic Value Score method used here is unpublished and it is recommended that the method be published in a peer-reviewed journal. This will ensure the method is more widely used for grassland surveys and will standardise the methodology for scientists, consultants and members of Landcare groups in the ACT and surrounding Southern Tablelands region seeking to measure the condition of grasslands for reporting and adaptive management purposes.
6. The management of weeds in the NTG sites of the ACT is inadequate. The aims of the weed management should be to eliminate all 'significant' weeds from the 50 odd sites in Canberra and close surrounds and to minimise the numbers of other exotic plant species. This requires commitment, training and increased resources. It is recommended that a well trained person focus on weed management of the NTG sites in Canberra.
7. The burning of NTG sites is essential to maintain native plant species; mowing and grazing are not substitutes. Scientific evidence now supports autumn, and not spring, as the preferred season for burning. Further research is required to find the preferred fire regime for NTG supporting rare and threatened plant and animal species. It is recommended that more resources be allocated for environmental and scientific fire ecology studies of NTG.
8. The continuation of grazing of NTG and Native Pastures in urban and peri-urban Canberra by domestic stock and large populations of kangaroos is not supported by this survey. The five sites currently grazed had FVS's that were zero or very low.
9. It is recommended that each NTG site have a current Management Plan. The MP prepared for the York Park, Barton site (CC05) should be used as the

standard. In each MP there should be consideration of threatening processes relevant to the site.

Terms of Reference

SCHEDULE 2

THE SERVICES

For the purposes of the Insurance Determination, this Schedule 2 constitutes the **Activity Schedule** (as defined in the Insurance Determination).

The Consultant must provide the Services as follows within any specified timeframes.

Item Number	Details of Services	Timeframe for Completion
1	Inspect and take at least one photograph of each natural temperate grassland site in the ACT except for the Belconnen Naval Transmitting Station site.	31 July 2013
2	Identify, through a visual inspection, those sites, if any, that are still approaching or have reached a critical threshold beyond which unacceptable degradation will occur and identify the causes of the deterioration.	31 July 2013
3	Identify, measure and score using the Floristic scoring method recommend a 20x20m quadrant the following High priority sites areas where no other monitoring is currently in place: MA06 Majura West JE06 Harman Bonshaw south JE07 Harman Bonshaw north BE04a Umbagong south BE04b Umbagong north BE08b Lawson Commonwealth BE10 Caswell Drive BE11 Glenloch interchange TU01 Isabella Pond Using a quicker subjective assessment of species richness, cover and any threats. For the following five Category 2 sites (moderate) JE01 Mugga Mugga Homestead JE04 Woods Lane BE01 Ginninderra Exp Stn CC05 York Park CC08 Dudley Street Note For item3 this should be undertaken at different times in the year first in **Autumn**	31 July 2013

	2013 and again in **Spring 2013**	

4	Review the existing management arrangements in relation to each grassland site and: (a) in relation to each site approaching a critical threshold beyond which unacceptable degradation will occur identify the actions needed to protect the natural temperate grassland on the site in the: (i) immediate to short-term; and (ii) long term. (b) in relation to all other grassland sites identify, for specific individual sites and/or a group of sites, any management changes that are needed to protect the natural temperate grassland on the site or sites in the: (i) short term; and (ii) long-term.	
5	Provide an interim report on the Autumn monitoring by August 2013 Final written report including autumn and spring monitoring addressing items 1 – 4 above by December 2013	Interim report by 1 September 2013 Final report by December 2013.

Introduction

The ACT Government published in 1998 a comprehensive plan for the conservation of the natural capital of the ACT. In broad terms, the need for reserving important natural areas in the ACT was established, the importance of complementary off-reserve systems was recognised, the task of restoring species and plant communities threatened with extinction was understood, the need to monitor biodiversity was seen to be critical for management and reporting, the threats to biodiversity in the ACT were identified to be pest animals, environmental weeds, changed fire regimes, degradation of aquatic systems and the clearing of natural vegetation, and finally the imperative to involve the community in nature conservation was stated clearly. This foundation document adequately brought together the best-practice that had emerged from Australia's ecological research and local knowledge. The document is comprehensive; it has not been weakened by subsequent scientific theories or research.

In the following seven years, the programs and strategies required to implement the plan were developed (ACT Government 2005), including a strategy for conservation of the ecological community recognised as Natural Temperate Grassland (NTG). The strategy was built on knowledge of present natural capital obtained by ecological survey. It was recognised that before European settlement NTG occupied 11% of the ACT. Today NTG's occupy less than 1% of the ACT and what remains is degraded and continually threatened by human activity and invasion of exotic plant species. The strategy for conservation of these remnant patches of NTG involved categorising and development of management plans tailored for each patch. Category 1 sites are core conservation sites because they are of high botanical significance or they are habitat for key threatened species even though they are of moderate botanical significance. Category 2 sites are complementary conservation sites of moderate botanical significance and threatened species habitat or sites of medium area high botanical significance. Category 3 sites are landscape and urban sites of low to very low botanical significance and unlikely to support small populations of threatened species. In addition, two principles for general management of these grasslands, whatever their Conservation Category, were advocated; best practice and adaptive. Best practise management is extensively explored in the document but adaptive management is only outlined and it is still unclear how this might operate.

Canberra was designed to allow people to co-exist and interact with nature. Nature is the natural grassland and woodland on urban and peri-urban land, and to a lesser extent the planted native and exotic vegetation of the Parks and Gardens on public land, along roads verges and in residential and business gardens. Most people value the many natural and semi-natural areas.

NTG is the most threatened natural plant community in Australia (Parsons 1994). Therefore the central task for managers of NTG is to maintain the ecological fabric of the high Conservation Category sites (1 and 2) and rehabilitate the low Conservation Category sites (3) to restore their ecological value. This is required for the enjoyment and satisfaction of people and future generations of people living amongst the patches and corridors of grasslands and linked wooded grasslands in the 'bush Capital'.

The once extensive NTG within the ACT is now highly fragmented and greatly reduced in area. NTG is now confined to 38 small and isolated patches in the ACT. About 1000 ha of these patches are in a more or less natural condition and a further 550 ha are in poorer condition. The patches or sites of NTG are embedded in highly degraded grasslands dominated by weeds (plant species of exotic origin or native species not natural to the area). These isolated patches range in size from <1 ha to 300 ha. In 1996 the NTG in the ACT was declared endangered and an action plan was developed to conserve the remnants (Action Plan 1997). The scientific literature relevant to the ecology and management of native and weedy remnant grassland sites in urban Canberra was reviewed and management recommendations drawn in a report to the ACT Government (Hodgkinson 2005).

The urban grassland ecosystem (NTG patches within a predominant matrix of degraded grasslands) comprise many unique plant and animal species; grasses, forbs, shrubs, trees, vertebrate animals and invertebrate animals. Responses to human activity of the populations of each species have been variable; some have increased in population size, while others have decreased (Dorrough 1995) or been unaffected. It will take some time to fully document and monitor these changes. Six species of the NTG ecosystem have been declared endangered or vulnerable in the ACT; Striped Legless Lizard (*Dema impar*), Grassland Earless Dragon (*Tympanocryptis pinguicolla*)[1], Golden Sun Moth (*Synemon plana*), Perunga Grasshopper (*Perunga ochracea*), Button Wrinklewort (*Rutidosis leptorrhynchoides*) and Ginninderra Peppercress (*Lepidium ginninderrense*). The Action Plan Number 28 (ACT Government 2005) details the management and strategies required to conserve viable populations of these endangered and vulnerable species in the NTG's of the ACT.

Given NTG is the most threatened plant community in Australia and given that four animal and two plant species of this ecosystem are now endangered or vulnerable in the ACT, it is appropriate to review the management of these lands from time to time.

Given the views of Canberra residents (ACT Government, 2002), the development of guiding principles for the ACT Government underpinning policy for sustainability in the ACT and knowledge that key floral and faunal components of the NTG ecosystems are now missing from much of urban and peri-urban Canberra, the retention and management of the NTG of Canberra is of high and critical importance for Government.

[1] When the name of a species first appears in the text both the common and the scientific names are used. When each species is named again, only the common name is used.

Methods

Determination of critical thresholds

The ecological processes operating within grassland ecosystems, and which are fundamental to maintenance and functionality of the systems, are generally well buffered (Ludwig *et al* 1997). Changes in the levels of stress (grazing, drought, fire, physical and other disturbances) on the systems are not significant unless the rise in stress level causes a critical threshold to be crossed. When this happens the system flips into another state and the ecological processes that maintain functionality are disrupted and the system becomes dysfunctional. The crossing of a critical threshold can be sudden and the change to another state or equilibrium in the ecosystem may be irreversible. If the system can be restored, the cost of doing so by adding limiting factors and changing management may be very expensive and prohibitive.

The time and resources required to accurately determine a theoretical framework and criteria for measuring whether critical thresholds were being approached in the NTG's of urban Canberra was beyond the activity schedule for this investigation. In the author's earlier report to the Commissioner (Hodgkinson 2009), subjective assessments based on the experience and perceptions of the author were used. The landscapes were 'read' at each site for evidence of approaching critical thresholds. The following visual methods were sequentially employed for each major stress when sites were visited again in this present investigation.

Grazing

First, the species of large herbivores present/recently present at each site were determined by a combination of methods; direct observation of the presence of herbivores, size and shape of dung scats and other knowledge, such as presence of active rabbit warrens and verbal information provided by managers.

Second, the level of current grazing was judged on the height of grasses, grass seed reproduction in the last growing season, inter-tussock spaces, appearance of the soil surface and presence of current erosion. If maximum heights of grasses were generally below 5 cm, if little or no grass seed production was occurring and there was soil erosion, the site was judged to be approaching a critical threshold beyond which plant survival and landscape function were likely to be compromised. The area or combined total area deemed to be overgrazed needed to be of significant size and the overgrazing needed to be recent. There had to be more than one patch being overgrazed in the site for this judgment to be made. When drought and grazing stresses combine there is synergy in the ecological response (Hodgkinson *et al* 2000, Hodgkinson and Marsden 2005, Hodgkinson and Muller 2005) but in this investigation the grasslands were not in drought.

Weeds

First, the weeds present were named.

Second, the area invaded by these weeds was subjectively judged. If weeds were becoming dominant at the site or were compromising the species richness of a NTG or were compromising a threatened plant or animal species the site was deemed to be approaching a critical threshold. This judgement was made with the understanding that weeds may remain at low densities for a long time but then irrupt because of changed climate and/or disturbance.

Mowing

First, the site was judged on whether it was being mowed regularly.

Second, if the grasses were mown below 10 cm, if no or little reproduction occurred this year, if there was a presence of Chilean Needle Grass (*Nassella neesiana*) and/or African Lovegrass (*Eragrostis curvula*) and if native species known to be sensitive to mowing were observed, the site was deemed to be approaching a critical threshold beyond which native species were compromised.

Fire

First, the degree of canopy closure was visually assessed.

Second, if the canopy was generally closed then the site was judged to be approaching a critical threshold beyond which lack of fire to open the canopy inhibits reproduction and establishment of native forbs and other native species. An additional reason for burning sites is that all Australian grasslands have evolved with the occurrence of fire for millennia and the plant communities and native species are adapted to certain fire regimes. These are described in terms of season, intensity, frequency and patchiness of fires. All the sites should be prescribed-burnt with a fire regime that maintains local populations of native plant species. Grazing does not substitute for fires because fire only occurs when the foliage is mostly dead and when the climatic conditions are conducive (high temperature, low humidity and high wind) to fire being carried. Grazing can occur at any time and condition of the foliage (generally grazing occurs when leaves are green and the plants actively growing). As a result of these and other factors, fire and grazing invoke different physiological and ecological plant and animal responses.

Physical disturbance

First, the presence of areas where earth had been moved or compacted was visually determined.

Second, if this disturbance was over a significant area within the site and continuing, a critical threshold was being approached beyond which persistence of local populations of native plant and animal species would be compromised.

Determination of Floristic Value Score

The method used to calculate the Floristic Value Score (FVS) is described by Rehwinkel (2007) in an unpublished document. It was developed by Rainer Rehwinkel, with significant inputs from Sarah Sharpe, David Edey and Greg Baines and others. The method is used by the Conservation Research and Planning group of the ACT Government and by NSW Environment and Heritage for determining the conservation value of grassland on the Southern Tablelands and for monitoring sites.

A standard area of 400 m^2 (a 20 m by 20 m quadrant configuration is recommended but it could be any shape as long as the total area remains 400 m^2) is located at each site after inspection of the whole site. The areas selected are judged to contain the highest plant species richness at a site. Plant species richness is scale dependant so for monitoring purposes it is essential that areas surveyed are constant in size and shape and precisely located so future measurements can be made on the same area of land. At nine of the 14 sites, two diagonal corners of the 20 m by 20 m plot were marked by driving into the ground coloured plastic pegs (one yellow and the other orange). A nail was hammered into the centre of each peg for easy later location with a metal-detector should the plant canopy become closed. The geographic location of each peg was determined by GPS measurement. On the top of each peg the direction of two sides of the plot was indicated by arrows marked using a permanent ink pen. At the remaining five sites (termed 'virtual' quadrants in this report) the 20 m by 20 m area was temporarily delineated by laying out tapes to form each side of a square but no corner pegs were driven into the ground. At the centres of the quadrants a GPS measurement was made.

On three occasions (July, October and December) the plant species in each of the 14 quadrants and their cover-abundance scores (using the scales of Braun-Blanquet, 1932) were determined. There was no quicker substitute for determining the floristic condition of the 'virtual' quadrants so the same procedure was used on all 14 sites.

It was found to be essential to revisit the quadrants because plant identification is based on floral characteristics and species have different phenologies. The three visits substantially increased the chance of correct plant identification. Identification of the plant species was based on descriptions from several sources (Edey *et al* 1998, Wood and Wood 2005, Jacobs *et al* 2008, PlantNET of the NSW National Herbarium and Census of plants of the Australian Capital Territory (ACT)). If a plant species could not be immediately identified, a specimen of the species was taken from outside the quadrant and placed in a specimen press for later identification. Species of the genus *Rhytidosperma*

always required close examination of floral structures under a binocular microscope to determine the species.

The data obtained in each quadrant (actual and 'virtual') from the three visits were consolidated and entered into Microsoft Excel spreadsheets and the Excel Program developed by Conservation Research and Planning was used to calculate the FVS and other summary statistics. The data and statistics for each quadrant are in Appendix 2 and a summary of the statistics is shown in Tables 1 and 2.

Site evaluations

Ginninderra Experimental Station (BE01)
Belconnen: National Land

View of the 'virtual' quadrant facing south. This quadrant was placed in the middle of one of two paddocks at the site. The dominant grass is Kangaroo Grass (*Themeda triandra*) which is common on crests and slopes of this landscape; introduced grasses dominate the bottoms (not visible in this image). Date of image is 15 August 2013.

Closer view of the crest of this modestly grazed NTG. Centre of the 'virtual' 20 x 20 m plot is latitude -35.175513 and longitude 149.050834 at 606 m. Note the abundance of fresh kangaroo dung in the foreground between tussocks. Date of image is 15 August 2013.

Site report
The site of 19.4 ha comprises 18.9 ha of NTG and 0.8 ha of Exotic Pasture at the bottom of slopes on either side of the main access road. There are three parts to the site; a small 'reserve' not grazed by domestic herbivores and sections of two paddocks for grazing as shown in Appendix 1. The area of the 'reserve' shown on the aerial view is actually larger and extends to the southern track, thereby doubling its size. During the first visit in August, a mob of about 200 kangaroos were grazing in the southern paddock. This mob would be mobile and probably grazes anywhere on this western portion of the Experimental Station beyond Kuringa Drive and other nearby pastoral land in both New South Wales and the

ACT. Sheep were not grazing either paddock during the three visits. No threatened species are known to be on the site and the Conservation Category is 2. Weeds were not observed in the quadrant (Table 2) neither in the two paddocks, but there were some weeds in the 'reserve'. The vegetation cover on the site overall was high, a result of the high early spring rainfall and prudent grazing management.

The geographic Cartesian coordinates for the centre of the 'virtual' quadrant were 686756 and 6105567 from Datum GDA94 in zone 55H.

Critical thresholds

At the previous inspection in 2008 at the height of drought, kangaroos were heavily grazing the site (fresh kangaroo dung was abundant) and the landscape was judged to be approaching a critical threshold for landscape stability. Most grasses were grazed to a height of less than 2 cm and there were multiple patches of active surface erosion on steeper slopes. In 2013, no active eroding patches were found during the 3 visits to the site, no significant weeds were present in the quadrant but there was a critical threshold being approached because of failure to autumn-burn this NTG site.

Floristic Value Score

The FVS was 7 (Table 1) which is a low floristic condition; there were only 3 'indicator species' in the quadrant. However this is typical of grazed NTG because sheep selectively feed on, and thereby eventually eliminate, many of the native forbs which are generally highly palatable compared with native grasses such as Kangaroo Grass and the 'significant' weeds.

Management of the site

The manager of the site (CSIRO) is effectively controlling weeds and achieving some natural resource conservation by prudent sheep grazing management. There were several large mobs of kangaroos present on the Experimental Station during the 15 August 2013 visit, but there was no evidence at this time of their grazing being detrimental. Forage availability was high in 2013 because of the preceding three year period when rainfall was regular and high. In drought times it would be important to reduce kangaroo populations, and numbers of sheep grazing the two paddocks, to prevent 'death traps' for grasses where the combined stresses of drought and grazing accelerate mortality.

A general "Biodiversity and Conservation Management Advise" document has been issued to CSIRO. It is not clear whether a Memorandum of Understanding (MOU) or a Management Plan (MP) exists but a letter from CSIRO (dated 26 February 2013) indicated Dr Maxine Cooper (the previous Commissioner) had met with CSIRO in October 2008 and that in this meeting CSIRO agreed to update the MOU but there has been no follow up by the ACT Government with CSIRO on this matter. CSIRO remain committed to protection of NTG on their land and are prepared to enter into discussions for a new MOU. **In the immediate to short term**, the ACT Government should develop a new MOU and MP with CSIRO. The MP should state how threatening processes, at this and other sites, will be managed in the context of climate variability, grazing (both sheep and kangaroos) and the loss of native plant richness by natural seed attrition.

Also in the MP it is recommended CSIRO should change grazing and fire management of the two paddocks that comprise the site, if there is flexibility in the overall management of the Station's sheep flock to do so. The two paddocks should be autumn-burnt every 3 to 5 years to generate the non-grass flora from the soil seed pool and by resting the paddocks from sheep grazing during the spring/summer periods to allow these native plant species to grow and reproduce viable seed and for the biomass to rise to carry the prescribed autumn-burns. Grazing of sheep during the autumn/winter period should remain prudent. The 'reserve' area should also be autumn-burnt every 3 to 5 years. These managements may not substantially impact on the management of the sheep component of the operation and would be an important contribution to conservation of biodiversity in the threatened NTG's of the ACT. **In the immediate to longer term** the quadrant should become permanent and assessed biennially. In making this assessment, and this applies to all botanical assessments of the remnant patches of NTG in the ACT whether made by staff of the Conservation, Research and Planning group or by consultants, density of plant species in the quadrants should be determined by point-to-plant measurements (in addition to the useful cover-abundance scores estimated by the scales of Braun-Blanquet, 1932). This would enable the collection of data suitable for estimation of species evenness indices (see Cottam and Curtis 1956, and other papers, especially those describing the point-centered quarter method), an essential attribute of grasslands to be measured alongside species richness estimations, in the determination of plant diversity.

Umbagong District Park south (BE04a)
Belconnen: Territory Land

General view of the NTG site. The tape indicates one side of the quadrant. Note the dense and moribund grass cover at this high quality site and the soil disturbance and erosion along the *ad hoc* cycling and walking track through the grassland. The image was taken on 18 June 2013.

Closer view of the NTG. At the end of the 20 m of measuring tape is a 'steelie' post which is a permanent transect marker. Diagonally from this corner marker is a yellow peg at latitude -35.216847 and longitude 149.020839 and at 559 m. The image was taken on 18 June 2013.

Site report

This small site of 2.8 ha in Umbagong District Park is a NTG of high floristic quality, locally known as the 'Blue Devil Grassland'. The Park occupies an area of about 50 ha of the Ginninderra Creek corridor in the suburb of Latham (see aerial view of the Park in Appendix 1). The site has a Conservation Category classification of 2 and no threatened species have yet been found at the site (Crawford 2000).

This site is of considerable interest to botanists and zoologists. The plant species at the site have been determined on many occasions; in 1998-99 by Isobel Crawford, several occasions in 1992 by Alison Rowell and on several occasions in the period 1992 to 2008 by Sarah Sharpe. An unpublished report of the data from these surveys up to 2000 was prepared by Isobel Crawford for the Umbagong Landcare Group.

The volunteers from the Umbagong Landcare Group, particularly Robert Cruickshank, regularly hand weed the site. Despite this dedicated and effective weeding, two 'significant' weed species were found in the quadrant (Table 2).

The site has been burnt on five occasions during the last 20 years according to diaries kept by Robert Cruickshank for the Umbagong Landcare Group. Significant sized fires occurred in this grassland on 7 & 12 October 1994 (Government prescribed spring burns), 15 June 2000 (arson), 24 March 2001 (arson), 13 May 2007 (arson) and 23 October 2009 (Government prescribed spring burn).

The geographic Cartesian coordinates where the yellow plastic peg was driven into the ground at a corner of the quadrant were 683930 and 6101038 from Datum GDA94 in zone 55H. In the diagonal corner was a 'steelie' (shown in the above images, a permanent marker of a sampling transect set up by Sarah Sharpe, probably in 1992, on which is a metal tag, secured by nuts and bolts, engraved "Environment ACT biodiversity monitoring Phone 6207 9777". The coordinates for the 'steelie' (shown in the first image above) in the diagonal corner from the yellow peg, were 683915 and 6101059.

The site is grazed by kangaroos as fresh dung was found on the ground at the June visit. However, the population of kangaroos is small (five in number according to Caroline Wegner, Convenor of the Umbagong Landcare Group) and could be permanent, despite the high numbers of people who use or pass through the Park.

Critical thresholds

There was no evidence of any approaching critical threshold at the site from the threatening processes of grazing, weed invasion, mowing or physical disturbance. The *ad hoc* path shown in the image is of some concern but it is unlikely people will venture from the path and disturb the grassland. However the site should be autumn-burnt by prescribed burning every 2 to 3 years. In 2000, 2001 and 2007 the site was autumn-burnt by arson. It would be desirable for Government prescribed burning to change from spring to autumn burning.

Floristic Value Score

The FVS was 31, third in order (Table 1) for floristic condition which confirms the high floristic value of this site. The high FVS for the quadrant was based on the presence of 11 native 'indicator' species and 15 native common/increaser species. There were 2 'significant' weed species at the site.

Management of the site

The MP for the Umbagong District Park was sighted in 2008 and although brief, it did direct that this grassland site be burned every 2 to 3 years in the autumn. At the North Belconnen Landcare Group study site at Croke Place along the same Ginninderra Creek corridor, a positive floristic change from biennial autumn burns supports the practice of frequent autumn burning at this site. **In the longer term**, regular monitoring of the quadrant I have now established, to determine trend in FVS, will confirm whether the fire season and frequency of 2 or 3 years is appropriate for the site.

This site is independently managed as public open space by several discreet units in ACT Government, each with different mandates. In addition, significant volunteer conservation work is carried out by members of the Umbagong Landcare Group under the umbrella of the Ginninderra Catchment Group. There is currently no agreed and shared vision for the management of the grasslands in the Park and this has led to conflicts over management practices by these independent groups with their different agenda's, mandates and people. **In the immediate to short term**, four recommendations are made.

1. Units of Government and the Umbagong Landcare Group should meet to develop a shared vision for the NTG and other modified grasslands in the Park, to exchange statements on mandates, management plans and strategies and to draft an update of the MP for Government acceptance.
2. Managers of the relevant units in Government should meet from time to time with the Convenor (or Co-convenors) of the Ginninderra Catchment Group to share information and maintain dialogue on proposed activities in the Park and along the Ginninderra Creek corridor.
3. This site should be autumn-burnt every 2 to 3 years, not spring-burnt every 15 years as seems to be the practice of Government over the last 20 years despite the direction for autumn-burning given in the existing MP (sighted in 2008).
4. The Conservation Category for this site should be raised from 2 to 1 on the grounds that the Floristic Value Score of 31 is high. The site is of high botanical significance and although no threatened species have been reported, the site appears to meet the criteria for Category 1.

Umbagong District Park north (BE04b)
Belconnen: Territory Land

General view of the NTG site. The 'steelie' amongst the trees in the middle distance (painted white at the top) is one corner of the quadrant. Note the dominance of Kangaroo Grass in the quadrant. The image was taken on 22 June 2013.

Closer view of the NTG site. The location of the yellow corner peg of this permanent quadrant is latitude -35.211600 and longitude 149.029453 and at 558 m. The image was taken on 22 June 2013.

Site report

This medium sized site of 12.7 ha comprises 7.2 ha of NTG, 1.8 ha of Native Pasture and 4.7 ha of Exotic Pasture (see Appendix 1 for an aerial view of the Umbagong District Park and locations of these grassland groups). No threatened species are known to exist at the site and the Conservation Category is 3. The level of weediness in the quadrant was low (only one 'significant weed' species) and acceptable. There is regular weeding by a group of volunteers from the Umbagong Landcare Group.

The geographic Cartesian coordinates where the yellow plastic peg was driven into the ground were 684726 and 6101604 from Datum GDA94 in zone 55H. The coordinates for the 'steelie' (shown in the first image above) in the diagonal corner from the yellow peg, were 684733 and 6101628.

Critical thresholds

There is an approaching critical threshold for losing forbs from the site because of the smothering effect of extensive patches of moribund Kangaroo Grass. The actions needed at this and the south (BE04a) site of Umbagong District Park is to autumn-burn these every 2 to 3 years.

There was no evidence of any approaching critical threshold at the site from the other threatening processes of grazing, weed invasion, mowing or physical disturbance.

Floristic Value Score

The FVS was 12, ninth in order (Table 1) which conforms to the Conservation category of 3. The quadrant only exhibited four level 2 'indicator' species but it is likely there are more of these level 2 species in the soil seed pool that could be 'generated' by autumn burning. There was one 'significant' weed species in the quadrant.

Management of the site

The MP for the Umbagong District Park was sighted in 2008 and there was no mention of burning areas other than the BE04a Umbagong south site. **In the short term** both BE04 sites should be autumn-burnt every 2 to 3 years coupled with assessment and monitoring of the quadrants to determine the effectiveness of the management. The comments on burning the BE04a site and the recommendation to develop a shared vision and updating the MP for the grasslands in the Park, apply to both sites.

Lawson Commonwealth (BE08b)
Belconnen: National Land

General view of the site and part of the permanent quadrant in the foreground. The suburb of McKellar is in the valley over the ridge. The site is on the north side of the entrance drive into the defence establishment. This image was taken on 30 July 2013.

Closer view of quadrant area. Note the moribund character of the grassland. This requires autumn-fires for regeneration and reproduction of flora. Location of the yellow corner peg of this quadrant is latitude -35.221700 and longitude 149.099367 and it is at 558 m. The image was taken on 22 June 2013.

Site report

This area of NTG, adjacent to the security fence of the defence establishment, is part of a large area of about 140 ha (see Appendix 1) of species-rich NTG. The site is in Conservation Category 1. There are populations of four threatened species, Striped Legless Lizard, Grassland Earless Dragon, Golden Sun Moth, and Perunga Grasshopper present at the site. In addition the site is known to have high floristic value. The conservation condition of the quadrant is still high but canopy closure of the grassland is suppressing establishment of forbs.

The geographic Cartesian coordinates where the yellow plastic peg was driven into the ground were 691070 and 6100348 from Datum GDA94 in zone 55H. The coordinates for the orange peg, in the diagonal corner from the yellow peg, was 691052 and 6100325.

Critical thresholds

The site appeared to be lightly grazed by kangaroos (there were only a few clusters of kangaroo dung seen on the ground) on each of the three visits. Two 'significant' weed species were found in the quadrant but in general weed density is low and is adequately controlled by the manager. The grassland is in a moribund state and in need of prescribed autumn-burning. However, in line with the Precautionary Principle, autumn-burning of the site to open the grass canopy cannot be recommended because the effect of fire regimes on populations of each of the threatened species at the site is poorly understood by ecologists; there are no relevant studies in peer-reviewed literature. No other critical thresholds were being approached at the site in respect to threatening processes.

Floristic Value Score

The FVS was 32 (Table 1), the 2nd highest floristic condition of the quadrants at the 14 sites. A large portion of this site was inside the high wire security fence of this defence establishment and was not examined, so it cannot be confirmed that the small part of the site examined outside the security fence is typical of the whole. Other botanists have previously recognised the high floristic value of the site overall so it is likely the established quadrant is typical of the site. There were 12 'indicator species' in the quadrant.

Management of the site

No MOU between Department of Defence and ACT Government or MP documents for the site were sighted. A letter sighted from Department of Defence to the Commissioner dated 8 April 2013 stated the MOU signed in September 1998 had now expired and had not been renewed. Defence expressed the opinion that updating the MOU was not now necessary because the issues addressed in the MOU were addressed in the Federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Furthermore the Department of Defence is "currently undertaking activity to dispose of the Bonshaw and former Belconnen Naval Transmission Station sites."

In the immediate and short term it is recommended the Commissioner gain an understanding of the plans for, and implications of, the disposal of the Lawson Commonwealth (BE08) site, for the conservation of the high-biodiversity in the area and, in particular, the maintenance of viable populations of the threatened animal species at the site. The site is clearly of high floristic and faunal value with a FVS of 32 in the quadrant and a Conservation Category of 1 for the site overall, and should be permanently and legally conserved**.** There does not appear to be a case for biodiversity offsetting as these NTG's are the most threatened of any plant community in Australia (see Introduction) and any remnants should be conserved and not used for other purposes. A new MOU and MP should be developed between the ACT Government and the new managers of the land. The Department of Defence consider that a MOU and a MP are now redundant given the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This Act is general in nature whereas the MOU's and MP's are specific for the sites. Both are still necessary to specify how a local area of land, with unique characteristics and history, should be managed to protect the natural environment and achieve conservation of the biodiversity at the specific site. **In the longer term** the site should be managed by autumn-fire (probably by patch

burning to ensure viability of threatened faunal species) and weeding of exotic plant species.

Caswell Drive (BE10)
Belconnen: Territory Land

View of the grassland/Snow Gum woodland interface, with Black Mountain in the distance. Note the eroded banks of the dry stream bed in the middle distance (probably caused by a long history of domestic grazing, now ceased) and the very closely grazed grassland in the foreground. The image was taken on 26 June 2013.

Close up of the quadrant showing the active erosion in patches and the pedestal nature of the grass tussocks. The location of the yellow corner peg of this quadrant is latitude -35.277672 and longitude 149.081495 at 586 m. The image was taken on 26 June 2013.

Site report

This small site (4.8 ha) of NTG has been placed in Conservation Category 1 without there being any threatened species reported for the site. The site is part of the larger Aranda Snow Gum Reserve formed in 2002 by means of Variation 182 to the Territory Plan. The site is heavily grazed by kangaroos and some rabbits. Most Kangaroo Grass plants and other native grasses and forbs were very closely grazed, severely limiting reproduction by seed and substantially raising the risk of their accelerated mortality from drought-induced stress. Soil erosion was evident over the area and in several patches there were pedicel roots of the grass plants, as shown in the above image.

Friends of Aranda Bushland have been undertaking weed control in the Reserve since 1999.

The geographic Cartesian coordinates where the yellow plastic peg was driven into the ground were 689310 and 6094177 from Datum GDA94 in zone 55H. The coordinates for the orange peg, in the diagonal corner from the yellow peg, was 689336 and 6094192.

Critical thresholds

At the inspection in 2008, during the last protracted drought, kangaroos and rabbits were found to be heavily grazing the site (determined by abundance of fresh kangaroo and rabbit dung) and the landscape was judged to be approaching a critical threshold for landscape stability. Most grasses are still being grazed to a height of less than 2 cm and there are several patches of active surface erosion on steeper slopes. One 'significant' weed species was found in the quadrant.

The site is approaching a critical threshold for grazing damage and unless the kangaroo grazing pressure is urgently reduced the grassland will continue to lose function.

Floristic Value Score

The FVS for the quadrant was 5 (Table 1), which indicates that this site is currently exhibiting low floristic value; there were only 3 'indicator species' in the quadrant. However this low FVS is typical of grazed NTG (see BE01, JE06 and JE07) because sheep and kangaroos selectively consume the native forbs which are palatable and if they are constrained and in high density, their grazing prevents many species from flowering and setting viable seed.

Management of the site

The action required in the immediate to short term is to reduce kangaroo numbers at the site and if possible, limit the entrance of kangaroos from the adjacent Black Mountain Reserve area. **In the longer term** when grazing is much reduced, prescribed autumn-burning should begin in the NTG. Fire will need to be kept from the adjacent Snow Gum woodlands as this relict population of Snow Gums on the outer edge of its distribution range, may be adversely affected and unable to survive the stress of fire.

Glenlock interchange (BE11)
Belconnen: Territory Land

General view of the site. Black Mountain is in the distance. Note the ungrazed appearance of the grassland. Kangaroos from Black Mountain appear to be deterred from grazing the site because of the heavy traffic on the surrounding roads. The image was taken on 27 June 2013.

Close-up of the grassland with the yellow corner peg in the middle foreground. The location of this peg is latitude -35.280481 and longitude 149.083766 at 576 m. The image was taken on 27 June 2013. Note the heavy infestation of St. John's Wort shown in the upper part of the image.

Site report

This small site of 2.2 ha of NTG forms an ecological bridge between Black Mountain Nature Reserve and the NTG's of the Kama/Molonglo area. The site is placed in the Conservation Category of 1. It does not appear to contain any threatened plant or animal species. The high conservation classification would derive from the high plant species richness of the site and the presence of a marginal population of Snow Gum (*Eucalyptus pauciflora*). The botanical/ecological significance of the site was recognised soon after the commencement of Canberra (Pryor, 1938).

This population of Snow Gum is at 575 m on the upper edge of the frost hollow. The size of the population was measured in 2004 by Jean Geue of Friends of Aranda Bushland and found to be 12 trees and 37 saplings (of height greater than 15 cm). One of the trees is very old and known as Pryor's 'notable tree', a

photograph of which appears in Pryor and Banks (2001). The height of this tree is about 8 m and its girth at breast height is 3.2 m. The population comprises three discrete patches of Snow Gum trees, typical of a marginal population.

The site is recognised as being of Aboriginal heritage value but it was not possible to determine the nature of artefacts/carvings found at the site or of the heritage significance placed on the site.

The site appears to be currently managed by ACT Roads; it is completely surrounded by roads that form the recently constructed Glenloch Interchange. It is likely the interchange was designed to accommodate the marginal population of Snow Gums and the presence of Aboriginal artefacts or a site of cultural significance. The site presumably will be handed over eventually to another section of the ACT Government for long term management.

The geographic Cartesian coordinates where the yellow plastic peg was driven into the ground for the quadrant were 689510 and 6093861 from Datum GDA94 in zone 55H. The coordinates for the orange peg, in the diagonal corner from the yellow peg, were 689531 and 6093884.

The site in general is very weedy although the quadrant in the NTG of the frost hollow contains only one significant weed species. According to Jean Geue, the weeds of the site were last cleared by 6 work parties (with 20 to 30 people, including rangers, in each party) in 2001 and 2002.

Critical thresholds

Two critical thresholds are being approached at this site because of lack of appropriate management; suppression of NTG species by weed build-up and encroachment and local elimination of native plant species by failing to prescribe burn the NTG.

Floristic Value Score

The FVS was 26 (Table 1), which indicates this part of the site is of high floristic condition; there were 10 'indicator species' in the quadrant compared with only 3 in the quadrant at BE10. In the quadrant there was 1 'significant' weed species.

Management of the site

The action required in the immediate to short term is to manage the weeds (St John's Wort (*Hypericum perforatum*), Blackberry (*Rubus discolor*), Hawthorn (*Crataegus monogyna*) and exotic grasses) and eliminate them from the site and begin a 2 to 3 year autumn-burning of the site. Both these operations need to be done carefully to protect the Snow Gums. Native forbs too are very vulnerable to careless spraying and spray drift.

Glenloch Interchange is probably still a construction site under Roads ACT and the question of subsequent responsibility and management needs resolution as this will impact on the commencement of weed and fire management. The land is 'designated' as of national importance under the Territory Plan and should be added to Canberra Nature Park.

No MOU or MP appears to exit for the site and this should be prepared **in the longer term**.

York Park, Barton (CC05)
Central Canberra and Tuggeranong: National Land

The site is to the left of the footpath. In the middle distance is an information board describing some of the conservation significance of the site; the sign does not describe the presence of the uncommon Canberra Raspy Cricket. This image was taken on 10 July 2013.

Close-up view of the site. The centre of this 'virtual' plot is latitude -35.311830 and longitude 149.132137 at 570 m. The image was taken on 10 July 2013.

Site report
This small site of 0.4 ha is located at the 'edge' of the Federal Government Department precinct. Here the NTG is habitat for a population of the threatened Golden Sun Moth (GSM) and has been placed in the Conservation Category of 2. This lower rating is because the site is considered to be of only low to moderate botanical significance. The site has been surveyed often for botanical composition and the population of GSM has been intensively surveyed and studied in the past.

It has been reported that active burrows of the uncommon Canberra Raspy Cricket (*Cooraboorama canberrae*) occur throughout the site and it is known that the endangered Grassland Earless Dragon (GED) use the abandoned burrows of this species as shelter sites. However there are no known population of GED at the site but there is potential for a population to establish here.

On inspection the NTG portion of the site does not appear to have been recently mown. It is lightly grazed by rabbits; the piles of rabbit dung were few. Two weeds of significance, 15 exotic species and 2 native grass species deliberately introduced to the site, were identified.

The geographic Cartesian coordinates for the epicentre of the 'virtual' quadrant were 693835 and 6090290 from Datum GDA94 in zone 55H.

Critical thresholds

A critical threshold for weeds is being approached at the site. In the 'virtual' quadrant two significant weed species found, African Lovegrass and St John's Wort and elsewhere Chilean Needlegrass, Paterson's Curse (*Echium plantagineum*) and Serrated Tussock (*Nassella trichotoma*) were found. These, and other minor exotic species, are a threat to NTG. In addition, planted native grasses, Poa Tussock (*Poa labillardieri*) and Kangaroo Grass, are spreading and would be a threat to the survival of the population of GSM.

Floristic Value Score

The FVS was 24 (Table 1), which is a high floristic condition; there were 10 'indicator species' in the quadrant. On 9 November 2007, botanist Alison Rowell surveyed the vegetation in a 20 m x 20 m quadrant located in the NTG of the site and using the same method as used in this present survey calculated a FVS for the quadrant of 23. Although in an earlier and climatically different year and a nearby but different location in the NTG, Rowell's FVS is very close which may suggest the vegetation is stable at the site. The number of exotic species was 15 (Table 2) and there were two weed species of significance found in the 'virtual' quadrant.

Management of the site

The MOU for the site has not been sighted. However a MP was prepared for the Department of Finance and Deregulation and finalised in June 2008 and this was sighted along with a letter dated 13 March 2013 from the Department to the Commissioner. The MP is comprehensive, specific and is an excellent example of what a MP should contain. However on completion of the third visit to the site, it became apparent that management of weeds at the site is inadequate. The MP stated that the significant weed species should be eradicated from the site (this had not been achieved) and that the two planted native grasses should be contained to the planted areas (these two grasses were actively spreading beyond their planted areas and were beginning to threaten the habitat of the GSM). **The action required in the immediate to short term** is to commit more resources to weed elimination and native grass confinement at the site under the guidance of a qualified botanist with knowledge of weed management in NTG.

In the longer term plans for making a road at one end of the NTG site and the erection of buildings on the grossly disturbed portion (about 2/3^{rds} of the site) should be evaluated by the Commissioner to ensure that the viable population of GSM and the high plant species richness of the NTG portion of the site are not compromised by road making and building developments. Both could seriously compromise survival of plant and animal populations by reducing the amount of solar radiation received at the site, reducing the area of NTG, changing the

climate especially by warming from buildings and lethal vibrations during any construction.

Dudley Street, Yarralumla (CC08)
Central Canberra and Tuggeranong: Territory Land

General view of the site towards the north. Recently the site had been mown at a 'safe' height of about 15 cm ensuing minimal defoliation stress on the grasses. The image of the site was taken on 12 July 2013.

Close-up view of the quadrant. The plant species richness index for the 20 x 20 m plot was 7. Center of the virtual plot is latitude -35.312449 and longitude 149.094154 at 583 m. The site is only lightly grazed by kangaroos. The image was taken on 12 July 2013.

Site report

This small site of 2.2 ha, of which 1.5 ha is NTG and 0.7 ha is Exotic Pasture, is next to very weedy exotic grassland. The site is placed in Conservation Category 2 and provides habitat for a population of threatened Golden Sun Moth. Previously this site was approaching a critical threshold because the close and frequent mowing was threatening survival of Speargrass (*Austrostipa scabra*) plants and the native perennial forbs. This threat has now been removed by raising the height of mowing and avoiding mowing during the growing and reproduction season for the native species.

The geographic Cartesian coordinates for the centre of the 'virtual' quadrant were 690380 and 6090295 from Datum GDA94 in zone 55H.

Critical thresholds

There were two critical thresholds being approached at the site from the threatening processes of weed invasion and soil seed attrition. Weeds need to be eliminated from the site and prescribed autumn-burning is required to increase the native plant species at the site.

Floristic Value Score

The FVS was 10 (Table 1), which is a low floristic condition; there were only 4 'indicator species' in the quadrant. However this is typical of NTG that has been heavily grazed in past management; sheep selectively feed on many of the native forbs which are generally highly palatable compared with native grasses such as Kangaroo Grass and 'significant' weeds. Whether there are seed of more native species in the soil seed bank is problematic. There was 1 'significant' weed species in the quadrant.

Management of the site

The MP, previously sighted in 2009, specified a twice-a-year mowing regime with no recommended height. **In the immediate to short term** the MP needs to be revisited for amendment to once-a-year mowing in autumn at a height of 10 cm or higher and prescribed autumn-burning every 2 to 3 years. The MP also needs to be upgraded to the standard of the MP for York Park, Barton (CC05).

‘Mugga Mugga’ Homestead (JE01)
Jerrabomberra Valley: Territory Land

General view upslope from the ‘virtual’ quadrant towards the “Mugga Mugga Homestead” on the crest to the right. This image was taken on 31 July 2013.

Close-up view of the vegetation in the ‘vitual’ quadrant. Centre of the ‘virtual’ quadrant is latitude -35.347199 and longitude 149.145665 at 605 m. The site is lightly grazed by kangaroos. The image was taken on 31 July 2013.

Site report

This medium sized site of 15.1 ha is associated with the historic Mugga Mugga Homestead. No threatened plant or animal species have been reported at this NTG site and because of its low native plant content, the site has been placed in Category 2. The number of weed species at the site is on the high side but each species is at a low density because of the persistent weed management at the site. NTG plant species are generally rare at the site except for some rocky areas which are moderately NTG species rich and it was here the ‘virtual’ quadrant was established.

The site is grazed by 4 or 5 ‘camp’ horses. These horses were grazing in small enclosures elsewhere on the site. The ‘historic trust’ representative, Kate Gardiner, was in the process of setting up electric fences to rotationally rest parts of the site by excluding the horses. This is a well established technique for improving forage productivity and plant diversity and is recommended.

Ideally, the rocky areas of the site should be autumn-burned but grassland fire would be perceived as risk to the survival of the historic Homestead. However prescribed autumn-burning, if carried out with care, would not be a significant to the Homestead.

The geographic Cartesian coordinates for the epicentre of the 'virtual' quadrant were 6904980 and 6086340 from Datum GDA94 in zone 55H.

Critical thresholds

There were three critical thresholds being approached at the site from the threatening processes of continuous grazing, weeds and local extinction of native species from death of soil seed populations.

Floristic Value Score

The FVS was 13 (Table 1), which is a low floristic condition; there were only 6 'indicator species' in the 'virtual' quadrant. This low score is typical of grazed NTG because sheep selectively feed on many of the native forbs which are generally highly palatable compared with native grasses such as Kangaroo Grass and 'significant' weeds. However given the presence of Blue Devil (*Eryngium rostratum*) and Common Everlasting (*Chrysocephalum apiculatum*) and other native species in the quadrant there are probably further native plant species that could be germinated from the soil seed bank by prescribed autumn-burning.

Management of the site

A draft MP was sighted in 2009. Given that historically the site was a horse paddock associated with the Homestead, the only possible change to horse grazing management would be to rotationally rest in sequence, sections of the paddock which should benefit and increase NTG species. This is now taking place and should benefit the species of the NTG site. Areas of exotic pasture should be grazed during the spring and summer months so that areas of NTG are rested from grazing in these seasons to benefit recruitment and survival of native plants.

In the immediate and short term the quadrant should become permanent and assessed biennially. The MP should be developed with the 'historic trust' and prescribed autumn-burning and weed eradication should be part of the MP, in addition to the emerging rest/rotation grazing plan for the horses. **In the longer term** the monitoring of the quadrant and discussion with the 'historic trust' should be the platform for adaptive management of the site.

Woods Lane (JE04)
Jerrabomberra Valley: Territory Land

General view south along the long and narrow Woods Lane at the NSW/ACT border. On the distant rise, and at the end of the Lane, are locked gates preventing 4WD traffic. The image was taken on 25 July 2013. The virtual plot is in the foreground of the image and the narrow track on the right is formed by passage of kangaroos.

Close-up view of a planted area of the threatened species Button Wrinkle Wort disturbed by kangaroos passing through the hole in the fence. The image was taken on 25 July 2013. Center of the plot is latitude -35.360412 and longitude 149.196019 at 597 m.

Site report
This very elongated site of 10.3 ha of NTG contains a localised population of the threatened species Button Wrinkle Wort (*Rutidosis leptorrhynchoides*). The site has been placed in the Conservation Category of 2. Weeds are present but not in high densities. The considerable soil disturbance on a large scale that occurred throughout the site has now been rectified by closing off the Lane beyond the entrance to the farmers homestead. This rehabilitating section of Woods Lane was not inspected. The 'virtual' quadrant was established where there was a Button Wrinkle Wort population. This area of NTG is adjacent to the security fence of the defence establishment.

The geographic Cartesian coordinates for the epicentre of the 'virtual' quadrant were 699524 and 6084774 from Datum GDA94 in zone 55H.

Critical thresholds

There are approaching critical thresholds from disturbance by kangaroos, extinction of native species from the soil seed pool by natural attrition and presence of weeds.

Floristic Value Score

The FVS obtained was 29; there being 13 indicator species present and a total of 23 native species. There was 1 'significant' weed species.

Management of the site

No MP is available for this site. **In the immediate to short term** a MP should be developed for this significant site that equates to the MP for York Park (CC05). The plan should indicate how kangaroos will be managed at the site, how weeds will be eliminated and how 2 to 3 year prescribed autumn-burning will be carried out. In addition, the Conservation Category for the site should be upgraded from 2 to 1 given the high FVS for the quadrant and the presence of an apparently stable population of the threatened species of Button Wrinkle Wort.

Harmon Bonshaw south (JE06)
Jerrabomberra Valley: National and Territory Lands

General view of the Native Pasture towards the south and the Alexander Maconochie Centre. The image was taken on 29 July 2013.

Close-up of the site. The location of the yellow corner peg of the established plot is latitude -35.360785 and longitude 149.184408 at 601 m. The image was taken on 29 July 2013.

Site report

This large site of 105.7 ha of Native Pasture in a commercial farm contains populations of three threatened species, Striped Legless Lizard, Perunga Grasshopper and Golden Sun Moth. The site has been placed in the Conservation Category of 3. There were few weeds and given the abundance of weeds in 2008 it is apparent that weed management is has improved. No critical threshold was apparent.

The geographic Cartesian coordinates where the yellow plastic peg was driven into the ground were 698468 and 6084754 from Datum GDA94 in zone 55H. The coordinates for the orange peg, in the diagonal corner from the yellow peg, was 698445 and 6084737.

Critical thresholds

There were no apparent critical thresholds being approached. It is problematic whether autumn-burning would raise the measurable plant species richness.

Floristic Value Score

The FVS was 1 (Table 1), which is a low floristic condition; there were only 1 'indicator species' in the quadrant. However this is typical of grazed Native Pasture because sheep selectively feed on many of the native forbs which are generally highly palatable compared with native grasses such as Kangaroo Grass and 'significant' weeds.

Management of the site

The Land Management Agreement for this site was viewed in 2008 but not at this time.

The current management of this land appears to be appropriate. **In the longer term** the condition of the populations of the three threatened animal species on the site should continue to be monitored and consideration given to developing a MP that would ensure their maintenance. Given that this site is Native Pasture and not NTG, there does not seem any point in raising the FVS for the site by autumn-burning.

Harmon Bonshaw north (JE07)
Jerrabomberra Valley: National and Territory Lands

General view of the site towards the north and an unrecognisable complex. The image was taken on 29 July 2013.

Close-up of the site. The location of the yellow corner peg of the established plot is latitude -35.355100 and longitude 149.188650 at 592 m. The image was taken on 29 July 2013.

Site report

This large site of Native Pasture contains populations of three threatened species, Striped Legless Lizard, Perunga Grasshopper and Golden Sun Moth. The site has been placed in the Conservation Category of 3. There were many weeds at this site (in contrast to JE06) including Scotch Thistles (3 spp.) and Serrated Tussock. Given the abundance of weeds in 2008 it is apparent that weed management here is problematic.

The geographic Cartesian coordinates where the yellow plastic peg was driven into the ground were 698866 and 6085380 from Datum GDA94 in zone 55H. The coordinates for the orange peg, in the diagonal corner from the yellow peg, was 698878 and 6085404.

Critical thresholds

There was an approaching threshold for weeds. The site contained 1 'significant' weed species, Serrated Tussock, and the site was sufficiently weedy to justify increasing resources for weed management.

Floristic Value Score

The FVS was 0 (Table 1); there were only 8 native plant species in the quadrant and no 'indicator species'. However this is typical of grazed Native Pasture because sheep selectively feed on many of the native forbs which are generally highly palatable compared with native grasses such as Kangaroo Grass and 'significant' weeds.

Management of the site

The Land Management Agreement for this site was viewed in 2008 but not at this time. The Agreement was very broad.

The current management of this site of Native Pasture is commensurate with a farming operation, except for weed management which is inadequate. **In the immediate to short term** more resources need to be invested in weed management. **In the longer term** the condition of the populations of the three threatened animal species on the site should continue to be monitored and consideration given to developing a MP that would ensure their maintenance. Given that this site is Native Pasture and not NTG, it is problematic whether the FVS could be raised for the site by autumn-burning. However it should be noted that the Majura West (MA06) site is similarly designated as Native Pasture and has a FVS of 26. There is a case for enclosing by fencing a small area of this Native Pasture, and applying spring and autumn burning treatments, to find out if plant species, as seed in the soil, can be coaxed to regenerate and become established.

Majura West (MA06)
Majura Valley: National and Territory Lands

General view of site east towards the Canberra Airport complex. The image was taken on 11 July 2013.

Close-up of the quadrant area. The location of the yellow corner peg of the established plot is latitude -35.277013 and longitude 149.179231 at 593 m. The image was taken on 11 July 2013.

Site report

This large site of 133.3ha of Native Pasture contains a population of the threatened species of Stripped Legless Lizard. The site has been placed in the Conservation Category of 1. The site is grazed by kangaroos and rabbits and possibly sheep. Weeds are present but are at present not a problem.

The geographic Cartesian coordinates where the yellow plastic peg was driven into the ground were 698202 and 6094055 from Datum GDA94 in zone 55H. The coordinates for the orange peg, in the diagonal corner from the yellow peg, was 6998195 and 6094083.

Critical thresholds

No critical threshold is being approached although some erosion was evident but this is light and patchy.

Floristic Value Score

The FVS was 26 (Table 1), which is a high floristic condition; there were 10 'indicator species' in the quadrant which indicates that Native Pasture is capable of supporting a diverse native flora.

Management of the site

A Grazing Licence dated 2008 allows intermittent grazing but not continuous grazing by livestock. No MP for the site has been sighted. **In the immediate to short term** a MP should be developed similar to the plan for York Park (CC05) addressing the threats for the site and management to address these.

Isabella Pond, Monash (TU01)

General view of the site towards the south. Image taken on 24 July 2013.

Close-up view of the quadrant showing the closed nature of the grass canopy. The center of the quadrant is latitude -35.420608 and longitude 149.080685 at 586 m. The site is lightly grazed by kangaroos. The image was taken on 24 July 2013.

Site report

This small site of 1.2 ha of NTG on the crest of the hill and down slope is predominantly exotic/weedy grassland. No threatened plant or animal species are known to occur at the site. The site is placed in the Conservation Catalogue of 1. Weed level at the site was low.

The geographic Cartesian coordinates where the yellow plastic peg was driven into the ground were 688903 and 6078323 from Datum GDA94 in zone 55H. The coordinates for the orange peg, in the diagonal corner from the yellow peg, was 688926 and 6078309.

Critical thresholds

The site is approaching a critical threshold with respect to fire; the 'closed' canopy of the grassland would prevent regeneration of forbs from seed and given the short seed-life of many of the species it is necessary to 'open' and stimulate by fire the grassland in the short term. The site should be autumn-burned every 2 to 3 years.

Floristic Value Score

The FVS was 40 (Table 1), the highest FVS of the 14 sites surveyed. There were 14 'indicator' species' in the quadrant. There were no 'significant' weed species at the site.

Management of the site

The MP (sighted in 2008) specified burning every 2 to 3 years. **In the immediate to short term** a revised MP, similar in detail to York Park (CC05) should be developed specifying autumn-burning.

Tables

Table 1: Floristic Value Scores and numbers of native plant species in groupings based on floristic significance for the quadrants at the 14 sites. The sites are grouped into those that are currently grazed by large herbivores and those that are not. Sites are arranged in order of FVS's within ungrazed and grazed groups.

Site Name	FVS	Common/ increaser species	Indicator species, Level 1	Indicator species, Level 2	Total native species
Ungrazed					
TU01 Isabella Pond	40	6	1	13	20
BE08b Lawson Commonwealth	32	13	1	11	25
BE04a Umbagong south	31	15	1	10	26
JE04 Woods Lane	29	10	2	11	23
MA06 Majura West	26	13	2	8	23
BE11 Glenloch Interchange	26	10	2	8	20
CC05 York Park	24	10	3	7	20
BE04b Umbagong north	12	12	2	4	18
CC08 Dudley Street	10	10	1	3	14
Grazed					
JE01 Mugga Mugga Homestead	13	9	2	4	15
BE01 Ginninderra Expt Station	7	7	1	2	10
BE10 Caswell Drive	5	6	2	1	9
JE06 Harman Bonshaw south	1	9	1	0	10
JE07 Harman Bonshaw north	0	8	0	0	8

Table 2: Floristic Value Scores and numbers of 'Significant Weeds' and total exotic species in the quadrants at the 14 sites. The sites are grouped into those that are currently grazed by large herbivores and those that are not. Sites are arranged in order of FVS's within ungrazed and grazed groups.

Site Name	FVS	Significant weeds	Total exotic species
Ungrazed			
TU01 Isabella Pond	40	0	8
BE08b Lawson Commonwealth	32	2	10
BE04a Umbagong south	31	2	16
JE04 Woods Lane	29	1	16
MA06 Majura West	26	1	12
BE11 Glenloch Interchange	26	1	10
CC05 York Park	24	2	15
BE04b Umbagong north	12	1	17
CC08 Dudley Street	10	1	7
Grazed			
JE01 Mugga Mugga Homestead	13	1	17
BE01 Ginninderra Expt Station	7	0	10
BE10 Caswell Drive	5	1	14
JE06 Harman Bonshaw south	1	0	11
JE07 Harman Bonshaw north	0	1	14

References

ACT Government (1998). The A.C.T. Nature Conservation Strategy. Canberra, ACT Government.

ACT Government (2002). Your Canberra Your Say: A report to the community on issues and ideas for the future of Canberra. Canberra, ACT Government.

ACT Government (Chief Ministers Department) (2003). ACT Office of Sustainability. In: People Place Prosperity: a policy for sustainability in the ACT. Canberra, ACT Government.

ACT Government (2005). National Recovery Plan for Natural temperate Grassland of the Southern Tablelands (NSW and ACT): an endangered ecological community. Canberra, ACT Government.

Action Plan (1997). A Natural Temperate Grassland: an endangered ecological community. In: 'Environment ACT, ACT'. (Ed. ACT Government).

Braun-Blanquet, J. (1932). Plant Sociology (transl. G.D. Fuller and H.S. Conrad). (McGraw-Hill, New York).

Census of plants of the Australian Capital Territory (ACT) http://www.anbg.gov.au/cpbr/ACT-census-2012/vascular-2012-gen-alpha.html

Cottam, G. and Curtis, J.T. (1956). The use of distance measures in phytosociological sampling. *Ecology* **37,** 451-460.

Crawford, I. (2000). Umbagong District Park Blue Devil Grassland: an inventory of plant and animal species and suggested management activities. (unpublished report to Umbagong Landcare Group, June 2000 – a copy containing many handwritten notes was loaned by Robert Cruikshank).

Dorrough, J. (1995). Grassland conservation in the ACT: an historical perspective. *Bogong* **16**, 4-5.

Eddy, D., Mallinson, D., Rehwinkel, R. and Sharpe, S. (1998). Grassland Flora a field guide for the Southern Tablelands (NSW & ACT).

Hodgkinson, K.C. (2005). Management options for Canberra urban grasslands. Final report to Canberra Urban Parks and Places, ACT Government.

Hodgkinson, K.C. (2009). Future proofing Natural Temperate Grasslands in urban and peri-urban Canberra. (Report to Commissioner for Sustainability and the Environment).

Hodgkinson, K. C., Marsden, S. G. and Muller, W. J. (2000). Defoliation sets the death-trap for grasses and drought springs the trap. In 'Symposium papers, Australian Rangeland Society Centenary Symposium, Broken Hill 21-24 August 2000.' (Eds S. Nicholson and J. C. Noble). pp. 188-189. (Australian Rangeland Society: Broken Hill).

Hodgkinson, K.C. and Marsden, S.G. (2005). Sheep grazing during drought collapses the perennial grass resource in Australian semi-arid wooded grasslands. In 'XX International Grassland Congress: Offered papers.' (Eds F.P. O'Mara, R.J. Wilkins, L 't Mannetje, D.K. Lovett, P.A.M. Rogers and T.M. Boland). p. 525. (Wageningen Academic Publishers Wageningen).

Hodgkinson, K.C. and Muller, W.J. (2005). Death model for tussock perennial grasses: a rainfall threshold for survival and evidence for landscape control of death in drought. *The Rangeland Journal* **27**:105-115.

Jacobs, S.W.L., Whalley, R.D.B. and Wheeler, D.J.B. (2008). Grasses of New South Wales, 4th Edition. (University of New England, Armidale).

Ludwig, J.A., Tongway, D.J., Freudenberger, D.O., Noble, J.C. and Hodgkinson, K.C. (1997). Landscape ecology, function and management: principles from Australia's rangelands. (CSIRO Publishing, Australia).

McDougall, K. and Kirkpatrick, J.B. (1994). Conservation of Lowland Grasslands in South-Eastern Australia. (World Wide Fund For Nature, Australia).

Parsons, R.F. (1994). Preface. In 'Conservation of Lowland Grasslands in South-Eastern Australia. (Eds K. McDougall and J.B. Kirkpatrick). p. 5. (World Wide Fund for Nature, Australia).

PlantNET New South Wales FloraOnline www.plantnet.rbgsyd.nsw.gov.au/search/simple.htm(accessed 30 January 2014).

Pryor, L.D. (1938). Vegetation Map of the ACT. (Department of Interior, Canberra).

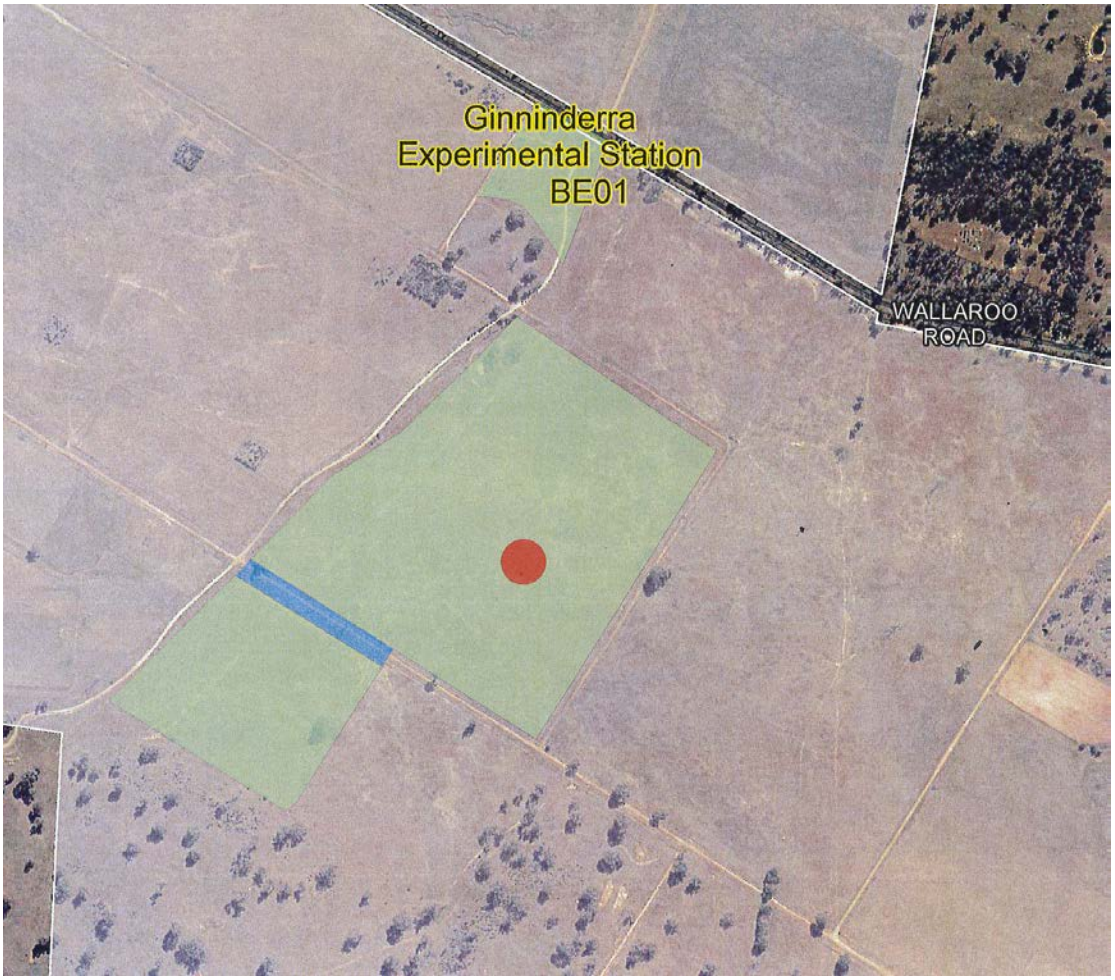
Pryor, L.D. and Banks, J.C.G (2001). Trees and Shrubs in Canberra. (Little Hills Press, Canberra). 2nd Edition.

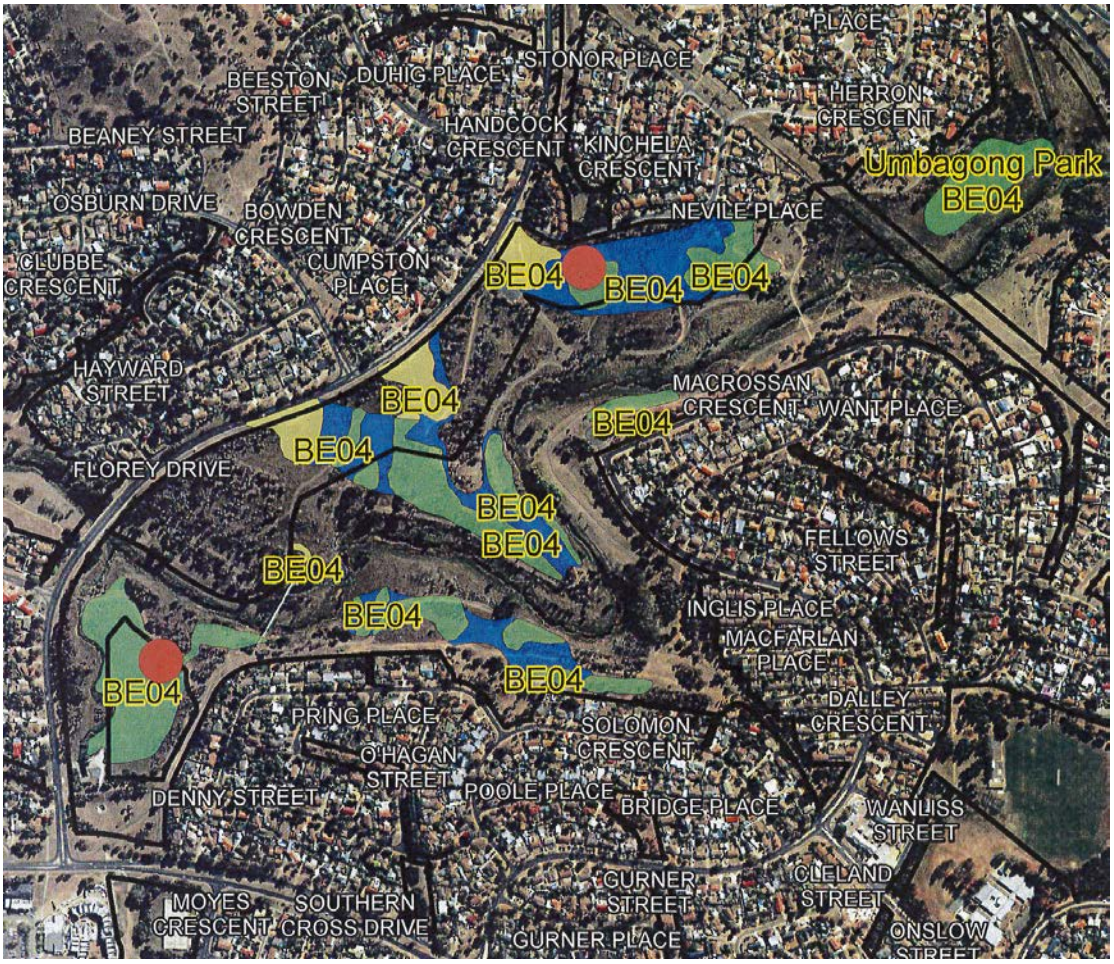
Rehwinkel, R. (2007). A method to access grassy ecosystem sites: using floristic information to assess a site's quality. NSW Department of Environment and Climate Change (unpublished document).

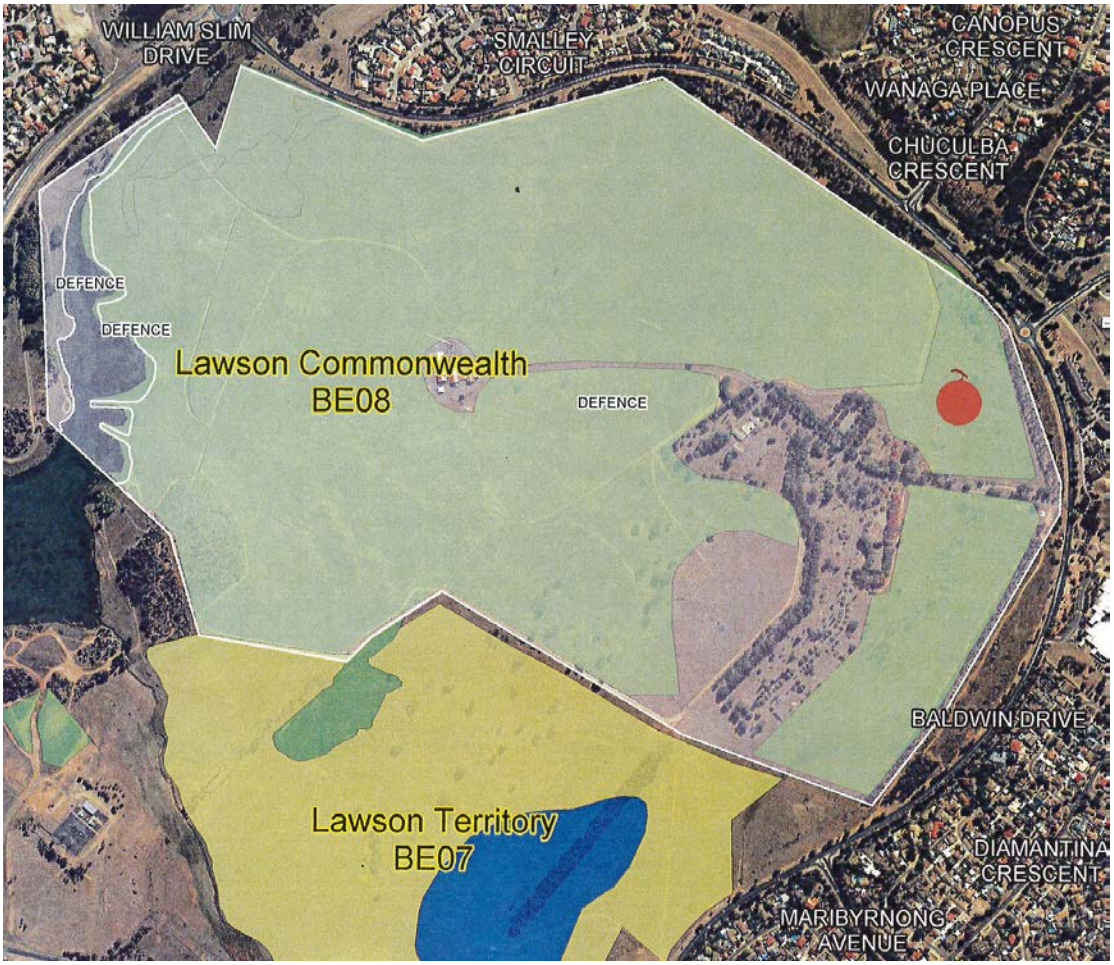
Wood, D. and Wood, B. (2005). Flowers of the ACT & Region: a field guide. (Wood's Books, Canberra).

Appendix 1

Sites from the air. The fourteen sites are mostly isolated but where they occur close to another site(s), more than one site is shown in the image. The images are arranged in the order used in this report. Areas in green are NTG's, areas in yellow are Native Pastures and areas in blue are Exotic Pastures. The approximate location of the 20 m by 20 m quadrant at a site is indicated by the red circles (closed).


Ginninderra
Experimental Station
BE01
WALLAROO
ROAD


PLACE
STONOR PLACE
BEESTON STREET
DUHIG PLACE
HERRON CRESCENT
BEANEY STREET
HANDCOCK CRESCENT
KINCHELA CRESCENT
Umbagong Park
BE04
OSBURN DRIVE
BOWDEN CRESCENT
NEVILE PLACE
CLUBBE CRESCENT
CUMPSTON PLACE
BE04
BE04
BE04
HAYWARD STREET
BE04
MACROSSAN CRESCENT
WANT PLACE
BE04
BE04
FLOREY DRIVE
BE04
BE04
FELLOWS STREET
BE04
INGLIS PLACE
BE04
MACFARLAN PLACE
BE04
BE04
DALLEY CRESCENT
PRING PLACE
SOLOMON CRESCENT
O'HAGAN STREET
DENNY STREET
POOLE PLACE
BRIDGE PLACE
WANLISS STREET
GURNER STREET
CLELAND STREET
MOYES CRESCENT
SOUTHERN CROSS DRIVE
GURNER PLACE
ONSLOW


WILLIAM SLIM DRIVE
SMALLEY CIRCUIT
CANOPUS CRESCENT
WANAGA PLACE
CHUCULBA CRESCENT
DEFENCE
DEFENCE
Lawson Commonwealth BE08
DEFENCE
BALDWIN DRIVE
Lawson Territory BE07
DIAMANTINA CRESCENT
MARIBYRNONG AVENUE

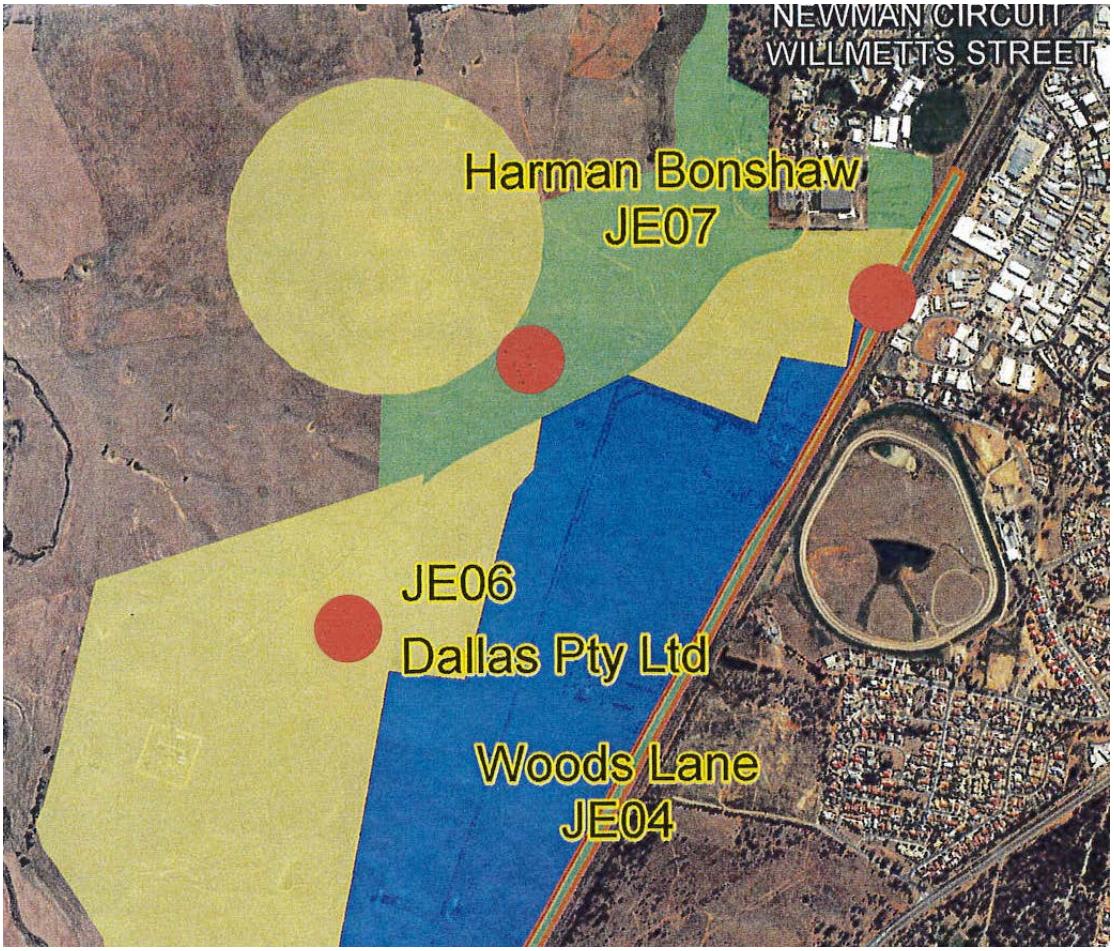

WILLIAM
HOVELL DRIVE
Caswell Drive
BE10

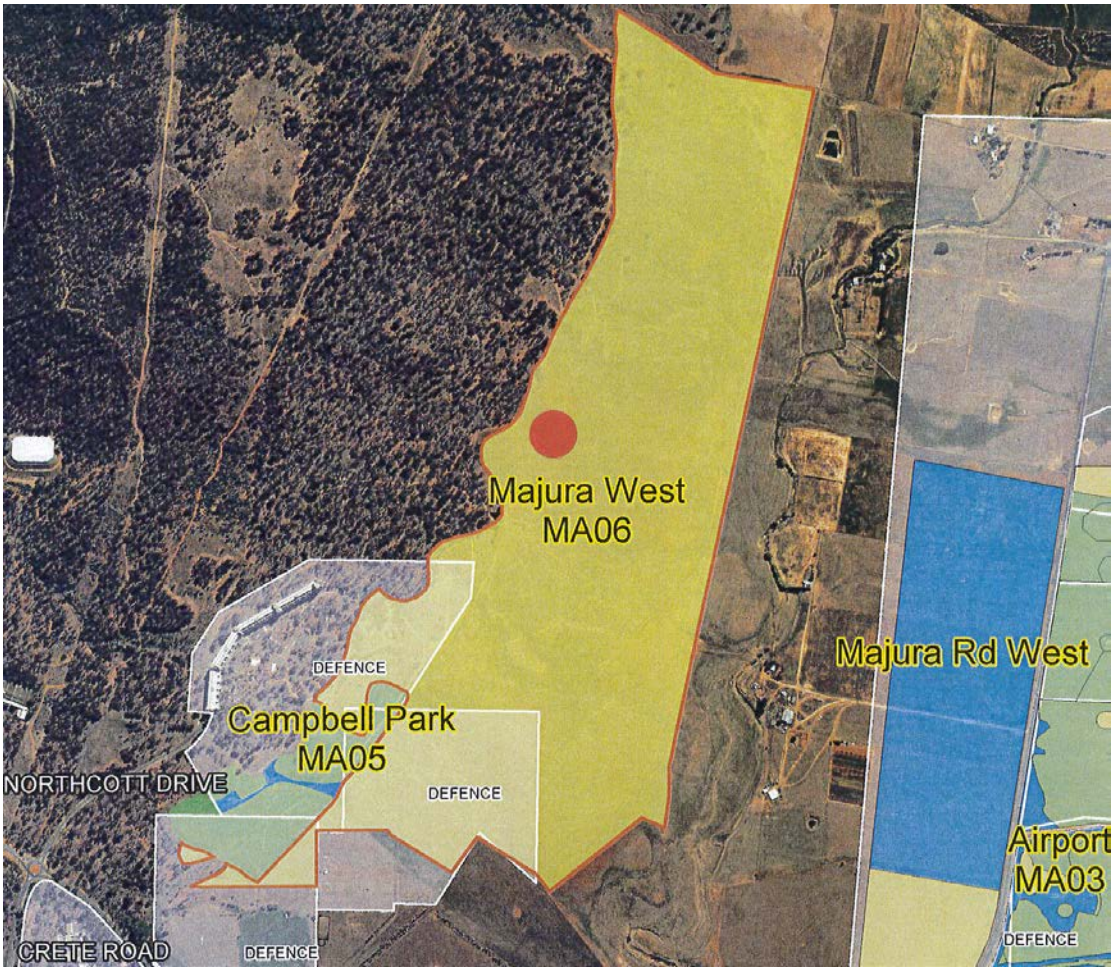

Caswell Drive
BE10
Glenloch Interchange
BE11
WILLIAM
HOVELL DRIVE
PARKES WAY
TUGGERANONG
PARKWAY


DFA
York Park Barton
CC03
NATIONAL
CIRCUIT
SYDNEY
AVENUE


Dudley St Yarralumla
CC08
DUDLEY STREET
COTTER ROAD


HINDMARSH
DRIVE
Mugga Mugga'
JE01


NEWMAN CIRCUIT
WILLMETTS STREET
Harman Bonshaw
JE07
JE06
Dallas Pty Ltd
Woods Lane
JE04


Majura West
MA06
Majura Rd West
DEFENCE
Campbell Park
MA05
NORTHCOTT DRIVE
DEFENCE
Airport
MA03
CRETE ROAD
DEFENCE
DEFENCE


BALLARD PLACE
GRIFFIN PLACE
WILLIAM HUDSON CRESCENT
Lake Isabella Monash TU01
ARNOT PLACE

Appendix 2

The plant species located at the 14 sites and derived Floristic Value Scores and other summary data, are displayed in order in the following tables. For the York Park, Barton site (CC05) two sets of data are given; one collected by Alison Rowell in 2007 and the other by Ken Hodgkinson in 2013. The summary data from all 14 quadrants is presented in Tables 1 and 2.

Date of survey	Site name	Site ID Code	Species code	Braun-Blanqet code	Species Name	Indicator sp. code
11/12/2013	Ginninderra Experiment Station	BE01				
			aira sp	1	Aira sp.	e
			briz mino	1	Briza minor	e
			card tenu	r	Carduus tenuiflorus	e
			conz sp	+'	Conyza sp.	e
			holc lana	+'	Holcus lanatus	e
			hypo radi	1	Hypochaeris radicata	e
			petr nant	r	Petrorhagia nanteuilii	e
			plan lanc	+'	Plantago lanceolata	e
			rume cris	+'	Rumex crispus	e
			trif sp	1	Trifolium sp.	e
			vulp sp	1	Vulpia sp.	e
			brom moll	+'	Bromus mollis	e
			brom dian	+'	Bromus diandrus	e
			aust caes	2	Rytidosperma caespitosum	c
			aust carp	2	Rytidosperma carphoides	c
			aust bige	1	Austrostipa bigeniculata	c
			aust scab	2	Austrostipa scabra	c
			cras vari	+'	Craspedia variabilis	2
			loma fili	+'	Lomandra filiformis	1
			poa sieb	1	Poa sieberiana	c
			rume brow	+'	Rumex brownii	c
			sene quad	r	Senecio quadridentatus	c
			them tria (3 or >)	4	Themeda triandra	2

Floristic Value Score (FVS)	**7**

Number of common species	**7**
Number of indicator level 1 species	**1**
Number of indicator level 2 species	**2**
Total number of native species	**10**
Number of exotic species	**13**
Number of significant weed species	**0**

Plot information:

Datum	**GDA94**
AMG Easting	**686756**
AMG Northing	**6105567**

Surveyor name(s)

Ken Hodgkinson

Date of survey	Site name	Site ID Code	Species code	Braun-Blanqet code	Species Name	Indicator sp. code
26/11/2013	**Umbagong south**	**BE04a**	**acet vulg**	**r**	Acetosella vulgaris	e
			aira sp	1	Aira sp.	e
			aven sp	2	Avena sp.	e
			chon junc	+'	Chondrilla juncea	e
			hypo glab	+'	Hypochaeris glabra	e
			hypo radi	r	Hypochaeris radicata	e
			nass nees	1	Nassella neesiana	s
			nass tric	r	Nassella trichotoma	s
			petr nant	r	Petrorhagia nanteuilii	e
			plan lanc	r	Plantago lanceolata	e
			tolp umbe	r	Tolpis umbellata	e
			trag dubi	+'	Tragopogon dubius	e
			trag porr	r	Tragopogon porrifolius	e
			acae ovin	r	Acaena ovina	c
			aspe conf	+'	Asperula conferta	2
			aust bige	r	Austrostipa bigeniculata	c
			both macr	+'	Bothriochloa macra	c
			chry apic	+'	Chrysocephalum apiculatum	1
			conv erub	r	Convolvulus angustissimus (syn. C. erubescens)	c
			cyno suav	r	Cynoglossum suaveolens	c
			dian revo	1	Dianella revoluta	2
			dich repe	r	Dichondra repens	c
			dich fimb	p	Dichopogon fimbriatus	2
			chei aust	p	Cheilanthes austrotenuifolia	2
			enne nigr	1	Enneapogon nigricans	c
			epil bill	r	Epilobium billardierianum	c
			eryn ovin	p	Eryngium ovinum	2
			glyc taba	+'	Glycine tabacina	2
			oxal pere	r	Oxalis perennans	c
			plan gaud	1	Plantago gaudichaudii	2
			plan vari	1	Plantago varia	2
			poa sieb	1	Poa sieberiana	c
			rume dumo	r	Rumex dumosus	c
			scho apog	r	Schoenus apogon	c
			sene quad	r	Senecio quadridentatus	c
			tric elat	+'	Tricoryne elatior	2
			wahl lute	r	Wahlenbergia luteola	c
			brom moll	+'	Bromus mollis	e
			brom rube	+'	Bromus rubens	e
			trif arve	r	Trifolium arvense	e
			ryti eria	1	Rytidosperma erianthum	c
			them tria (3 or >)	5	Themeda triandra	2

Floristic Value Score (FVS)	31

Plot information:

Datum	GDA94
AMG Easting	683915
AMG Northing	6101059

Surveyor name(s)

Ken Hodgkinson

Number of common species	15
Number of indicator level 1 species	1
Number of indicator level 2 species	10
Total number of native species	26
Number of exotic species	16
Number of significant weed species	2

Date of survey	Site name	Site ID Code	Species code	Braun-Blanqet code	Species Name	Indicator sp. code
1/12/2013	Umbagong south	BE04b			#N/A	#N/A
			acto vulg	p	Acetosella vulgaris	e
			aira sp	+'	Aira sp.	e
			aven sp	r	Avena sp.	e
			briz mino	r	Briza minor	e
			fest elat	r	Festuca elatior	e
			holc lana	r	Holcus lanatus	e
			hord sp	r	Hordeum sp.	e
			hype perf	p	Hypericum perforatum	s
			hypo glab	r	Hypochaeris glabra	e
			pasp dila	r	Paspalum dilatatum	e
			petr nant	r	Petrorhagia nanteuilii	e
			plan lanc	r	Plantago lanceolata	e
			rume cris	+'	Rumex crispus	e
			acae ovin	r	Acaena ovina	c
			aust scab	1	Austrostipa scabra	c
			both macr	1	Bothriochloa macra	c
			chry apic	2	Chrysocephalum apiculatum	1
			dian revo	+'	Dianella revoluta	2
			erag trac	r	Eragrostis trachycarpa	c
			loma brac	+'	Lomandra bracteata	1
			loma mult	r	Lomandra multiflora	2
			micr unif	+'	Microtis unifolia	2
			pani effu	r	Panicum effusum	c
			poa sieb	1	Poa sieberiana	c
			wahl comm	+'	Wahlenbergia communis	c
			brom moll	r	Bromus molliformis	e
			trif camp	r	Trifolium campestre	e
			trif arve	r	Trifolium arvense	e
			acae nova	r	Acaena novae-zelandiae	c
			ryti tenu	+'	Rytidosperma tenuius	c
			ryti seta	+'	Rytidosperma setaceum	c
			ryti caes	+'	Rytidosperma caespitosum	c
			ryti carp	+'	Rytidosperma carphoides	c
			cent eryt	r	Centaurium erythraea	e
			them tria (3 or >)	5	Themeda triandra	2

Floristic Value Score (FVS)	12

Number of common species	12
Number of indicator level 1 species	2
Number of indicator level 2 species	4
Total number of native species	18
Number of exotic species	17
Number of significant weed species	1

Plot information:

Datum	GDA94
AMG Easting	684733
AMG Northing	6101628

Surveyor name(s)

Ken Hodgkinson

Date of survey	Site name	Site ID Code	Species code	Braun-Blanqet code	Species Name	Indicator sp. code
11/12/2013	**Lawson Commonwealth**	**BE08b**	**aira sp**	**2**	Aira sp.	e
			aven sp	2	Avena sp.	e
			briz mino	1	Briza minor	e
			brom sp	1	Bromus sp.	e
			echi plan	p	Echium plantagineum	s
			holc lana	p	Holcus lanatus	e
			nass nees	+'	Nassella neesiana	s
			plan lanc	2	Plantago lanceolata	e
			rubu frut	r	Rubus fruticosus	e
			rume cris	1	Rumex crispus	e
			acae ovin	r	Acaena ovina	c
			aris ramo	p	Aristida ramosa	c
			aust spd	3	Rytidosperma sp.	c
			aust bige	+'	Austrostipa bigeniculata	c
			aust scab	1	Austrostipa scabra	c
			both macr	2	Bothriochloa macra	c
			chry apic	1	Chrysocephalum apiculatum	1
			chry semi	+'	Chrysocephalum semipapposum	2
			cras vari	p	Craspedia variabilis	2
			eryn ovin	+'	Eryngium ovinum	2
			good pinn	+'	Goodenia pinnatifida	2
			junc fili	p	Juncus filicaulis	c
			lept squa	2	Leptorhynchos squamatus	2
			loma mult	1	Lomandra multiflora	2
			meli urce	+'	Melichrus urceolatus	2
			sene quad	+'	Senecio quadridentatus	c
			tric elat	+'	Tricoryne elatior	2
			trip pygm	r	Triptilodiscus pygmaeus	2
			vitt grac	+'	Vittadinia gracilis	c
			wahl comm	+'	Wahlenbergia communis	c
			wahl lute	+'	Wahlenbergia luteola	c
			aspe gunn	p	Asperula gunnii	2
			rume brow	1	Rumex brownii	c
			acae nova	r	Acaena novae-zelandiae	c
			them tria (3 or >)	2	Themeda triandra	2

Floristic Value Score (FVS)	32

Number of common species	13
Number of indicator level 1 species	1
Number of indicator level 2 species	11
Total number of native species	25
Number of exotic species	10
Number of significant weed species	2

Plot information:

Datum	GDA94
AMG Easting	691070
AMG Northing	6100348

Surveyor name(s)

Ken Hodgkinson

Date of survey	Site name	Site ID Code	Species code	Braun-Blanquet code	Species Name	Indicator sp. code
1/12/2013	Caswell Drive	BE10	**arct cale**	**r**	Arctotheca calendula	e
			cart lana	r	Carthamus lanatus	e
			cony sp	r	Conyza sp.	e
			echi plan	r	Echium plantagineum	s
			erod cicu	+'	Erodium cicutarium	e
			fest elat	p	Festuca elatior	e
			hypo glab	r	Hypochaeris glabra	e
			hypo radi	+'	Hypochaeris radicata	e
			phal aqua	+'	Phalaris aquatica	e
			plan lanc	+'	Plantago lanceolata	e
			aust spd	4	Rytidosperma sp.	c
			both macr	2	Bothriochloa macra	c
			chry apic	1	Chrysocephalum apiculatum	1
			chry semi	+'	Chrysocephalum semipapposum	2
			euch spha	+'	Euchiton sphaericus	c
			loma brac	+'	Lomandra bracteata	1
			sene quad	+'	Senecio quadridentatus	c
			acae agni	r	Acaena agnipila	c
			caps burs	r	Capsella bursa-pastoris	e
			epil hirt	r	Epilobium hirtigerum	c
			trif arve	+'	Trifolium arvense	e
			brom moll	+'	Bromus molliformis	e
			trif subt	+'	Trifolium subterranean	e

Floristic Value Score (FVS)	**5**

Number of common species	**6**
Number of indicator level 1 species	**2**
Number of indicator level 2 species	**1**
Total number of native species	**9**
Number of exotic species	**14**
Number of significant weed species	**1**

Plot information

Datum	**GDA94**
AMG Easting	**689310**
AMG Northing	**6094177**

Surveyor name(s)

Ken Hodgkinson

Date of survey	Site name	Site ID Code	Species code	Braun-Blanquet code	Species Name	Indicator sp. code
3/12/2013	Glenloch Interchange	BE11	**aira sp**	**1**	Aira sp.	e
			briz mino	1	Briza minor	e
			gnap amer	1	Gnaphalium americanum	e
			hype perf	2	Hypericum perforatum	s
			hypo glab	1	Hypochaeris glabra	e
			hypo radi	1	Hypochaeris radicata	e
			petr nant	1	Petrorhagia nanteuilii	e
			plan lanc	1	Plantago lanceolata	e
			verb thap	r	Verbascum thapsus	e
			acae ovin	r	Acaena ovina	c
			aust spd	1	Rytidosperma sp.	c
			both macr		Bothriochloa macra	c
			chry apic	2	Chrysocephalum apiculatum	1
			chry semi	1	Chrysocephalum semipapposum	2
			cryp amar	+'	Cryptandra amara	2
			good pinn	+'	Goodenia pinnatifida	2
			hype gram	+'	Hypericum gramineum	2
			lept squa	+'	Leptorhynchos squamatus	2
			loma fili	+'	Lomandra filiformis	1
			pani effu	r	Panicum effusum	c
			poa sieb	1	Poa sieberiana	c
			scho apog	r	Schoenus apogon	c
			sene quad	r	Senecio quadridentatus	c
			stac mono	+'	Stackhousia monogyna	2
			trip pygm	+'	Triptilodiscus pygmaeus	2
			wahl comm	+'	Wahlenbergia communis	c
			wahl lute	+'	Wahlenbergia luteola	c
			cony albi	r	Conyza albida	e
			acae nova	r	Acaena novae-zelandiae	c
			them tria (3 or >)	5	Themeda triandra	2

Floristic Value Score	26

Number of common species	10

(FVS)	

Plot information:

Datum	GDA94
AMG Easting	689510
AMG Northing	6093861

Surveyor name(s)

Ken Hodgkinson

Number of indicator level 1 species	2
Number of indicator level 2 species	8
Total number of native species	20
Number of exotic species	10
Number of significant weed species	1

Date of survey	Site name	Site ID Code	Species code	Braun-Blanquet code	Species Name	Indicator sp. code
9/11/2007	York Park	CC05	**aira sp**	**1**	Aira sp.	e
			aven sp	+'	Avena sp.	e
			briz mino	1	Briza minor	e
			brom sp	+'	Bromus sp.	e
			gnap amer	+'	Gnaphalium americanum	e
			hype perf	r	Hypericum perforatum	s
			hypo radi	2	Hypochaeris radicata	e
			plan lanc	1	Plantago lanceolata	e
			trif sp	+'	Trifolium sp.	e
			vulp sp	1	Vulpia sp.	e
			aust bige	3	Austrostipa bigeniculata	c
			both macr	2	Bothriochloa macra	c
			bulb bulb	r	Bulbine bulbosa	2
			chei sieb	1	Cheilanthes sieberi	2
			chry apic	2	Chrysocephalum apiculatum	1
			elym scab	+'	Elymus scaber	c
			good pinn	2	Goodenia pinnatifida	2
			loma brac	1	Lomandra bracteata	1
			loma fili	1	Lomandra filiformis	1
			pime curv	1	Pimelea curviflora	2
			tric elat	1	Tricoryne elatior	2
			wahl comm	1	Wahlenbergia communis	c
			wahl lute	1	Wahlenbergia luteola	c
			aust spd	1	Rytidosperma sp.	c
			ryti carp	1	Rytidosperma carphoides	c
			them tria (3 or >)	1	Themeda triandra	2
			pani effu	1	Panicum effusum	c
			calo citr	1	Calocephalus citreus	2
			eryn sp	r	Eryngium sp.	2
			oxal pere		Oxalis perennans	c
			conv erub	+'	Convolvulus angustissimus (syn. C. erubescens)	c
			sene sp	r	Senecio sp.	*
			aust scab	+'	Austrostipa scabra	c
			oxal pere	+'	Oxalis perennans	c
			ryti sp	1	Rytidosperma sp.	c
			ryti sp	+'	Rytidosperma sp.	c

Floristic Value Score (FVS)	23

Number of common species	14
Number of indicator level 1 species	3
Number of indicator level 2 species	8
Total number of native species	25
Number of exotic species	11
Number of significant weed species	1

Plot information:

Datum	WGS84
AMG Easting	693832
AMG Northing	6090303

Surveyor name(s)

Alison Rowell

Date of survey	Site name	Site ID Code	Species code	Braun-Blanquet code	Species Name	Indicator sp. code
10/12/2013	York Park	CC05	**aira sp**	**1**	Aira sp.	e
			aven sp	1	Avena sp.	e
			briz mino	2	Briza minor	e
			brom sp	1	Bromus sp.	e
			cent eryt	1	Centaurium erythraea	e
			dact glom	2	Dactylis glomerata	e
			erag curv	1	Eragrostis curvula	s
			gnap amer	r	Gnaphalium americanum	e
			hype perf	p	Hypericum perforatum	s
			hypo radi	1	Hypochaeris radicata	e
			pasp dila	1	Paspalum dilatatum	e
			plan lanc	2	Plantago lanceolata	e
			trif sp	1	Trifolium sp.	e
			vulp sp	1	Vulpia sp.	e
			aris ramo	2	Aristida ramosa	c
			aust bige	3	Austrostipa bigeniculata	c
			aust scab	3	Austrostipa scabra	c
			both macr	2	Bothriochloa macra	c
			bulb bulb	1	Bulbine bulbosa	2
			chei aust	1	Cheilanthes austrotenuifolia	2
			chry apic	1	Chrysocephalum apiculatum	1
			elym scab	1	Elymus scaber	c
			erag trac	1	Eragrostis trachycarpa	c
			good pinn	1	Goodenia pinnatifida	2
			loma brac	1	Lomandra bracteata	1
			loma fili	1	Lomandra filiformis	1
			pime curv	1	Pimelea curviflora	2
			tric elat	+'	Tricoryne elatior	2
			trip pygm	+'	Triptilodiscus pygmaeus	2
			wahl comm	1	Wahlenbergia communis	c
			wahl lute	1	Wahlenbergia luteola	c
			ryti tenu	1	Rytidosperma tenuius	c
			ryti carp	2	Rytidosperma carphoides	c
			them tria (3 or >)	1	Themeda triandra	2

Floristic Value Score (FVS)	24

Plot information:

Datum	GDA94
AMG Easting	693835
AMG Northing	6090290

Surveyor name(s)

Ken Hodgkinson

Number of common species	10
Number of indicator level 1 species	3
Number of indicator level 2 species	7
Total number of native species	20
Number of exotic species	15
Number of significant weed species	2

Date of survey	Site name	Site ID Code	Species code	Braun-Blanqet code	Species Name	Indicator sp. code
4/12/2013	Dudley Street	CC08	**aira sp**	**1**	Aira sp.	e
			cony sp	+'	Conyza sp.	e
			gnap amer	+'	Gnaphalium americanum	e
			hype perf	1	Hypericum perforatum	s
			hypo radi	1	Hypochaeris radicata	e
			pasp dila	1	Paspalum dilatatum	e
			plan lanc	1	Plantago lanceolata	e
			aust bige	1	Austrostipa bigeniculata	c
			aust scab	1	Austrostipa scabra	c
			both macr	2	Bothriochloa macra	c
			chry apic	2	Chrysocephalum apiculatum	1
			elym scab	1	Elymus scaber	c
			good pinn	1	Goodenia pinnatifida	2
			plan vari	+'	Plantago varia	2
			poa sieb	1	Poa sieberiana	c
			rume brow	+'	Rumex brownii	c
			wahl comm	+'	Wahlenbergia communis	c
			wahl lute	+'	Wahlenbergia luteola	c
			ryti carp	3	Rytidosperma carphoides	c
			ryti tenu	3	Rytidosperma tenuius	c
			them tria (3 or >)	1	Themeda triandra	2

Floristic Value Score (FVS)	**10**

Number of common species	**10**
Number of indicator level 1 species	**1**
Number of indicator level 2 species	**3**
Total number of native species	**14**
Number of exotic species	**7**
Number of significant weed species	**1**

Plot information:

Datum	**GDA94**
AMG Easting	**690380**
AMG Northing	**6090295**

Surveyor name(s)

Ken Hodgkinson

Date of survey	Site name	Site ID Code	Species code	Braun-Blanquet code	Species Name	Indicator sp. code
4/12/2013	**Mugga Mugga Homestead**	**JE01**	**acet vulg**	**1**	Acetosella vulgaris	e
			aven sp	1	Avena sp.	e
			briz mino	1	Briza minor	e
			briz maxi	2	Briza maxima	e
			brom sp	1	Bromus sp.	e
			cart lana	+'	Carthamus lanatus	e
			cony sp	+'	Conyza sp.	e
			echi plan	+'	Echium plantagineum	s
			fest elat	1	Festuca elatior	e
			hypo radi	+'	Hypochaeris radicata	e
			loli rigi	+'	Lolium rigidum	e
			pasp dila	1	Paspalum dilatatum	e
			petr nant	1	Petrorhagia nanteuilii	e
			plan lanc	1	Plantago lanceolata	e
			trag porr	1	Tragopogon porrifolius	e
			trif sp	1	Trifolium sp.	e
			verb thap	r	Verbascum thapsus	e
			aust scab	2	Austrostipa scabra	c
			both macr	3	Bothriochloa macra	c
			chei aust	+'	Cheilanthes austrotenuifolia	2
			chry apic	1	Chrysocephalum apiculatum	1
			conv erub	r	Convolvulus angustissimus (syn. C. erubescens)	c
			dich crin	+'	Dichelachne crinita	c
			elym scab	r	Elymus scaber	c
			enne nigr	+'	Enneapogon nigricans	c
			eryn ovin	+'	Eryngium ovinum	2
			loma fili	r	Lomandra filiformis	1
			loma mult	1	Lomandra multiflora	2
			wahl lute	+'	Wahlenbergia luteola	c
			ryti caes	2	Rytidosperma caespitosum	c
			ryti carp	2	Rytidosperma carphoides	c
			them tria (3 or >)	2	Themeda triandra	2

Floristic Value	13	Number of common species	9

Score (FVS)	

Plot information:

Datum	GDA94
AMG Easting	694980
AMG Northing	6086340

Surveyor name(s)

Ken Hodgkinson

Number of indicator level 1 species	2
Number of indicator level 2 species	4
Total number of native species	15
Number of exotic species	17
Number of significant weed species	1

Date of survey	Site name	Site ID Code	Species code	Braun-Blanqet code	Species Name	Indicator sp. code
4/12/2013	Woods Lane	JE04	**aven sp**	**2**	Avena sp.	e
			cent eryt	+'	Centaurium erythraea	e
			dact glom	1	Dactylis glomerata	e
			fest elat	1	Festuca elatior	e
			hirs inca	r	Hirschfeldia incana	e
			hype perf	+'	Hypericum perforatum	e
			hypo radi	+'	Hypochaeris radicata	e
			nass tric	+'	Nassella trichotoma	s
			pasp dila	+'	Paspalum dilatatum	e
			petr nant	+'	Petrorhagia nanteuilii	e
			phal aqua	1	Phalaris aquatica	e
			plan lanc	1	Plantago lanceolata	e
			rubu frut	+'	Rubus fruticosus	e
			tara offi	+'	Taraxacum officinale	e
			trif sp	1	Trifolium sp.	e
			acae ovin	r	Acaena ovina	c
			aust spd	1	Rytidosperma sp.	c
			aust scab	2	Austrostipa scabra	c
			both macr	2	Bothriochloa macra	c
			bulb bulb	+'	Bulbine bulbosa	2
			chry apic	1	Chrysocephalum apiculatum	1
			chry semi	+'	Chrysocephalum semipapposum	2
			conv erub	r	Convolvulus angustissimus (syn. C. erubescens)	c
			elym scab	+'	Elymus scaber	c
			eryn ovin	+'	Eryngium ovinum	2
			good pinn	+'	Goodenia pinnatifida	2
			loma fili	+'	Lomandra filiformis	1
			loma mult	+'	Lomandra multiflora	2
			meli urce	r	Melichrus urceolatus	2
			pime curv	r	Pimelea curviflora	2
			plan vari	r	Plantago varia	2
			ruti lept	1	Rutidosis leptorhynchoides	2
			scho apog	+'	Schoenus apogon	c
			sene quad	+'	Senecio quadridentatus	c
			wahl lute	+'	Wahlenbergia luteola	c
			boss foli	+'	Bossiaea foliosa	2
			euph drum	r	Euphorbia drummondii	e
			acae nova	r	Acaena novae-zelandiae	c
			them tria (3 or >)	4	Themeda triandra	2

Floristic Value Score (FVS)	29

Number of common species	10
Number of indicator level 1 species	2
Number of indicator level 2 species	11
Total number of native species	23
Number of exotic species	16
Number of significant weed species	1

Plot information:

Datum	GDA94
AMG Easting	699524
AMG Northing	6084774

Surveyor name(s)

Date of survey	Site name	Site ID Code	Species code	Braun-Blanquet code	Species Name	Indicator sp. code
12/12/2013	Harmon Bonshaw south	JE06	acet vulg	+'	Acetosella vulgaris	e
			brom sp	1	Bromus sp.	e
			cirs vulg	r	Cirsium vulgare	e
			gnap amer	+'	Gnaphalium americanum	e
			holc lana	+'	Holcus lanatus	e
			hord sp	2	Hordeum sp.	e
			hypo radi	+'	Hypochaeris radicata	e
			phal aqua	+'	Phalaris aquatica	e
			sper rubr	+'	Spergularia rubra	e
			vulp sp	3	Vulpia sp.	e
			aust spd	3	Rytidosperma sp.	c
			aust bige	2	Austrostipa bigeniculata	c
			aust scab	2	Austrostipa scabra	c
			aust nivi	1	Austrostipa nivicola	c
			chry apic	+'	Chrysocephalum apiculatum	1
			conv erub	r	Convolvulus angustissimus (syn. C. erubescens)	c
			oxal pere	r	Oxalis perennans	c
			poa sieb	+'	Poa sieberiana	c
			wahl comm	r	Wahlenbergia communis	c
			cras alat	+'	Crassula alata	e
			stua hama	+'	Stuartina hamata	c

Floristic Value Score (FVS)	1

Number of common species	9
Number of indicator level 1 species	1
Number of indicator level 2 species	0
Total number of native species	10
Number of exotic species	11
Number of significant weed species	0

Plot information:

Datum	GDA94
AMG Easting	698468
AMG Northing	6084754

Surveyor name(s)

Ken Hodgkinson

Date of survey	Site name	Site ID Code	Species code	Braun-Blanquet code	Species Name	Indicator sp. code
12/12/2013	Harmon Bonshaw north	JE07	acet vulg	+'	Acetosella vulgaris	e
			aira sp	1	Aira sp.	e
			brom sp	1	Bromus sp.	e
			cart lana	r	Carthamus lanatus	e
			cony sp	r	Conyza sp.	e
			hypo radi	+'	Hypochaeris radicata	e
			nass tric	+'	Nassella trichotoma	s
			petr nant	1	Petrorhagia nanteuilii	e
			trif sp	+'	Trifolium sp.	e
			verb thap	r	Verbascum thapsus	e
			vulp sp	1	Vulpia sp.	e
			aust spd	5	Rytidosperma sp.	c
			aust scab	1	Austrostipa scabra	c
			junc fili	+'	Juncus filicaulis	c
			junc subs	+'	Juncus subsecundus	c
			wahl mult	+'	Wahlenbergia multicaulis	c
			card nuta	+'	Carduus nutans	e
			caps burs	r	Capsella bursa-pastoris	e
			aust nivi	1	Austrostipa nivicola	c
			junc phae	+'	Juncuc phaeanthus	c
			junc tenu	r	Juncus tenuis	c
			stel medi	+'	Stellaria media	e

Floristic Value Score (FVS)	0

Number of common species	8
Number of indicator level 1 species	0
Number of indicator level 2 species	0
Total number of native species	8
Number of exotic species	14
Number of significant weed species	1

Plot information:

Datum	GDA94
AMG Easting	698866
AMG Northing	6085380

Surveyor name(s)

Ken Hodgkinson

Date of survey	Site name	Site ID Code	Species code	Braun-Blanqe t code	Species Name	Indic ator sp. code
13/12/2013	Majura West	MA06	**aira sp**	**1**	Aira sp.	e
			briz mino	+'	Briza minor	e
			brom sp	1	Bromus sp.	e
			cent eryt	1	Centaurium erythraea	e
			cony sp	+'	Conyza sp.	e
			hype perf	r	Hypericum perforatum	s
			hypo glab	r	Hypochaeris glabra	e
			hypo radi	1	Hypochaeris radicata	e
			petr nant	+'	Petrorhagia nanteuilii	e
			plan lanc	1	Plantago lanceolata	e
			tolp umbe	1	Tolpis umbellata	e
			vulp sp	1	Vulpia sp.	e
			acae ovin	r	Acaena ovina	c
			aust spd	2	Rytidosperma sp.	c
			aust bige	1	Austrostipa bigeniculata	c
			aust scab	4	Austrostipa scabra	c
			both macr	2	Bothriochloa macra	c
			brac dent	1	Brachyscome dentata	2
			chry apic	1	Chrysocephalum apiculatum	1
			chry semi	1	Chrysocephalum semipapposum	2
			conv erub	r	Convolvulus angustissimus (syn. C. erubescens)	c
			cras vari	1	Craspedia variabilis	2
			cymb laws	1	Cymbonotus lawsonianus	c
			elym scab	r	Elymus scaber	c
			eryn ovin	1	Eryngium ovinum	2
			good pinn	1	Goodenia pinnatifida	2
			loma fili	+'	Lomandra filiformis	1
			loma mult	+'	Lomandra multiflora	2
			rume brow		Rumex brownii	c
			sene quad	r	Senecio quadridentatus	c
			tric elat	+'	Tricoryne elatior	2
			trip pygm	+'	Triptilodiscus pygmaeus	2
			wahl comm	r	Wahlenbergia communis	c
			wahl lute	r	Wahlenbergia luteola	c
			euch arge	1	Euchiton argentifolius	c

Floristic Value Score (FVS)	26

Number of common species	13
Number of indicator level 1 species	2
Number of indicator level 2 species	8
Total number of native species	23
Number of exotic species	12
Number of significant weed species	1

Plot information:

Datum	GDA94
AMG Easting	698202
AMG Northing	6094055

Surveyor name(s)

Ken Hodgkinson

Date of survey	cae ovin	Site ID Code	Species code	Braun - Blanquet code	Species Name	Indicator sp. code
4/12/2013	Isabella Pond	TU01	**aven sp**	**2**	Avena sp.	e
			cony sp	+'	Conyza sp.	e
			dact glom	1	Dactylis glomerata	e
			hypo radi	1	Hypochaeris radicata	e
			phal aqua	1	Phalaris aquatica	e
			plan lanc	1	Plantago lanceolata	e
			trag dubi	+'	Tragopogon dubius	e
			trif camp	1	Trifolium campestre	e
			acae ovin	+'	Acaena ovina	c
			aust spd	1	Rytidosperma sp.	c
			bulb bulb	+'	Bulbine bulbosa	2
			chei aust	+'	Cheilanthes austrotenuifolia	2
			chry apic	1	Chrysocephalum apiculatum	1
			conv erub	r	Convolvulus angustissimus (syn. C. erubescens)	c
			cryp amar	+'	Cryptandra amara	2
			dian long	+'	Dianella longifolia	2
			dian revo	+'	Dianella revoluta	2
			elym scab	1	Elymus scaber	c
			eryn ovin	+'	Eryngium ovinum	2
			loma long	1	Lomandra longifolia	2
			meli urce	1	Melichrus urceolatus	2
			pime curv	1	Pimelea curviflora	2
			plan vari	1	Plantago varia	2
			poa sieb	2	Poa sieberiana	c
			stac mono	+'	Stackhousia monogyna	2
			them tria (3 or >)	5	Themeda triandra	2
			wahl comm	+'	Wahlenbergia communis	c
			pult proc	+'	Pultenaea procumbens	2

Floristic Value Score (FVS)	**40**

Number of common species	**6**
Number of indicator level 1 species	**1**
Number of indicator level 2 species	**13**
Total number of native species	**20**
Number of exotic species	**8**
Number of significant weed species	**0**

Plot information:

Datum	**GDA94**
AMG Easting	**688903**
AMG Northing	**6078323**

Surveyor name(s)

Ken Hodgkinson

Appendix 3

CURRICULUM VITAE
Kenneth Charles HODGKINSON

CONTACTS
Phone (02) 6258 5380
Mobile 0429 606 788
Email ken.hodgkinson@csiro.au

EDUCATION
1963 B.Agric.Sc., Victoria University of Wellington, New Zealand
1968 Ph.D., University of New England, Australia
2011 D.Sc., Massey University, New Zealand

RESEARCH FIELDS
Grassland ecology; critical thresholds for adaptive management of natural resources; biodiversity conservation; management of urban, farmed and pastoral landscapes.

PROFESSIONAL AFFILIATIONS
Australian Rangeland Society (Fellow)
Australian Society of Plant Scientists
Linnaean Society of London (Fellow)
Royal Society of New Zealand

POSITIONS (selected)
1968-90 Research Scientist, CSIRO Rangelands Research Centre, Australia.
1975 Visiting Associate Professor, Range Science Dept, Utah State University, USA.
1990-2002 Senior Principal Research Scientist, CSIRO Wildlife and Ecology, Australia.
1999- Visiting Professor, Open Research Laboratory of Forest Plant Ecology, Northeast Forestry University, China.
2002- Honorary Research Fellow, CSIRO Ecosystem Sciences
2007- Visiting Professor, Northeast Normal University, China.
2011– Visiting Research Fellow, Fenner School of Environment and Society, ANU

PUBLICATIONS (selected)

123 publications including 42 papers in refereed journals, 22 book chapters, 33 conference papers and 3 edited books.

Hodgkinson, K. C. (1976). The effects of frequency and extent of defoliation, summer irrigation and fertiliser on the production and survival of the grass *Danthonia caespitosa* Gaud. *Australian Journal of Agricultural Research* **27,** 755-767.
Hodgkinson, K. C., Harrington, G. N., Griffin, G. F., Noble, J. C. and Young, M. D. (1984). Management of vegetation with fire. In 'Management of Australia's

Rangelands'. (Eds. G.N. Harrington, A.D. Wilson and M.D. Young). pp. 141-56. (CSIRO: Melbourne).
Hodgkinson, K. C. and Harrington, G. N. (1985). The case for prescribed burning to control shrubs in eastern semi-arid woodlands. *Australian Rangeland Journal* **7,** 64-74.
Wilson, A. D., **Hodgkinson, K. C.** and Noble, J. C. (1988). Vegetation attributes and their application to the management of Australian rangelands. In 'Vegetation Science Applications for Rangeland Analysis and Management'. (Ed. P. T. Tueller). pp. 253-294. (Kluwer Academic Publishers).
Hodgkinson, K. C. (1992). Elements of grazing strategies for perennial grass management in rangelands. In 'Desertified Grasslands: Their Biology and Management'. (Ed. G. P. Chapman). pp. 77-94. (Academic Press: London).
Hodgkinson, K. C. (1993). Identification of critical thresholds for opportunistic management of rangeland vegetation. In 'Proceedings IVth International Rangeland Congress, April 1991, Montpellier, France'. pp. 127-129.
Hodgkinson, K. C., Terpstra J. W. and Muller, W. J. (1995). Spatial and temporal pattern in the grazing of grasses by sheep within a semi-arid wooded landscape. *The Rangeland Journal* **17,** 154-165.
Ludwig, J. A., Tongway, D. J., Freudenberger, D. O., Noble, J. C. and **Hodgkinson, K. C.** (1997). Landscape ecology, function and management: principles from Australia's rangelands*. CSIRO, Melbourne.*
Hodgkinson, K. C., Marsden, S. G., and Muller, W. J. (2000). Defoliation sets the death-trap for grasses and drought springs the trap. Symposium papers, Australian Rangeland Society Centenary Symposium, Broken Hill 21-24 August 2000. (Eds S. Nicholson and J. C. Noble) 188-189. (Australian Rangeland Society: Broken Hill).
Hodgkinson, K. C. (2001). De-intensification of grasslands: understanding the processes to find the balance. In 'Grassland Ecosystems: an Outlook into the 21st Century, Proceedings of the XIX International Grassland Congress.' (Eds. J. A. Gomide, W. R. S. Mattos and S. C. da Silva). pp. 987-993. (Brazilian Society of Animal Husbandry, Sociedade Brazileira de Zootecnia: Piracicaba).
Hodgkinson, K. C. (2002). Fire regimes in *Acacia* wooded landscapes: effects on functional processes and biological diversity. In 'Flammable Australia: The Fire Regimes and Biodiversity of a Continent.' (Eds R. A. Bradstock, J. E. Williams, and A. M. Gill). pp. 259-277. (Cambridge University Press: Cambridge).
Hodgkinson, K. C. and Muller, W. J. (2005). Death model for tussock perennial grasses: a rainfall threshold for survival and evidence for landscape control of death in drought. *The Rangeland Journal* **27,** 105-115.
Hodgkinson, K. C., Marsden, S. and Muller, W. J. (2005). Sheep grazing during drought collapses the perennial grass resource in Australian semi-arid wooded grasslands. In 'XX International Grassland Congress: Offered papers' (Eds F.P. O'Mara, R.J. Wilkins, L. 't Mannetje, D.K. Lovett, P.A.M. Rogers and T.M.Boland) p. 525. (Waganingen Academic Publishers; Waganingen).
Hacker, R. B., **Hodgkinson, K. C.,** Melville, G. J., Bean, J. and Clipperton, S. (2006). Death model for tussock perennial grasses: thresholds for grazing-induced mortality of mulga Mitchell grass (*Thyridolepis mitchellianna*). *The Rangeland Journal* **28**, 105-114.
Wang, L., Wang, D., He, Z., Liu, G. F., and **Hodgkinson, K. C.** (2010). Mechanisms linking plant species richness and foraging performance of a large herbivore. *Journal of Applied Ecology* **47**, 868-875.