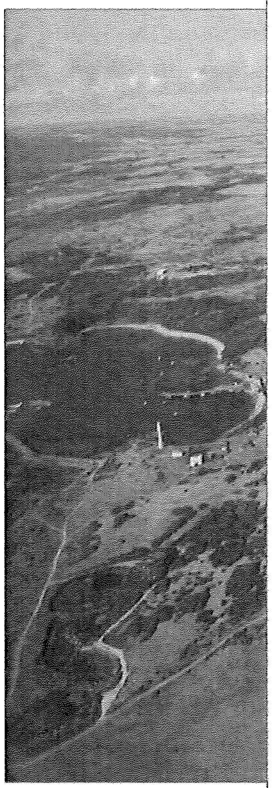
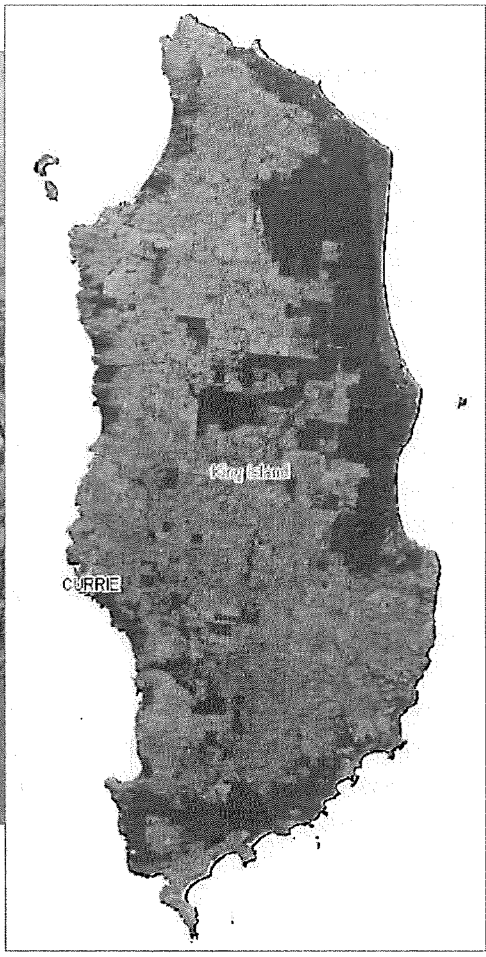
TASMANIAN INSTITUTE OF AGRICULTURAL RESEARCH

UTAS

ALTERNATIVES TO THE USE OF 1080 PROGRAM

Implications of Browsing by Native Wildlife on Improved Pastures and Native Vegetation Communities on King Island, Tasmania





FINAL REPORT

Professor Tony Norton and Nick Johannsohn

June 2010

Implications of Browsing by Native Wildlife on Improved Pastures and Native Vegetation Communities on King Island, Tasmania

Executive Summary

During August 2008 – March 2010 a scientific study was undertaken to examine the ecological and economic implications of browsing by native wildlife on the pastures and native vegetation of King Island, Tasmania. The study was led by the Tasmanian Institute of Agricultural Research in partnership with the King Island Natural Resource Management group. The study formed part of an ambitious 4 year program considering the 'Alternatives to the Use of 1080' as a control measure for native and exotic wildlife in agricultural landscapes in Tasmania that was a joint initiative of the Australian and Tasmanian governments.

The study built on the wildlife population survey undertaken on the island by Mark Branson and colleagues in 2008, and indicated quantitatively, for the first time, the significant and geographically-widespread impacts of wildlife browsing on farming systems and native vegetation communities across both the coastal and inland regions of King Island. The report outlines the findings of field research undertaken at 28 monitoring sites across the island and makes recommendations about options to mitigate the impacts of wildlife browsing on pasture-based enterprises such as beef and dairy farms, and native vegetation ecosystems. The report outlines options to improve the management of native wildlife.

The population size of Bennett's Wallaby on King Island is extraordinary – over 500,000 animals are estimated to forage on pasture systems covering an area of just 66,413 ha. A positive relationship was demonstrated between the relative abundance of Bennett's Wallaby and pasture loss to wildlife browsing. Measured pasture loss was around 50% of pasture production, on average, at unfenced sites. Shooting wallabies typically had no medium term effect on reducing animal numbers at unfenced sites, and hence typically may have no practical benefit at these sites in terms of reducing pasture loss to wildlife. The one apparent exceptional was where intensive shooting was combined with on-going monitoring and follow-up shooting to keep the number of Bennett's Wallaby low. Shooting of this nature may have a central role in future wildlife population management and the mitigation of browsing impacts on pasture provided that it is undertaken systematically at a landscape level. The combined use of well constructed wallaby-proof fencing and systematic shooting worked most effectively, and reduced pasture loss to almost zero.

A number of uncertainties may arise when estimating the pasture loss resulting from wildlife browsing and the potential dollar value of these losses. As a consequence, a range of estimates of pasture loss and the value of losses were provided based on the scientific findings of the research and the different assumptions used to make these estimates. It was estimated that total annual pasture loss to browsing on King Island could range from 7,103 to 82,687 tonnes of dry matter (DM), depending on the assumptions. The total dollar value of the estimated annual pasture loss for the island ranged from $2.4 million to around $28 million, again dependent on the assumptions made. For example, based on average pasture losses of 42% and 28% within 100 m and beyond 100 m of bush-lines, respectively, and with

30% of pasture loss eaten by wildlife, the estimated annual pasture loss to browsing on King Island was 24,806 tonnes (DM) with an estimated value of $8,463,977.

If all pastures were afforded protection from wildlife browsing by the use of a combination of wallaby-proof fencing and shooting, the potential annual savings appear highly significant. Because of the high numbers of native wildlife such as Bennett's Wallaby, these animals are also degrading and modifying native vegetation. By excluding native wildlife from sites, we showed that vegetation condition can be improved in the shorter term and seedling recruitment and plant growth can occur. This finding is promising for future investments in biodiversity conservation including fire, vegetation and habitat management on the island.

We argue that the future of King Island is not sustainable unless a credible strategy is developed to manage native wildlife, especially Bennett's Wallaby. In the absence of suitable controls on wildlife population levels and wildlife management, significant ecological and economic impacts will continue. Such a strategy needs to be holistic and cover both pasture production systems and native vegetation communities as the wildlife exploit both systems. The welfare of native animals must be respected. The proposed strategy will require wide community support and good communication to stakeholders and consumers of the island's agricultural produce. Governments have a central role to play in making this option a reality. This is the most comprehensive study of its kind yet to be undertaken in Tasmania and few comparable studies are reported from around the world.

Implications of Browsing by Native Wildlife on Improved Pastures and Native Vegetation Communities on King Island, Tasmania

Contents of Report

List of Tables

List of Figures

List of Appendices

Acknowledgements

The project was undertaken in partnership with King Island NRM (KINRM), and we are very grateful for the support of Ms Jenny Thorn, Chairperson of KINRM, the KINRM Committee, and staff of the organisation. Ms Eva Finzel (KINRM) and Mr John Brewster (ex-Chairperson of KINRM) provided invaluable support and advice for the project during the development and early operational period.

Dr Mick Statham of the Tasmanian Institute of Agricultural Research (TIAR) was a research investigator on the project and made important contributions to its development. Mark Branson (KINRM & TIAR) oversaw the development and implementation of 'Phase 1' of the project to quantify the population size and density of native wildlife species on the island that browse pastures. Ms Lauren Barrow (KINRM) provided scientific advice on the development of the project. Rowan Smith, Jo Lyall and Jessica Coad of TIAR provided invaluable support for the project and assisted with the project design and data analysis. Jo Lyall and Jim Lyall (TIAR) provided important field assistance. Karen Eyles of TIAR provided support for data analysis and map production.

The project received generous and widespread support from the King Island community, including from many landholders and land managers. We thank all of these people for their involvement and cooperation. We are especially grateful to Robbie Payne, Wayne Adams, Bob Cooper, Peter Bowling, Jamie Roebuck, Len Sullivan, and Arnold Payne for providing access to their properties for the field study. Many people gave invaluable assistance in the field. We especially thank Dale Reed and Teagan Cooper-Watts for assistance with spotlight monitoring, and Robyn Eades, and Graeme and Margaret Batey for assisting with the vegetation surveys. Jim Cooper, Yvonne Bowling, Greg Morris, Rod Mcgarvie and many others provided important advice and support for the project. We thank John North, Greg Blackwell, and Dave Leguis for their advice and support in conducting the project, and for providing access to data from the shooting control project they oversaw on the island for the Tasmanian Department of Primary Industry, Parks, Wildlife and Environment (DPIPWE).

The provision of spatial data sets and related information for the project was facilitated by several agencies and local governments including the DPIPWE, Cradle Coast NRM, and the Cradle Coast Authority. We are grateful for the support and advice provided by James Shaddick of Cradle Coast NRM.

Mr John Dawson of DPIPWE, manager of the Alternatives to the Use of 1080 Program, provided significant project advice and support, and we are particularly grateful for his invaluable contribution. Chris Grose of DPIPWE provided valuable comments to help finalise the report.

Disclaimer

Care has been taken in the development of this report and the data presented herein. However, this does not guarantee that the report is without flaws or its conclusions and recommendations are wholly appropriate for all purposes or situations. Therefore, the authors disclaim all liability for any loss or other consequence which may arise from reliance on any information contained in the report.

1. INTRODUCTION

1.1 INTRODUCTION

During the period August 2008 – March 2010 a scientific study was undertaken to examine the ecological and economic implications of browsing by native wildlife on the pastures, native vegetation and biodiversity of King Island, Tasmania. The study was led by the Tasmanian Institute of Agricultural Research (TIAR) and University of Tasmania (UTAS) in partnership with the King Island Natural Resource Management group (KINRM).

The study formed part of an ambitious 4 year program considering the 'Alternatives to the Use of 1080' as a control measure for native and exotic wildlife in agricultural landscapes in Tasmania. The program was a joint initiative of the Australian and Tasmanian governments, and was administered through the Tasmanian Department of Department of Primary Industries, Parks, Water and Environment (DPIPWE).

The findings of the study indicate quantitatively, for the first time, the geographically-widespread impacts of wildlife browsing on farming systems and native vegetation communities across both the coastal and inland regions of King Island. The report outlines the scientific findings of the field research and makes recommendations about options to mitigate the apparent impacts of wildlife browsing on pasture-based enterprises such as beef and dairy farms, and native vegetation ecosystems on King Island. The report outlines options to improve the management of native wildlife and the sustainable management of terrestrial ecosystems.

1.2 BACKGROUND

King Island is located off the north west of mainland Tasmania in western Bass Strait. The island covers approximately 110,160 hectares and supports a human population of around 1500 people with major settlements at Currie and Grassy (Barnes and Duncan 2002). The island receives annual rainfall of up to 1,050mm and has, on average, 215 rain days per year (Donaghey 2003).

The King Island economy is largely based on agriculture, minerals, fisheries and marine resources, and nature-based tourism (K. Eyles, UTAS unpublished data 2010). Agricultural production is principally based on pasture-based enterprises such as beef and dairy farming. The market branding of King Island's agriculture as producing premium food products in an environmentally-sustainable manner is very important since most of the agricultural produce is exported to other parts of Australia and internationally (Norton 2010).

Since permanent European occupation of King Island in the late 1800's, more than 70% of the native vegetation has been cleared for agricultural land use and the island has undergone a dramatic reduction in biodiversity values (Donaghey 2003; Threatened Species Section 2010). A number of plant and animal species have become extinct as a result of these land use impacts (Barnes and Duncan 2002; Donaghey 2003). Seven per cent of the remaining native vegetation is protected within State Reserves, Nature Reserves or Conservation Areas (Barrow 2008), and up to 25 native vegetation communities still occur on the island (Barnes and Duncan 2002; Lacey and Norton 2010). Due to a history of intensive land clearing and a high fire frequency, much of the former woodlands and forest understorey that covered the island has been replaced with *Melaleuca* and *Leptospermum* dominated scrub and heath-scrub complex (Barnes and Duncan 2002). Native vegetation occurs across the island as isolated small patches, planted windrows, and two relatively large stands in the northeast and south of the island (Lacey and Norton 2010) (Figure 1).

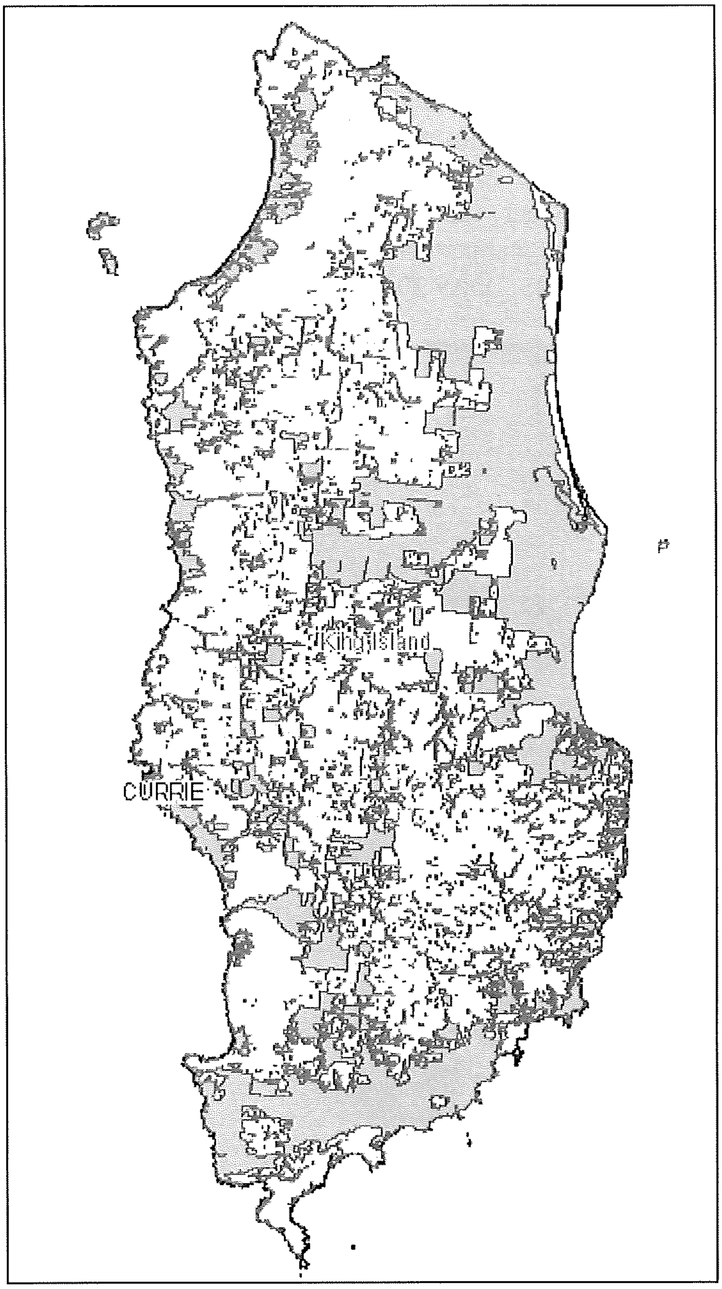


Figure 1. Distribution of remnant patches of native vegetation (pink) within a highly fragmented agricultural landscape (white) on King Island, Tasmania. Larger patches of native vegetation are shown in green including the Lavinia State Reserve in the north east of the island. (Top to bottom of King Island is ~60 km.) The image was generated using BITE©.

Wildlife Management on King Island

The highly-modified landscapes found on King Island today provide habitat for several species of browsing native animals including Bennett's Wallaby (*Macropus rufogriseus*), Brushtail Possum (*Trichosurus vulpecula*) and the Tasmanian Pademelon (*Thylogale billardierii*) (Anon 1996; Anon 2005).

Many landholders report that browsing native herbivores have increased in number in recent decades, and have become a serious management issue for farmers. These anecdotal reports appear generally consistent with data collected during DPIPWE wildlife spotlighting surveys undertaken along roads during 2001-2006/2007 (Figures 2 and 3). The observed number of animals was lower in 2008. These data suggest that the population density of the Bennett's Wallaby may have increased during at least the first half of the decade despite the shooting of around 30,000 wallabies per annum, on a non-commercial basis, for crop and pasture protection (Anon 2005; DPIW 2005;) (Table 1).

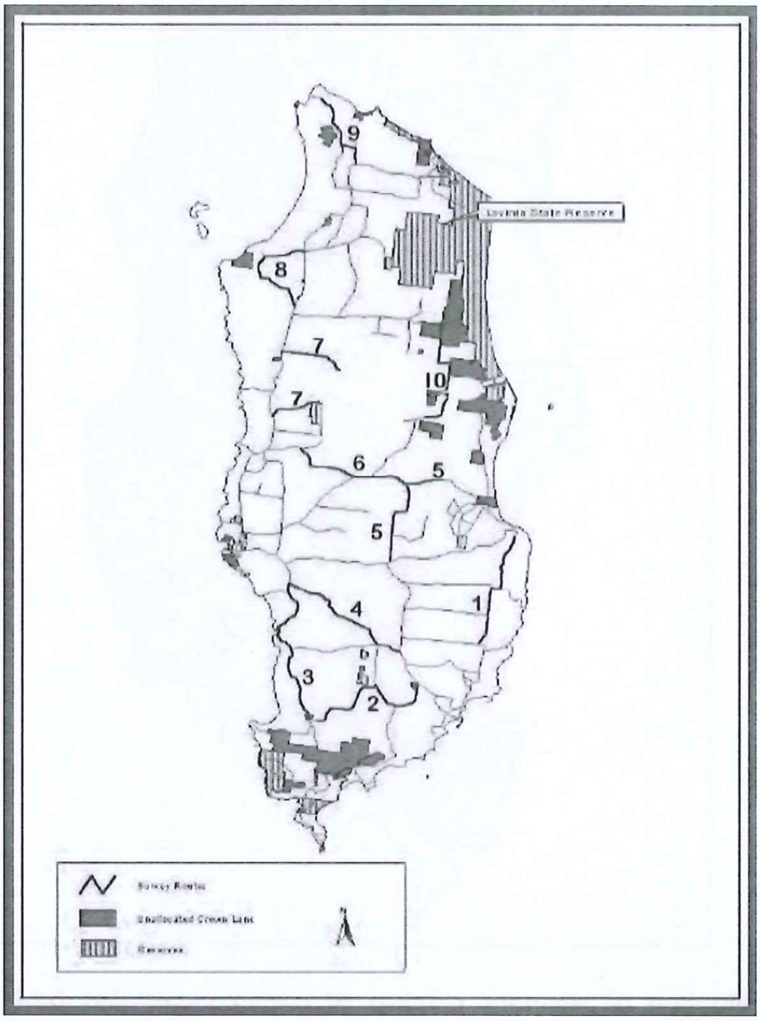


Figure 2. Location of DPIPWE spotlight survey transects (shown in blue, numbered 1-10) used to estimate the relative abundance of native wildlife on King Island, Tasmania (adapted from DPIW 2005). (Top to bottom of the island is ~60 km.)

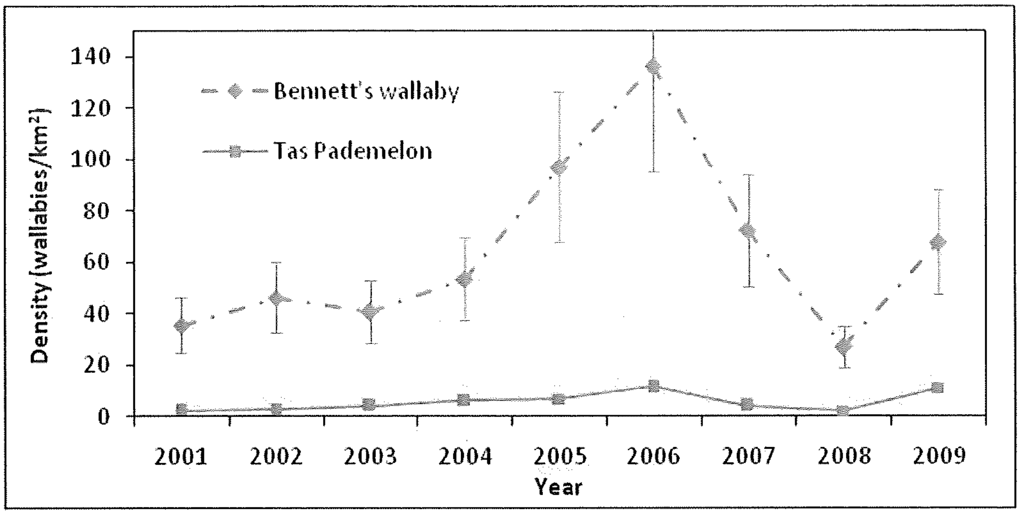


Figure 3. Trends in the index of population density in Bennett's Wallaby and Tasmanian Pademelon on King Island for the period 2001-2009. Trend line includes standard error bars (adapted from DPIW 2005).

Prior to 2005, the management of native herbivores on King Island was undertaken using techniques such as 1080 poison baiting, localised shooting, vegetation clearance, wallaby-proof fencing and commercial harvesting (DPIW 2005). Most reported wildlife control was carried out on a property scale with the occasional 'strategic' use of 1080 poison (DPIW 2005).

Year	Property Permits	Estimate of Take
1999	27	-
2000	29	-
2001	19	30,000
2002	23	30,000
2003	18	30,000
2004	25	30,000
2004/05	62	28,700
2005/06	25	24,100
2006/07	28	7,600
2007/08	95	32,016
2008/09**	67	13,699*

* Preliminary figures only (as of 30 June 2009). Also approximately 3,000 non-commercially harvested wallabies taken under the Alternatives to 1080 program yet to be entered into DPIPWE database (J. Dawson pers. comm.).

** Permit months submitted = 80 (3,070 BW, 941 TP); Permit months outstanding = 277 (estimated take 10,629 BW, 3,258 TP).

Table 1. Estimate of the number of Bennett's Wallaby taken by non-commercial shooting on King Island for the period 1999-2009 (source: Kris Carlyon, DPIPWE 2010).

The use of 1080 poison on King Island was abandoned in 2005 because the use of toxins conflicted with the image of the King Island export 'Brand' (Branson 2008). During the same period, a decision was taken by the Tasmanian Government to phase out the use of 1080 as a wildlife management control as a result of public concern about animal welfare and the potential impact of 1080 on non-target species including threatened species of native wildlife (DAFF 2009).

Shooting as a wildlife control measure

Since the use of 1080 as a wildlife control measure on King Island ceased to be an option, landholders have persisted with alternative measures such as shooting. Landholders can apply for a Crop Protection Permit from the Tasmanian DPIPWE to cull wallabies in order to protect crops or pasture on their land. Permits are issued for a period of up to 12 months, and specify the species to be taken, property, and method of control. The latter depends upon the nature of the problem, but usually involves shooting at night with the aid of a spotlight. Shooting may be undertaken by the landholder, their employees or family, or by other persons named on the permit as agents. Permits to shoot wallabies are issued subject to an annual assessment of population trends undertaken during the standard spotlight survey program.

However, the usefulness of shooting as a viable, long-term wildlife control measure on King Island appears uncertain. In the absence of careful planning, the use of shooting of native wildlife as a method of control can be problematic. Ad-hoc or inefficient use of shooting in an area can make the effective use of this control option more difficult as animals become particularly sensitive to disturbance. In terms of wildlife management at a landscape level, localised shooting may have only limited or no lasting benefit since the local area may be rapidly occupied by animals moving in from neighbouring, uncontrolled areas where the wildlife population remains high.

There are concerns within the local community about the apparently large number of animals that are shot and may be left in farm paddocks. The carcasses may provide an extraordinary source of food for many species including the Forest Raven (*Corvus tasmanicus*). Apparently, as a result of increased food availability from this source, the population of ravens on the island has increased significantly and is considered to have a detrimental ecological impact (R. Donaghey, personal communication 2010).

Fencing as a wildlife control measure

Wallaby-proof fencing is used on King Island to help reduce pasture and crop losses from wildlife. The boundaries of several properties have been partially or fully fenced with wallaby proof fencing. Although fencing may be relatively expensive and requires ongoing maintenance, it can help to reduce pasture loss to wildlife browsing. The case study outlined by Statham and Statham (2009) illustrated some of the benefits of wallaby-proof fencing observed by Mr Peter Bowling for his properties in the southern part of King Island. Mr Bowling reported improvements in the quality of his pastures and has been able to increase the stocking rate of his herd of Grey cattle since installation of the fencing (Statham and Statham 2009).

Although comprehensive benefit cost analyses of the use of wallaby-proof fencing are yet to be undertaken for King Island or other parts of Tasmania, the quantitative findings from this study (see below) indicate the degree to which pasture losses could be reduced by using wallaby-proof fencing in combination with systematic shooting.

Commercial harvesting of wildlife

A Wildlife Trade Management Plan has been developed by the Tasmanian Government for the King Island population of Bennett's Wallaby (DPIW 2005). The plan aims to satisfy the requirements for an *Approved Wildlife Trade Management Plan* under Section 303FO of the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999*, thereby allowing products of wallabies from King Island to be exported to overseas markets. The program applies from 1 July 2005 to 30 June 2010.

At present, there is no export operation on King Island. The economic viability of commercial operations appears limited by relatively high freight costs and input costs associated with processing animals on the island.

The Wildlife Trade Management Plan aims to ensure the ecological sustainability of wallaby harvesting on King Island by regularly monitoring population trends and adopting appropriate management in response to these trends (DPIW 2005).

King Island Population Survey of Native Wildlife in 2008

On-going concerns about wildlife management on King Island resulted in the initiation of a new population survey of native wildlife in 2007. KINRM was contracted by the Tasmanian Government to undertake a systematic program of wildlife spotlight surveys across King Island during February to April 2008 to quantify the population size and density of several native wildlife species associated with browsing on pastures (Branson 2008).

The wildlife species of special interest were Bennett's Wallaby, Brushtail Possum and the Tasmanian Pademelon, owing to the perceived impacts that these species may have on pasture production (Branson 2008).

The principal aim of the study was to obtain accurate population estimates for the Bennett's Wallaby, Brushtail Possum and the Tasmanian Pademelon (Branson 2008). In addition, an important aspect of the research was to test different wildlife census techniques and to identify the most suitable for the conditions on King Island.

The survey provided an opportunity to compare the population census data and population estimates with those derived from the DPIPWE roadside surveys (Branson 2008). This enabled the two wildlife population sampling approaches to be evaluated.

A literature review was undertaken by Branson (2008) to identify the most appropriate monitoring procedures available, and a pilot study was used to trial selected techniques. Strip transects of 400 m length and 50 m half-width were selected as the most appropriate to undertake wildlife surveys on farms with pastures on King Island. This survey method was also employed for the present project (see below). Branson (2008) used an environmental stratification of King Island to select 30 field sites where the survey data would allow the calculation of the relative abundance of each wildlife species (using a weighted mean estimate per hectare).

Additional roadside spotlight monitoring was undertaken at historical sites used by DPIPWE and within Pegarah Forestry and Lavinia Reserve to provide a seasonal comparison with historical data on wildlife abundance.

Branson (2008) estimated a population of between 440,000 and 535,000 Bennett's Wallaby was foraging in pastures on King Island (Figure 3a). This estimate was significantly higher than any previously published population estimate.

The Tasmanian Pademelon was found in relatively low abundance and Branson (2008) estimated the population at between 18,000 and 31,000 on pastures. The species appeared most common in the Pegarah area and southern regions of the island.

The Brushtail Possum appeared to be relatively evenly distributed across the island, and had an estimated population of 55,000 – 93,000 in pasture (Branson 2008).

It was suggested that the population size of the Bennett's Wallaby and Brushtail Possum may be increasingly over time, whereas the Pademelon population may be in decline.

The study made three recommendations (Branson 2008):

- that a biannual aerial survey program be developed to monitor the impact of any commercial harvesting operations and culling permits on King Island, as is the standard in other States of Australia.
- that the Tasmanian Pademelon should not be approved for culling permits on King Island, unless it is demonstrated that an abnormally high relative abundance of the species is present on a given property.
- investigate the health of the Tasmanian Pademelon population on King Island in relation to toxoplasmosis and other diseases.

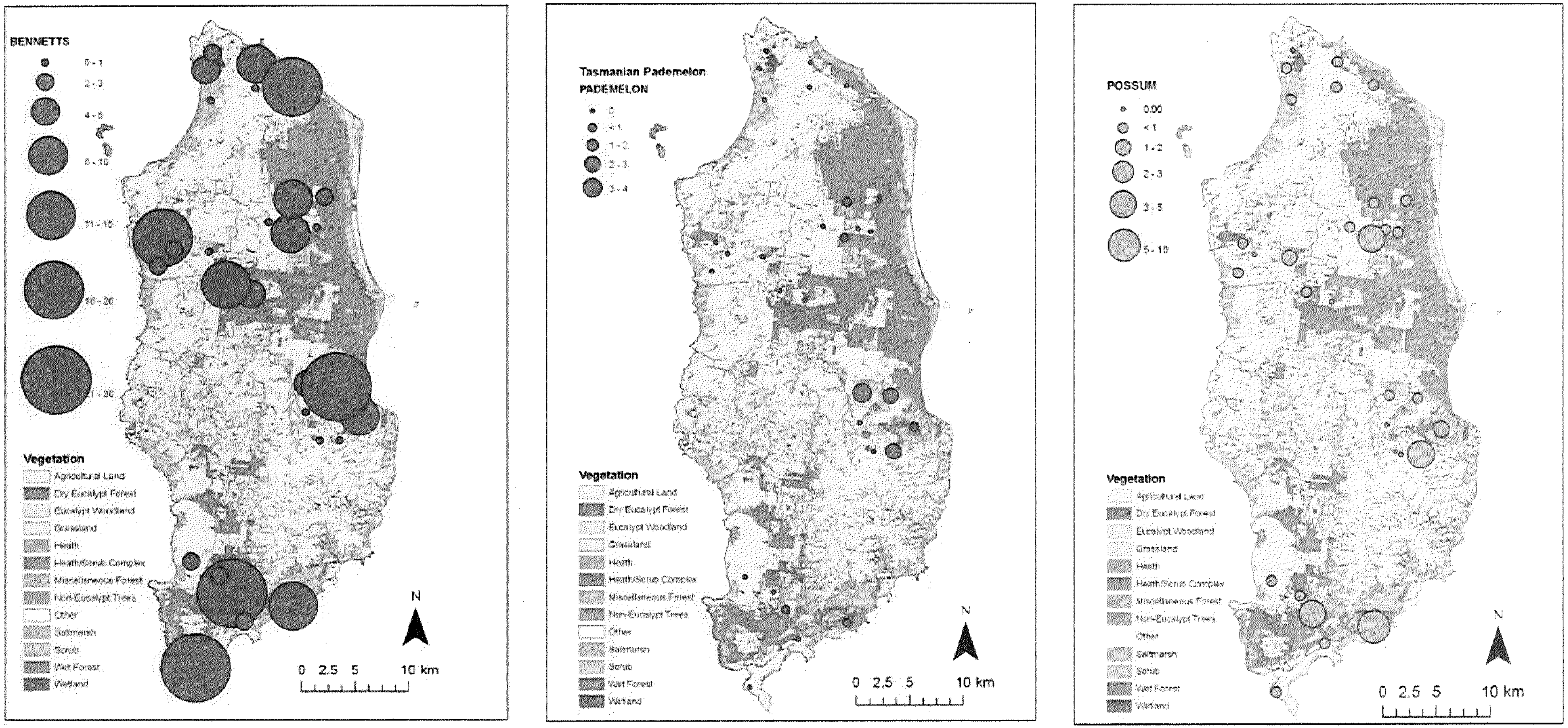


Figure 3a. Mean relative abundance of Bennett's Wallaby (left), Tasmanian Pademelon (middle), and Brushtail Possum (right) at 30 sites on King Island (adapted from Branson 2008). Circles are shown in proportion to the relative abundance of wildlife species. Land cover including native vegetation community types is shown in the vegetation key at bottom left in each map.

1.3 AIMS OF THE PRESENT PROJECT

The aims and objectives of the present study were developed in the context of the overall 'Alternatives to the Use of 1080 Program, and the findings of the study reported by Branson (2008). Of particular interest was the potential ecological and economic impact that a very high population of native wildlife herbivores may have on pasture-based enterprises such as beef and dairy farming on King Island, and on native vegetation communities and its associated biodiversity. If these impacts were shown to be significant then it is important to identify credible and practical options to mitigate these impacts.

The objectives of the project were to:

- Examine the relationships between the relative abundance of native herbivores on King Island and their impact on pastures.

- Assess the impact of culling intensity and frequency on the relative abundance of herbivores in pasture, and the relationship between the relative abundance of herbivores and pasture damage at a property scale.

- Assess the effectiveness of 'wallaby-proof' fencing for mitigating pasture production loss resulting from wildlife browsing.

- Examine if thresholds can be established between the relative abundance of herbivores and browsing damage to pasture and agricultural productivity on King Island.

- Consider the feasibility of a commercial wallaby and possum harvesting industry on King Island based on the results of the herbivore control approaches.

- Assess the impact of native herbivores on the condition of remnant native vegetation across agricultural landscapes with and without 'wallaby-proof' fencing.

1.4 HOW THE REPORT IS STRUCTURED

The report comprises four major sections. The introduction to report provides the background to the study and outlines its key objectives. Section 2 outlines the design of the field research and presents the major scientific findings of the field study undertaken between August 2008 and March 2010. Section 3 discusses the ecological and economic implications of native wildlife browsing for the terrestrial ecosystems on the island. The major conclusions and recommendations are presented in section 4.

Scientific field data not directly employed in the main body of the report are presented in the Appendices. Data on the relative abundance of wildlife species, and pasture production and losses to browsing are included for each site and property. Similarly, site and property level data for each biodiversity monitoring plot are included. These data may be useful for benchmarking and monitoring changes over time where landholders and land managers adopt new mitigation measures to manage native wildlife.

2. DETERMINING THE SIGNIFICANCE OF WILDLIFE BROWSING

2.1 INTRODUCTION

The significance of browsing by native wildlife on pastures and native vegetation communities on King Island was examined between August 2008 and March 2010, inclusive, using a combination of complementary scientific field studies.

A total of 28 field sites were established and monitored using several field staff and over 2000 person hours of time. The location of sites was permanently recorded so, if required, they could be used in future studies including for long-term monitoring.

The design of the field research program and the scientific methods used for collecting and analyzing data are outlined below.

2.2 DESIGN OF FIELD RESEARCH PROGRAM

The design of the field research program and selection of study sites used in this project built upon the approach adopted in the wildlife surveys undertaken across the island in 2008 by Branson (2008). Five areas located around Wickham, Reekara, Bungaree, Pegarah and South were selected for the wildlife surveys in 2008 because they reflected the diversity of native vegetation, soils, local hydrology and drainage, and pasture types found on farms across both coastal and inland regions of the island.

Twelve field sites were identified in the same five areas of the island to examine the relationships between the relative abundance of native wildlife, wildlife browsing, and pasture loss (Figure 4 and Table 2). These sites were called the 'pasture monitoring sites' and were improved pastures that were not regularly irrigated.

An additional 16 sites were chosen as 'biodiversity monitoring sites' to evaluate the affect of wildlife browsing on native vegetation communities (Figure 4 and Table 2).

An important consideration of the selection of all pasture monitoring sites was the presence or absence of wallaby-proof fencing at a landscape level, and other management practices imposed on a site (e.g. no controls, commercial shooting, intensive shooting, fencing and shooting) so that these factors could be examined as well (Table 2).

The decision to use these factors to select field sites for monitoring pasture loss meant that areas of pasture at greater distance from bush-lines were not sampled. As a consequence, this placed limitations on attempts to model pasture loss to browsing for all pasture situations on the island.

'Commercial shooting' was defined as shooting at a site that was at a level consistent with that undertaken by professional shooters during a commercial harvesting activity. 'Intensive shooting' was defined as a level of shooting that enabled the removal of every individual of each target species from the site at the time of shooting.

Site Type	Site No.	Site Name	Location	Vegetation	Mgt. Regime
Pasture & Wildlife Monitoring					
	1	Reekara A	Reekara	Pasture	Fence/Intensive Shoot
	2	Reekara B	Reekara	Pasture	Fence/Intensive Shoot
	3	Reekara C	Reekara	Pasture	No Control
	4	Pegarah	Pegarah	Pasture	Intensive Shoot
	5	Loorana A	Loorana	Pasture	Intensive Shoot
	6	Wickham A	Wickham	Pasture	Commercial Harvest
	7	Wickham A	Wickham	Pasture	Commercial Harvest
	8	Pearshape A	Pearshape	Pasture	No Control
	9	Seal Rocks	Seal Rocks	Pasture	Commercial Harvest
	10	Pearshape B	Pearshape	Pasture	No Control
	11	Loorana B	Loorana	Pasture	No Control
	12	Pearshape C	Pearshape	Pasture	Commercial Harvest
Biodiversity Monitoring					
	1	Seal rocks A	Seal Rocks	SKK	Fencing
	2	Seal rocks B	Seal Rocks	SKK	Fencing
	3	Black point A	Black Point	Coastal	Fencing
	4	Black point B	Black Point	Coastal	Fencing
	5	Currie A	Currie	Coastal	No fencing
	6	Currie B	Currie	Coastal	No fencing
	7	Currie C	Currie	Coastal	No fencing
	8	Currie D	Currie	Coastal	No fencing
	9	Reekara A	Reekara	SKK	Fencing
	10	Reekara B	Reekara	SKK	Fencing
	11	Reekara C	Reekara	SKK	No fencing
	12	Reekara D	Reekara	SKK	No fencing
	13	Red Hut A	Red Hut	Coastal	Fencing
	14	Red Hut B	Red Hut	Coastal	Fencing
	15	Wickham A	Wickham	SKK	No fencing
	16	Wickham B	Wickham	SKK	No fencing

Table 2. Location, vegetation and fencing found at field sites used to assess and monitor the affects of browsing by native wildlife on King Island, Tasmania. SKK = King Island Scrub Complex vegetation; coastal = King Island Coastal Complex vegetation (Norton and Lacey 2010).

2.3 SCIENTIFIC METHODS

Estimating wildlife species composition and relative abundance

The relative abundance of wildlife was assessed at each pasture monitoring site using a vehicle-based survey of a line transect 400 m in length and 100 m in width (Figure 5). Transects were marked with star pickets and flagging tape that could be readily observed at night using spotlights (Figure 5).

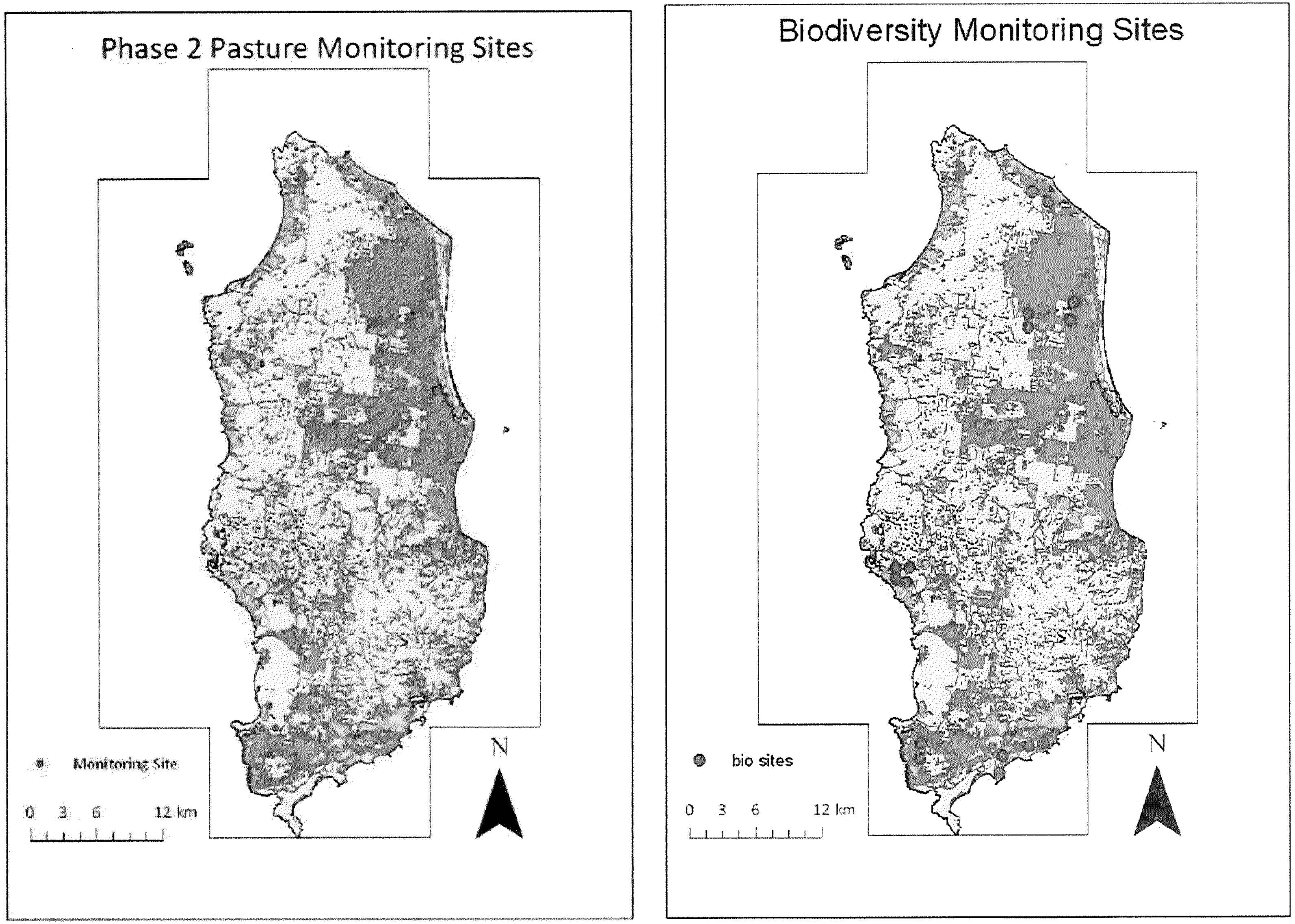


Figure 4. (left) Location of 12 field sites used for measuring pasture production and pasture loss to wildlife browsing, and transect spotlight surveys to determine the relative abundance of wildlife; (right) Location of 16 field sites used for assessing and monitoring the influence of browsing and habitat use by native wildlife on native vegetation communities.

This survey method was selected because research undertaken in 2007 (a pilot survey involving Mr Mark Branson, KINRM, and Mr Rowan Smith, TIAR) and 2008 (main wildlife survey by Branson) had demonstrated the utility of this design for the field conditions on King Island. The survey technique had to be able to accommodate the tall grass (>30 cm) found at some sites, cryptic nature of the Tasmanian Pademelon (Le Mar and Southwell 2001; Le Mar and McArthur 2005), and relatively small size of the Brushtail Possum.

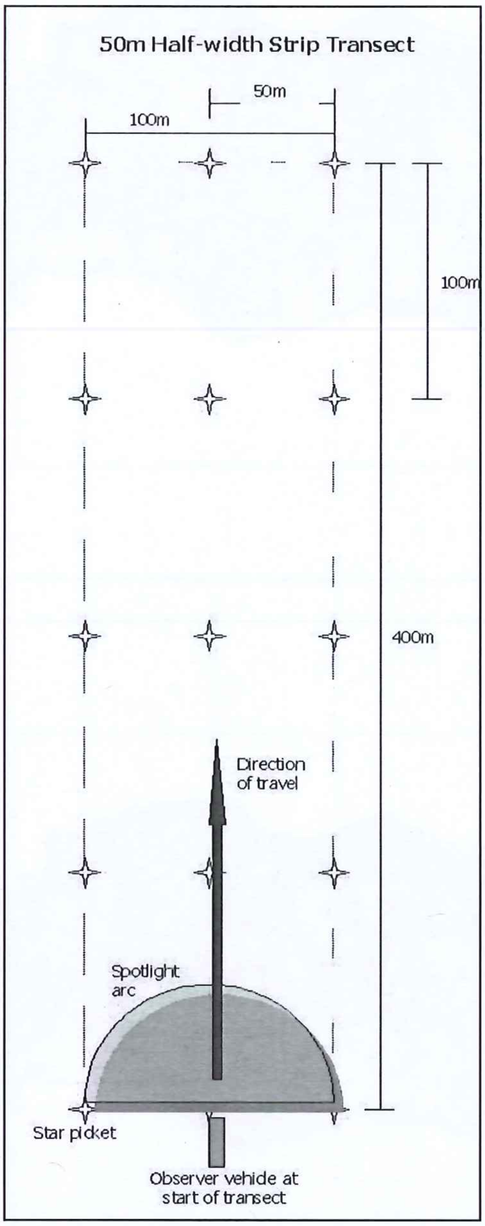


Figure 5. Strip transect design that was used for spotlighting to determine the relative abundance of native wildlife at each pasture monitoring site.

Vehicle line-transects using distance categories (modified from Le Mar and Sothwell 2001; Wayne and Cowling 2005) were found by Branson (2008) to provide greater perspective, and earlier detection and greater identification confidence of wildlife at distance. The method also reduced the masking effect of tall grass, thus providing greater detectability of the smaller wildlife species (Southwell 1994; Southwell and Weaver 1995; Pople and Cairns 2003). The influence of the vehicle on the species did increase the level of flushing, but in most cases, animals were recorded while stationary, indicating that they were detected prior to flushing.

Two people (one driver and one observer) using a 4WD flat-tray vehicle undertook the survey of each transect. The vehicle was driven through the middle line of the transect using the star pickets for guidance. The observer spotlighted from the tray of the 4WD, dictating into a voice recorder, while the vehicle traversed the transect at a speed less than 5km/h (first gear idle). In winter months it was sometimes necessary to travel through some sections of a transect at speed to avoid getting stuck.

The observer was trained in the spotlight technique and in the identification of species by eyeshine, pelage colour and locomotion traits.

Spotlighting commenced 40 minutes after sunset and was not conducted during high winds, persistent rain or fog (Hocking and Driessen 1992). Orientation and familiarisation with the site was undertaken prior to the spotlighting to identify hazards and ensure observer safety. To reduce the observer effect, vehicles approached transects as silently as possible without headlights, and stopped approximately 50 m before the start of each transect. Fifteen minutes was allowed to pass before the transect survey was commenced, using only the spotlight and no headlights.

To maximise observations and to allow the driver to maintain safe operation of the vehicle, the observer scanned the spotlight in a 180-degree arc about the centre line at head height (Figure 5). All mammals on the ground and in trees within the strip were recorded to species. Pouch-young and animals behind the observer were not accounted for. Emphasis was put on the observer's responsibility to count all individuals within each transect, and to record each individual only once (Triggs 1999). Site transects were surveyed monthly to provide an index of relative abundance of wildlife for each pasture monitoring site.

Several assumptions are associated with the use of the spotlight transects to estimate the relative abundance of native wildlife (see Branson 2008), including that:

- animals observed are correctly identified to species level. Only trained researchers were allowed to conduct spotlight observations. Of the three species, identification errors are likely to be restricted to confusing Bennett's Wallaby and the Tasmanian Pademelon. This error was assumed to be small.

- all animals in a transect were counted, and only counted once. This assumption is almost certainly violated in all nocturnal research. The most likely scenario is a negative bias due to crypsis and flushing responses (Le Mar and McArthur 2005).

- detectability of species is equal at any given site. Bennett's Wallaby are the largest and least cryptic of the species in this study. Estimates for this species should be regarded as more accurate than estimates for pademelon and possum.

- detectability within species is equal across all sites. Transects with high animal numbers are more likely to produce a negatively biased result than sparsely populated transects. Areas with very dense groundcover were not surveyed as they were likely to induce a negative detection bias.

Measuring pasture production and pasture loss resulting from wildlife browsing

The pasture species composition of the pasture monitoring sites was typically dominated by Cocksfoot, Sub-clover, Ryegrass and Fescue (Table 2). Measurements of pasture production, and pasture loss to wildlife browsing were made using wire cage exclosures (55 cm x 55 cm x 55 cm) and paired un-caged plots of the same size. The paired plots were permanent, randomly assigned, and repeatedly measured over time. These plots were set in rows of four at a distance of 10 m, 25 m, 50 m and 100 m from the bush-line (edge of patches of remnant native vegetation) to allow an assessment of pasture loss with distance from vegetation.

Cages at each site were installed after stock had been taken out of a paddock and pasture was harvested prior to the stock re-entering. Two samples were collected from each plot (caged and un-caged) using a lawn mower and hand clippers to collect the pasture samples. Pasture cuts were made at 3 cm above ground level. Samples were dried for 24 hours then weighed to obtain measurements in kilograms of dry matter production and loss from browsing. Pasture loss trials were employed for the duration of the project between August 2008 and March 2010, inclusive, which allowed for the measurement of seasonal variation of pasture production rates and losses.

Predicting the significance of wildlife browsing on pasture production

The significance of pasture loss resulting from wildlife browsing was estimated for every property with pastures on King Island, and for the island as a whole, using a software tool called BITE© (cf. Statham 1983; Norton and Lacey 2010). The concept for BITE© was developed in mid 2006 by Prof. Tony Norton to quantify and map the loss of pastures resulting from browsing by native herbivores across Tasmania's agricultural landscapes. The concept involves bringing together information on land cover and land use held within a computer-based geographic information system (GIS) with spatial information on farm pasture production and pasture loss from wildlife browsing. The software tool allows pasture production and loss to be mapped at the farm or property level. This information can be used to 'scale up' and estimate pasture losses, and the dollar value of these losses, at a catchment and regional level.

BITE© uses existing spatial information on land cover and land use, including satellite imagery (Norton and Lacey 2010). Estimates of pasture growth or production are generated using an established and well-tested agronomic model called DairyMod (Cullen *et al.* 2008; Johnson *et al.* 2008; Rawnsley *et al.* 2009) that has been used widely in the dairy industry. Information on pasture loss to native herbivores on King Island that is used in BITE© was generated by the present study. BITE© was developed as part of the Alternatives to the Use of 1080 Program and was scripted by Dr Michael Lacey who is based at the University of Tasmania. The Visual Basic script used in BITE© is © Michael J. Lacey.

A number of uncertainties arise when attempting to model and predict pasture losses across the agricultural landscapes of King Island. For example, the design of the field monitoring of pasture loss was limited by the available resources, including time, and by the need to include a consideration of wallaby-proof fencing on animal numbers and pasture loss from browsing. This meant that not all environmental settings within pastures on the island could be sampled, nor could the sampling extend over a longer time period to measure longer temporal fluctuations that may result from factors such as climate variability.

The use of relatively small exclosure cages to measure pasture loss may also have influenced the results. The cages may produced their own micro-environment that is more conducive to pasture growth by trapping moisture, and reducing wind speed and evaporation. Since no buffers of retained pasture were used around the exclosures, it is possible that the light regime was improved within the cages, and competition was reduced from adjacent pasture plants that were exposed to wildlife browsing. As a consequence, it is possible that the growth rate of pasture under cages was relatively higher than would otherwise be the case, and that the estimated pasture loss from browsing was higher than the true case, as well.

The uncertainties and limitations associated with modelling pasture loss to wildlife browsing mean that care needs to be taken in the use of BITE©, the interpretation of the model results, and the communication of any such findings to stakeholders.

Measuring the affects of wildlife browsing on native vegetation

The affects of browsing by native wildlife on native vegetation communities were examined at 16 sites across King Island (Figure 4). Exclosure plots with an area of 10 square metres were constructed at each field site to examine the response of the native vegetation to the removal of potential browsing and habitat use by native wildlife. The exclosure plots were created by driving four corner star pickets into the ground and placing straining wire around them.

For sites with sandy and steep terrain, extra pickets and steel pegs were used to secure fence midpoints. The tops of the exclosure plots were not covered to save on construction costs.

Sites were checked regularly for Brushtail Possum scats and other evidence of browsing within the exclosure, but none was found. If possum browsing had become an issue then the tops of the exclosures would have been covered with straining wire.

Within each exclosure plot, a 2 m^2 quadrat was established to measure the response of native vegetation to the removal of wildlife browsing and habitat use. Another 2 m^2 quadrat with similar vegetation and site characteristics was established outside the exclosure plot as a paired comparison.

Data on plant species composition, vegetation structure (<5 cm, >5 cm, <30 cm, >30 cm), and plant growth was collected for each exclosure and each quadrat. The nature of the ground cover (e.g. bare ground, moss and litter cover) and degree of disturbance was recorded. Where present, pasture species were also identified.

Photographs of each site were also captured before, after and during the monitoring.

It is anticipated that these sites will be maintained in the longer term by KINRM in collaboration with local landholders so that a longer time-series of monitoring data can be collected.

2.4 DURATION OF THE RESEARCH AND THE VOLUME OF DATA COLLECTED

Research on pasture production and pasture loss to wildlife browsing, and wildlife surveys were conducted from August 2008 until March 2010. During this period, 78 pasture harvests were completed for each field site. This resulted in a total of 2486 pasture samples that were cut, dried, weighed and analysed during the study.

During the same period, a total of 225 spotlight transect surveys were conducted to monitor the relative abundance of wildlife.

Four rounds of monitoring of the exclosures and paired quadrats located in native vegetation communities were completed between May 2009 and March 2010, inclusive, to produce a total of 96 quadrat surveys.

Overall, the combined field and laboratory-based research presented in the report represents a contribution of over 5000 person hours of time from a number of professional staff.

A digital copy of the field data collected during the study was deposited with KINRM at Currie.

2.5 SCIENTIFIC RESULTS AND DISCUSSION

Wildlife Spotlight Surveys

The species composition and relative abundance of native wildlife was assessed using spotlighting surveys. The three main species detected at sites were the Bennett's Wallaby, Brushtail Possum and Tasmanian Pademelon (Figure 6 and Appendix 1). Bennett's Wallaby was the most abundant species. It was recorded at all sites during the survey period. The relative abundance of Bennett's Wallaby at some sites was close to 15 animals per hectare (Figure 6).

The Brushtail Possum and Tasmanian Pademelon was recorded at all field sites during the study period. The relative abundance of both species was low. The highest (relative) abundance of Tasmanian Pademelon was observed at Site 4 in Pegarah.

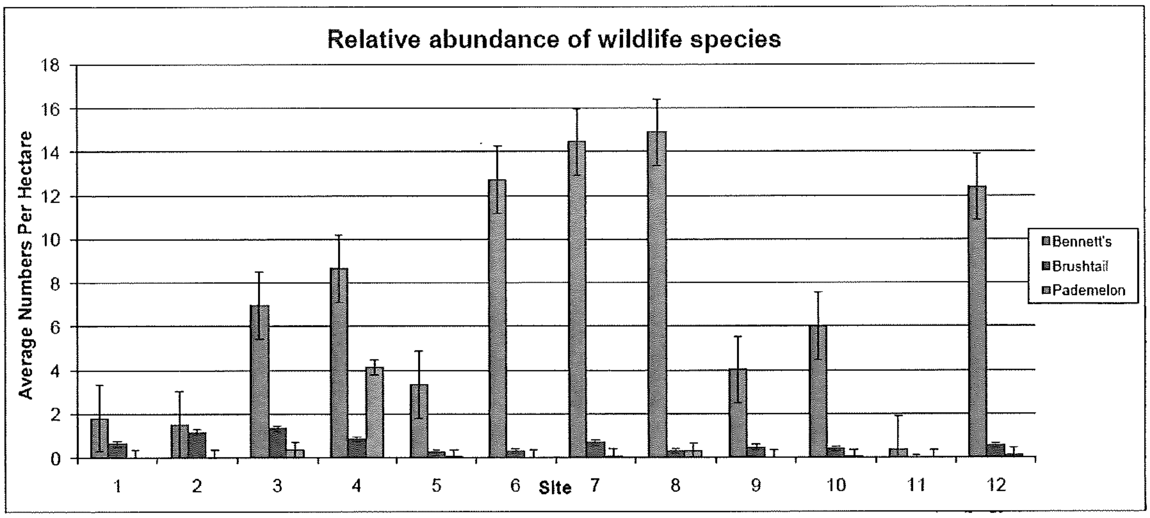


Figure 6. Relative abundance (average number of individuals per ha +/- SD) of Bennett's Wallaby (blue), Brushtail Possum (red) and Tasmanian Pademelon (green), respectively, recorded at 12 field study sites on King Island between August 2008 and March 2010.

These results were consistent with those found during the wildlife population survey undertaken across King Island in autumn 2008 that were reported by Branson (2008).

A number of landholders have commented that pademelons often appear blind and emaciated. Branson (2008) suggested that they may be affected by diseases such as toxoplasmosis, possibly due to feral cats acting as vectors for the disease. This issue requires further investigation.

Tasmanian pademelons displayed significant spatial variability around the Pegarah Forestry region, and it is known that this species prefers a pasture vegetation interface with greater understorey (Le Mar and McArthur 2005). The limited distribution of dense wet forest and low groundcover vegetation is likely to be limiting the distribution and dispersal of this species on King Island.

Pasture Production and Pasture Loss to Wildlife Browsing

Pasture production on King Island varied significantly during the year with climate. Daily pasture growth rates varied seasonally from close to zero to more than 90 kg of dry matter ha^{-1} day^{-1} (Figure 7). Expressed as mean aggregate pasture production, production for each site during the study period varied from <10 kg to around 40 kg of dry matter ha^{-1} day^{-1} (Figure 8).

Inland sites exhibited higher rates of pasture production compared to coastal sites, on average.

Observed geographic variation in pasture production appears closely linked to soil quality and improved environmental conditions for pasture growth associated with distance from the coast-line (Figure 8).

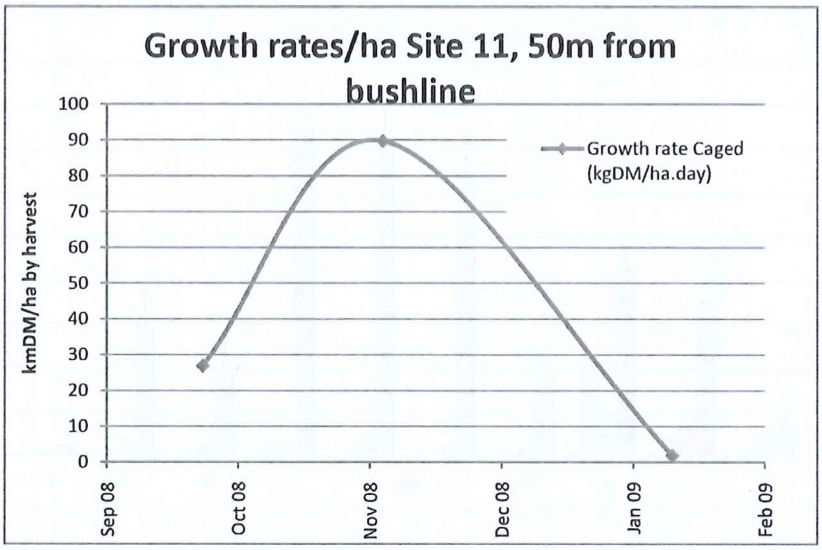


Figure 7. Example of seasonal variation in pasture production (kg DM ha-1 day-1) from pasture monitoring site 11 (Loorana B) that was located 50 m from the bush-line.

Pasture production, on average, was also higher on fenced sites than other sites (Figure 8). Potential explanations for these observed differences may include the recognition by land owners that these sites are inherently more suited to pasture production because of their environmental features, if released from browsing by wildlife.

In addition, the reduced browsing by wildlife may have allowed the pasture species to persist and maintain growth through drier periods and seasonally.

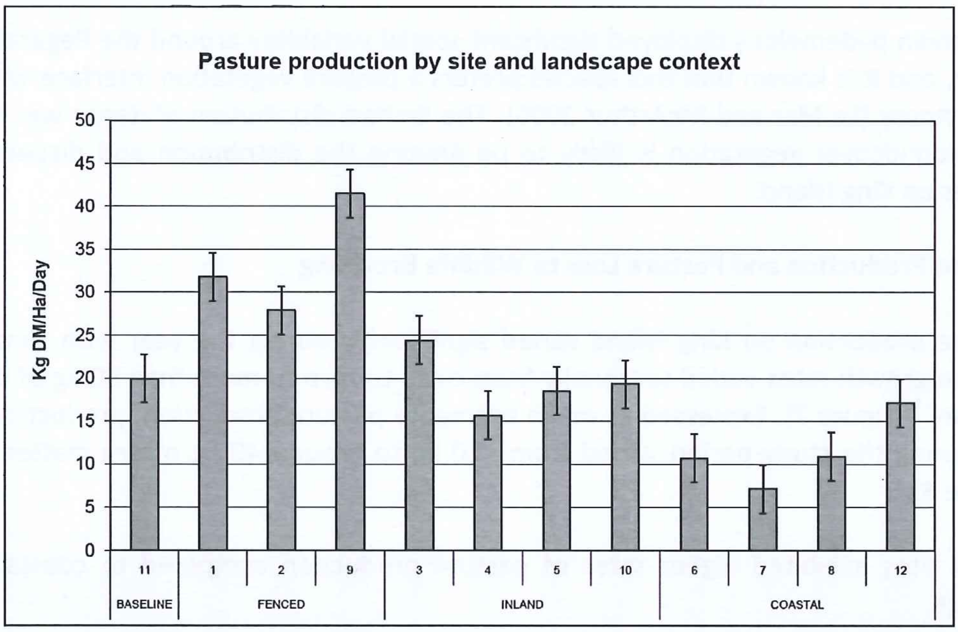


Figure 8. Mean aggregate pasture production (kg DM ha^{-1} yr^{-1} with +/- SD) for the 12 pasture monitoring sites located across King Island.

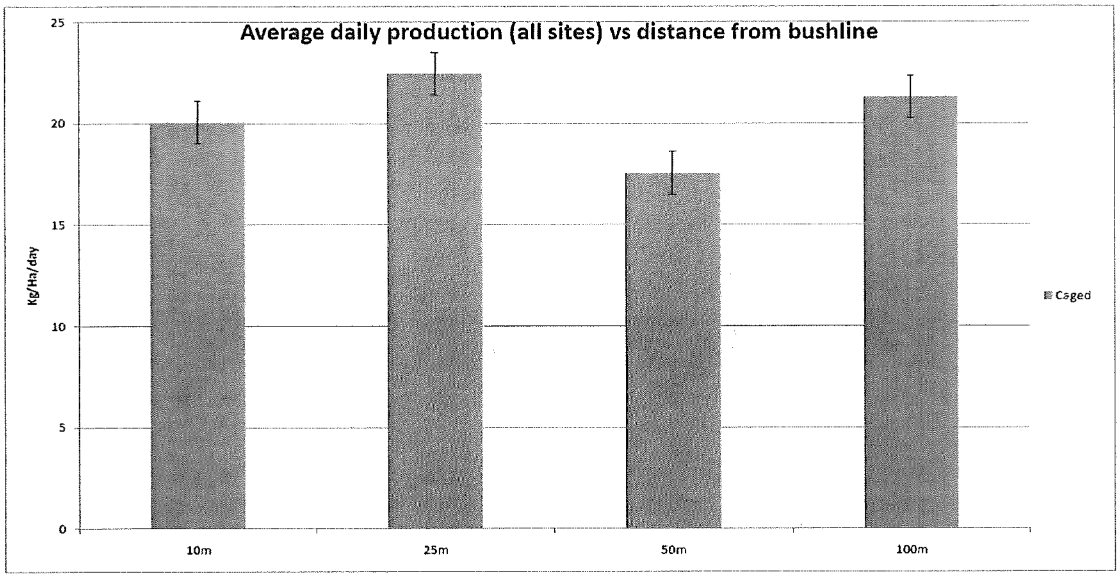


Figure 9. Mean aggregate pasture production (kg DM ha^{-1} yr^{-1} with +/- SD) for the 12 pasture monitoring sites located across King Island showing the production for each distance from the bush-line.

Pasture production was comparable within individual sites, irrespective of distance from the bush-line (Figure 9). Overall, measured pasture production recorded at sites during the study period was consistent with DairyMod predictions of pasture growth for the climate and pasture species composition of pastures on King Island (Rawnsley et al. 2009; Norton and Lacey 2010). Even so, it should be noted that other pasture production models predict that higher absolute rates of pasture production may be possible under suitable conditions (J. Thorn, KINRM personal communication 2010). For the life of the study, the average % pasture loss resulting from wildlife browsing ranged from around 50-70% for sites where wildlife numbers were not controlled by intensive shooting and/or fencing (Figure 10 and Figure 11; e.g. Sites 4, 7, 8 and 12).

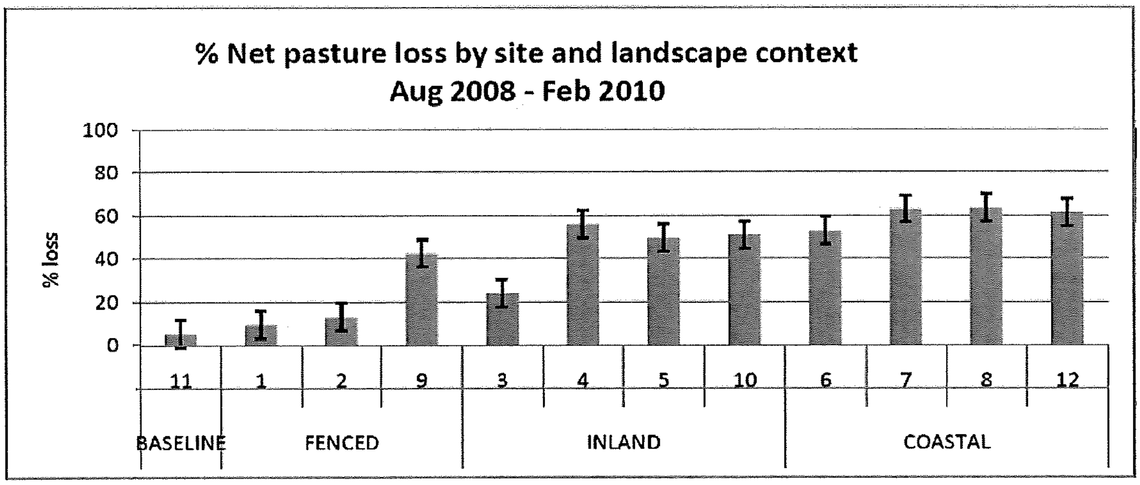


Figure 10. Mean aggregate % pasture loss (expressed as kg DM ha^{-1} yr^{-1} with +/- SD) for the 12 King Island field sites. Sites are grouped as 'Baseline', 'Fenced', 'Inland' and 'Coastal' to indicate their landscape context and management regime; see text for discussion.

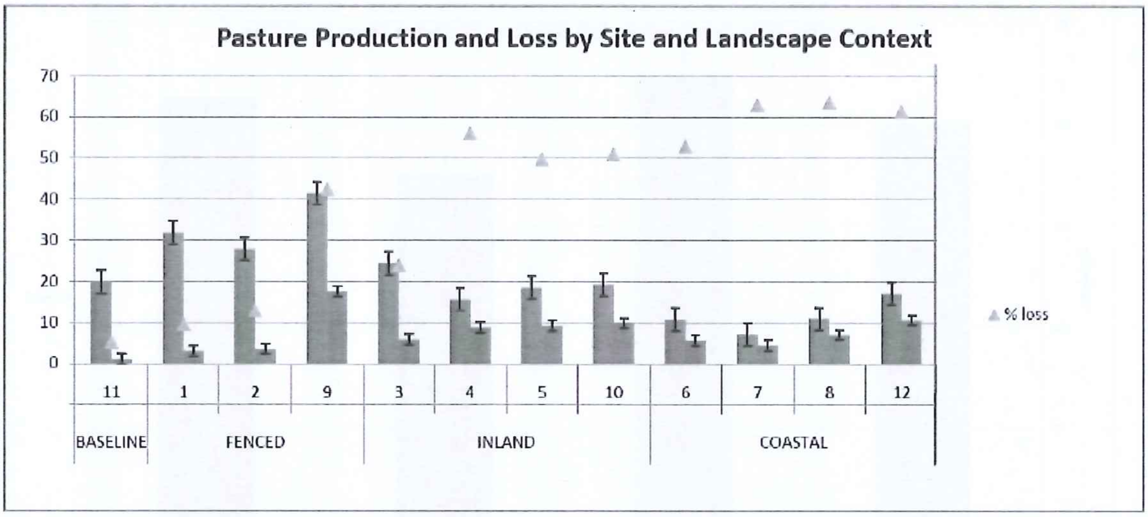


Figure 11. Mean aggregate pasture production (blue) and pasture loss (red) (both expressed as kg DM ha^{-1} yr^{-1} with +/- SD), and % of pasture loss (green triangles & Y-axis) for the 12 field sites across King Island. Sites are grouped as 'Baseline', 'Fenced', 'Inland' and 'Coastal' to indicate their landscape context and management regime; see text for discussion.

Browsing losses (expressed as a mean % of pasture production) at each pasture monitoring site appeared consistent and was relatively predictable across seasons (Figure 12).

Since the relative availability of pastures as food varied seasonally the browsing wildlife must have also varied their use of surrounding native vegetation as a source of food to sustain their energetic requirements.

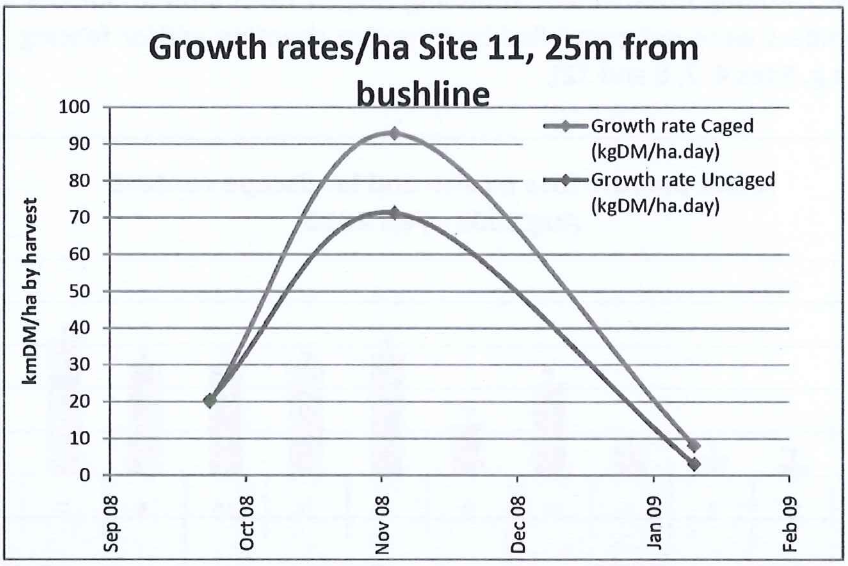


Figure 12. Example of seasonal variation in pasture production (blue) and pasture loss to wildlife browsing (red) (both expressed as kg DM ha-1 day-1) from pasture monitoring site 11 (Loorana B) that was located 25 m from the bush-line.

Shooting of wildlife and fluctuations in the relative abundance of wildlife would affect measures of pasture production (at uncaged control plots) and estimates of pasture loss to wildlife browsing over time at some field monitoring sites. To help account for this, average estimates of pasture loss to wildlife browsing were examined for field sites considered least likely to be affected by this factor.

Figure 13 shows the average percentage pasture loss resulting from wildlife browsing for the pasture monitoring sites not influenced by shooting and /or fencing compared to the sampling distance from the bushline.

Mean % pasture loss from wildlife browsing varied from 28-48%, but did not change significantly with distance from the bush-line.

Higher mean % pasture loss values for these sites were recorded for locations within 25 m of native vegetation.

When all 12 pasture monitoring sites were combined for the same analysis, pasture loss from wildlife browsing decreased as distance from the bush-line increased (Figure 14). For example, the mean value for all sites combined within 10 m of the bush-line was 43% compared to 28% at 100 m from the bush-line.

The difference in pasture loss between the 10 m and 100 m sites was significant. These data suggest that the browsing wildlife may be wary of feeding at greater distances away from bush-lines where shooting is prevalent.

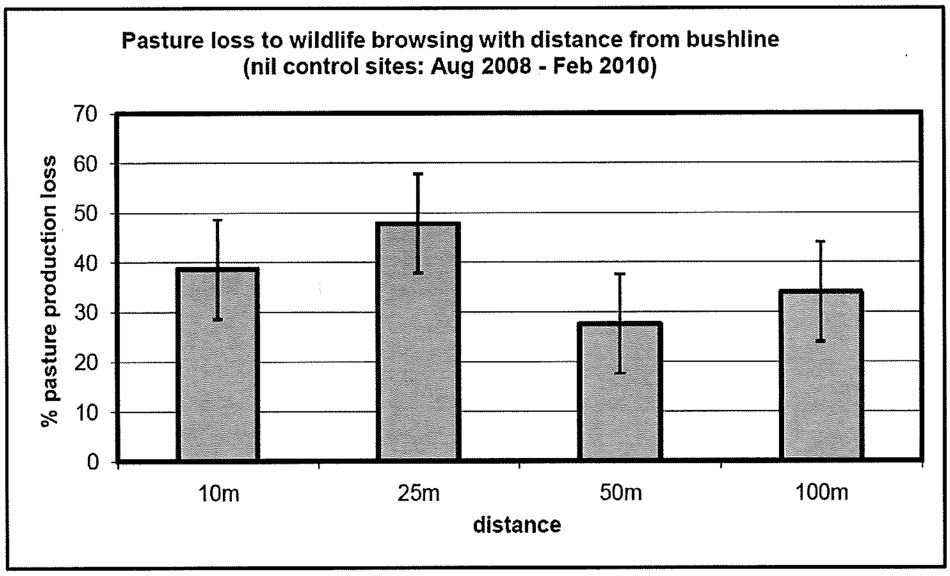


Figure 13. Estimated pasture loss (% +/- SD) to browsing by native wildlife with distance (10 m, 25 m, 50 m, 100 m) from the edge of remnant native vegetation (bush-line) on King Island; data are combined for sites not affected by fencing and/or shooting.

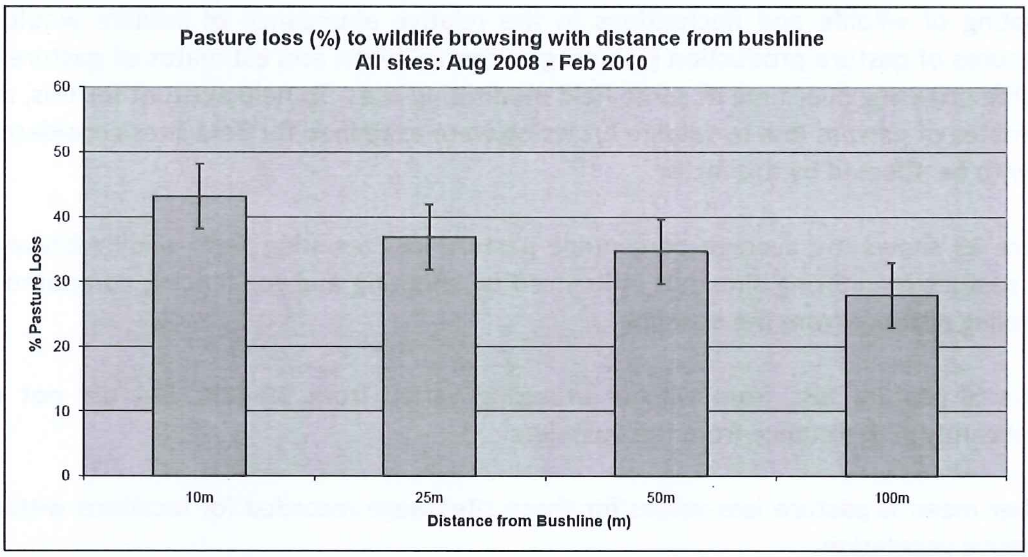


Figure 14. Estimated pasture loss (% +/- SD) to browsing by native wildlife with distance from the bush-line on King Island; data are combined for all 12 field sites.

Relationships between wildlife abundance and pasture loss to wildlife browsing

Estimates of average pasture production and the relative abundance of Bennett's Wallaby were calculated for each field site. Statistical relationships between these two data sets were then calculated. A positive relationship (best fitted as a polynomial function) was found between the relative abundance of Bennett's Wallaby and measured pasture loss resulting from browsing (Figure 15) at the 12 sites monitored during the study period.

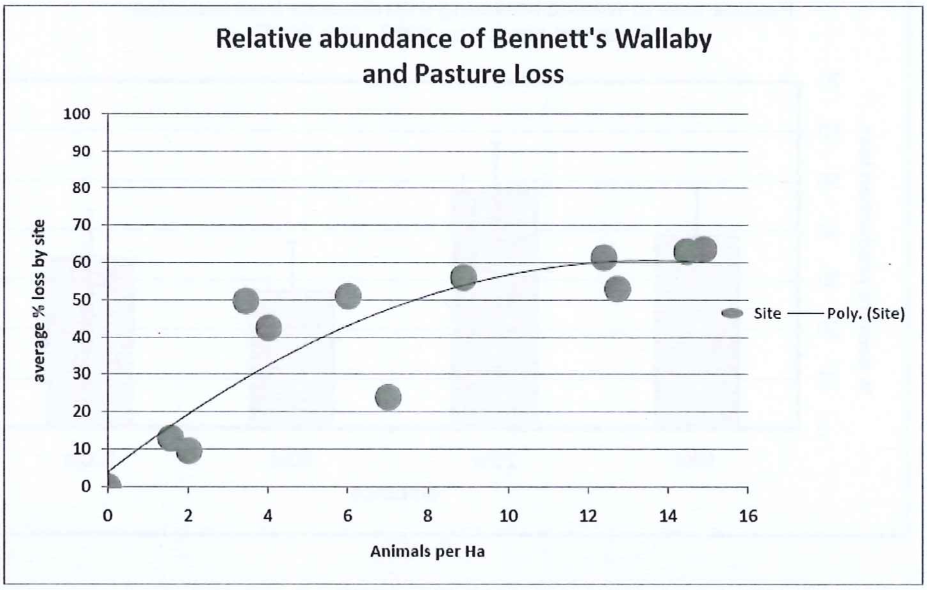


Figure 15. Relationship between the relative abundance of Bennett's Wallaby (animals ha^{-1}) and average % pasture loss to wildlife browsing; data for all 12 sites combined and assuming the curve arises from the origin - an x/y intercept of zero.

The relationship between the relative abundance of Bennett's Wallaby and average per cent pasture loss to wildlife browsing presented in Figure 15 implies that the number of wallabies at a site would need to be reduced to very low levels to significantly reduce pastures losses resulting from browsing. This may be possible to achieve at some sites where Bennett's Wallaby are feeding by using a combination of intensive shooting and on-going (follow-up) shooting. The rationale for this course of mitigation is discussed below.

Relative abundance of wildlife in relation to Management Regimes

The study provided an opportunity to assess pasture production loss to wildlife browsing under five different management regimes: no wildlife controls (site 3, 8 and 10), commercial shooting (sites 6, 7, 9 and 12), intensive shooting (sites 1, 2, 4 and 5), fencing (sites 1, 2 and 9), and fencing combined with shooting (sites 1 and 2).

The opportunity to assess the degree of pasture loss to wildlife browsing on sites exposed to shooting that simulated (or was consistent with) commercial harvesting arose through cooperation with landholders in coastal and inland areas of King Island, and DPIPWE staff and contractors who were undertaking a shooting project.

Information was available about the timing of shooting and the number of animals taken.

The opportunity to examine the affects of intensive shooting on pasture loss to wildlife browsing arose through cooperation landholders and DPIPWE. Pasture monitoring sites 1, 2, 4 and 5 were used for an intensive shooting study by agency staff and contractors from February 2009 to early 2010 (Mr John North personal communication 2010).

In the case of both simulated commercial harvesting and intensive shooting, pasture production and pasture loss to wildlife browsing was able to be monitored prior to and during the imposition of the shooting regimes.

Considerable fluctuation in the relative abundance of wildlife was observed at the sites used for intensive shooting (Appendix 4). The rate of increase in the relative abundance of wildlife at most sites after intensive shooting could be rapid and appeared most likely to be influenced by the presence or absence of wallaby-proof fencing, the frequency of shooting events, and the extent of nearby native vegetation from which new immigrants could be sourced.

Figure 16 shows the change in the relative abundance of Bennett's Wallaby, Brushtail Possum and Tasmanian Pademelon at site 5 (without wallaby-proof fencing) both before and after imposition of intensive shooting.

Observations at this site indicate that it may be possible to control the number of Bennett's Wallaby feeding in an area with a combination of intensive shooting and on-going shooting.

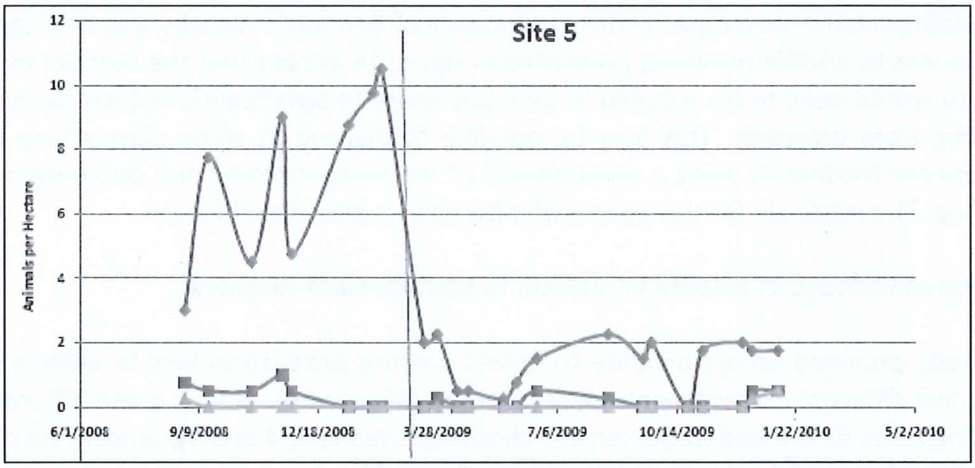


Figure 16. Changes in the relative abundance of native wildlife (animals per ha) before and after (blue vertical line) the commencement of intensive shooting at Site 5 by the DPIPWE research project team; blue = Bennett's Wallaby; red = Brushtail Possum; green = Pademelon.

Using shooting data supplied by DPIPWE from their intensive shooting trial (Mr John North personal communication 2009), an analysis of the total number of Bennett's Wallaby shot during that study and the average number of animals shot during each hour of shooting was summarized for sites with and without wallaby-proof fencing (Figure 17).

The total number of Bennett's Wallaby shot on unfenced sites of equivalent size was in the range of around 1000-1,500 animals, with 10-15 animals shot per hour. This contrasted to the fenced site 1 where much fewer than 500 animals were shot in total, and the number of animals shot per hour was around 5 (Figure 17).

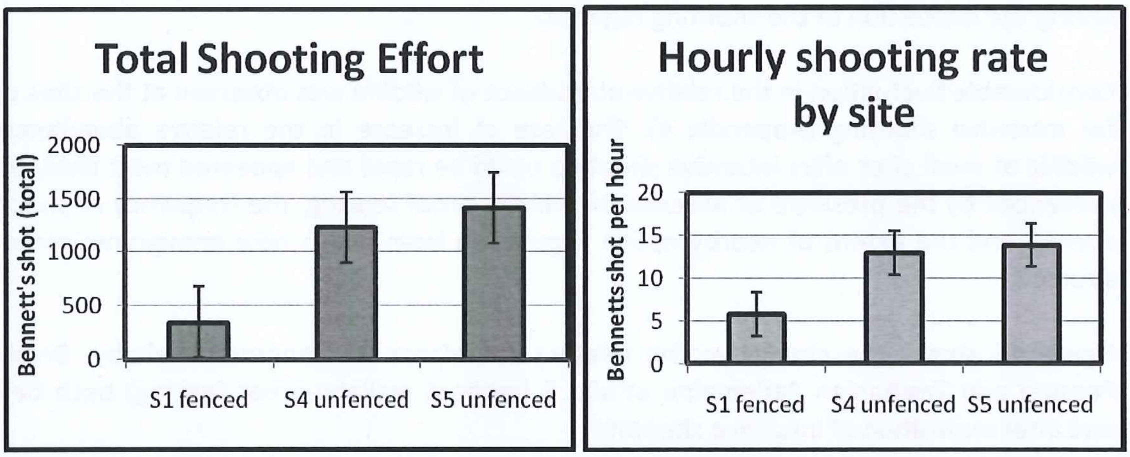


Figure 17. Total number of Bennett's Wallaby shot during the study (left) and the average number of animals shot during each hour of shooting (right) for sites (S) with and without wallaby-proof fencing; shooting data from DPIPWE in 2010.

The effect of wallaby-proof fencing on the movements and relative abundance of native wildlife at a paddock and property scale was examined by comparing spotlight data for neighbouring fenced and unfenced sites that were located in areas with a similar landscape context including the extent of remnant native vegetation (Figure 18).

In all cases, fenced sites at Reekara and South recorded a significantly lower relative abundance of Bennett's Wallaby compared to unfenced sites in the same areas. For example, the mean relative abundance of animals per ha on the unfenced sites at South was 18 compared to 4 for the fenced site (Figure 18).

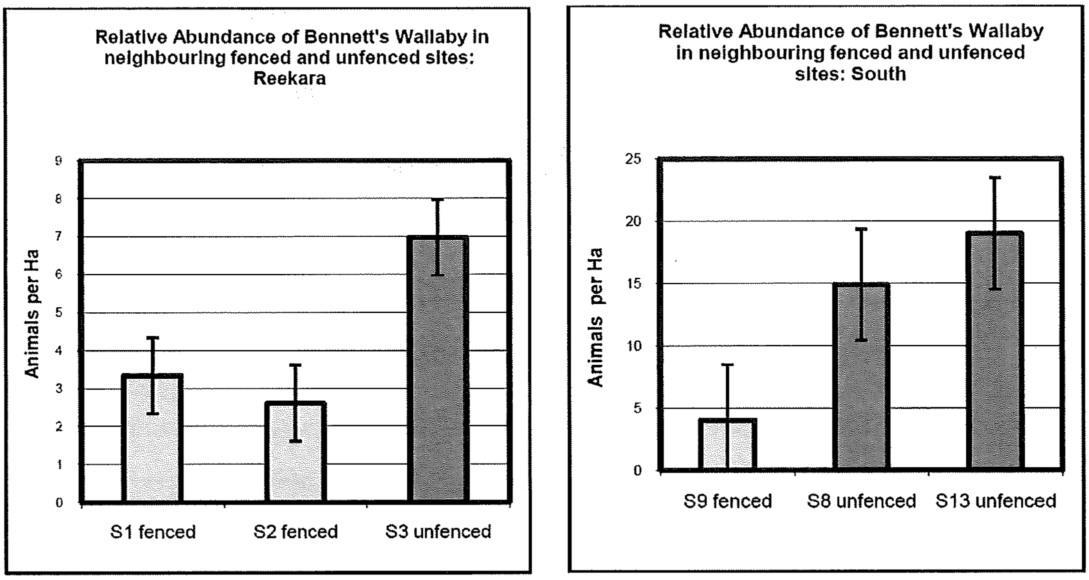


Figure 18. Relative abundance of Bennett's Wallaby in neighbouring fenced and unfenced field sites at Reekara (left) and South (right).

Pasture loss in relation to Management Regimes

Pasture loss to wildlife browsing varied significantly in relation to the management regime employed at a study site. Field sites with no wildlife controls had an average pasture loss to wildlife browsing of over 51% (Figure 19 and Figure 20).

Losses were greater on the less productive coastal sites where pasture production was reduced (Figure 19).

Field sites where commercial shooting was undertaken to reduce the number of native wildlife had an average pasture loss to browsing of 51% during the study. In other words, there was no difference in pasture loss between sites without wildlife controls and those subjected to a level of shooting that was consistent with commercial harvesting.

This finding indicated that, in the absence of fencing, Bennett's Wallaby can quickly move from surrounding areas without controls in to a site where shooting has occurred and, as a consequence, maintain browsing pressure on pastures.

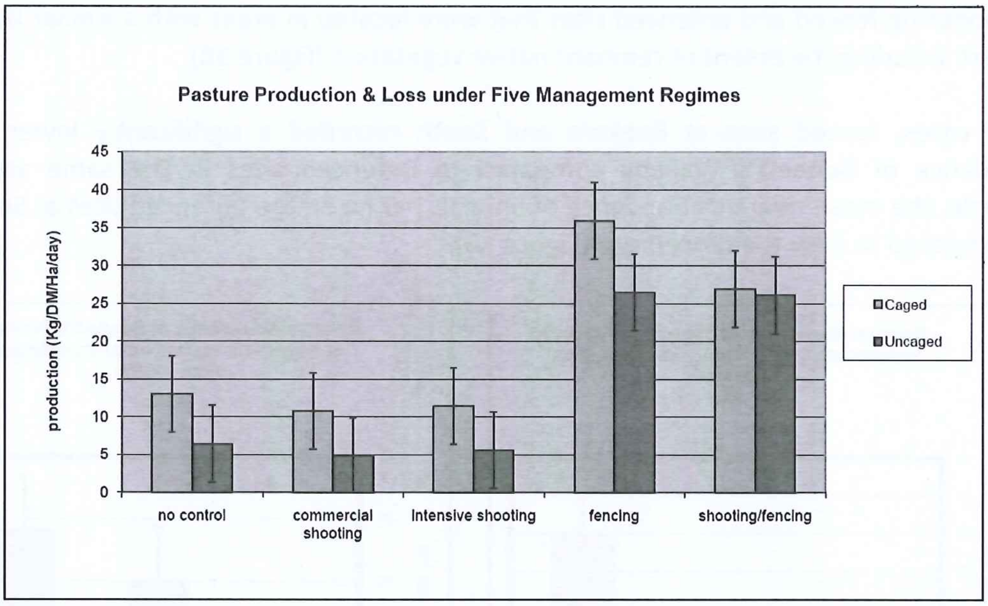


Figure 19. Estimated average pasture production (blue) and pasture loss (red) to wildlife browsing (kg DM $ha^{-1}day^{-1}$ +/- SD) under different wildlife control options (no controls, shooting, wallaby-proof fencing, combined wallaby-proof fencing and shooting).

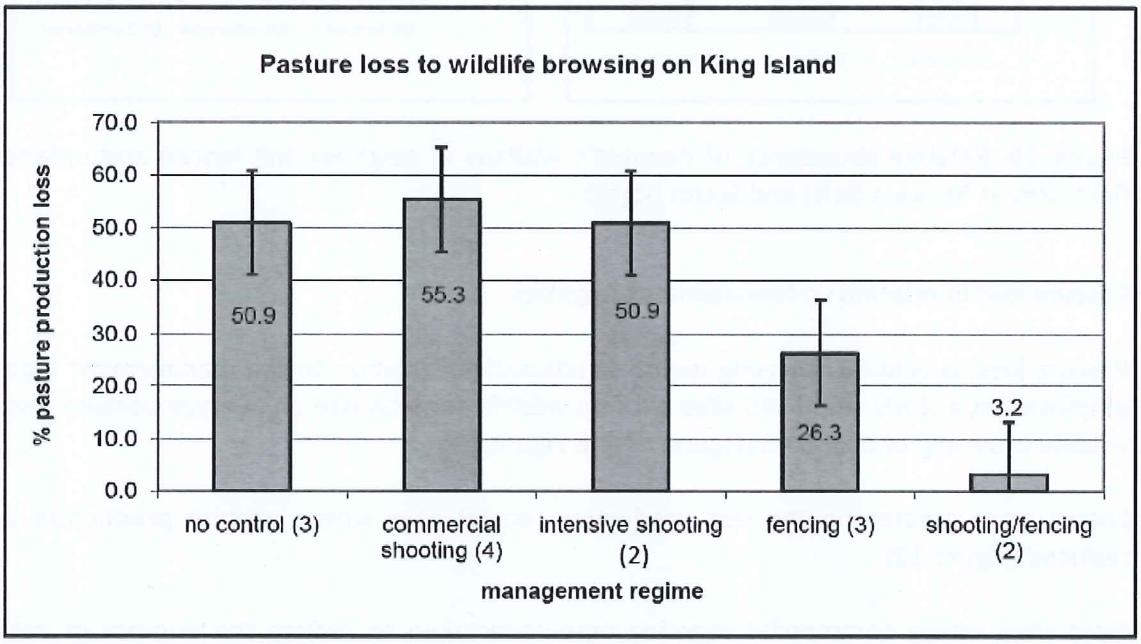


Figure 20. Estimated average pasture loss to wildlife browsing (% +/- SD) under different wildlife control options (no control, commercial shooting, intensive shooting, wallaby-proof fencing, combined wallaby-proof fencing and shooting; number of sites shown in brackets) during the study period on King Island, Tasmania.

Field sites under the 'fencing' regime had an average pasture loss to wildlife browsing of 26.3%. This level of pasture loss was a significant decrease from the 'no control' and 'shooting' regimes (Figure 20). Where a combination of wallaby-proof fencing and shooting was employed, measured pasture loss was reduced to an average 3.2% (Figure 20).

Estimating the economic cost of pasture loss to wildlife browsing

The predominant agricultural land uses on the island are beef cattle grazing, pastoralism and dairy farming (Figure 21) and these use a total area of up to 83,150 ha. Approximately 96% of this land was estimated to be used for grazing and pastoralism including coastal areas on 136 land titles that are used as open runs for both cattle and sheep. Dairy farms are found on 47 land titles and occupy 4% of the agricultural land (Figure 21). This land base includes 66,413 ha of improved pastures of which ~83%, ~10% and ~7% was estimated to support beef, sheep and dairying, respectively.

The BITE© decision support tool was used to estimate pasture production and pasture loss from wildlife browsing for all farms on King Island. BITE© uses the pasture growth model, DairyMod (Cullen *et al.* 2008; Johnson *et al.* 2008; Rawnsley *et al.* 2009) to predict mean daily, monthly and annual pasture production based on scientific information collected from a range of pasture growth studies.

DairyMod predicted a mean annual pasture production of 10340 kg DM ha-1 yr-1 (Lacey and Norton 2010) for King Island when water and nutrient availability does not limit pasture growth. However, the actual pasture production of farms is typically less than the maximum possible and may be reduced by 25-50% depending on the farm enterprise, pasture management and climate variability.

BITE© uses the baseline assumption (that can be varied by the user) that the actual pasture production is reduced by 25% and 40% of the maximum predicted by DairyMod for dairy and beef farms, respectively. This assumption was considered to be reasonable for King Island based on the pasture production measurements taken during this study at the 12 pasture monitoring sites. The measured average pasture production for all sites on an annual basis was around 7000 kg DM ha^{-1} yr^{-1} compared to the model prediction of 7755 kg DM ha^{-1} yr^{-1} for dairy and 6204 kg DM ha^{-1} yr^{-1} for beef farms, respectively.

The pasture loss data collected during the field study was used in BITE© to calculate pasture loss resulting from wildlife browsing with distance from bush-lines. Approximately 20% by area of pastures are found within 100 m of bush-lines (11,449 ha), 20% within 100-300 m of bush-lines (12,653 ha), and the balance beyond 300 m (42,312 ha).

A mean annual rate of pasture loss of 42% was obtained during the study for field sites located within 100 m of bush-lines where the level of known shooting was considered not to have unreasonably affected the representativeness of the measurements for this zone. No empirical data on pasture browsing loss from wildlife were available for pastures located in zones 100-300 m from bush-lines, and >300 m from bush-lines. Two estimates of average annual pasture loss for both zones were arbitrarily chosen for use in BITE© for the baseline modelling of pasture loss on the island, and its dollar value. The first estimate was set at 28% to reflect a single-step decay factor in browsing pressure with distance from bush-lines – this figure was two-thirds of that measured for the 0-100 m zone. The second estimate was 0%. This was chosen to illustrate the extreme lower end of browsing pressure likely to occur. Future studies of pasture loss to wildlife browsing on King Island could help to improve the estimates of pasture loss presented below by obtaining empirical data for the 100-300 m and >300 m zones from bush-lines.

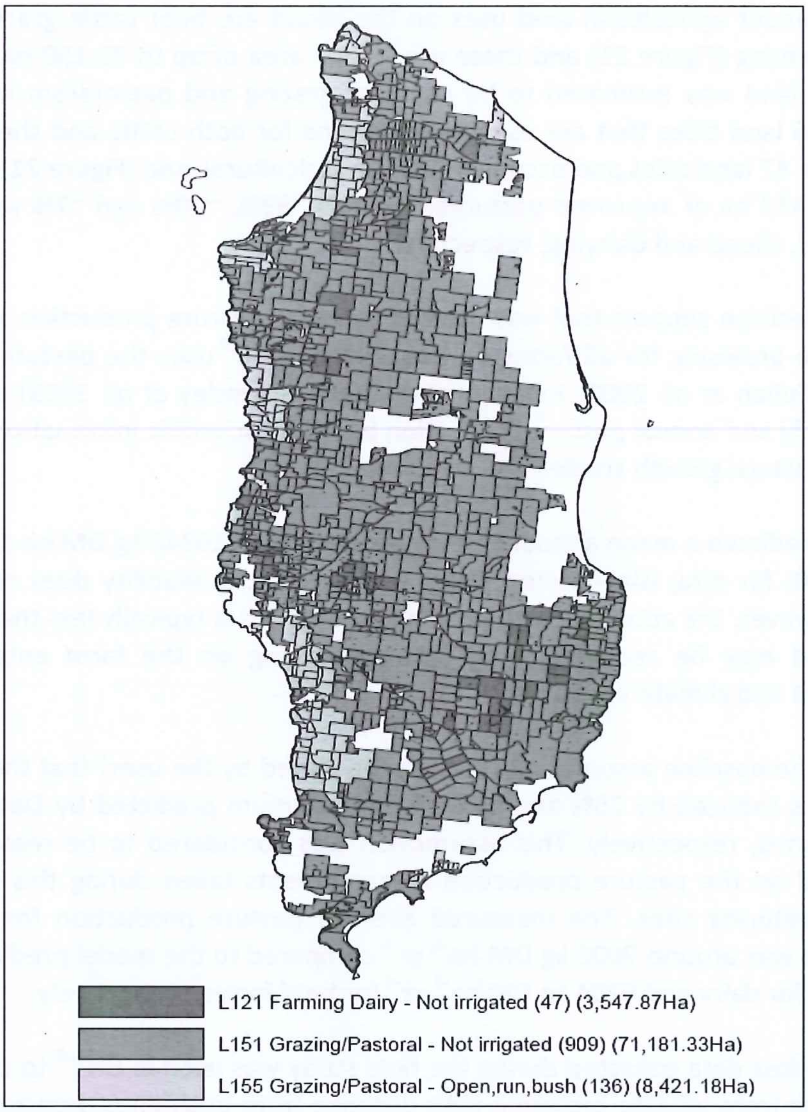


Figure 21. Distribution of farming systems (dairy farming, grazing/pastoral, grazing/pastoral on open run and bush sites) on King Island with number of land titles for each group shown in brackets; note the lack of irrigation, and that the area occupied by each system includes pastures and native vegetation.

Given these uncertainties, and uncertainties arising from the limitations of the field sampling outlined above, a range of estimates of pasture loss and the value of losses were derived (Table 3). These estimates were based on the scientific findings of the research and the different assumptions used to make these estimates.

It was estimated that total annual pasture loss to browsing on King Island could range from 7,103 to 82,687 tonnes of dry matter (DM) (Table 3), depending on the assumptions. The total dollar value of the estimated annual pasture loss for the island ranged from ~$2.4 million to around $28 million, again dependent on the assumptions made. For example, based on average pasture losses of 42% and 28% within 100 m and beyond 100 m of bush-lines, respectively, and with 30% of pasture loss eaten by wildlife, the estimated annual pasture loss to browsing on King Island was 24,806 tonnes (DM) with an estimated value of $8,463,977. However, the total dollar value of the estimated annual pasture loss for the island could be much higher and approach $28M if the same values of pasture loss are used, and all of the pasture loss was eaten by wildlife and otherwise would have supported farm production.

An indirect estimate of the pasture that may be lost to wildlife can be calculated using the wildlife population estimates of Branson (2008). That is, a combined wildlife herbivore population of 500,000 Bennett's Wallaby, 25,000 Tasmanian Pademelon and 80,000 Brushtail Possum could consume a total biomass of pastures each year equivalent to that required to support over 20,000 steers (each with a 400 kg bodyweight).

Since the recent market value of a 400 kg steer is around $700 (Dr Dale Miller, DPIPWE, personal communication 2009), the potential production loss from wildlife browsing could be in the order of $7M to in excess $14M if it is assumed that the native wildlife obtain between 50% - 100% of their diet from pastures, respectively.

Average Pasture Loss		Pasture Loss Eaten by Native Wildlife (%)	Estimated pasture loss to wildlife (tonnes.DM.yr^{-1})	Estimated value of pasture loss ($)
(0-100m of bushline)	(100-300m & >300m of bushline)			
42	28	100	82,687	~$28M
42	28	50	41,344	~$14M
42	28	30	24,806	$8,463,977
42	0	30	7,103	$2,423,544

Table 3. Estimated annual pasture loss to native wildlife on King Island and its annual dollar value using different assumptions about average annual pasture loss with distance from bush-line (0-100 m, 100-300 m, >300 m), and the amount of pasture eaten by native wildlife (100%, 50%, 30%).

While the precise dollar value of production that is lost to wildlife browsing on King Island remains unclear, the value may be very high. The estimated magnitude of lost production would suggest that serious wildlife population controls and wildlife management intervention is required to mitigate the impacts of wildlife browsing on pastures.

Native wildlife and the condition of native vegetation on King Island

Data were collected from 16 biodiversity monitoring sites with exclosures and paired control plots located outside of each exclosure to assess potential improvements in vegetation condition resulting from the exclusion of wildlife. Relative changes in the condition of native vegetation were recorded in the exclosure plots with the removal of browsing and habitat use by wildlife. While the winter of 2009 was wetter than a number of previous years on King Island, the observed relative improvements in vegetation condition were best explained by release from wildlife browsing and habitat use.

Although this study was in place for a relatively short period, a quantitative improvement or significant improvement was recorded for over 50% of the sites across the range of environments and the majority of vegetation communities that were sampled (Table 4).

No detectable change was discernable at 7 sites across both exclosures and control plots. The condition of the vegetation in the control plot of site 6 declined markedly during the study period, while that of site 13 improved.

Trend in Vegetation Condition	Site Number	Total Sites
Significant Improvement	1, 2, 3, 7, 10	5
Improvement	11, 12, 13, 16	4
No Detectable Change	4, 5, 6, 8, 9, 14, 15	7
Decline in Control Plot	6	1
Improvement in Control Plot	13	1

Table 4. Recorded trends in vegetation condition at 16 biodiversity monitoring sites on King Island.

Improvements in the condition of a range of vegetation life forms including vascular and non-vascular plants, annuals and perennials, grasses, shrubs and trees were observed (Figure 22). Changes in vegetation condition included:

- the recovery of ground cover,
- the reduction of bare ground on sandy soils that may be predisposed to erosion,
- recruitment of new plants species including plants that flowered,
- recruitment of new seedlings,
- recovery of plants heavily browsed by wildlife,
- an increase in the cover/abundance of plants,
- an increase in at least the above ground biomass of plants, and
- changes in light regime and exposure of plants as a result of plant growth.

Many of the sites where improvements in vegetation condition were recorded are known (or appear likely) to support a high relative abundance of wildlife, especially Bennett's Wallaby. These sites may have supported high number of animals for a significant period of time prior to the commencement of this study.

Given this situation, and the reduced rainfall on the island during the past several years, the improvement in vegetation condition recorded at many sites was considered an important finding.

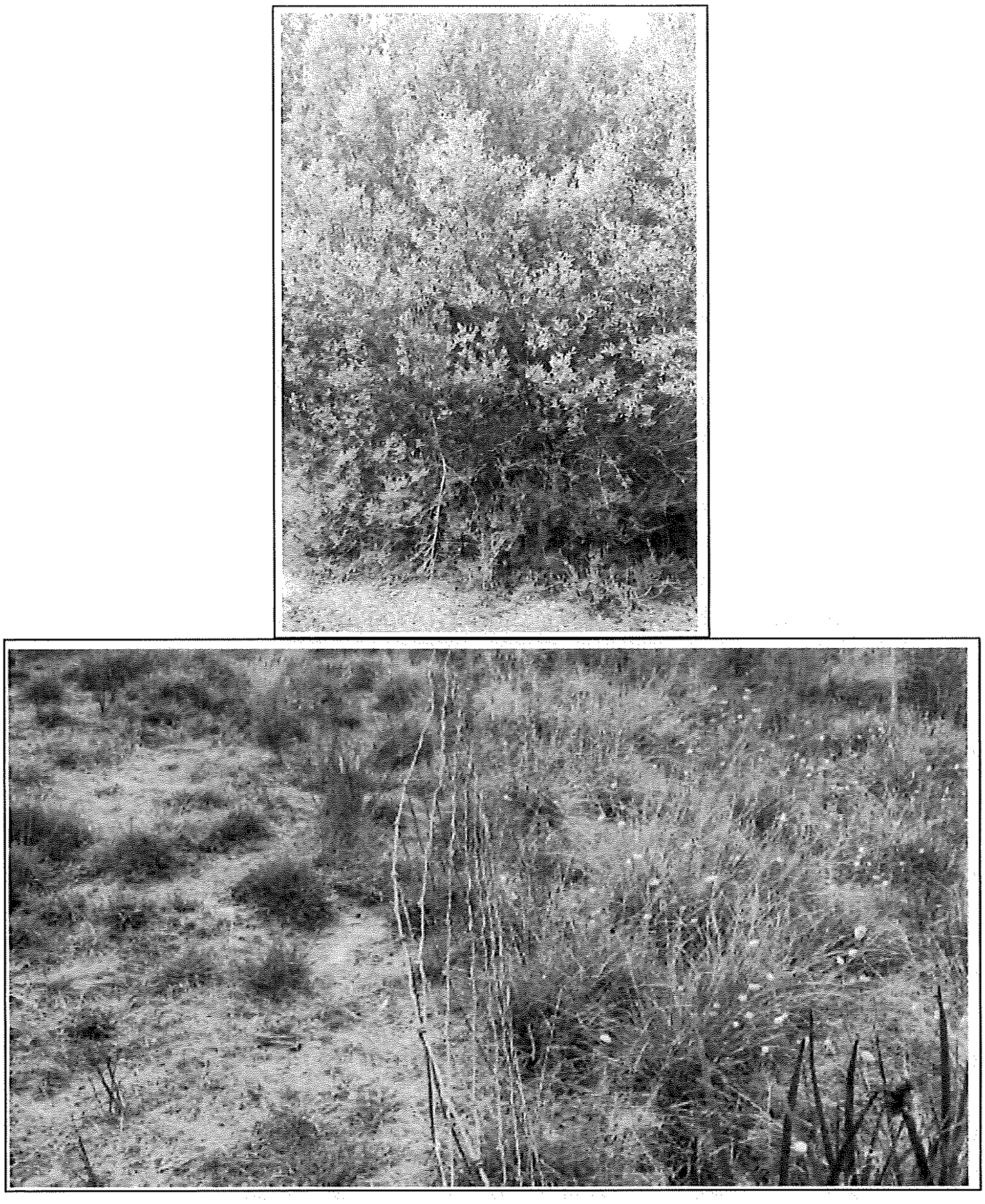


Figure 22. Examples of changes in the condition of native vegetation at the 16 biodiversity monitoring sites established across King Island; (top) Adjacent to Site 5 at Currie C was a *Calytrix tetragona* plant that had grown underneath a *Leptospermum laevegatum* plant that had been browsed by wildlife. With some plant species being more palatable to wildlife, browsing creates space for other plants altering the structure of remnant vegetation; (bottom) Site 7 at Black Point A showing significant improvement in vegetation condition within the exclosure at right.

3. IMPLICATIONS OF NATIVE WILDLIFE BROWSING

3.1 INTRODUCTION

Our study examined the implications of browsing by native wildlife for pasture production on farms, and native vegetation communities on King Island between August 2008 and March 2010. This is the most comprehensive study of its kind yet to be undertaken in Tasmania and few comparable studies are reported in the literature from around the world.

Many of the findings reported here are not surprising since landholders, land managers and other credible observers have expressed concern about the apparent large number of Bennett's Wallaby, in particular, on the island and the likely implications for pastures and bush. This study builds on the wildlife population survey undertaken by Branson (2008) and quantifies, for the first time, the nature and extent of the ecological and economic impacts that may result from inadequate wildlife management.

It should be noted that the purpose of this study was not to review the size of populations of native wildlife on King Island. However, based on the survey data collected during the study and other information, we believe that the population estimated by Branson (2008) for Bennett's Wallaby could have increased over the intervening period.

Since 2008 there appears to have been no significant reported change in the annual level of culling of native wildlife on the island while, at the same time, breeding Bennett's Wallaby (adult females with pouch young and young at foot) and young animals were regularly observed during the study.

3.2 MANAGEMENT IMPLICATIONS OF THE MAJOR RESEARCH FINDINGS

The study had 8 major objectives and these are considered below in the context of the findings reported in section 2.

The nature of pasture production and pasture loss to wildlife browsing

Pasture production across King Island was generally consistent with the predictions of DairyMod. Inland sites and other sites more conducive to pasture production approached or modestly exceeded 7 tonnes of pasture production (dry weight) ha^{-1} yr^{-1}. Variability in pasture production on farms was not extraordinary and appeared consistent with local variations in soils, site drainage and management.

The distribution of wildlife across King Island appears consistent with the known habitat requirements of the three species of major interest – Bennett's Wallaby, Tasmanian Pademelon and Brushtail Possum. Bennett's Wallaby and the Tasmanian Pademelon occupy similar foraging habitats throughout Tasmania and are considered sympatric species with discrete differences in roosting habitat selection (Le Mar and McArthur 2005). Bennett's Wallaby favours roost sites in heath, woodland and forest with sparse understorey vegetation, whereas the Pademelon prefers roosting habitats with a greater cover/abundance of understorey vegetation (Driessen 1992; Le Mar and McArthur 2005).

Pademelon will forage closer to shelter, whereas the Bennett's Wallaby will travel more widely in open habitats to feed (Le Mar and McArthur 2005; While and McArthur 2005). Differential roost site preferences and the differing responses of both species to (actual and potential) predation are the primary factors influencing their habitat selection in time and space, and their distribution across King Island (Branson 2008).

Measured pasture loss to wildlife browsing was around 50% of pasture production, on average, at sites without fencing. Pasture loss declined to some extent with greater distance from bush-lines.

It is important to note that these pasture loss figures are not significantly different from those observed, on average, at some farm sites on mainland Tasmania (where the dominant herbivore by biomass may be one or a combination of three native species – Tasmanian Pademelon, Bennett's Wallaby, Forester Kangaroo; DAFF 2009).

The major difference on King Island is the present occurrence of an extraordinarily high total population of Bennett's Wallaby that can occur in very high numbers across much of the island.

It is the absolute number of animals that now live in this highly modified and contained landscape that has dramatically changed the environmental and economic setting.

Relationships between the relative abundance of native herbivores on King Island and their impact on pastures

Helen Statham and Dr Mick Statham of the Tasmanian Institute of Agricultural Research have suggested for many years that using estimates of the relative abundance of wildlife to predict environmental impacts such as pasture loss to browsing is problematic (Dr M. Statham, personal communication 2008).

There are many reasons why animal surveys may fail to reliably sample the true population of an area, and result in inaccurate estimates of the size of wildlife populations. As a consequence, it is often very difficult to establish a reliable relationship between the relative abundance of native herbivores and pasture loss. Rather, as the Statham's would suggest, it is more effective to directly measure crop and pasture loss.

This research suggested a positive empirical relationship between the relative abundance of the Bennett's Wallaby and pasture loss to wildlife browsing. This was derived using data from sites with varied wildlife population management regimes. The data appear consistent with other field observations on wallaby numbers, animals and movements.

The ability to explore this relationship is likely, again, to be related to the absolute population size of Bennett's Wallaby on the island and their high relative abundance at many sites.

The impact of culling intensity and frequency on the relative abundance of herbivores in pasture, and the relationship between the relative abundance of herbivores and pasture damage at a property scale

Shooting wallabies typically had no medium term effect on reducing animal numbers at unfenced sites, and hence typically had no practical benefit at these sites in terms of reducing pasture loss to wildlife. The one apparent exceptional was where intensive shooting was combined with on-going monitoring and follow-up shooting to keep the number of Bennett's Wallaby low. With the exception of this approach, sheer population size 'won out'. Within a relative short period of time following most shooting events, the relative abundance of Bennett's Wallaby typically returned to a high level.

This was an important finding that is unlikely to have been made in the absence of the complementary shooting study undertaken by DPIPWE. It indicates that shooting may have a central role in wildlife population management and the mitigation of browsing impacts on pasture *provided* that a systematic approach of intensive shooting, careful population monitoring and follow-up shooting is used in an integrated way at a landscape level.

The effectiveness of 'wallaby-proof' fencing for mitigating pasture production loss resulting from wildlife browsing

Well constructed and maintained 'wallaby-proof' fencing is rarely completely wallaby-proof, but it can significantly reduce pasture loss to browsing by native wildlife. The data from this study suggested that a reduction in mean pasture loss of around 50% could be achieved by the proper installation of wallaby-proof fencing.

The economic benefits arising from the installation of such fencing may be a sufficient incentive in its own right for landholders. However, the data indicated that the most significant benefit arises when wallaby-proof fencing and systematic shooting are employed in combination as a wildlife control measure. This combination of techniques has the potential to reduce the loss of pasture to wildlife browsing to a negligible level (Figure 20). This option could appear especially attractive to dairy and beef producers on the island since the dollar value of pasture loss per annum was estimated to be relatively high.

The potential feasibility of a commercial wallaby and possum harvesting industry on King Island based on the project finings.

The population size of Bennett's Wallaby may have increased over time as more habitat for the species has been created due to an expansion of agriculture, improvements in pasture production and food availability, and, perhaps, improvements in the nutritional quality of feed. Predation of Bennett's Wallaby may have declined over time as native predators were lost from the island. Feral cats (*Felis catus*) may predate wallabies, but the number of animals killed in this manner is likely to be trivial compared to the total population. Moreover, a dedicated program is in place to attempt to reduce and ultimately remove feral cats from the island (Threatened Species Section 2010).

Prima facie, there could be a case to re-establish a commercial harvesting program on King Island for Bennett's Wallaby. A large number of animals may be required to be removed from the island population within a relatively short period of time if the overall population level of Bennett's Wallaby is to be reduced significantly. If this was to occur, it would appear desirable from an ecological perspective that the carcasses of shot animals be removed from the field. One potential use of these carcasses could be for processing as food for human consumption or for pet food.

Alternatively, if no significant rapid reduction in the population level of Bennett's Wallaby is undertaken in the near future, it would seem appropriate to undertake a scientific review of alternative ways to mitigate the ecological and economic impacts resulting from the herbivores examined in this study. Such a review may recommend a higher annual take for the commercial harvesting of Bennett's Wallaby than is currently possible under the authorised government management plan. If this was to occur, approval for a higher annual take of the wallaby species may be helpful to establishing an economically-viable business case for a renewed commercial harvesting industry for Bennett's Wallaby.

The population data on the Brushtail Possum were insufficient to allow comment on the possible role that this species may play in a future commercial harvesting industry on King Island.

The Wildlife Trade Management Plan 2005 – 2010 (DPIW 2005) is due for review soon and this will provide an opportunity to consider the future of the industry in the context of the scientific information arising from this study.

The impact of native herbivores on remnant native vegetation and biodiversity.

High population levels of Bennett's Wallaby and, locally, other wildlife species, may produce significant biophysical impacts on many native vegetation communities on King Island.

Many of the island's native vegetation communities exhibit features that suggest the native wildlife may have a significant affect on plant species composition, and the structure and function of these systems. However, the extent to which these species are implicated in the decline of vegetation and site condition, the reduction in and loss of local populations of plant species, and other potential impacts on biodiversity is unclear. Moreover, it is unclear if and how many of any actual changes could be reversed given suitable management intervention.

The detection of significant improvements in the condition of native vegetation during the limited duration of this study was unexpected. The fact that a significant improvement in vegetation condition was recorded at sites across the island and for a range of vegetation communities sampled is important. This finding appears promising for future investments in biodiversity conservation including fire, vegetation and habitat management on the island.

Our biodiversity monitoring sites included areas of native vegetation communities such as *Acacia melanoxylon* swamp forest, *Eucalyptus brookeriana* wet forest, and *Melaleuca ericifolia* swamp forest that are recognised as a high priority for biodiversity management

(Threatened Species Section 2010). The findings suggest that the vegetation condition of these communities could be enhanced by pro-active wildlife population management.

Options for managing native wildlife on King Island

The wildlife population management of Bennett's Wallaby is of particular interest. The species is listed as partly protected wildlife under the *Wildlife Regulations 1999* of the *Nature Conservation Act 2002* (DPIW 2005). The species can be taken by licensed hunters during an open season and permits can be issued to allow them to be taken at any time for crop protection, or other approved purposes.

Management of the Tasmanian Pademelon requires prudence as the species has a more localised distribution on the island and local populations could be susceptible to unintended shooting. Branson (2008) reported that the overall population may be in decline.

The most effective wildlife population control for reducing pasture loss to browsing would appear to be the integrated use of wallaby-proof fencing and systematic shooting. This could be done on a property level for the benefit of the local property owner. However, a coordinated approach involving many properties across regions may be more economical, effective and practical in terms of fence installation, shooting regime, and operational safety.

Sites with wallaby-proof fencing will require shooting, but the frequency and intensity of this activity will be reduced compared to unfenced sites.

The frequency and intensity of shooting is likely to be more modest over time if most neighbouring landholders are involved in a coordinated approach and the regional population of wildlife is reduced.

The non-commercial culling of wallabies for crop protection and recreational hunting is not managed under the harvesting plan. However, the number of wallabies killed on a non-commercial basis must be considered in the management of any commercial harvesting (DPIW 2005).

4. CONCLUSIONS AND RECOMMENDATIONS

The future of King Island's terrestrial ecosystems is not sustainable unless a credible strategy is developed to manage native wildlife, especially Bennett's Wallaby. In the absence of suitable controls on wildlife population levels and wildlife management, significant ecological and economic impacts will continue.

The challenge to create a new and effective approach to wildlife management is not trivial. Such a strategy will fail if it is not holistic, supported by the community, and well communicated to various stakeholders, interest groups and consumers of the island's agricultural produce. The socioeconomic dimensions of the issues require much further study and consideration.

A far more sophisticated and integrated approach to wildlife management on agricultural land is necessary. This almost certainly will require, inter alia, the installation of wallaby-proof fencing at a landscape level (across properties) and a coordinated approach to shooting using highly-trained professional staff. The local agricultural community will require government support and financial incentives to proceed in a more effective manner. However, taken alone, this initiative will be inadequate.

Holistic wildlife management requires that the ecological pressures imposed on terrestrial native ecosystems as a result of extraordinarily high population levels of wildlife be addressed as well. Similarly, the potential native animal welfare issues that may result from food scarcity due to the (wallaby-proof) fencing of significant areas of pasture must be addressed.

More comprehensive scientific consideration needs to be given to the preferred total and regional population levels of Bennett's Wallaby. This thinking could be usefully informed by population modelling, population viability analyses and vertebrate wildlife disease modelling.

Prima facie, there may be a case to re-establish a commercial harvesting program for Bennett's Wallaby on King Island.

A large number of animals may be required to be removed from the population within a relatively short period of time if the population level of the species is to be reduced significantly.

If this was to occur, it may be desirable from an ecological perspective that the carcasses of these animals were not left in the field.

Alternatively, if a reduction in the population level of Bennett's Wallaby was to be staggered over the medium term, a scientific review of the population situation may suggest that an increase in the level of commercial harvesting of Bennett's Wallaby above the present annual take level is warranted. If this was to occur, approval for a higher annual take may be helpful to establishing an economically-viable business case for a renewed commercial harvesting industry for Bennett's Wallaby.

A number of recommendations arise from the study, including that:

- A social science study is undertaken to examine and better understand the awareness of the community, governments, consumers of agricultural produce from the island and other major stakeholders and interested parties about the significance of the wildlife management issues confronting King Island and the social issues arising from different management options. This study should inform the nature and timing of the development of a wildlife management strategy for the island.

- A wildlife management strategy is developed for King Island. The strategy would be distinct from, but complementary to, the King Island (draft) Biodiversity Management Plan 2010-2020 (Threatened Species Section 2010). The strategy would be linked to any revised plan for the commercial harvesting of wallaby (see DPIW 2005).

- A more sophisticated approach to wildlife management on King Island's agricultural lands is developed. Use of wildlife population controls need to be considered and planned from a regional and catchment perspective (as opposed to a property level approach). Wildlife population measures to mitigate pasture loss to browsing are best undertaken using a combination of wallaby-proof fencing and systematic shooting by licensed, professional shooters. If landholders wish to undertake their own shooting controls, provided they are licensed, they should be given proper training on the most effective equipment and techniques to use. This could help landholders to build capacity and improve the quality of wildlife management using informed, local knowledge of ecological change at a property level.

- New wildlife control options such as Feratox™ (see DAFF 2009) should be trialled on the King Island as they become available.

- Landholders need to be aware of the ecological and economic implications of high population levels of native wildlife. Education and advice for landholders is required to allow a greater appreciation of the true costs to farm production, and to allow producers to build these costs, where appropriate, into farm business plans.

- New and additional support, investment and financial incentives are required from government in partnership with the local community to build awareness, provide high level support and professional advice for the development and implementation of a new strategy and its associated mitigation and management actions.

- The new strategy and its associated management interventions must be monitored. Native wildlife populations should be surveyed on a more regular basis using the methods of Branson (2008). Population trends and data on population culling must be maintained and reviewed regularly. Monitoring of native vegetation communities, habitat for priority plant and animal species would be put in place and maintained. The welfare of native wildlife must be monitored.

5. REFERENCES

Anderson, D. R. and Laake, J. (1979). Guidelines for line transect sampling of biological populations. *The Journal of Wildlife Management* 43(1): 70 - 78.

Anon. (1996). Management program for the Brushtail possum *Trichosurus vulpecula* (Kerr) in Tasmania - Review of background information, *Tasmanian Parks and Wildlife Service.* Hobart.

Anon. (2005). Wildlife trade management plan for the commercial harvest of Bennett's Wallabies on King Island, Tasmania 2005 - 2010. Tasmania, Nature Conservation Branch, *Tasmanian Department of Primary Industries, Water and Environment.* Hobart.

Barnes, R. W. and Duncan, F. (2002). The native vegetation of King Island, Bass Strait. Nature Conservation Report 02/6. *Tasmanian Department of Primary Industries, Water and Environment.* Hobart.

Barrow, L. (2008). Draft National Recovery Plan for King Island 2008-2013, *King Island Natural Resource Management Group.* Currie.

Branson, M. J. (2008) Nocturnal population estimates of Bennett's Wallaby (*Macropus rufogriseus*), Tasmanian Pademelon (*Thylogale billiardierii*) and Brushtail Possum (*Trichosurus vulpecula*) in pasture on King Island, Tasmania. *King Island Natural Resource Management Group*, Currie.

Caughley, G. and Grigg, G. C. (1981). Surveys of the distribution and density of kangaroos in the pastoral zone of South Australia, and their bearing on the feasibility of aerial survey in large and remote areas. *Australian Wildlife Research* 8: 1 - 11.

DPIW (2005). A Wildlife Trade Management Plan for King Island, 2005-2010. *Tasmanian DPIW*, Hobart.

DAFF (2009). Tasmanian Community Forest Agreement Research in to Alternatives to 1080. Newsletter 16, September 2009.

Dawson, J. (2007). Wildlife Management Branch 2006-07 Wildlife Spotlight Surveys Summary Results, *Tasmanian Department of Primary Industries and Water.* Hobart.

Donaghey, R. H., Ed. (2003). The fauna of King Island. A guide to identification and conservation management. *King Island Natural Resource Management Group*, Currie.

Driessen, M. M. (1992). The effects of hunting and rainfall on Bennett's Wallaby and Tasmanian Pademelon populations, *The Tasmanian Parks and Wildlife Service Scientific Report 92/3*, Hobart.

Hocking, G. J. and Driessen, M. M. (1992). Tasmanian spotlight survey manual. A set of instructions and maps for conducting spotlight surveys in Tasmania, *Tasmanian Department of Parks Wildlife and Heritage*, Hobart.

Johnson I. R., Chapman D. F., Snow V. O., Eckard R. J., Parsons A. J., Lambert M. G., Cullen B. R. (2008). DairyMod and EcoMod: biophysical pasture-simulation models for Australia and New Zealand. *Australian Journal of Experimental Agriculture* 48: 621-631.

Lacey, M. J. and Norton, T. W. (2010). User Guidelines for BITE - a decision support system for assessing the potential impacts of browsing by native wildlife on Tasmanian farms. DPIPWE, Hobart, 2010.

Le Mar, K. and McArthur, C. (2005). Comparison of habitat selection by two sympatric macropods, *Thylogale billardierii* and *Macropus rufogriseus rufogriseus*, in a patchy eucalypt-forestry environment. *Austral Ecology* 30: 674 - 683.

Le Mar, K., C. and Southwell, C. (2001). Evaluation of line-transect methods to estimate nocturnal densities of macropods in open and closed habitats. *Wildlife Research* 28: 9 - 16.

Norton, T.W. (2010). Mapping the agricultural estate of Tasmania - a case study from the Cradle Coast region. Phase 2. Cradle Coast Authority, Burnie.

Norton, T. W. and Lacey, M. J. (2010). User Guidelines for Patch Data Viewer. CERF Landscape Logic Data Library, 2010.

Pople, A. R. and Cairns, S. C. (2003). Monitoring kangaroo populations in southeastern New South Wales. *Consultancy Report to NSW NPWS*, Sydney.

Rawnsley R. P., Cullen B. R., Turner L. R., Donaghy D. J., Freeman M. and Christie K. M. (2009). Potential of deficit irrigation to increase marginal irrigation response of perennial ryegrass (*Lolium perenne* L.) on Tasmanian dairy farms. *Crop and Pasture Science* 60: 1156-1164.

Southwell, C. (1994). Evaluation of walked line transect counts for estimating macropod density. *The Journal of Wildlife Management* 58(2): 348 - 356.

Southwell, C. and Weaver, K. E. (1995). Abundance of macropods in north-eastern New South Wales, and the logistics of broad-scale ground surveys. *Wildlife Research* 22: 757 - 766.

Statham, H.C. (1983). Browsing damage in Tasmanian forest areas and effects of 1080 poisoning. *Tas. For. Comm. Bull.* 7: 1-261.

Statham M and Statham, H. (2009). Wallaby Proof fencing; a planning guide for Tasmanian Primary Producers, *Tasmanian Institute of Agricultural Research*, Hobart. p. 12.

Threatened Species Section (2010). Draft Guidelines for the Management of Biodiversity on King Island, Tasmania. DPIPWE, Hobart.

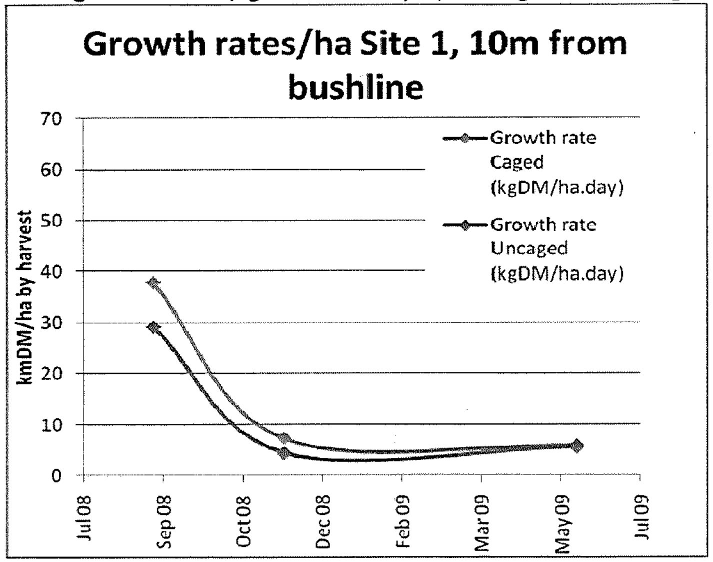
Triggs, B. (1999). *Tracks, scats and other traces: A field guide to Australian mammals.* Melbourne, Oxford University Press.

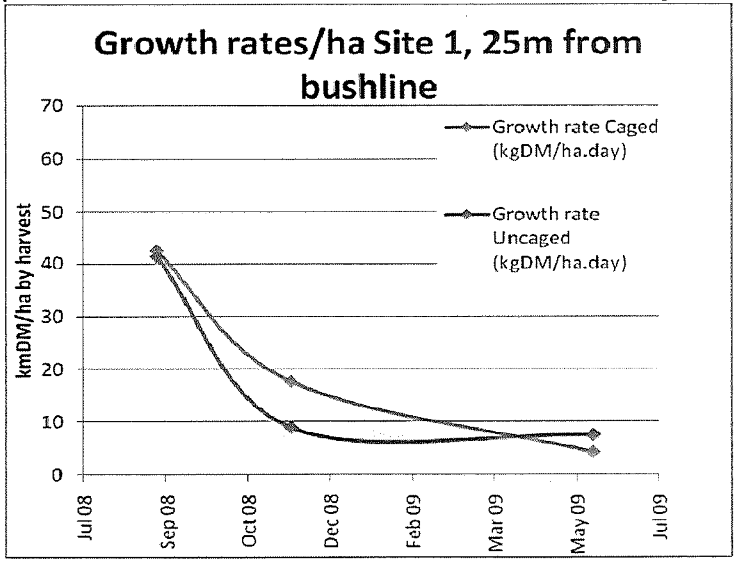
Wayne, A. F. and Cowling, A. (2005). Factors affecting the detection of possums by spotlighting in Western Australia. *Wildlife Research* 32: 689-700.

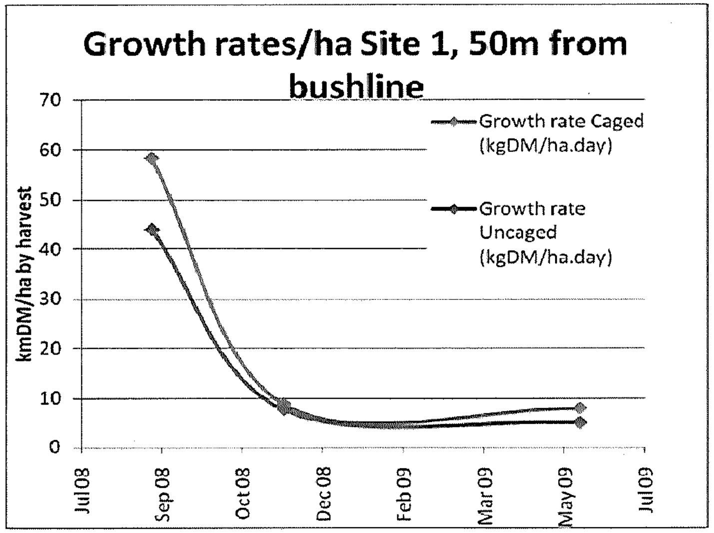
While, G. M. and McArthur, C. (2005). "oraging in a risky environment: a comparison of Bennett's wallabies *Macropus rufogriseus rufogriseus* (Marsupiala: Macropodidae) and Red-bellied Pademelons *Thylogale billardierii* (Marsupialia: Macropodidae) in open habitats. *Austral Ecology* 30: 756 - 764.

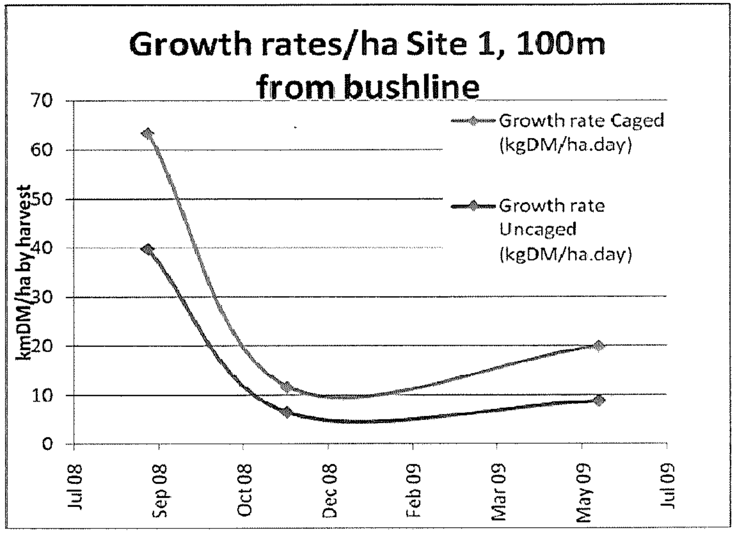
6. APPENDICES

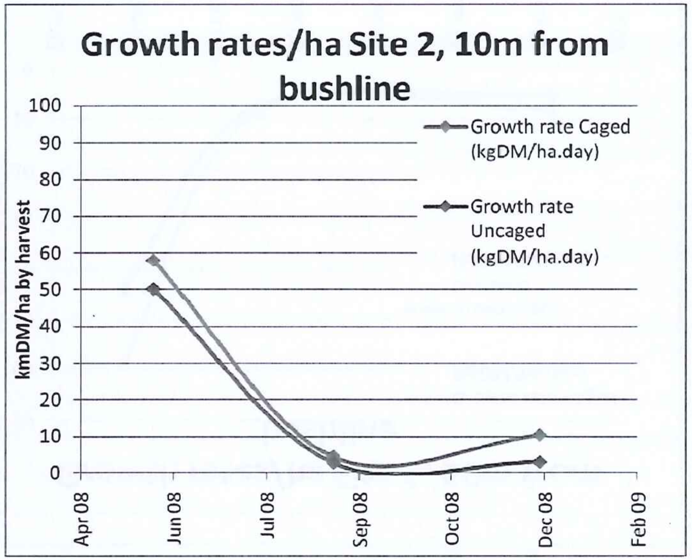
Appendix 1. Pasture growth rates (kg DM ha-1 day-1) for caged and uncaged plots with distance from bush-line for 12 field sites on King Island, Tasmania.

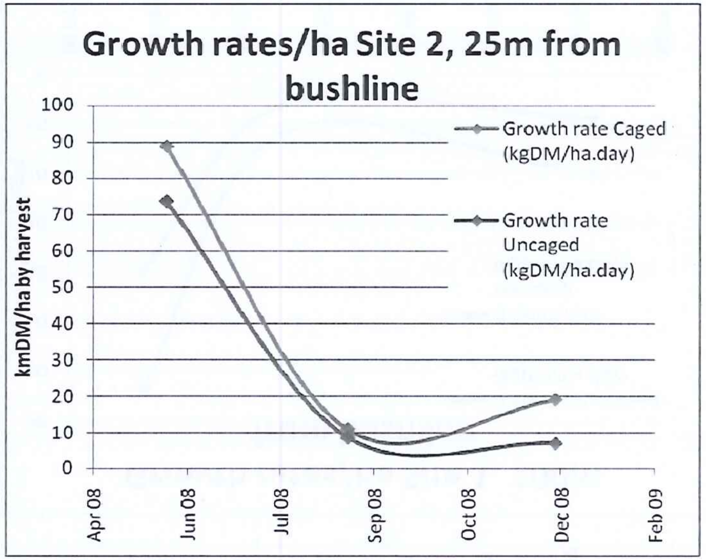


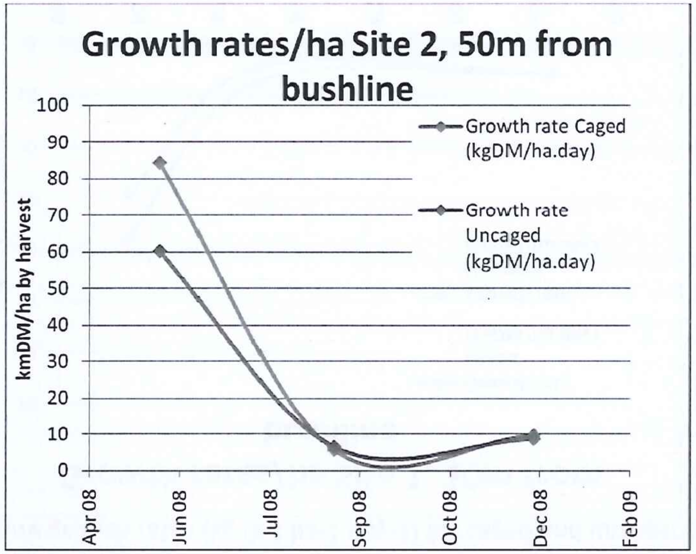


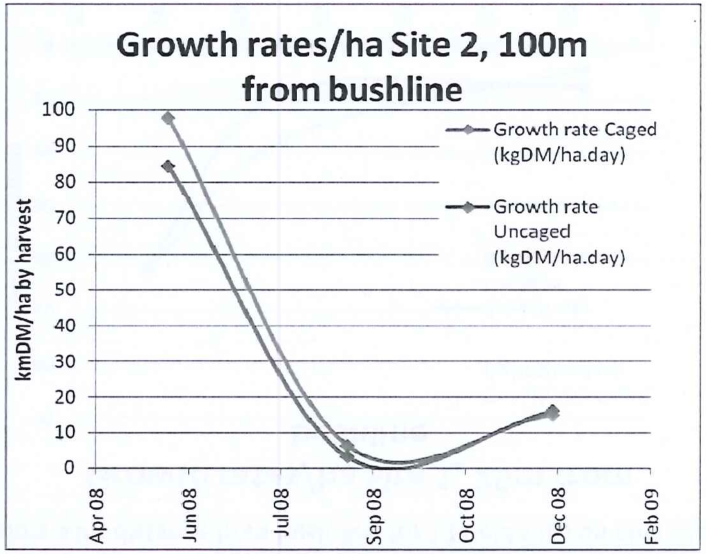


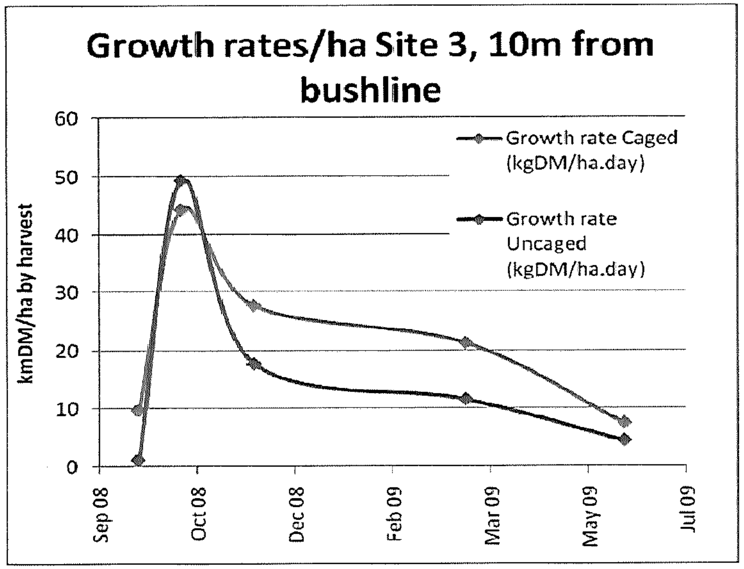


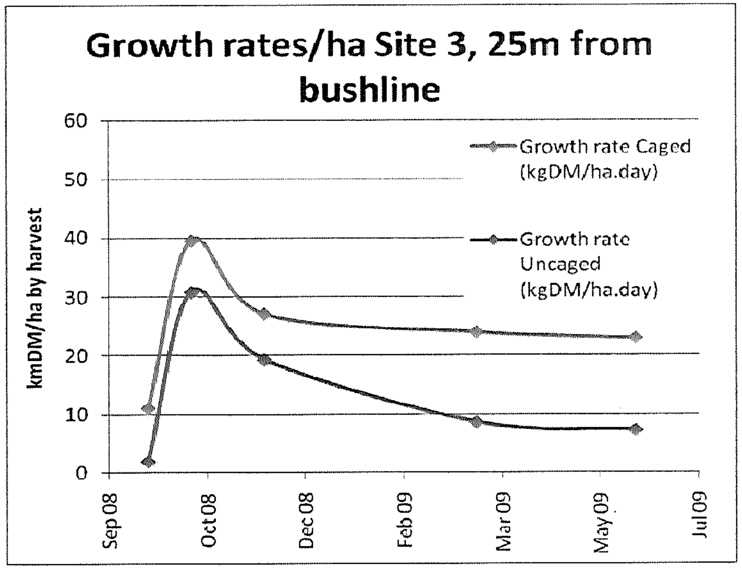

Growth rates/ha Site 2, 10m from bushline
kmDM/ha by harvest
100
90
80
70
60
50
40
30
20
10
0
Apr 08
Jun 08
Jul 08
Sep 08
Oct 08
Dec 08
Feb 09
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)

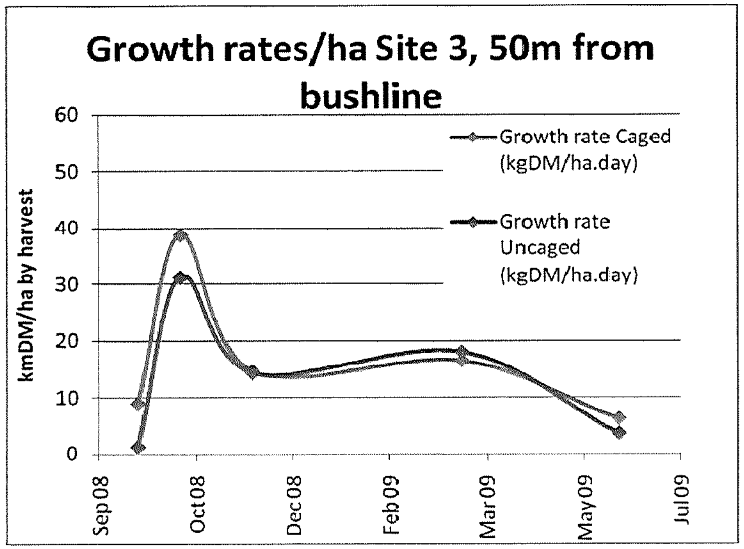

Growth rates/ha Site 2, 25m from bushline
kmDM/ha by harvest
100
90
80
70
60
50
40
30
20
10
0
Apr 08
Jun 08
Jul 08
Sep 08
Oct 08
Dec 08
Feb 09
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)

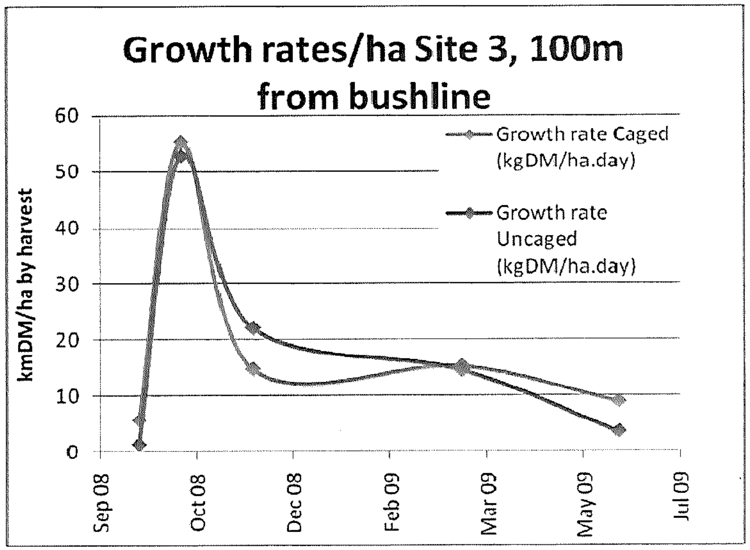

Growth rates/ha Site 2, 50m from bushline
kmDM/ha by harvest
100
90
80
70
60
50
40
30
20
10
0
Apr 08
Jun 08
Jul 08
Sep 08
Oct 08
Dec 08
Feb 09
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)

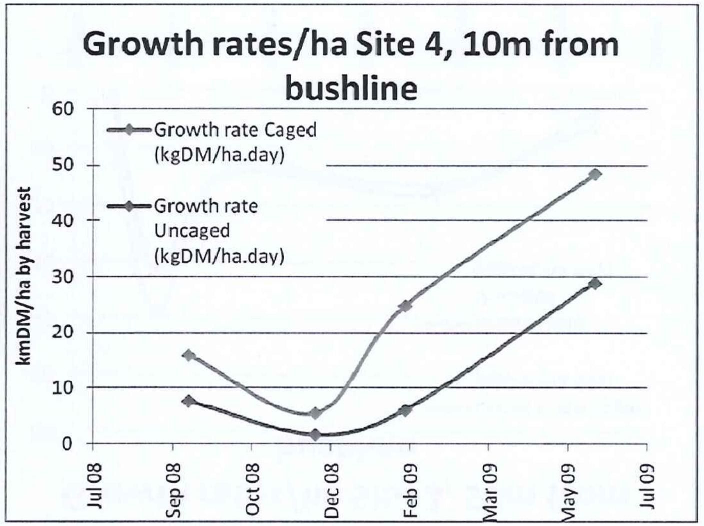

Growth rates/ha Site 2, 100m from bushline
kmDM/ha by harvest
100
90
80
70
60
50
40
30
20
10
0
Apr 08
Jun 08
Jul 08
Sep 08
Oct 08
Dec 08
Feb 09
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)

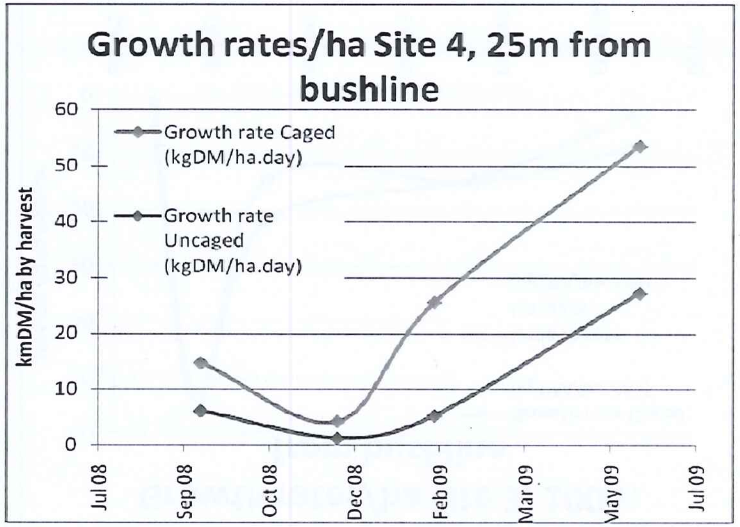

Growth rates/ha Site 3, 10m from bushline
60
50
40
30
20
10
0
kmDM/ha by harvest
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

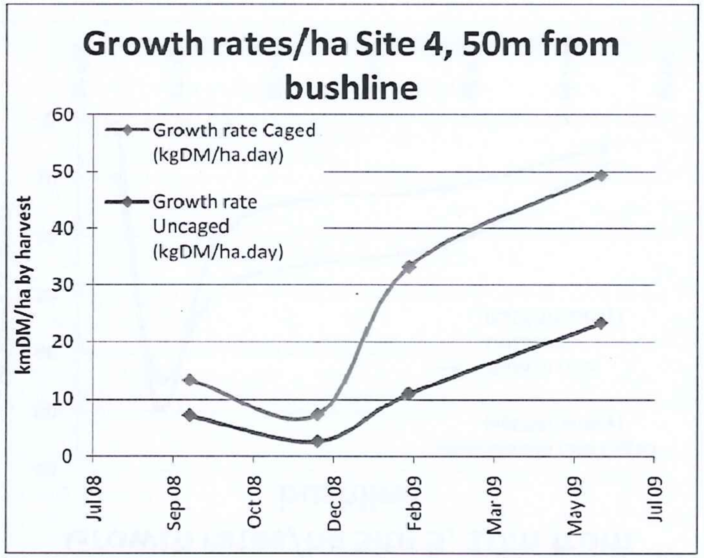

Growth rates/ha Site 3, 25m from bushline
60
50
40
30
20
10
0
kmDM/ha by harvest
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

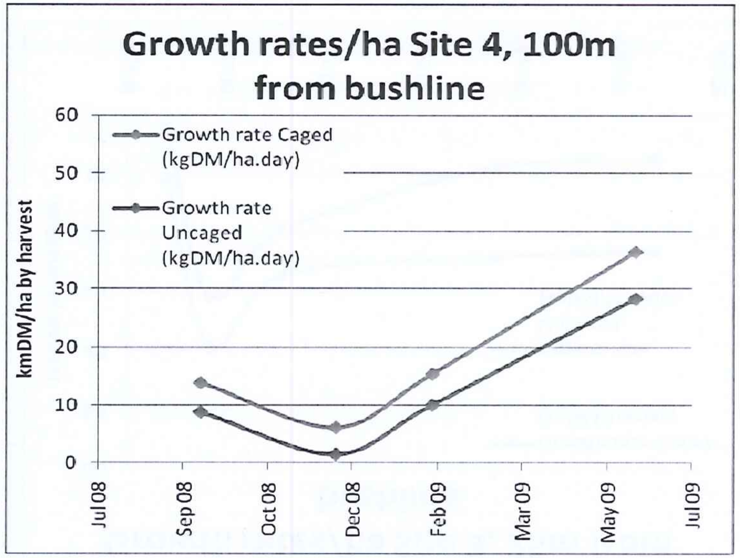

Growth rates/ha Site 3, 50m from bushline
60
50
40
30
20
10
0
kmDM/ha by harvest
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

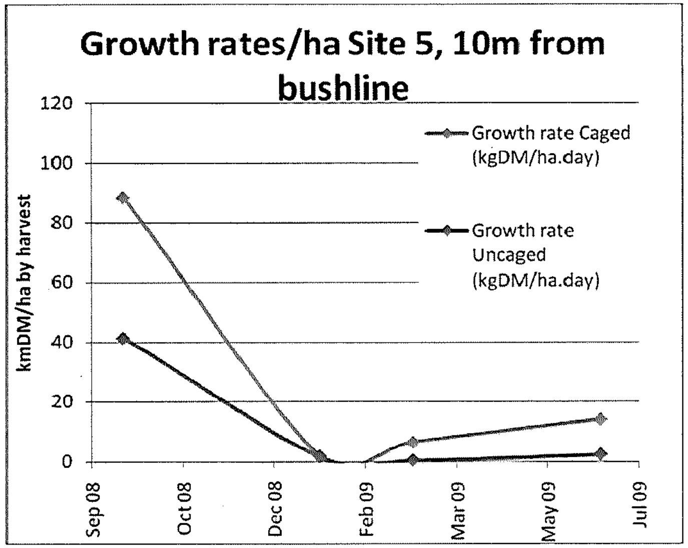

Growth rates/ha Site 3, 100m from bushline
60
50
40
30
20
10
0
kmDM/ha by harvest
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

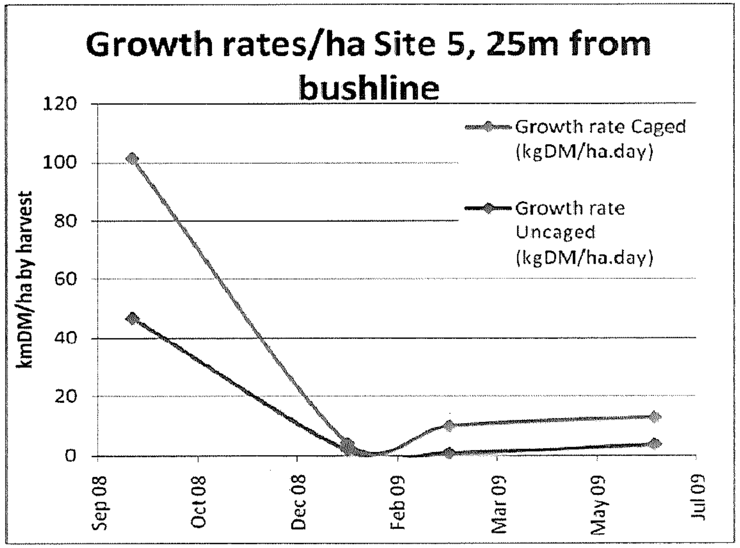

Growth rates/ha Site 4, 10m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
60
50
40
30
20
10
0
Jul 08
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

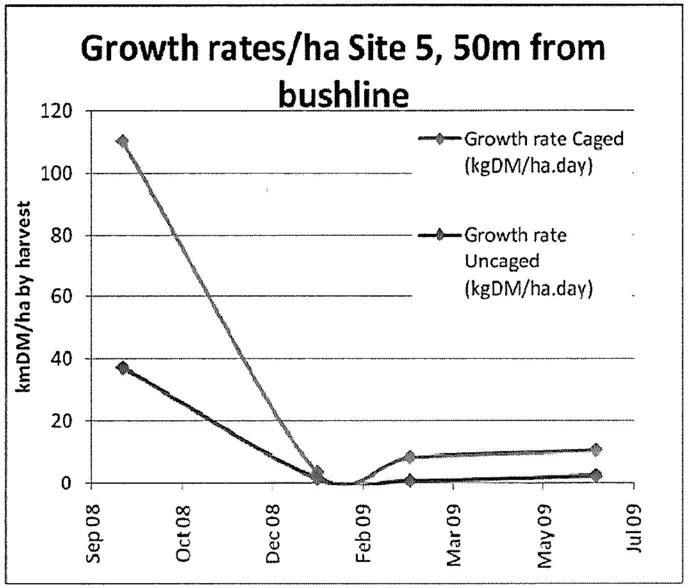

Growth rates/ha Site 4, 25m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
60
50
40
30
20
10
0
Jul 08
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

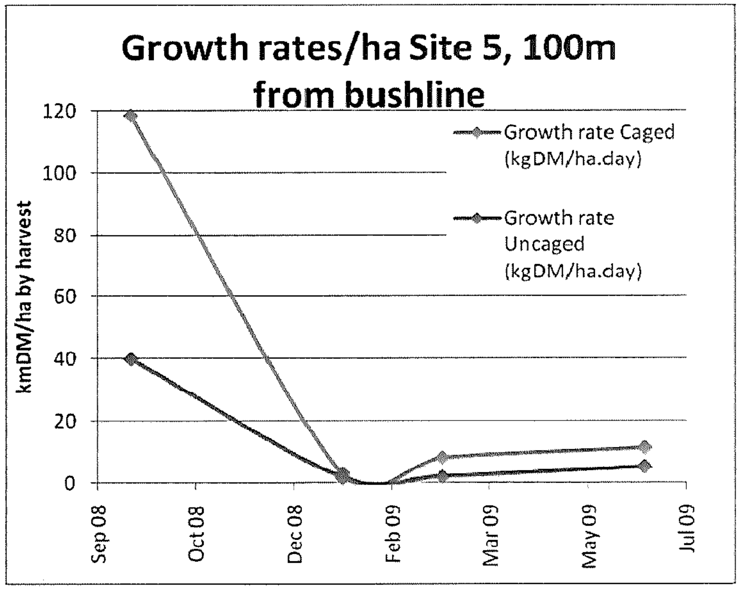

Growth rates/ha Site 4, 50m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
60
50
40
30
20
10
0
Jul 08
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

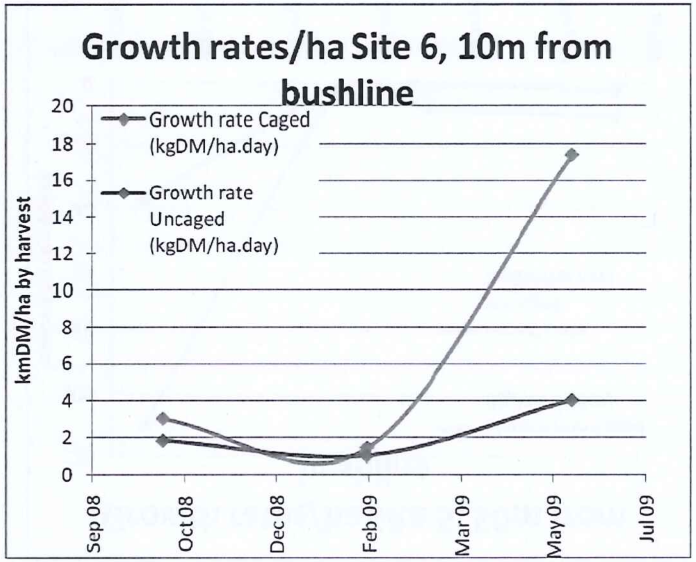

Growth rates/ha Site 4, 100m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
60
50
40
30
20
10
0
Jul 08
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

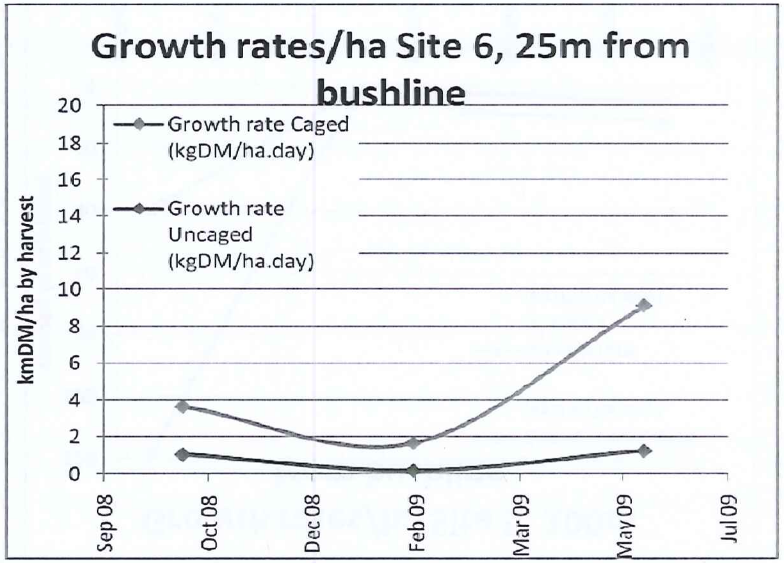

Growth rates/ha Site 5, 10m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
120
100
80
60
40
20
0
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

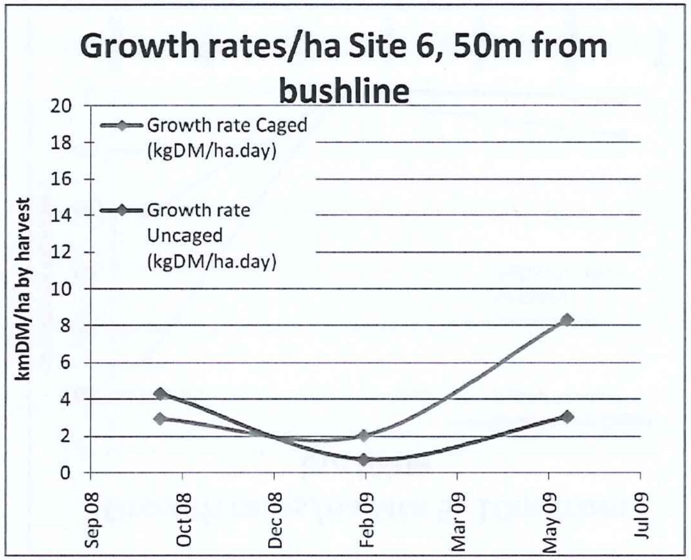

Growth rates/ha Site 5, 25m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
120
100
80
60
40
20
0
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

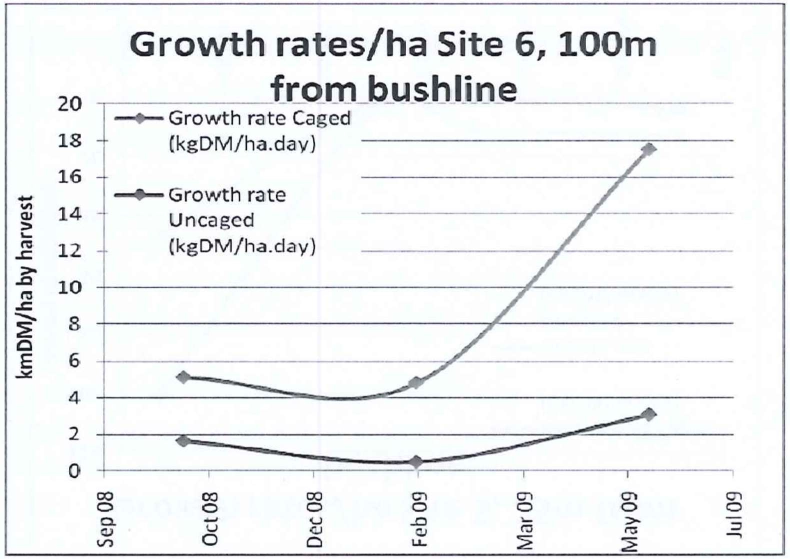

Growth rates/ha Site 5, 50m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
120
100
80
60
40
20
0
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

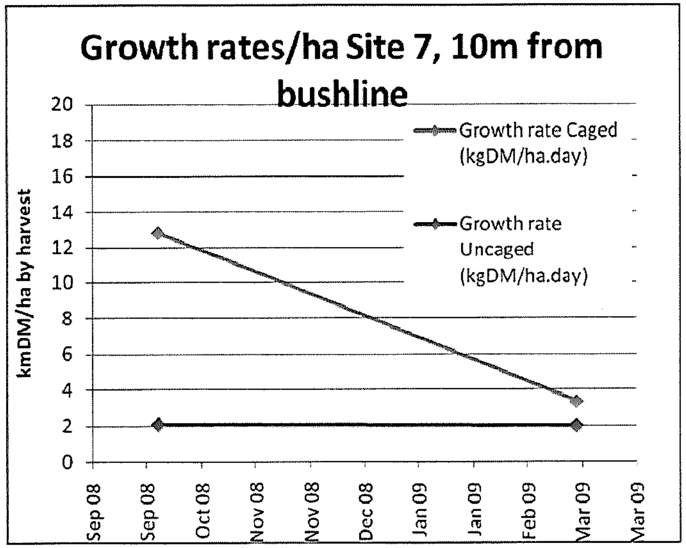

Growth rates/ha Site 5, 100m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
120
100
80
60
40
20
0
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

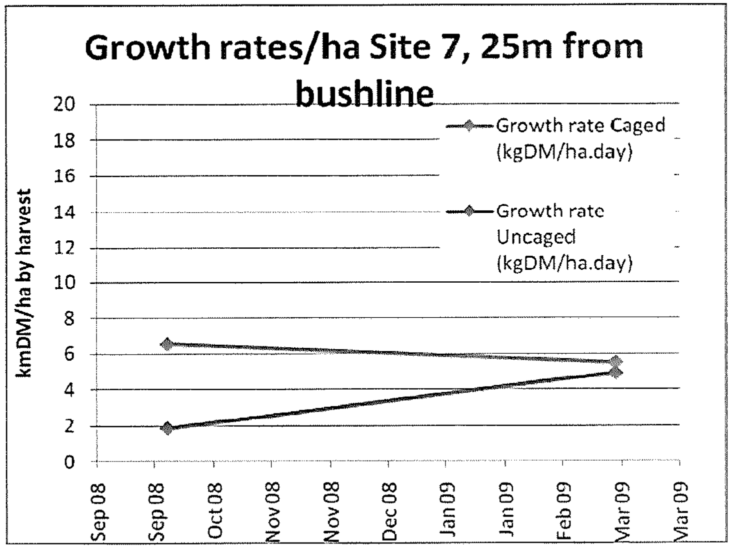

Growth rates/ha Site 6, 10m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
20
18
16
14
12
10
8
6
4
2
0
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

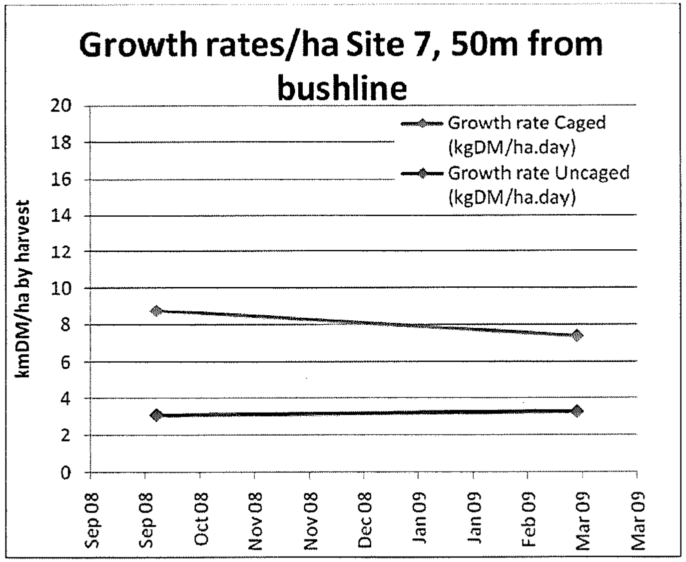

Growth rates/ha Site 6, 25m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
20
18
16
14
12
10
8
6
4
2
0
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

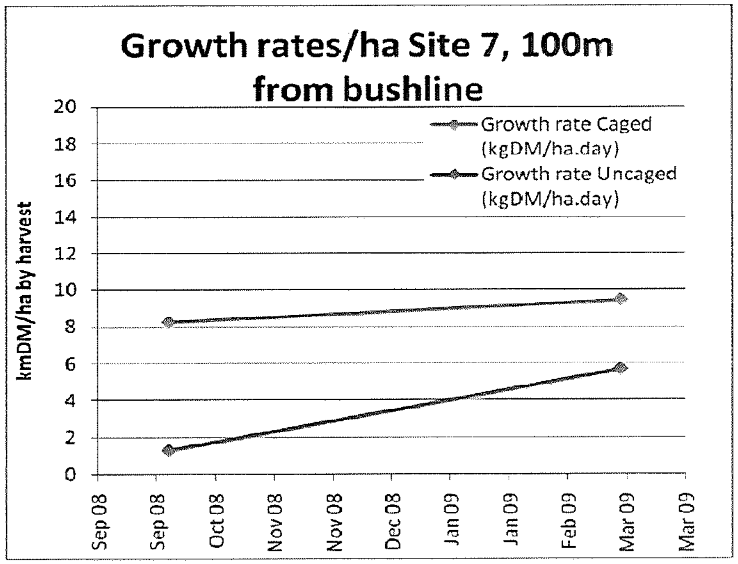

Growth rates/ha Site 6, 50m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
20
18
16
14
12
10
8
6
4
2
0
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

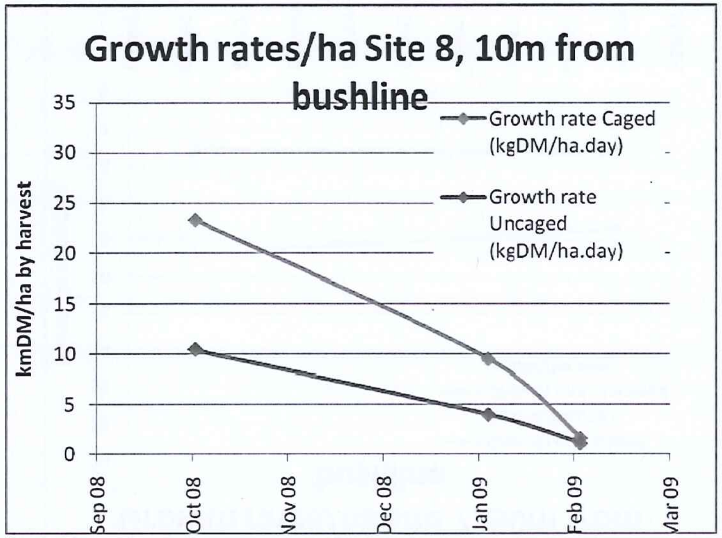

Growth rates/ha Site 6, 100m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
20
18
16
14
12
10
8
6
4
2
0
Sep 08
Oct 08
Dec 08
Feb 09
Mar 09
May 09
Jul 09

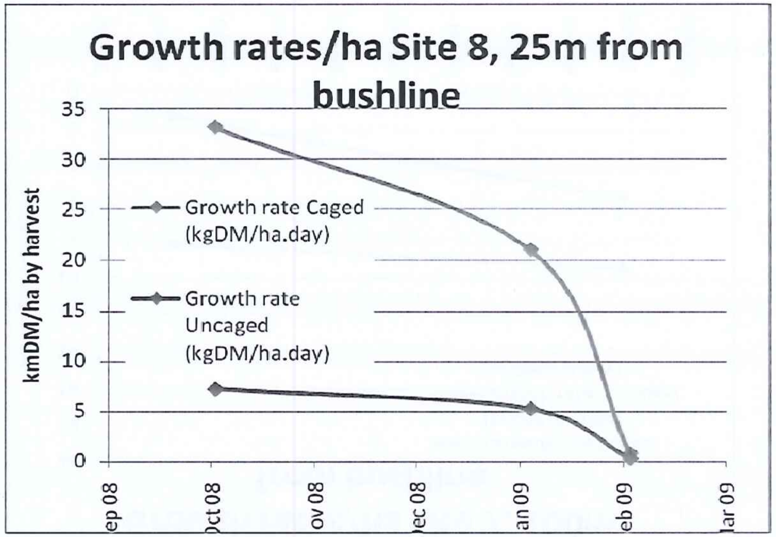

Growth rates/ha Site 7, 10m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
20
18
16
14
12
10
8
6
4
2
0
Sep 08
Sep 08
Oct 08
Nov 08
Nov 08
Dec 08
Jan 09
Jan 09
Feb 09
Mar 09
Mar 09

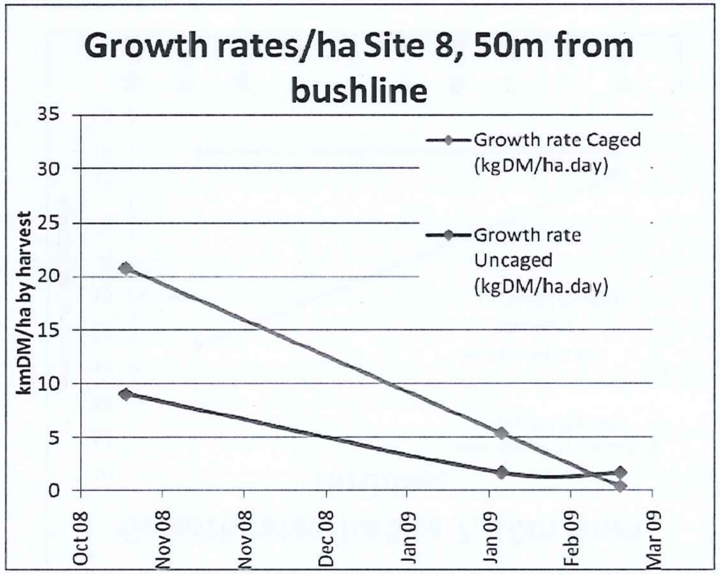

Growth rates/ha Site 7, 25m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
20
18
16
14
12
10
8
6
4
2
0
Sep 08
Sep 08
Oct 08
Nov 08
Nov 08
Dec 08
Jan 09
Jan 09
Feb 09
Mar 09
Mar 09

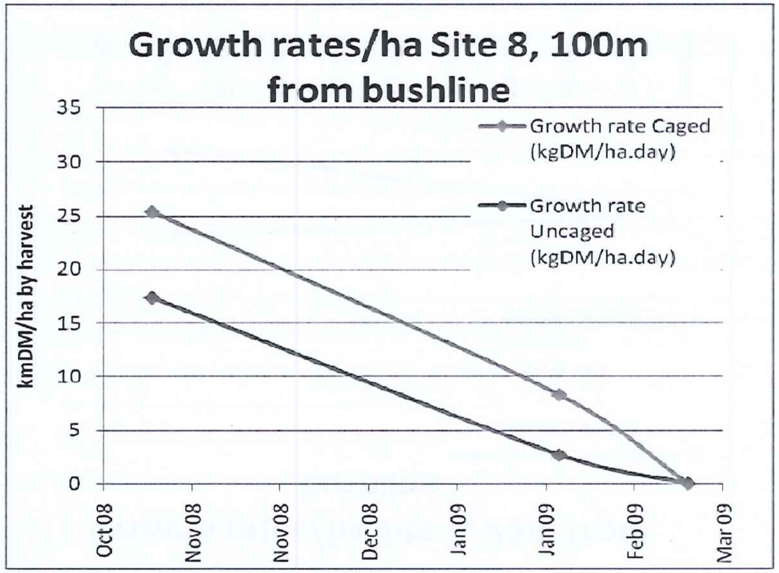

Growth rates/ha Site 7, 50m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
20
18
16
14
12
10
8
6
4
2
0
Sep 08
Sep 08
Oct 08
Nov 08
Nov 08
Dec 08
Jan 09
Jan 09
Feb 09
Mar 09
Mar 09

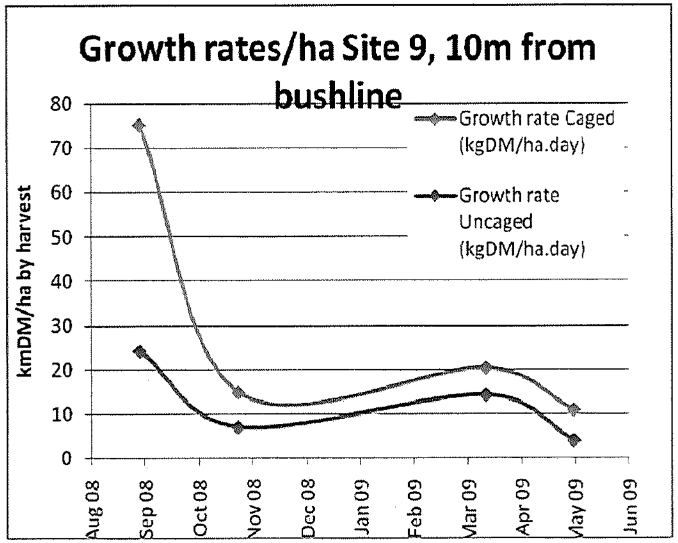

Growth rates/ha Site 7, 100m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
20
18
16
14
12
10
8
6
4
2
0
Sep 08
Sep 08
Oct 08
Nov 08
Nov 08
Dec 08
Jan 09
Jan 09
Feb 09
Mar 09
Mar 09

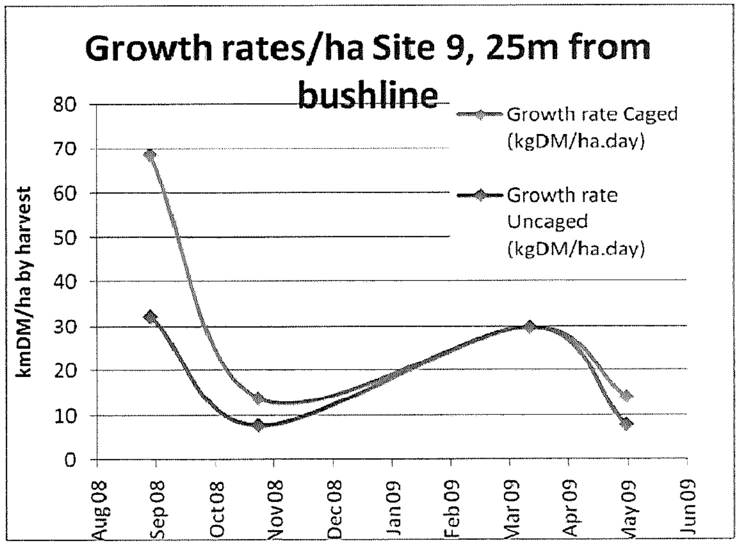

Growth rates/ha Site 8, 10m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
35
30
25
20
15
10
5
0
Sep 08
Oct 08
Nov 08
Dec 08
Jan 09
Feb 09
Mar 09

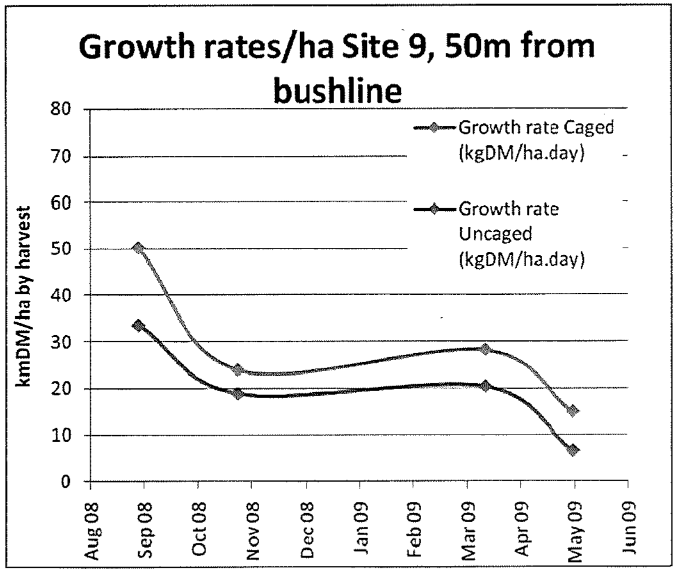

Growth rates/ha Site 8, 25m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
35
30
25
20
15
10
5
0

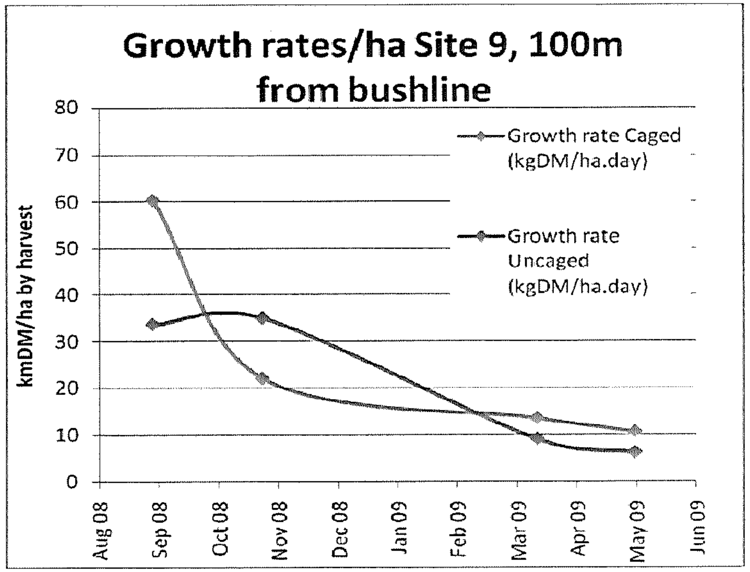

Growth rates/ha Site 8, 50m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
35
30
25
20
15
10
5
0
Oct 08
Nov 08
Nov 08
Dec 08
Jan 09
Jan 09
Feb 09
Mar 09

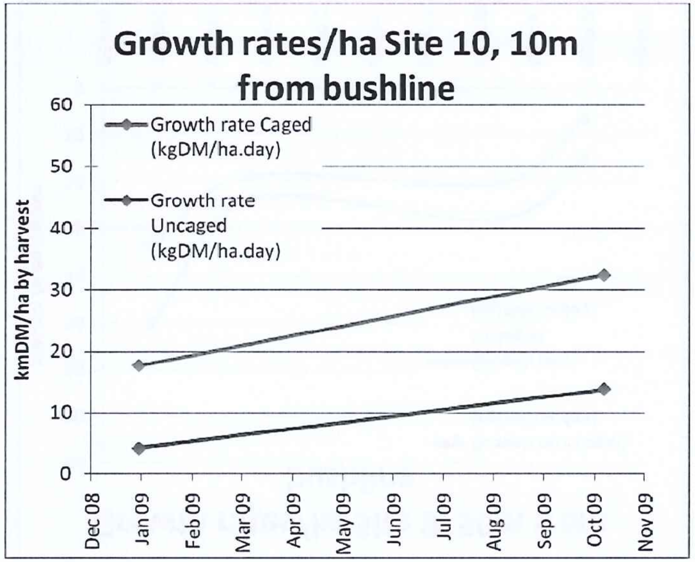

Growth rates/ha Site 8, 100m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
35
30
25
20
15
10
5
0
Oct 08
Nov 08
Nov 08
Dec 08
Jan 09
Jan 09
Feb 09
Mar 09

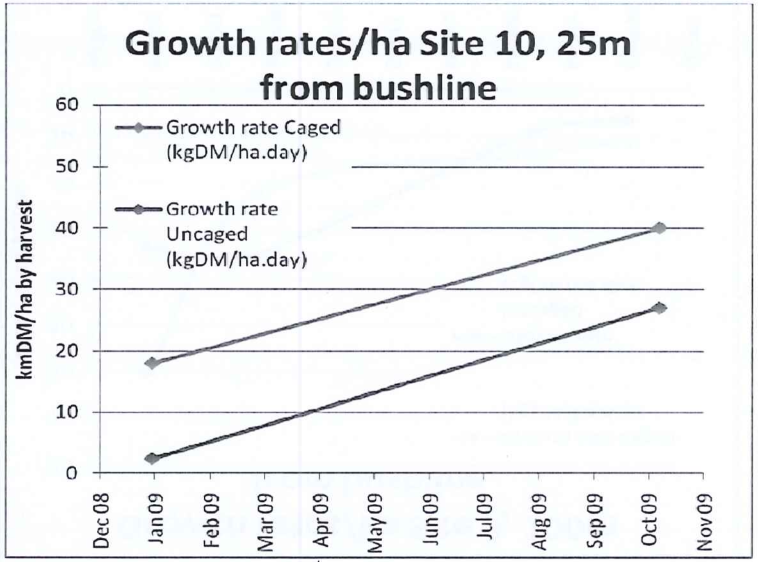

Growth rates/ha Site 9, 10m from bushline
kmDM/ha by harvest
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
80
70
60
50
40
30
20
10
0
Aug 08
Sep 08
Oct 08
Nov 08
Dec 08
Jan 09
Feb 09
Mar 09
Apr 09
May 09
Jun 09

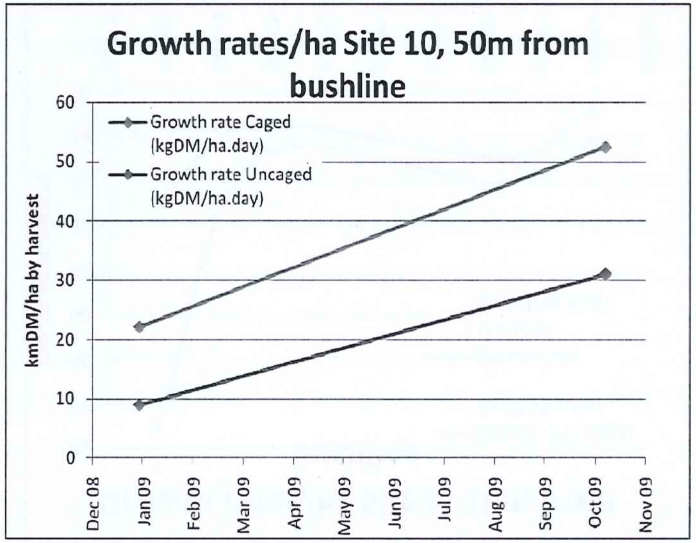

Growth rates/ha Site 9, 25m from bushline
kmDM/ha by harvest
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
80
70
60
50
40
30
20
10
0
Aug 08
Sep 08
Oct 08
Nov 08
Dec 08
Jan 09
Feb 09
Mar 09
Apr 09
May 09
Jun 09

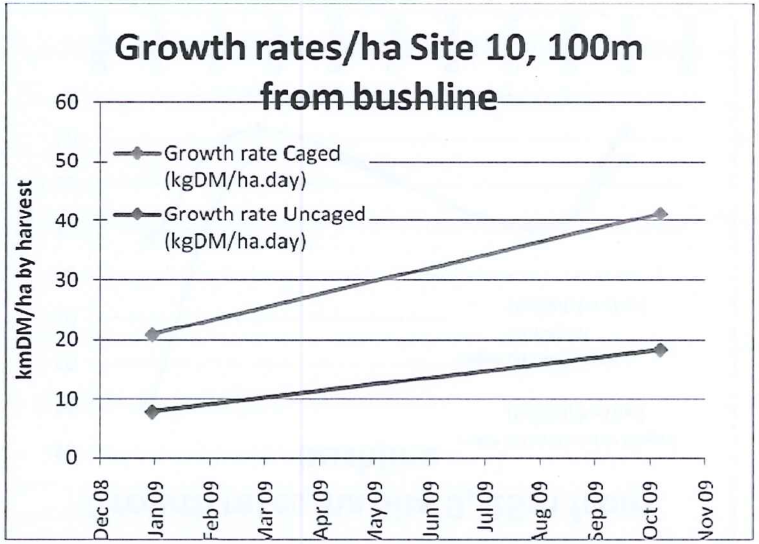

Growth rates/ha Site 9, 50m from bushline
kmDM/ha by harvest
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
80
70
60
50
40
30
20
10
0
Aug 08
Sep 08
Oct 08
Nov 08
Dec 08
Jan 09
Feb 09
Mar 09
Apr 09
May 09
Jun 09

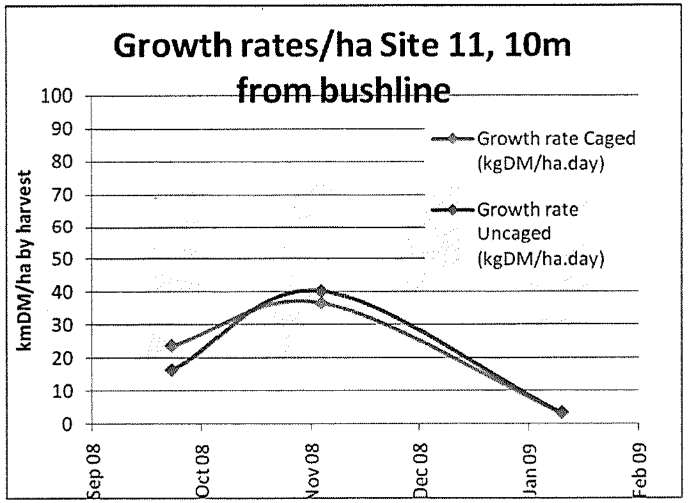

Growth rates/ha Site 9, 100m from bushline
kmDM/ha by harvest
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
80
70
60
50
40
30
20
10
0
Aug 08
Sep 08
Oct 08
Nov 08
Dec 08
Jan 09
Feb 09
Mar 09
Apr 09
May 09
Jun 09


Growth rates/ha Site 10, 10m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
0
10
20
30
40
50
60
Dec 08
Jan 09
Feb 09
Mar 09
Apr 09
May 09
Jun 09
Jul 09
Aug 09
Sep 09
Oct 09
Nov 09

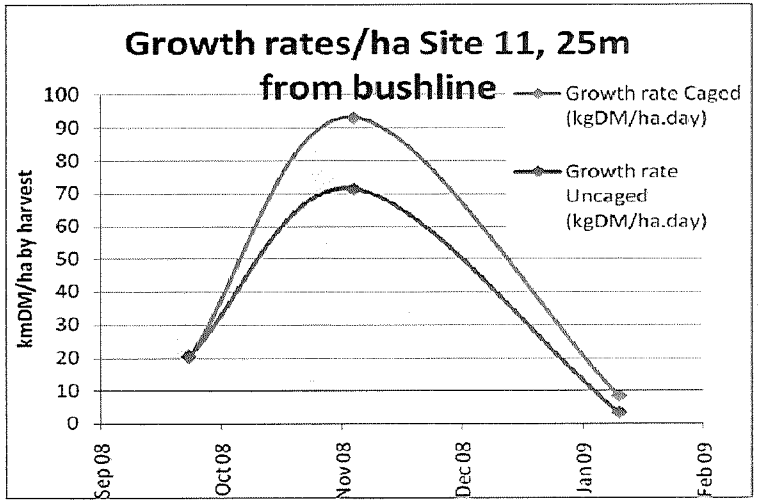

Growth rates/ha Site 10, 25m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
0
10
20
30
40
50
60
Dec 08
Jan 09
Feb 09
Mar 09
Apr 09
May 09
Jun 09
Jul 09
Aug 09
Sep 09
Oct 09
Nov 09


Growth rates/ha Site 10, 50m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
0
10
20
30
40
50
60
Dec 08
Jan 09
Feb 09
Mar 09
Apr 09
May 09
Jun 09
Jul 09
Aug 09
Sep 09
Oct 09
Nov 09

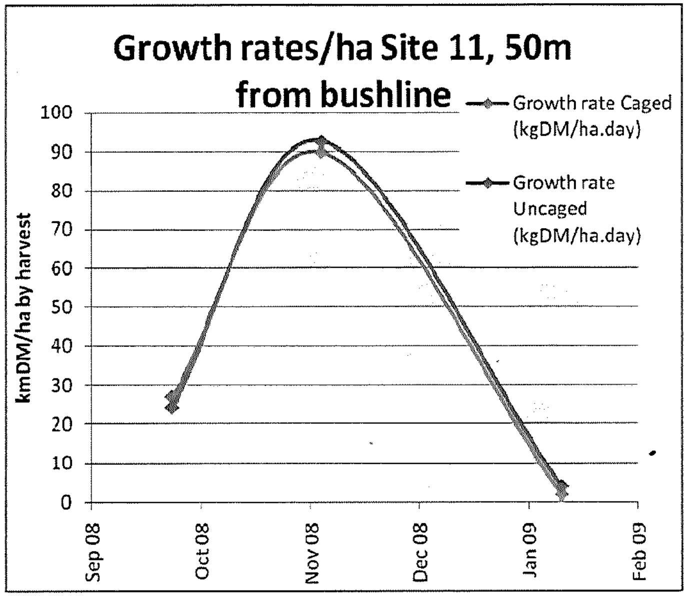

Growth rates/ha Site 10, 100m from bushline
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)
kmDM/ha by harvest
0
10
20
30
40
50
60
Jan 09
Apr 09
Jun 09
Jul 09
Oct 09



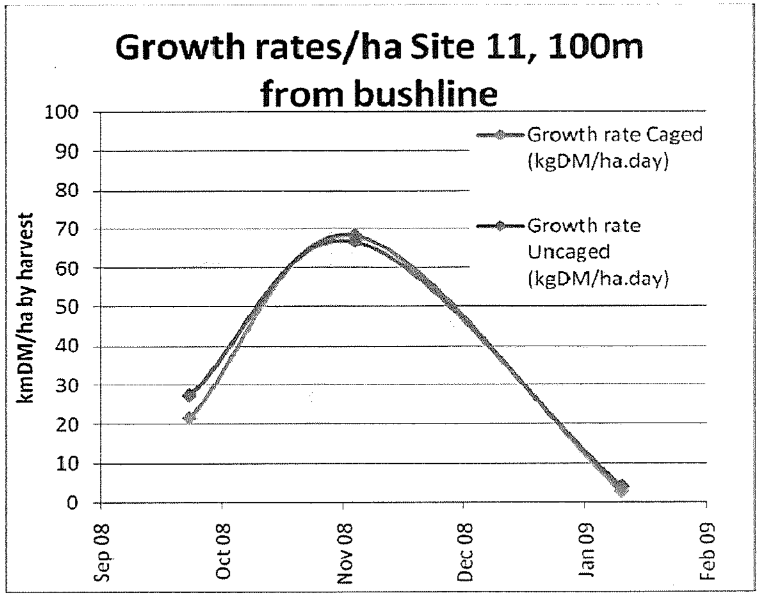
Growth rates/ha Site 11, 10m from bushline
kmDM/ha by harvest
100
90
80
70
60
50
40
30
20
10
0
Sep 08
Oct 08
Nov 08
Dec 08
Jan 09
Feb 09
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)



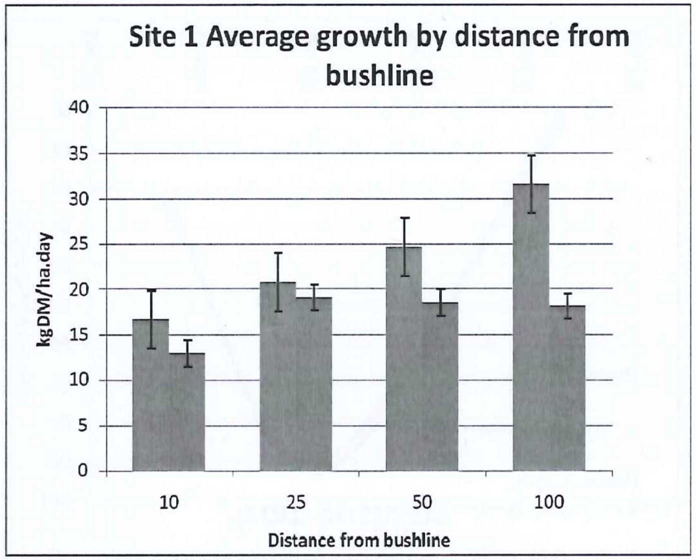
Growth rates/ha Site 11, 25m from bushline
kmDM/ha by harvest
100
90
80
70
60
50
40
30
20
10
0
Sep 08
Oct 08
Nov 08
Dec 08
Jan 09
Feb 09
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)

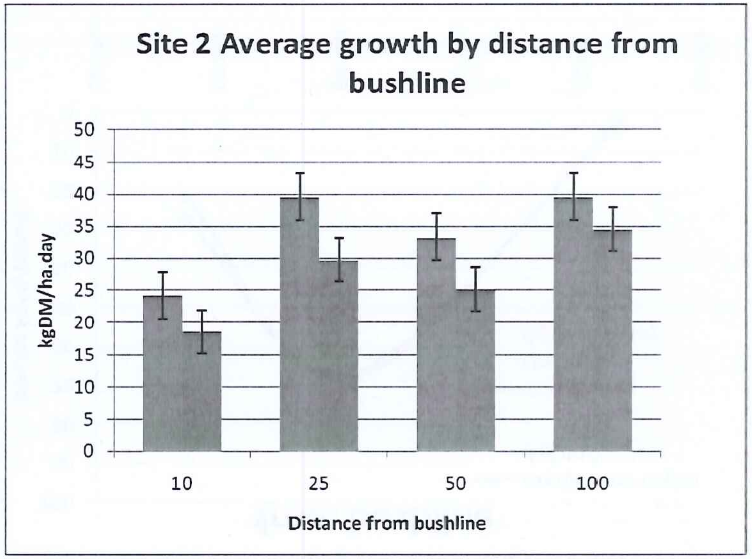


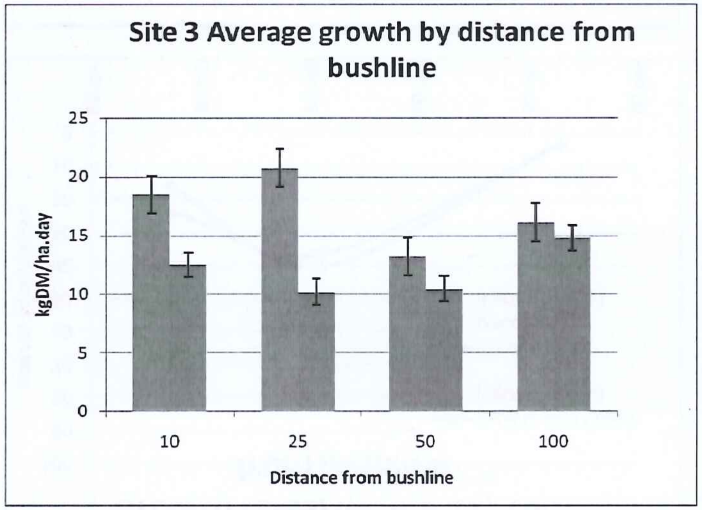
Growth rates/ha Site 11, 50m from bushline
kmDM/ha by harvest
100
90
80
70
60
50
40
30
20
10
0
Sep 08
Oct 08
Nov 08
Dec 08
Jan 09
Feb 09
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)

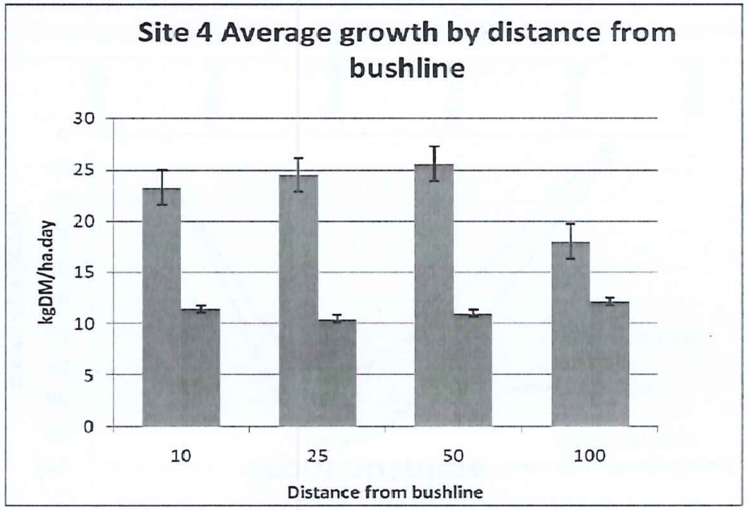


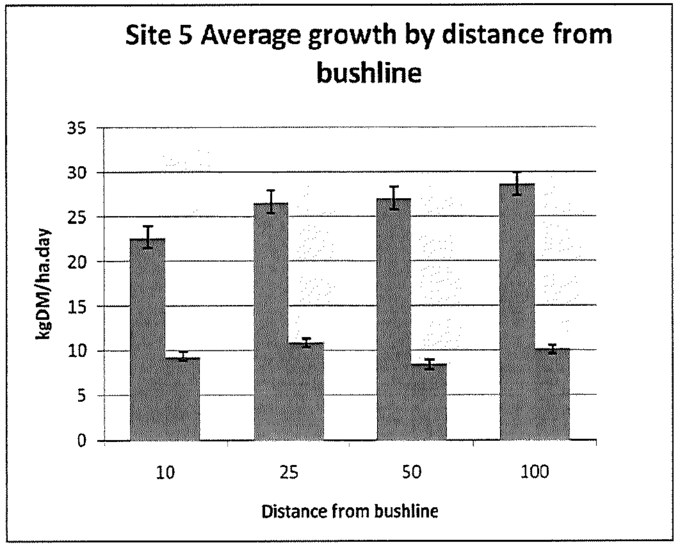
Growth rates/ha Site 11, 100m from bushline
kmDM/ha by harvest
100
90
80
70
60
50
40
30
20
10
0
Sep 08
Oct 08
Nov 08
Dec 08
Jan 09
Feb 09
Growth rate Caged (kgDM/ha.day)
Growth rate Uncaged (kgDM/ha.day)

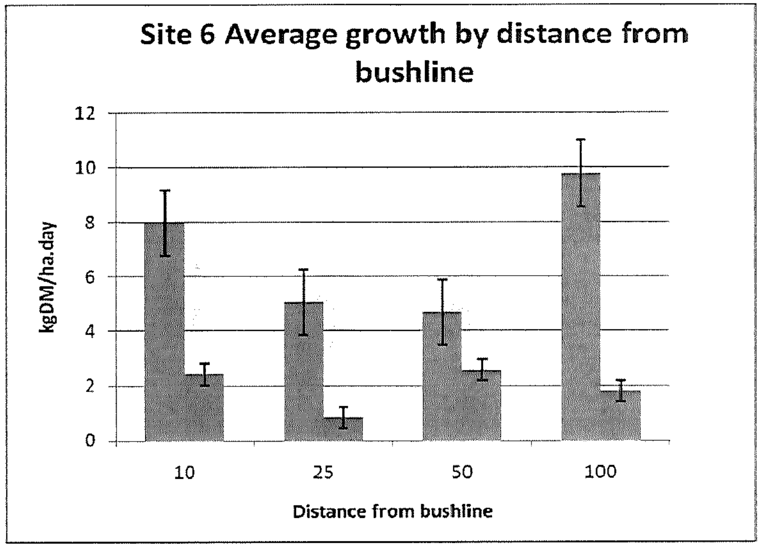

Site 1 Average growth by distance from bushline
kgDM/ha.day
40
35
30
25
20
15
10
5
0
10
25
50
100
Distance from bushline

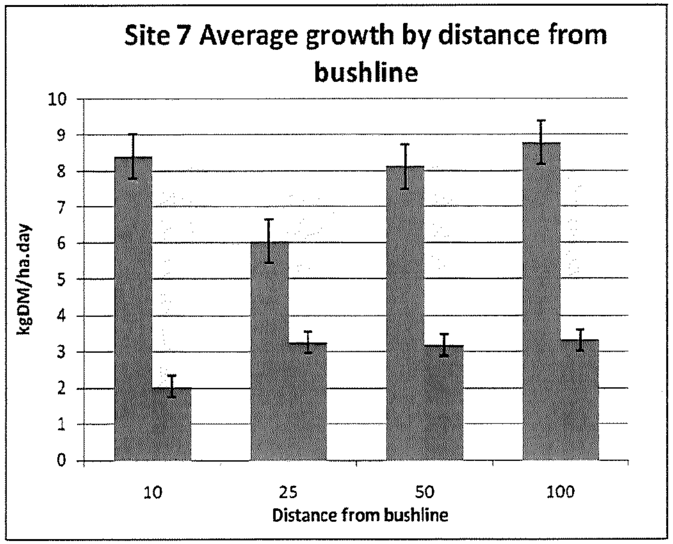

Site 2 Average growth by distance from bushline
kgDM/ha.day
50
45
40
35
30
25
20
15
10
5
0
10
25
50
100
Distance from bushline

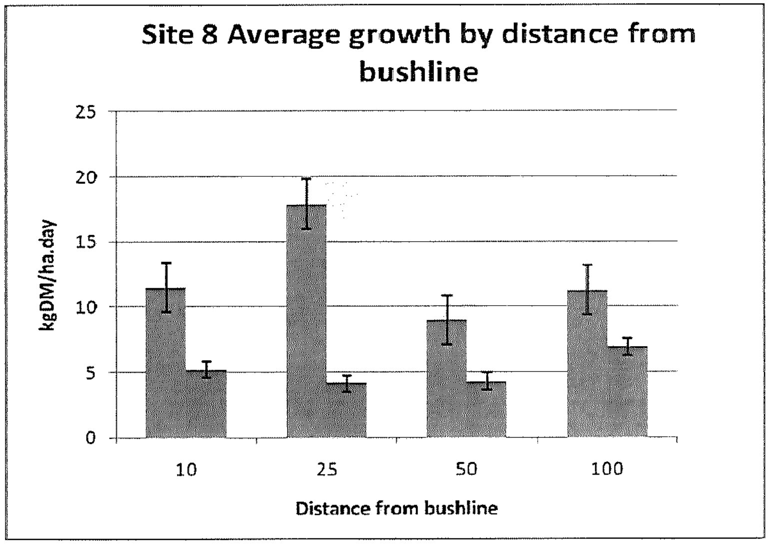

Site 3 Average growth by distance from bushline
kgDM/ha.day
25
20
15
10
5
0
10
25
50
100
Distance from bushline

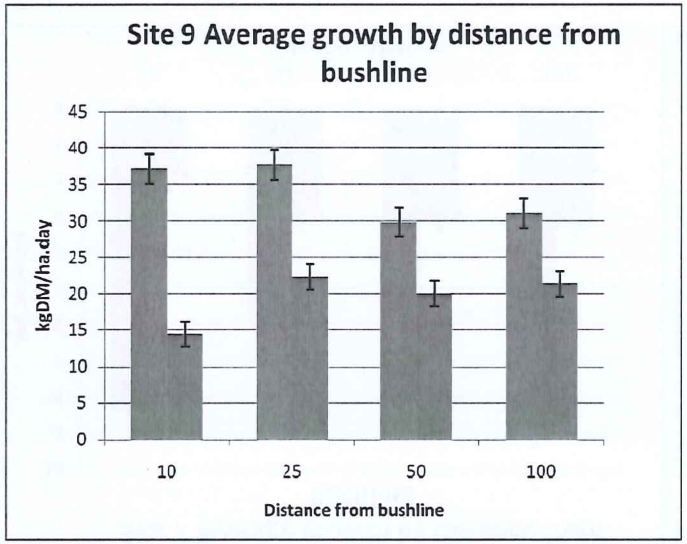

Site 4 Average growth by distance from bushline
kgDM/ha.day
30
25
20
15
10
5
0
10
25
50
100
Distance from bushline

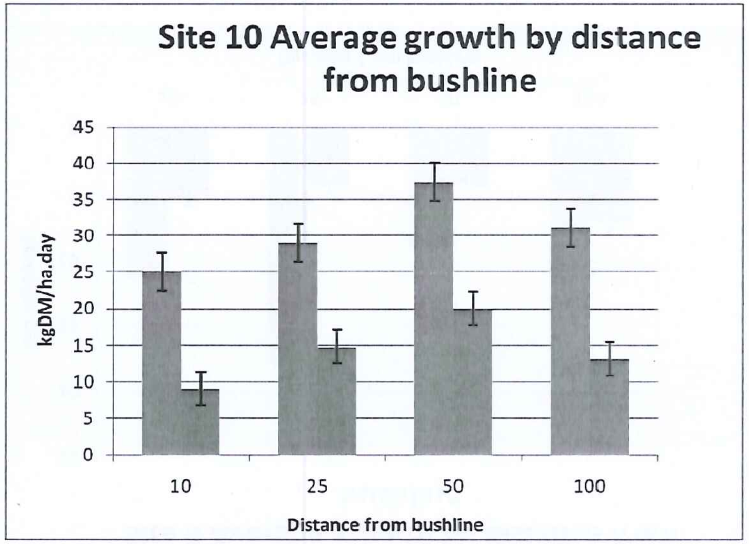

Site 5 Average growth by distance from bushline
kgDM/ha.day
35
30
25
20
15
10
5
0
10
25
50
100
Distance from bushline

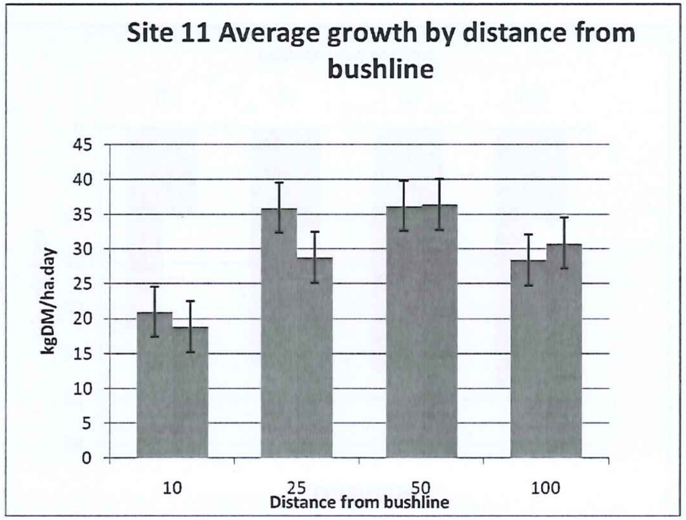

Site 6 Average growth by distance from bushline
kgDM/ha.day
12
10
8
6
4
2
0
10
25
50
100
Distance from bushline

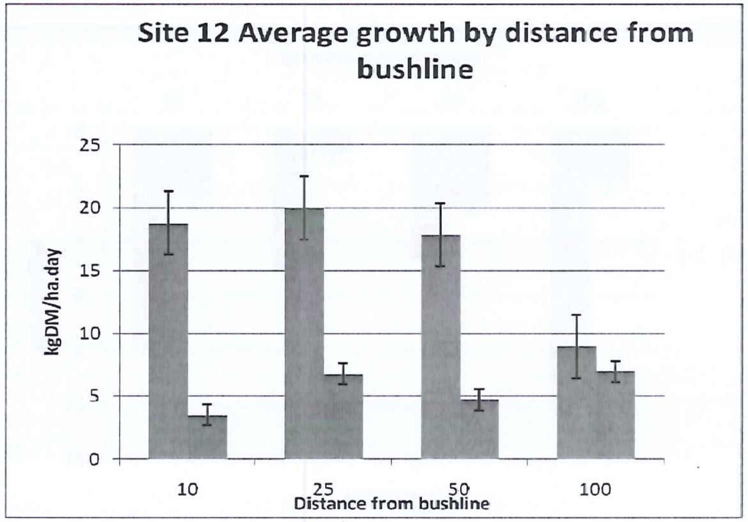

Site 7 Average growth by distance from bushline
kgDM/ha.day
10
9
8
7
6
5
4
3
2
1
0
10
25
50
100
Distance from bushline


Site 8 Average growth by distance from bushline
kgDM/ha.day
25
20
15
10
5
0
10
25
50
100
Distance from bushline

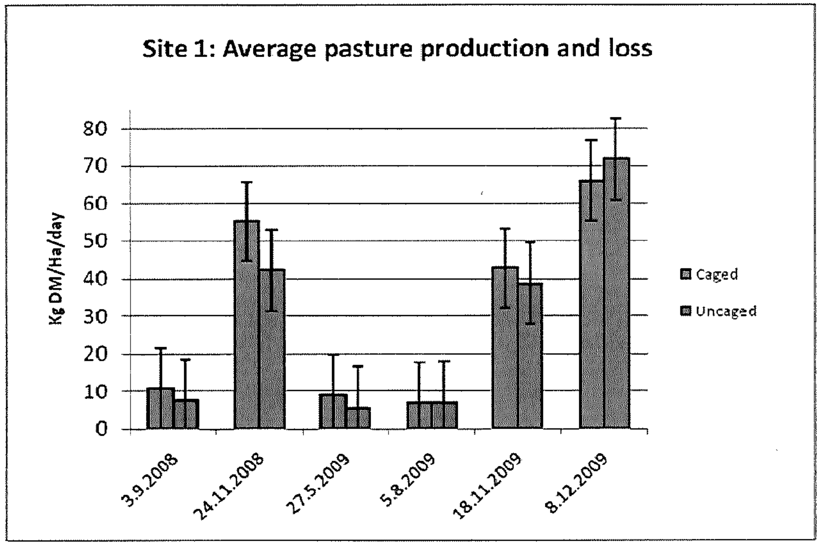

Site 9 Average growth by distance from bushline
kgDM/ha.day
45
40
35
30
25
20
15
10
5
0
10
25
50
100
Distance from bushline

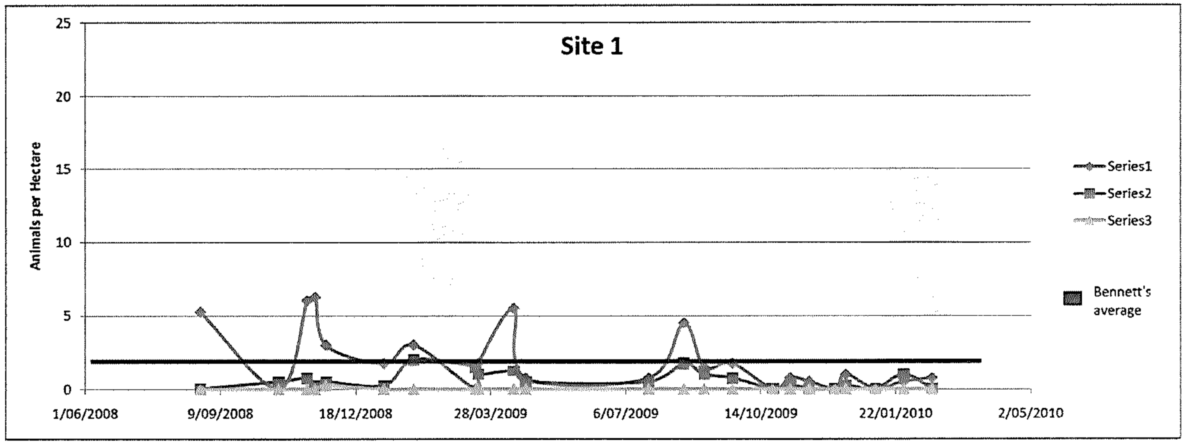

Site 10 Average growth by distance from bushline
kgDM/ha.day
45
40
35
30
25
20
15
10
5
0
10
25
50
100
Distance from bushline

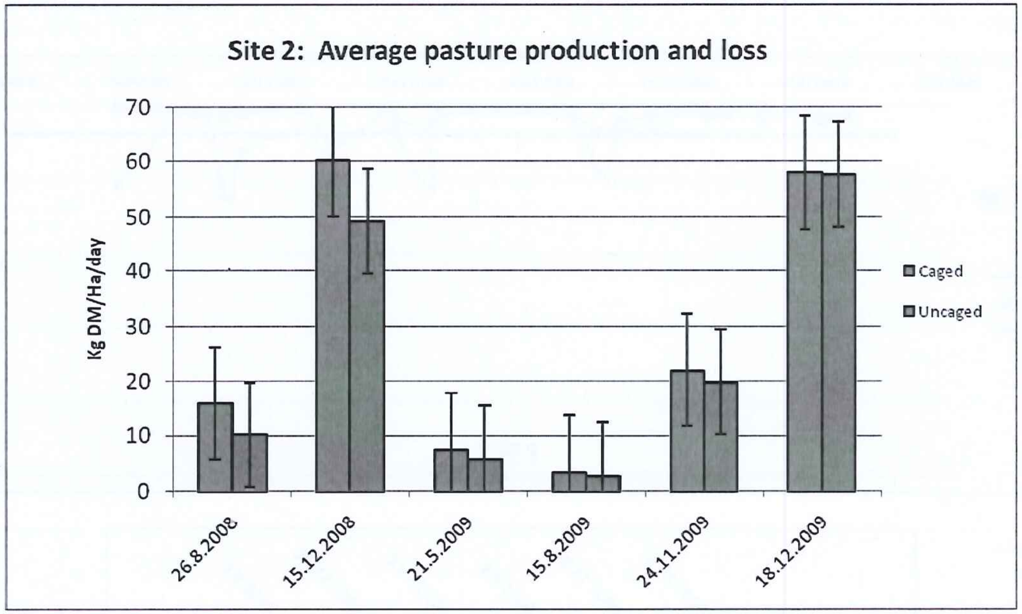

Site 11 Average growth by distance from bushline
kgDM/ha.day
45
40
35
30
25
20
15
10
5
0
10
25
50
100
Distance from bushline

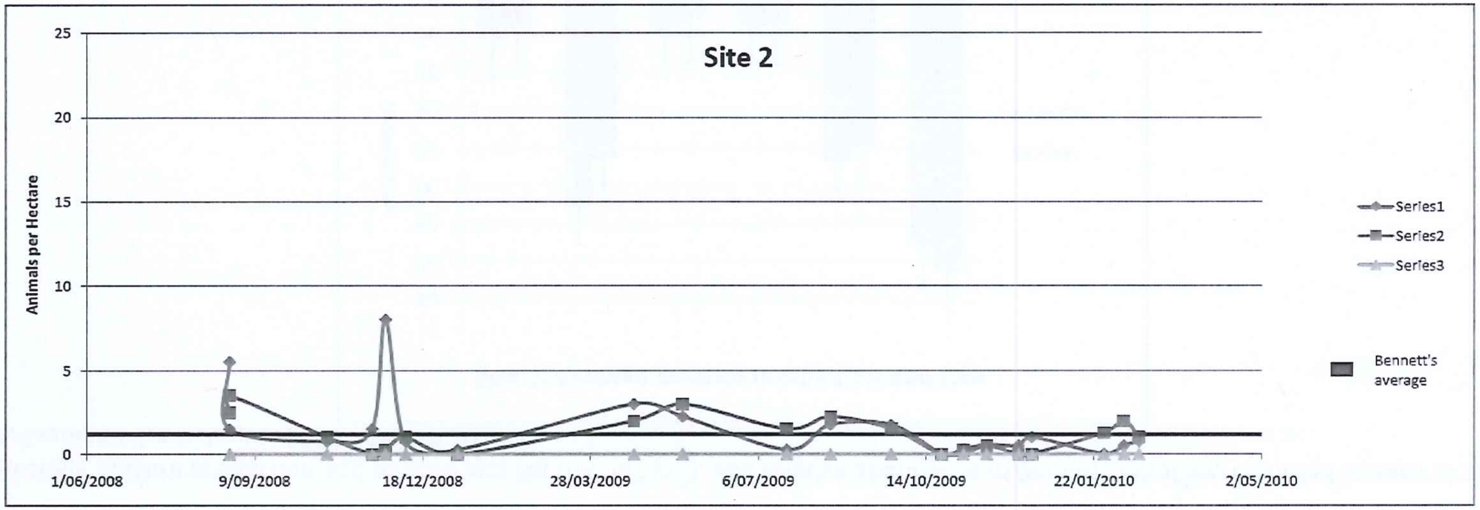

Site 12 Average growth by distance from bushline
kgDM/ha.day
25
20
15
10
5
0
10
25
50
100
Distance from bushline

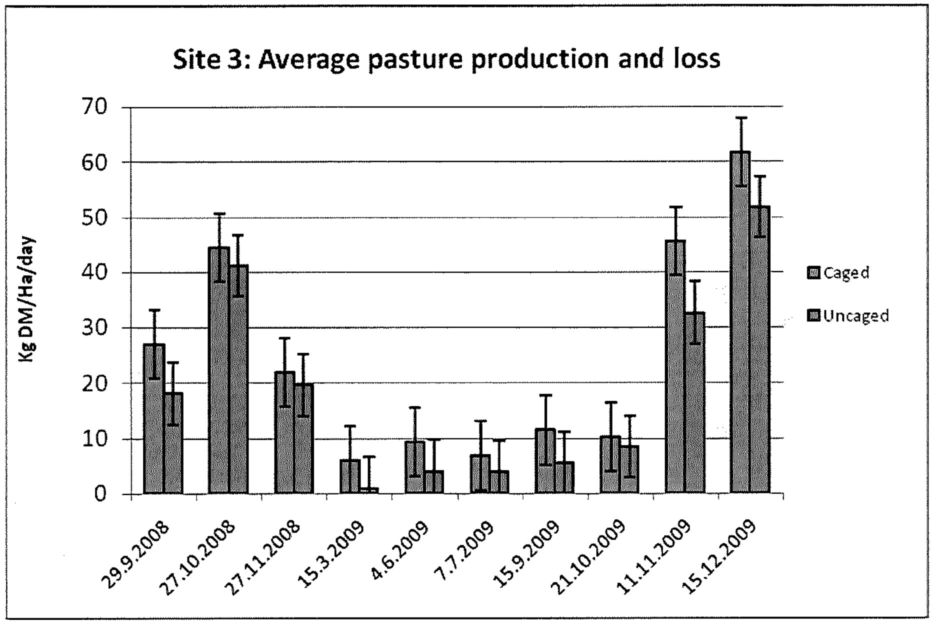
Appendix 2. Average pasture production and pasture loss (kg DM ha^{-1} yr^{-1}), and relative abundance of Bennett's Wallaby recorded at each of 12 field sites on King Island, Tasmania from August 2008 – March 2010.

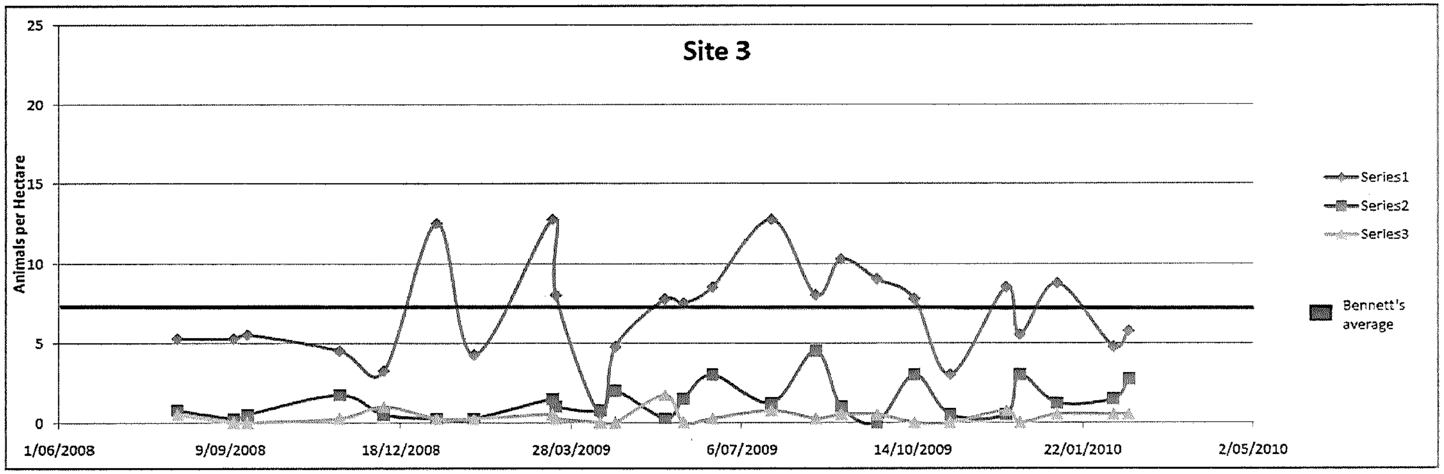


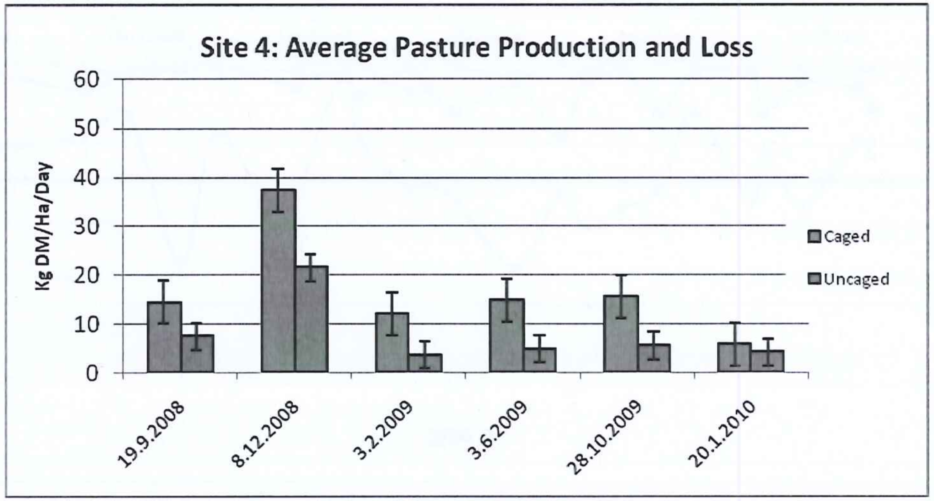


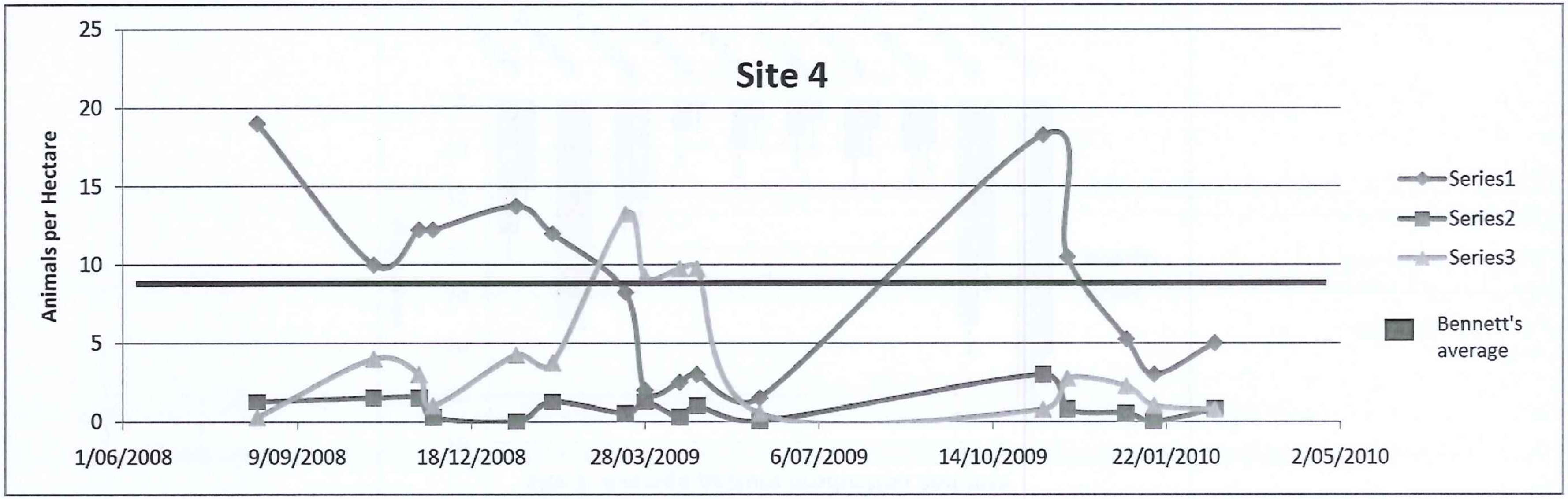

Site 2: Average pasture production and loss
Kg DM/Ha/day
70
60
50
40
30
20
10
0
26.8.2008
15.12.2008
21.5.2009
15.8.2009
24.11.2009
18.12.2009
Caged
Uncaged

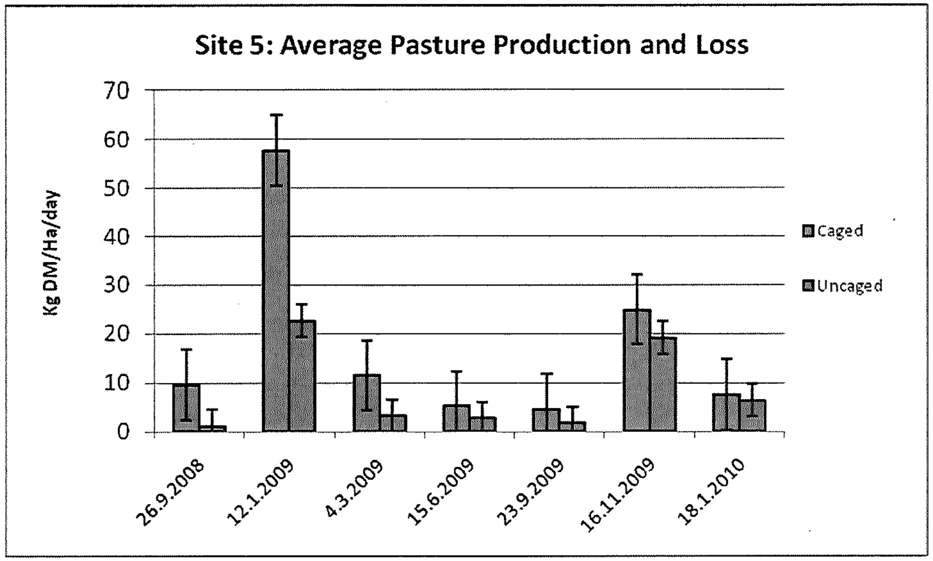

Site 2
Animals per Hectare
25
20
15
10
5
0
1/06/2008
9/09/2008
18/12/2008
28/03/2009
6/07/2009
14/10/2009
22/01/2010
2/05/2010
Series1
Series2
Series3
Bennett's average

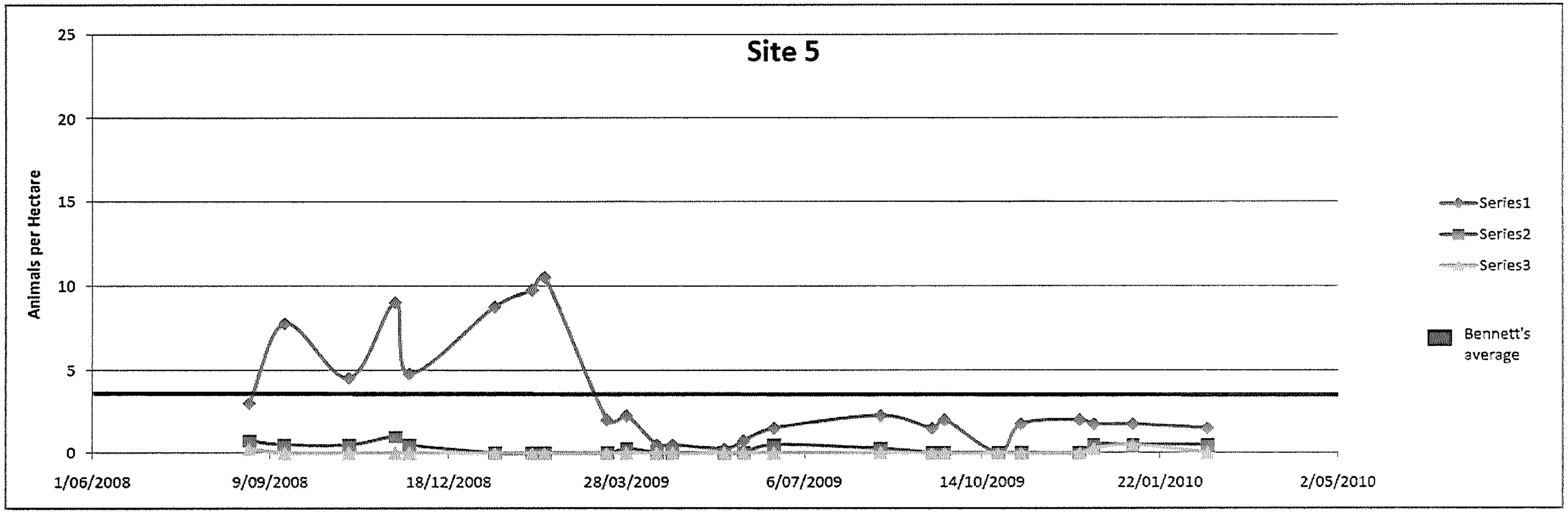

Site 3: Average pasture production and loss
Kg DM/Ha/day
70
60
50
40
30
20
10
0
29.9.2008
27.10.2008
27.11.2008
15.3.2009
4.6.2009
7.7.2009
15.9.2009
21.10.2009
11.11.2009
15.12.2009
Caged
Uncaged

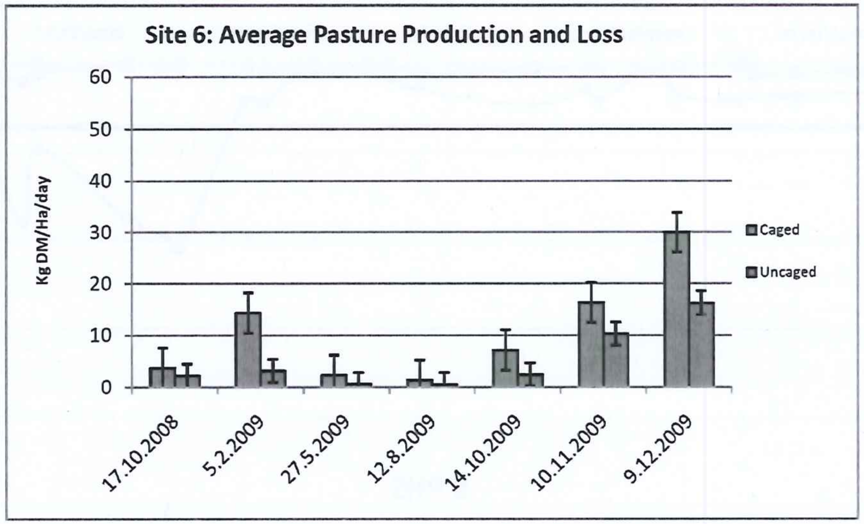

Site 3
Animals per Hectare
25
20
15
10
5
0
1/06/2008
9/09/2008
18/12/2008
28/03/2009
6/07/2009
14/10/2009
22/01/2010
2/05/2010
Series1
Series2
Series3
Bennett's average

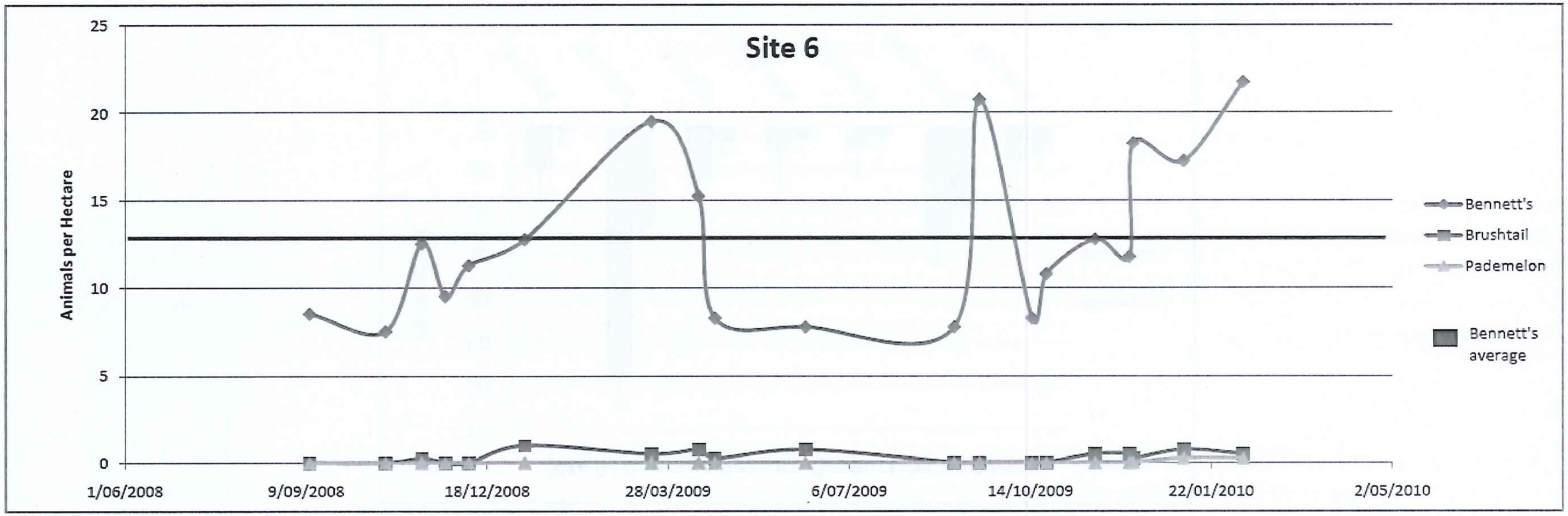

Site 4: Average Pasture Production and Loss
Kg DM/Ha/Day
60
50
40
30
20
10
0
19.9.2008
8.12.2008
3.2.2009
3.6.2009
28.10.2009
20.1.2010
Caged
Uncaged

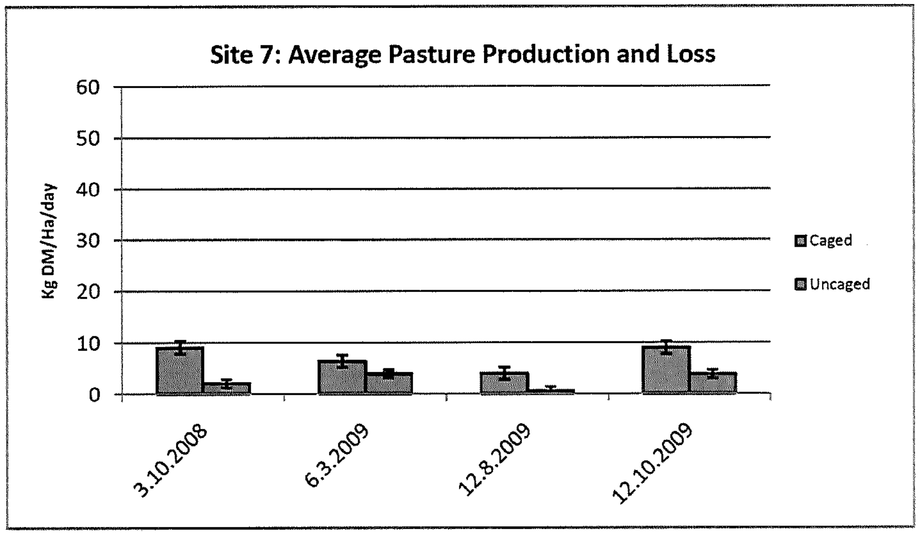

Site 4
Animals per Hectare
25
20
15
10
5
0
1/06/2008
9/09/2008
18/12/2008
28/03/2009
6/07/2009
14/10/2009
22/01/2010
2/05/2010
Series1
Series2
Series3
Bennett's average

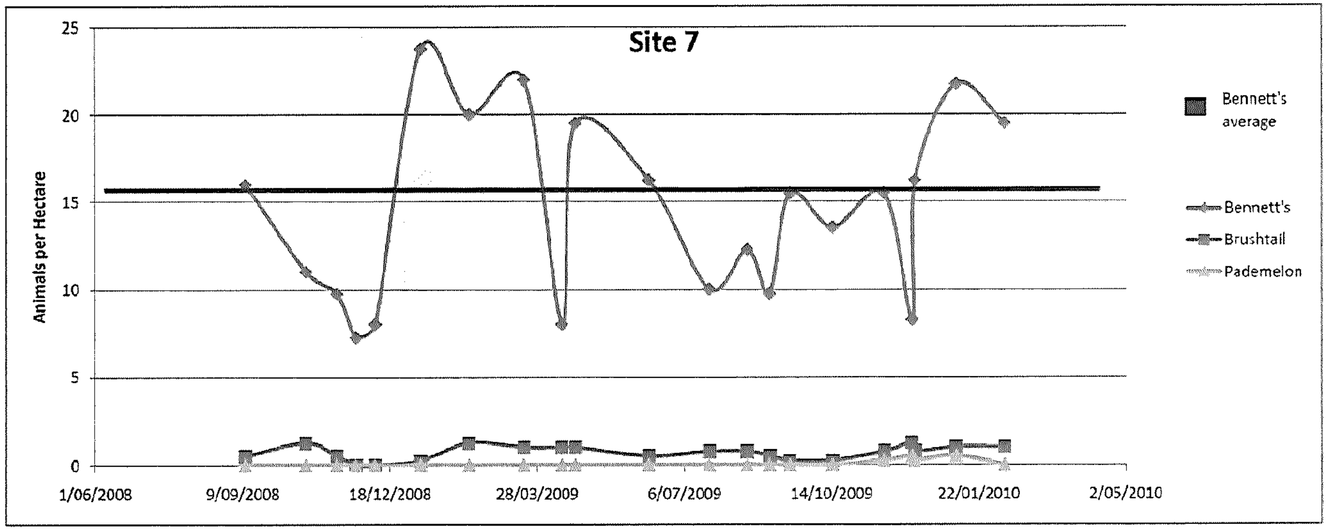

Site 5: Average Pasture Production and Loss
Kg DM/Ha/day
70
60
50
40
30
20
10
0
26.9.2008
12.1.2009
4.3.2009
15.6.2009
23.9.2009
16.11.2009
18.1.2010
Caged
Uncaged

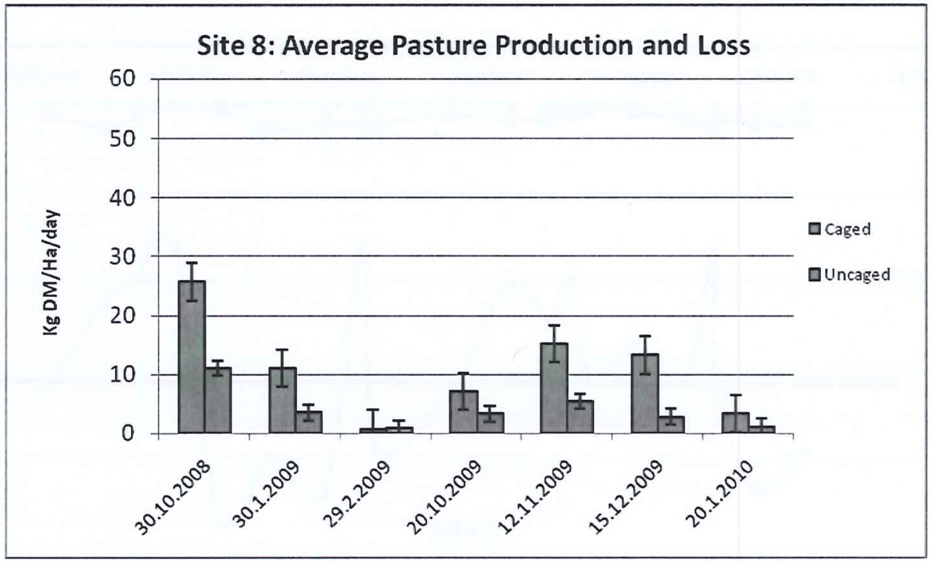

Site 5
Animals per Hectare
25
20
15
10
5
0
1/06/2008
9/09/2008
18/12/2008
28/03/2009
6/07/2009
14/10/2009
22/01/2010
2/05/2010
Series1
Series2
Series3
Bennett's average

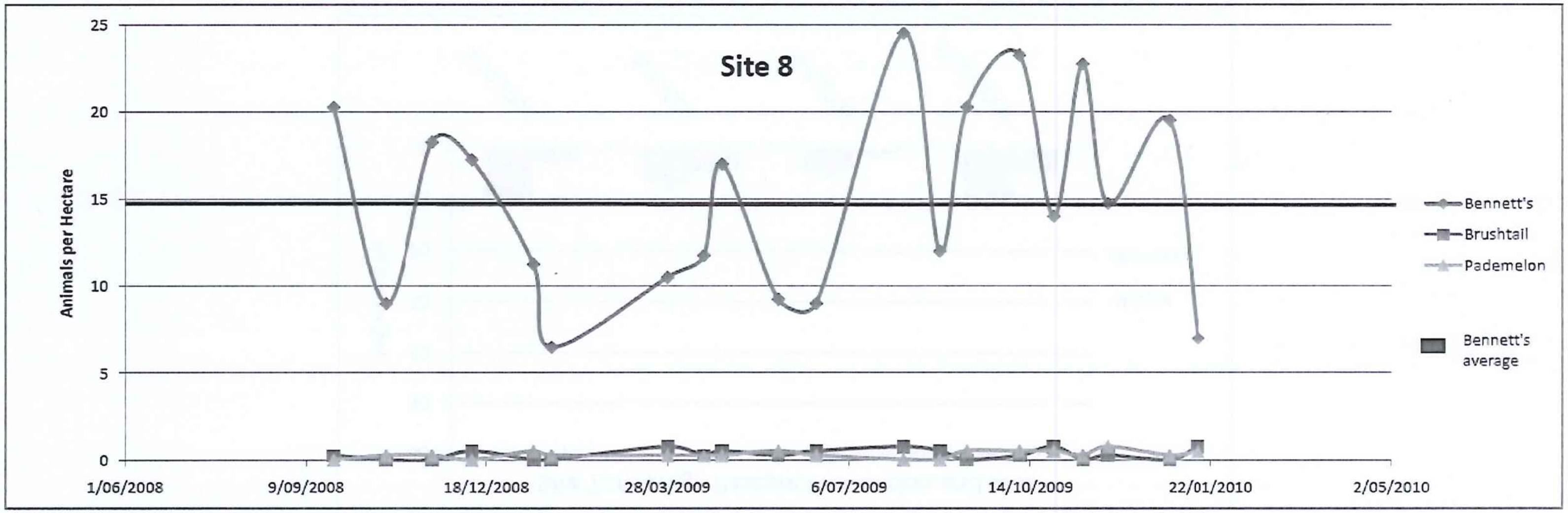

Site 6: Average Pasture Production and Loss
Kg DM/Ha/day
60
50
40
30
20
10
0
17.10.2008
5.2.2009
27.5.2009
12.8.2009
14.10.2009
10.11.2009
9.12.2009
Caged
Uncaged

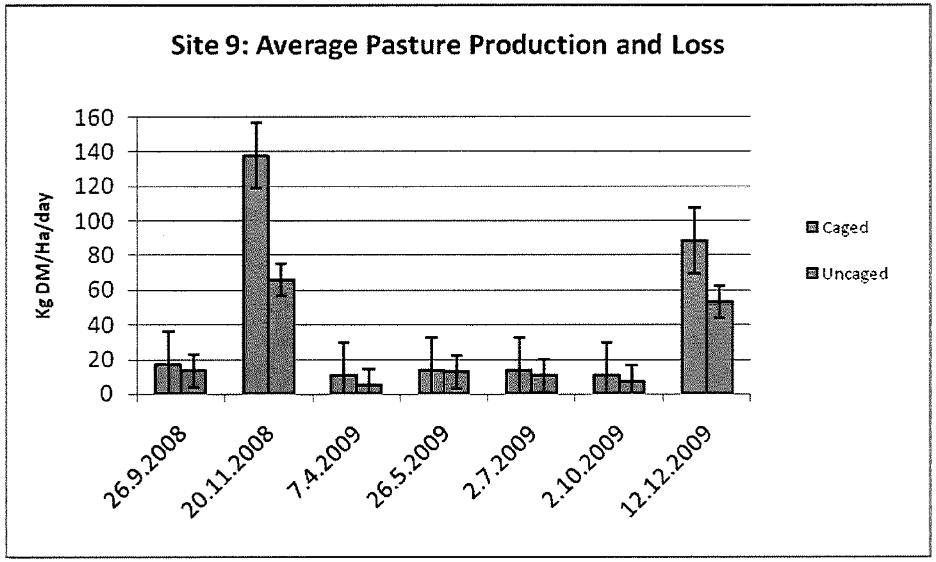

Site 6
Animals per Hectare
25
20
15
10
5
0
1/06/2008
9/09/2008
18/12/2008
28/03/2009
6/07/2009
14/10/2009
22/01/2010
2/05/2010
Bennett's
Brushtail
Pademelon
Bennett's average

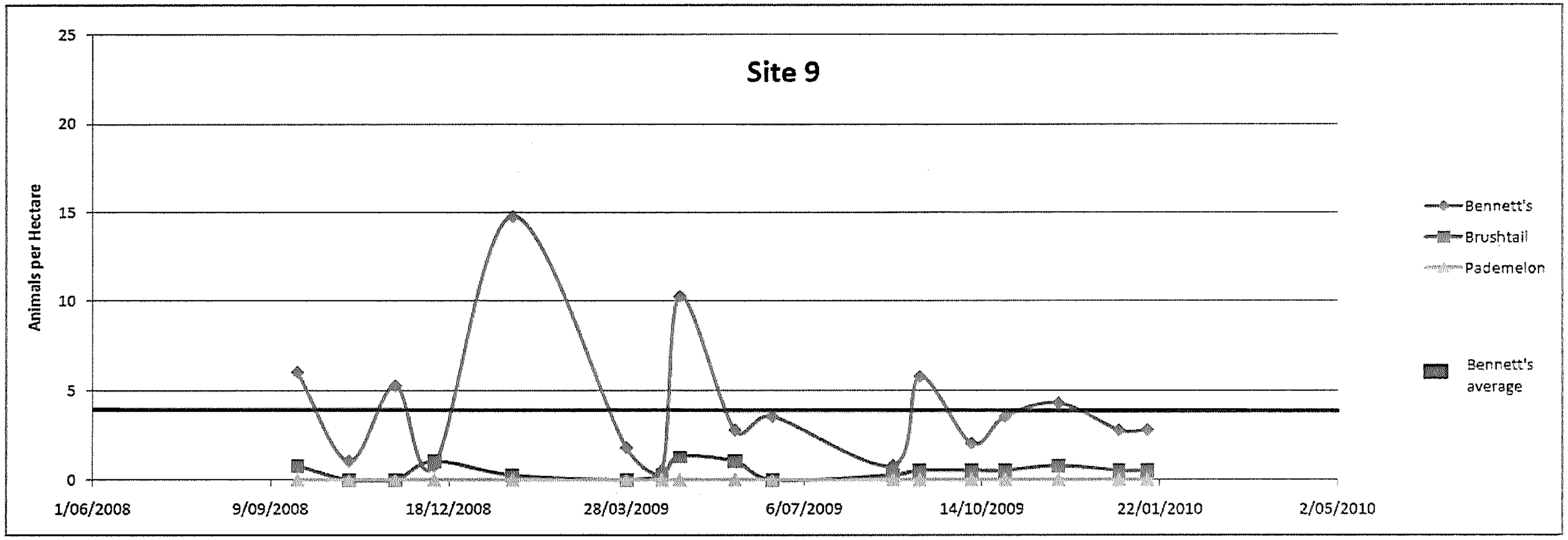

Site 7: Average Pasture Production and Loss
Kg DM/Ha/day
60
50
40
30
20
10
0
3.10.2008
6.3.2009
12.8.2009
12.10.2009
Caged
Uncaged

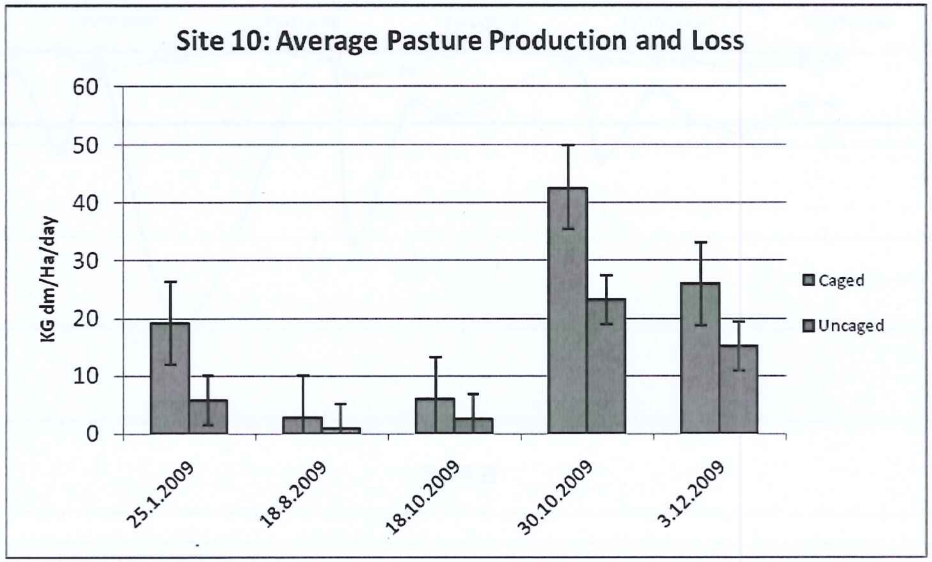

Site 7
Animals per Hectare
25
20
15
10
5
0
1/06/2008
9/09/2008
18/12/2008
28/03/2009
6/07/2009
14/10/2009
22/01/2010
2/05/2010
Bennett's average
Bennett's
Brushtail
Pademelon

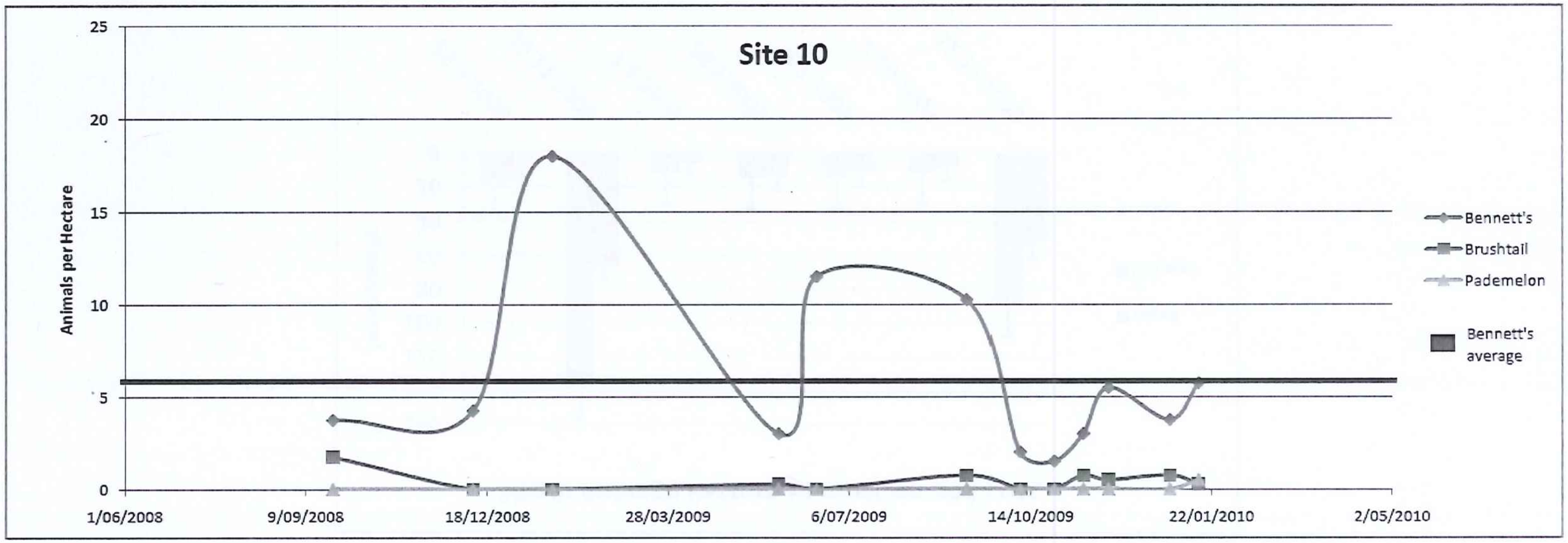

Site 8: Average Pasture Production and Loss
Kg DM/Ha/day
60
50
40
30
20
10
0
30.10.2008
30.1.2009
29.2.2009
20.10.2009
12.11.2009
15.12.2009
20.1.2010
Caged
Uncaged

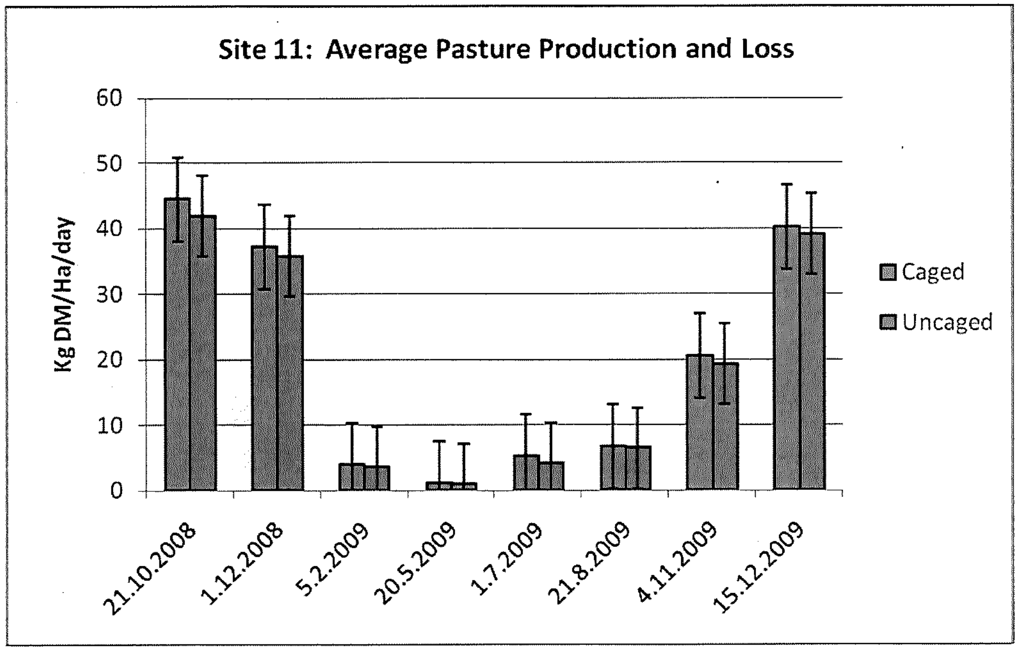

Site 8
Animals per Hectare
25
20
15
10
5
0
1/06/2008
9/09/2008
18/12/2008
28/03/2009
6/07/2009
14/10/2009
22/01/2010
2/05/2010
Bennett's
Brushtail
Pademelon
Bennett's average

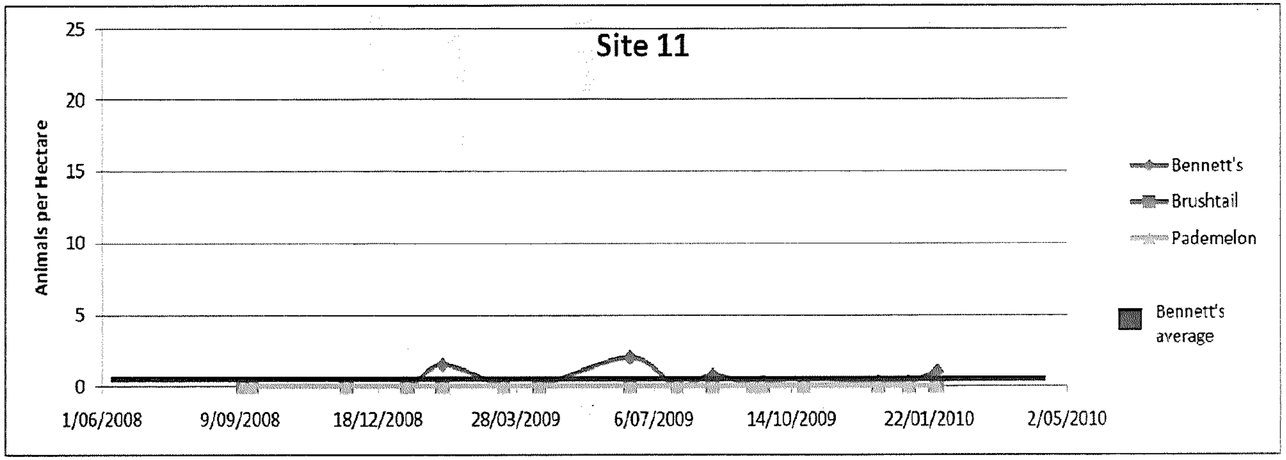

Site 9: Average Pasture Production and Loss
Kg DM/Ha/day
160
140
120
100
80
60
40
20
0
26.9.2008
20.11.2008
7.4.2009
26.5.2009
2.7.2009
2.10.2009
12.12.2009
Caged
Uncaged

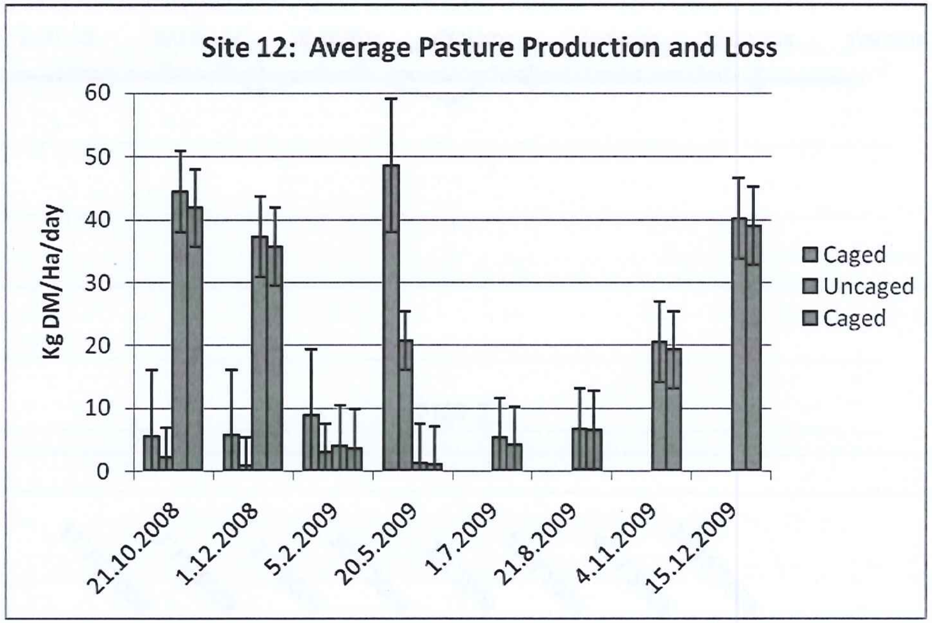

Site 9
Animals per Hectare
25
20
15
10
5
0
1/06/2008
9/09/2008
18/12/2008
28/03/2009
6/07/2009
14/10/2009
22/01/2010
2/05/2010
Bennett's
Brushtail
Pademelon
Bennett's average

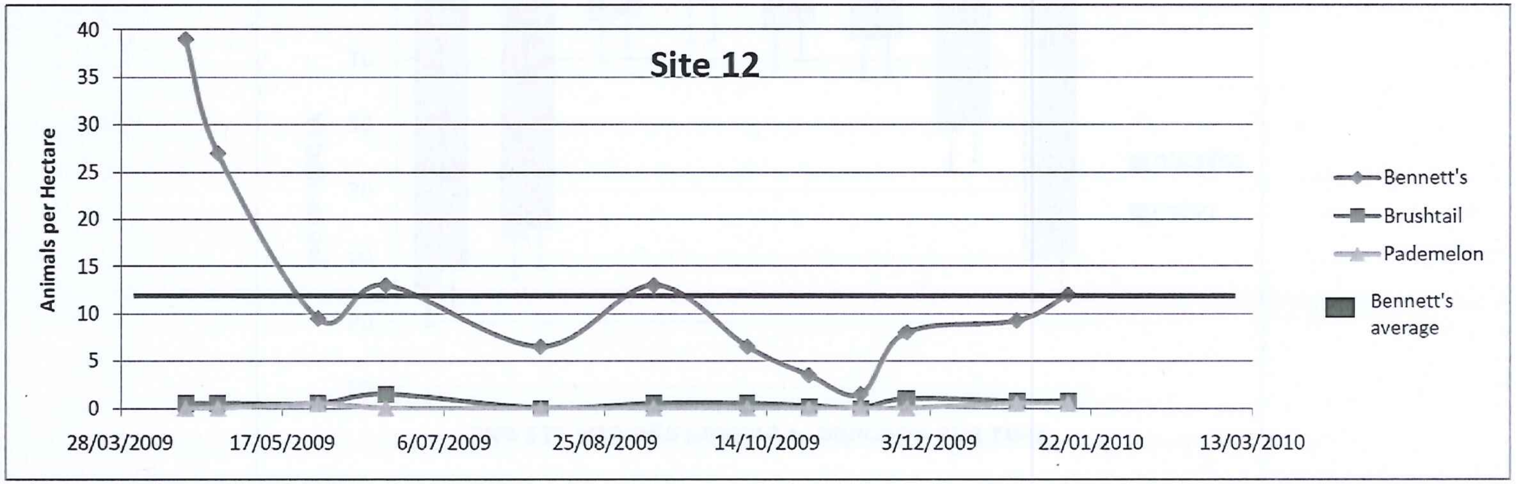

Site 10: Average Pasture Production and Loss
KG dm/Ha/day
0
10
20
30
40
50
60
25.1.2009
18.8.2009
18.10.2009
30.10.2009
3.12.2009
Caged
Uncaged


Site 10
Animals per Hectare
0
5
10
15
20
25
1/06/2008
9/09/2008
18/12/2008
28/03/2009
6/07/2009
14/10/2009
22/01/2010
2/05/2010
Bennett's
Brushtail
Pademelon
Bennett's average

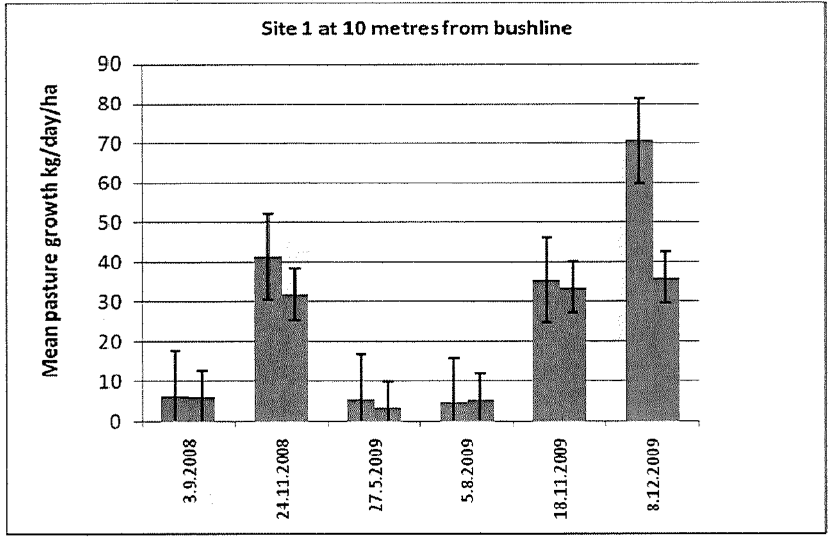

Site 11: Average Pasture Production and Loss
Kg DM/Ha/day
60
50
40
30
20
10
0
21.10.2008
1.12.2008
5.2.2009
20.5.2009
1.7.2009
21.8.2009
4.11.2009
15.12.2009
Caged
Uncaged

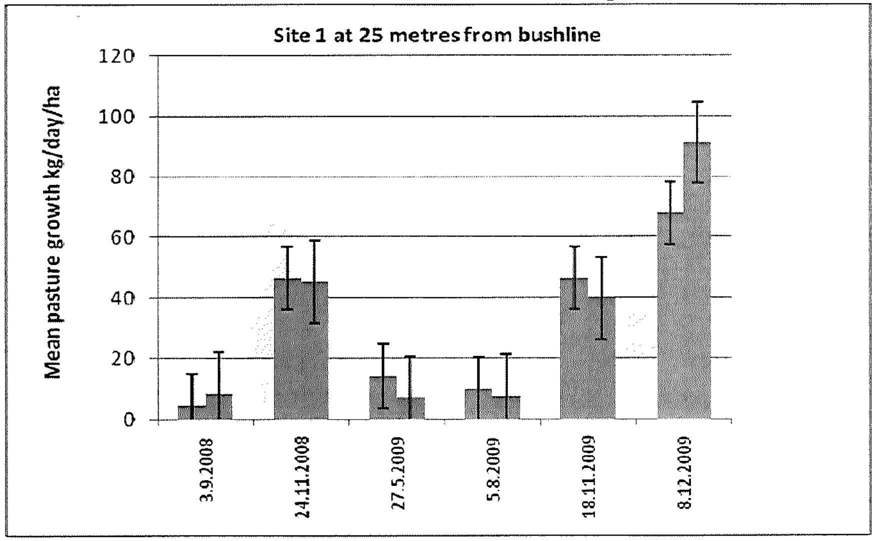

Site 11
Animals per Hectare
25
20
15
10
5
0
1/06/2008
9/09/2008
18/12/2008
28/03/2009
6/07/2009
14/10/2009
22/01/2010
2/05/2010
Bennett's
Brushtail
Pademelon
Bennett's average

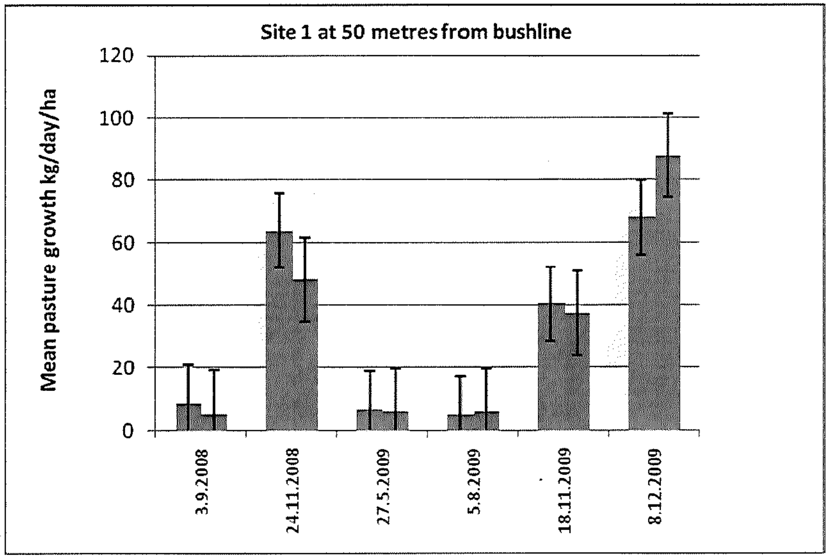

Site 12: Average Pasture Production and Loss
Kg DM/Ha/day
60
50
40
30
20
10
0
21.10.2008
1.12.2008
5.2.2009
20.5.2009
1.7.2009
21.8.2009
4.11.2009
15.12.2009
Caged
Uncaged
Caged

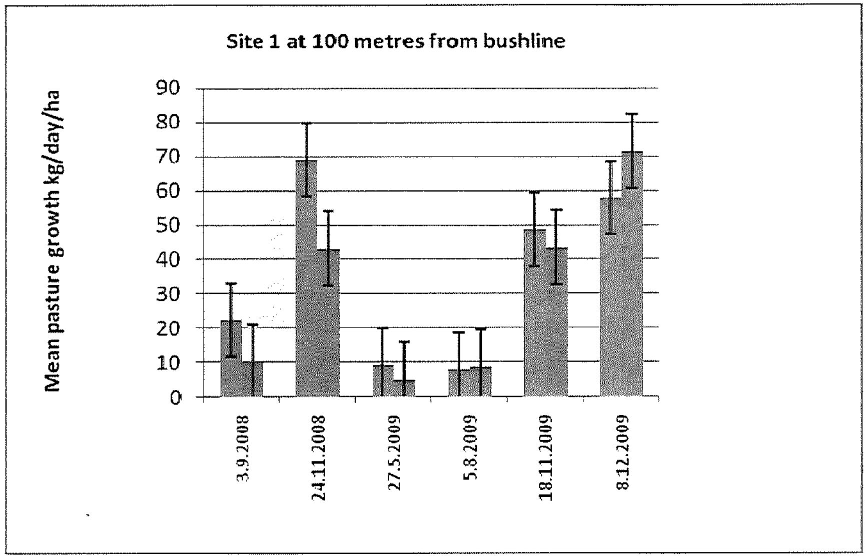

Site 12
Animals per Hectare
40
35
30
25
20
15
10
5
0
28/03/2009
17/05/2009
6/07/2009
25/08/2009
14/10/2009
3/12/2009
22/01/2010
13/03/2010
Bennett's
Brushtail
Pademelon
Bennett's average

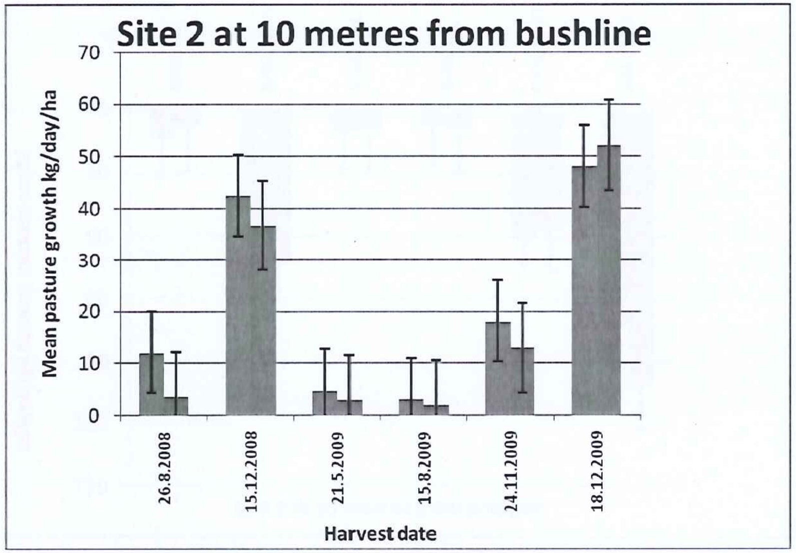
Appendix 3. Pasture production (blue) and pasture loss (red) (kg DM ha^{-1} day^{-1}) with distance from bush-line for 12 field sites on King Island, Tasmania.

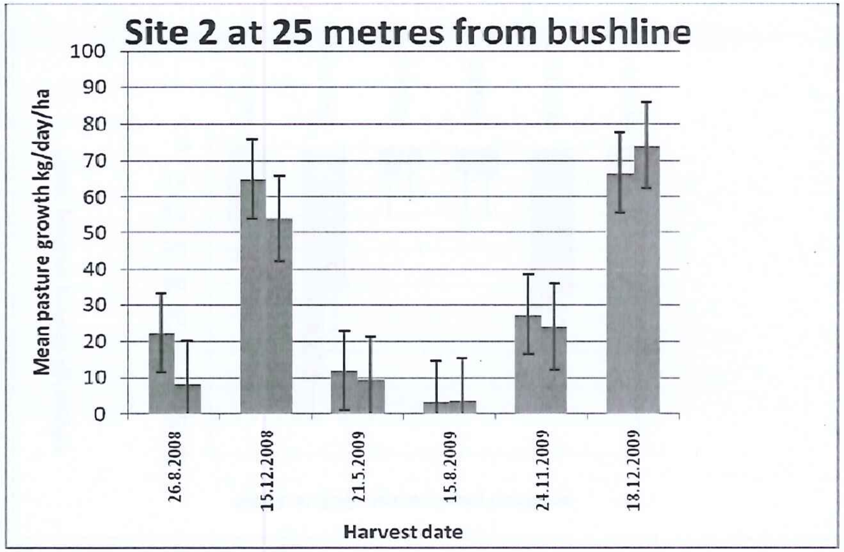


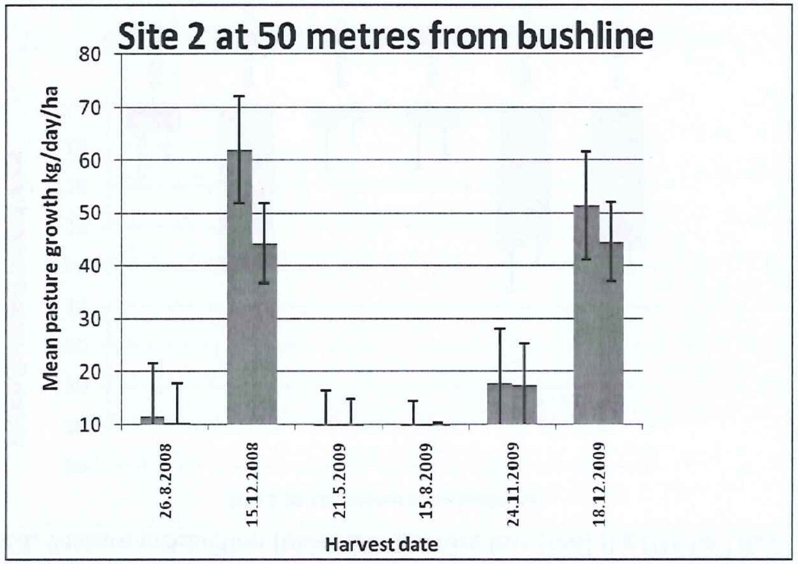


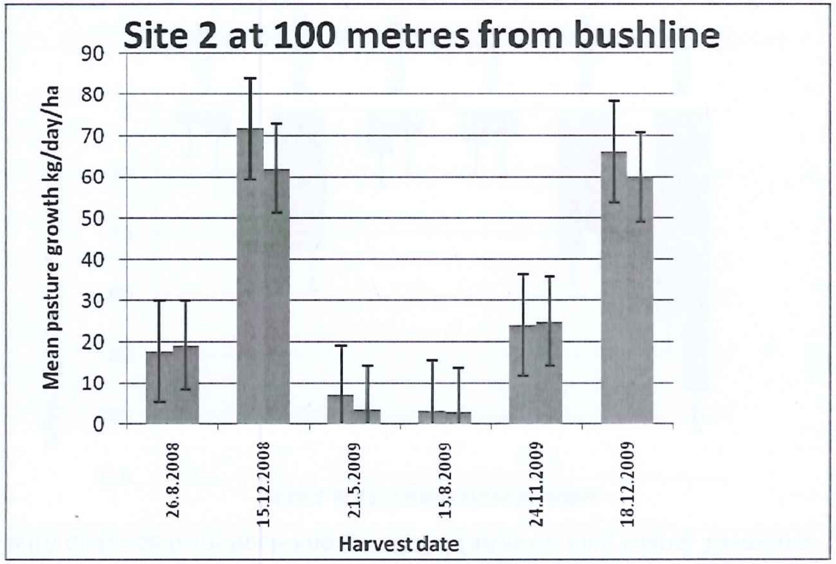


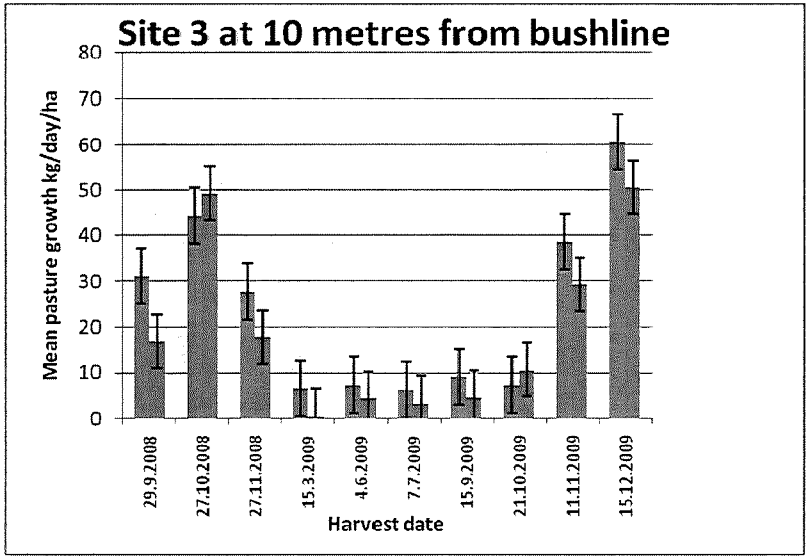


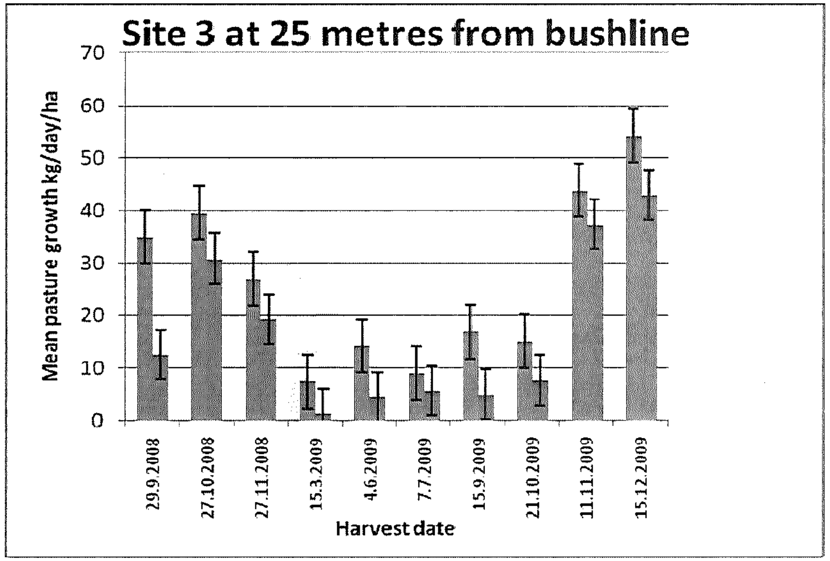

Site 2 at 10 metres from bushline
Mean pasture growth kg/day/ha
0
10
20
30
40
50
60
70
26.8.2008
15.12.2008
21.5.2009
15.8.2009
24.11.2009
18.12.2009
Harvest date

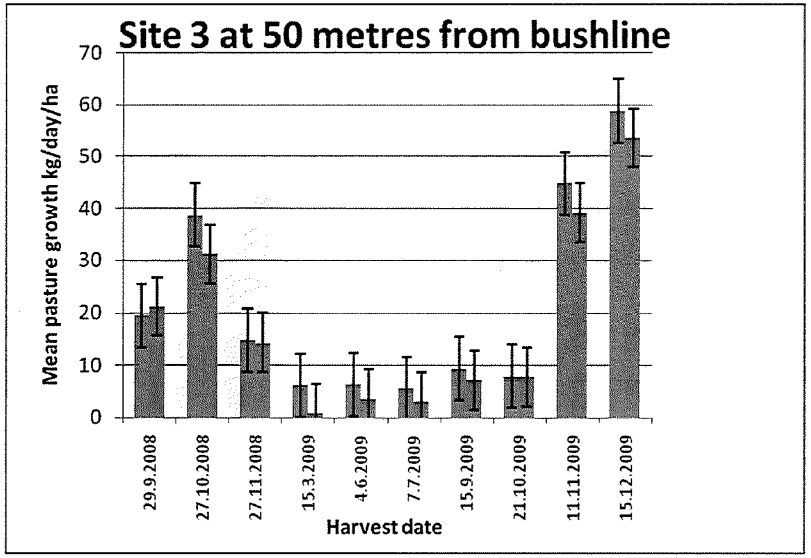

Site 2 at 25 metres from bushline
Mean pasture growth kg/day/ha
0
10
20
30
40
50
60
70
80
90
100
26.8.2008
15.12.2008
21.5.2009
15.8.2009
24.11.2009
18.12.2009
Harvest date

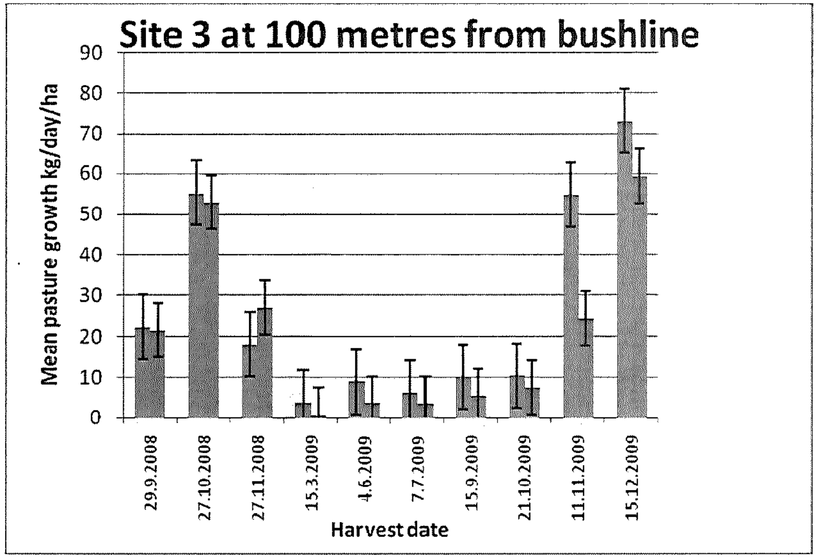

Site 2 at 50 metres from bushline
Mean pasture growth kg/day/ha
10
20
30
40
50
60
70
80
26.8.2008
15.12.2008
21.5.2009
15.8.2009
24.11.2009
18.12.2009
Harvest date

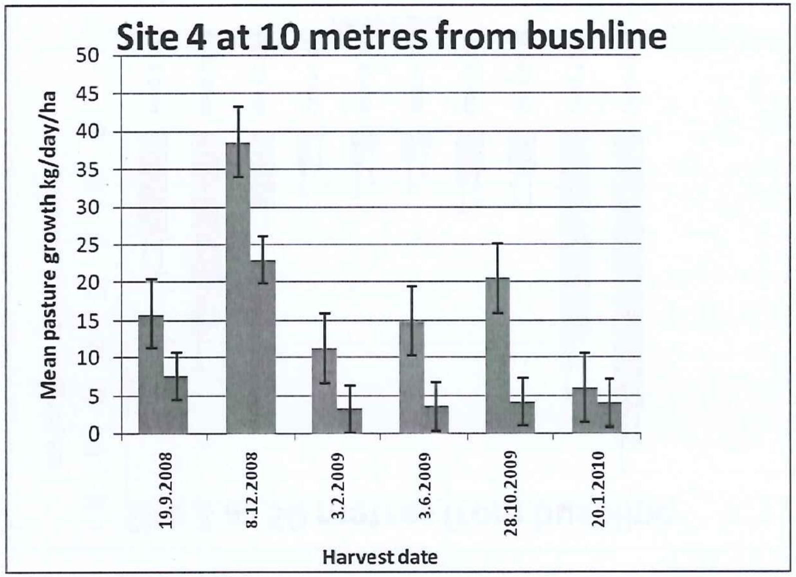

Site 2 at 100 metres from bushline
Mean pasture growth kg/day/ha
0
10
20
30
40
50
60
70
80
90
26.8.2008
15.12.2008
21.5.2009
15.8.2009
24.11.2009
18.12.2009
Harvest date

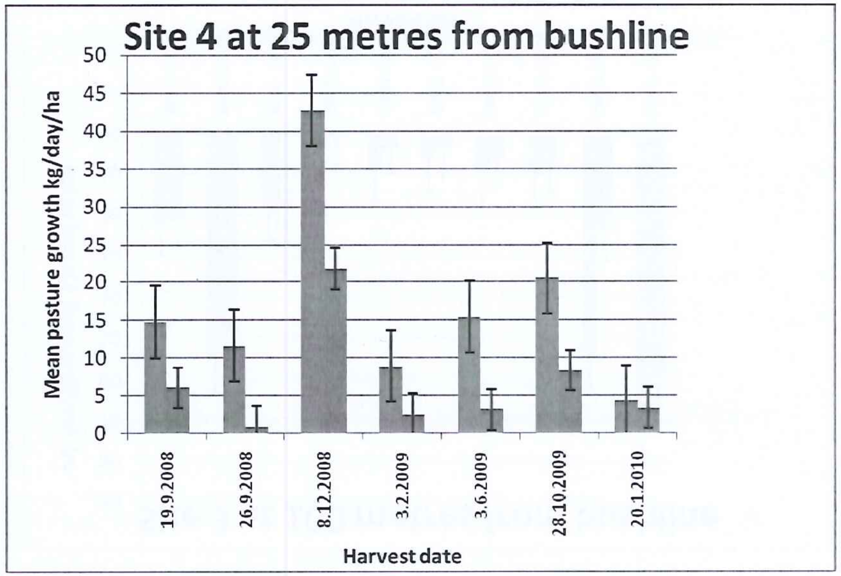

Site 3 at 10 metres from bushline
Mean pasture growth kg/day/ha
80
70
60
50
40
30
20
10
0
29.9.2008
27.10.2008
27.11.2008
15.3.2009
4.6.2009
7.7.2009
15.9.2009
21.10.2009
11.11.2009
15.12.2009
Harvest date

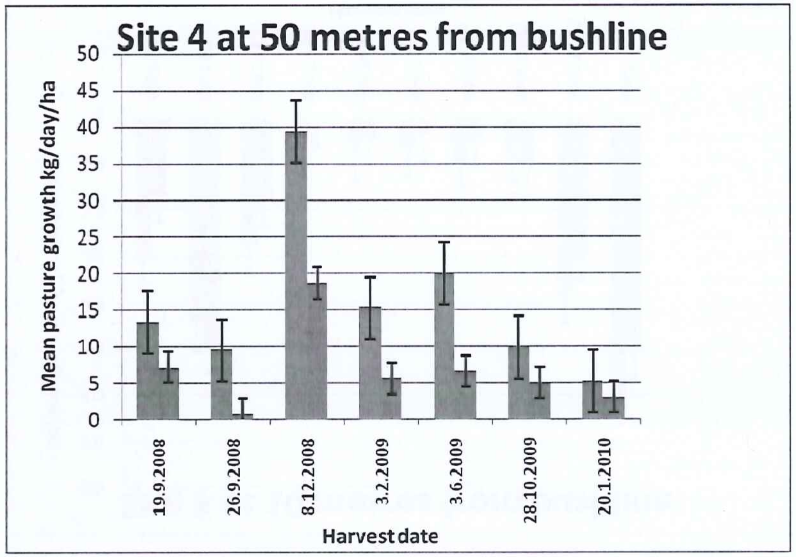

Site 3 at 25 metres from bushline
Mean pasture growth kg/day/ha
70
60
50
40
30
20
10
0
29.9.2008
27.10.2008
27.11.2008
15.3.2009
4.6.2009
7.7.2009
15.9.2009
21.10.2009
11.11.2009
15.12.2009
Harvest date

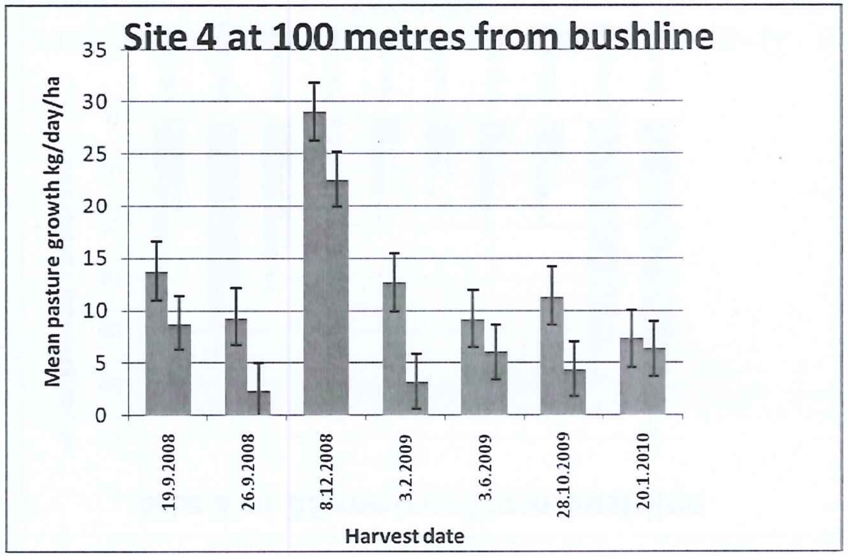

Site 3 at 50 metres from bushline
Mean pasture growth kg/day/ha
70
60
50
40
30
20
10
0
29.9.2008
27.10.2008
27.11.2008
15.3.2009
4.6.2009
7.7.2009
15.9.2009
21.10.2009
11.11.2009
15.12.2009
Harvest date

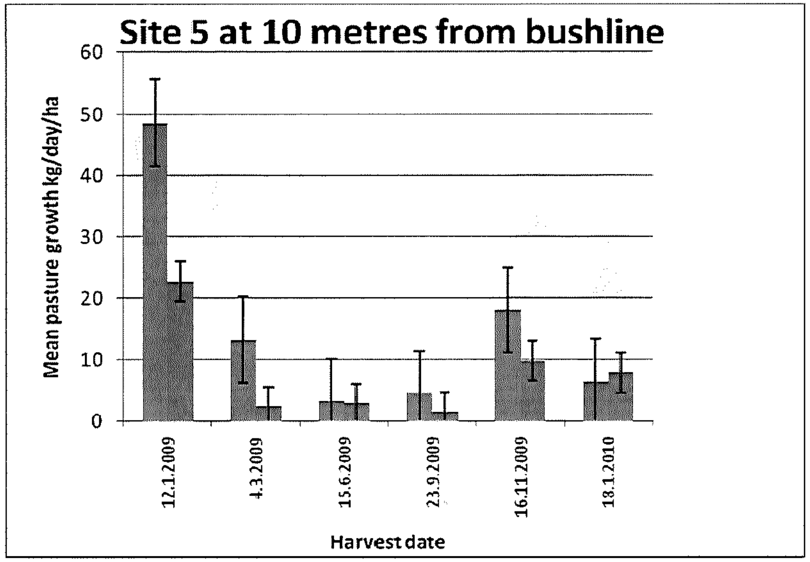

Site 3 at 100 metres from bushline
Mean pasture growth kg/day/ha
90
80
70
60
50
40
30
20
10
0
29.9.2008
27.10.2008
27.11.2008
15.3.2009
4.6.2009
7.7.2009
15.9.2009
21.10.2009
11.11.2009
15.12.2009
Harvest date

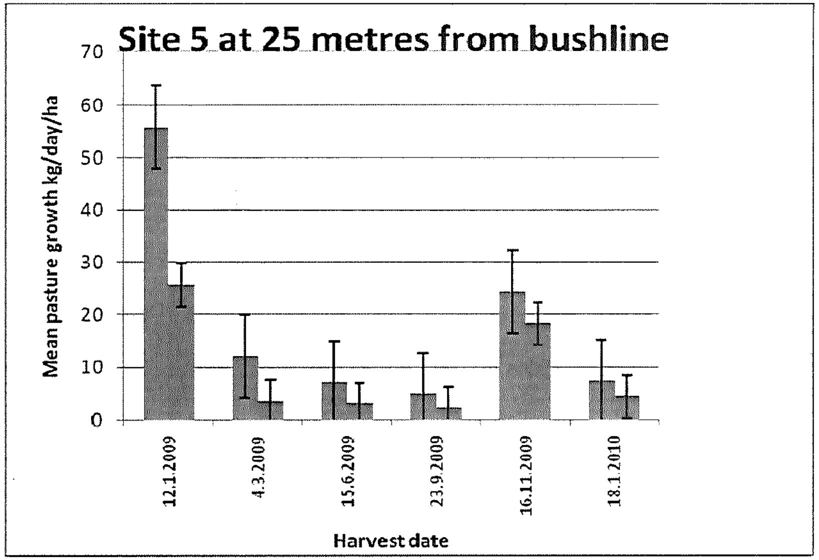

Site 4 at 10 metres from bushline
Mean pasture growth kg/day/ha
0
5
10
15
20
25
30
35
40
45
50
19.9.2008
8.12.2008
3.2.2009
3.6.2009
28.10.2009
20.1.2010
Harvest date

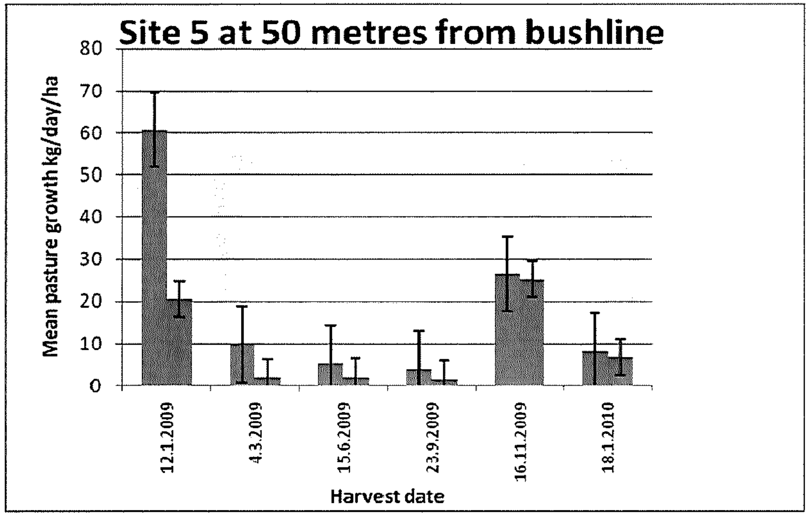

Site 4 at 25 metres from bushline
Mean pasture growth kg/day/ha
0
5
10
15
20
25
30
35
40
45
50
19.9.2008
26.9.2008
8.12.2008
3.2.2009
3.6.2009
28.10.2009
20.1.2010
Harvest date

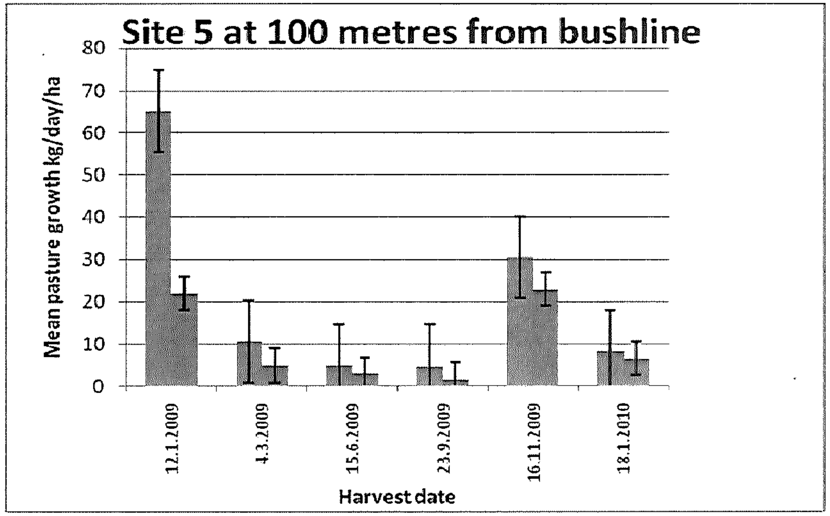

Site 4 at 50 metres from bushline
Mean pasture growth kg/day/ha
0
5
10
15
20
25
30
35
40
45
50
19.9.2008
26.9.2008
8.12.2008
3.2.2009
3.6.2009
28.10.2009
20.1.2010
Harvest date

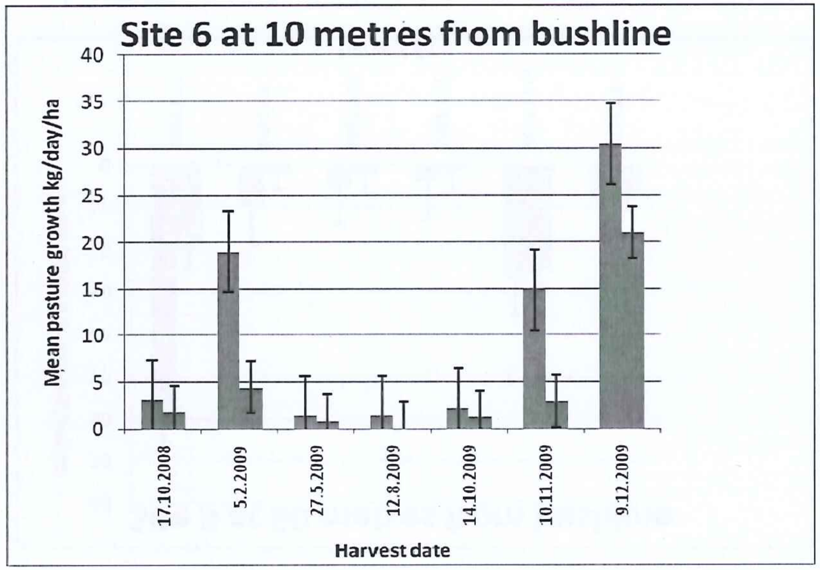

Site 4 at 100 metres from bushline
Mean pasture growth kg/day/ha
0
5
10
15
20
25
30
35
19.9.2008
26.9.2008
8.12.2008
3.2.2009
3.6.2009
28.10.2009
20.1.2010
Harvest date

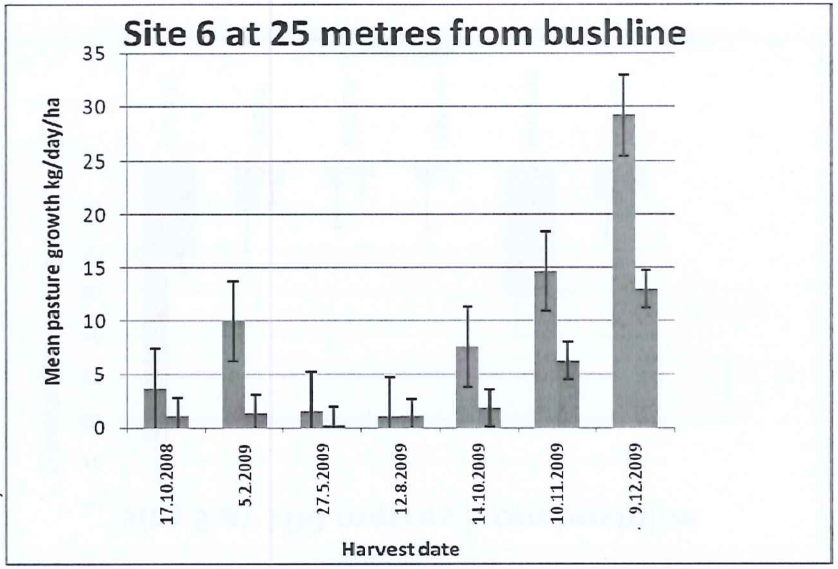

Site 5 at 10 metres from bushline
Mean pasture growth kg/day/ha
60
50
40
30
20
10
0
12.1.2009
4.3.2009
15.6.2009
23.9.2009
16.11.2009
18.1.2010
Harvest date

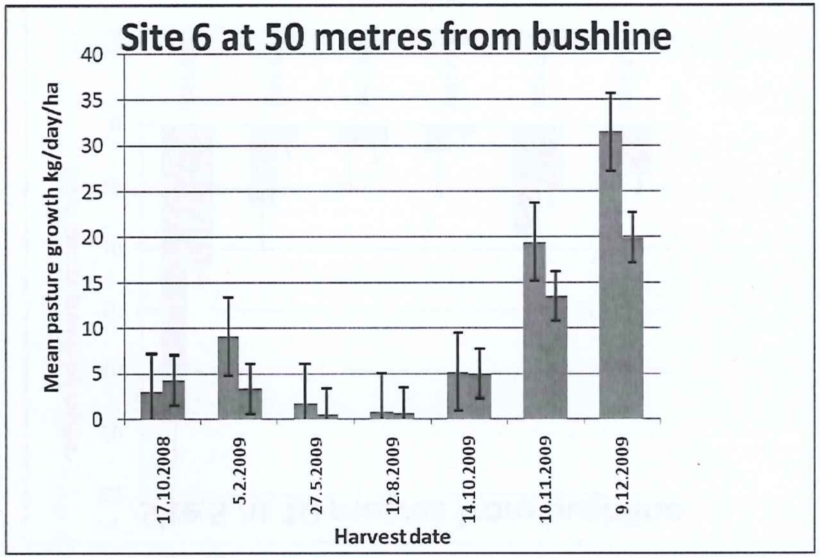

Site 5 at 25 metres from bushline
Mean pasture growth kg/day/ha
70
60
50
40
30
20
10
0
12.1.2009
4.3.2009
15.6.2009
23.9.2009
16.11.2009
18.1.2010
Harvest date

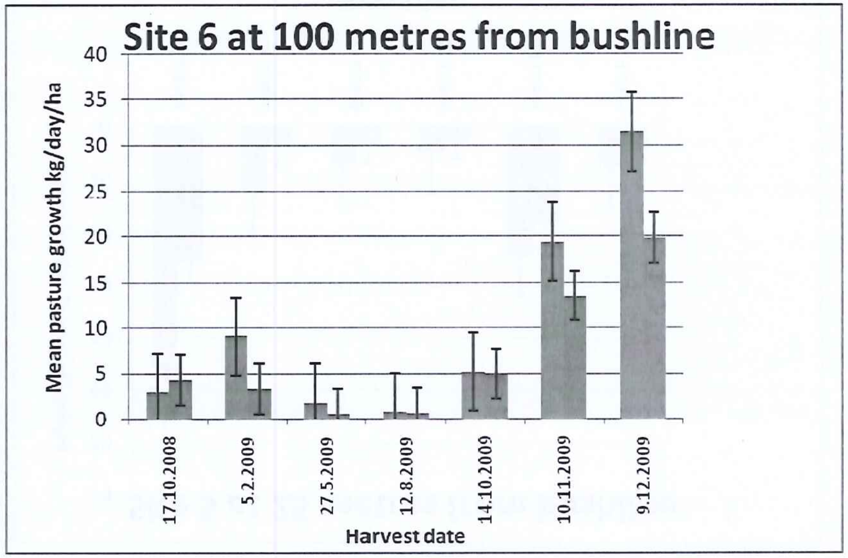

Site 5 at 50 metres from bushline
Mean pasture growth kg/day/ha
80
70
60
50
40
30
20
10
0
12.1.2009
4.3.2009
15.6.2009
23.9.2009
16.11.2009
18.1.2010
Harvest date

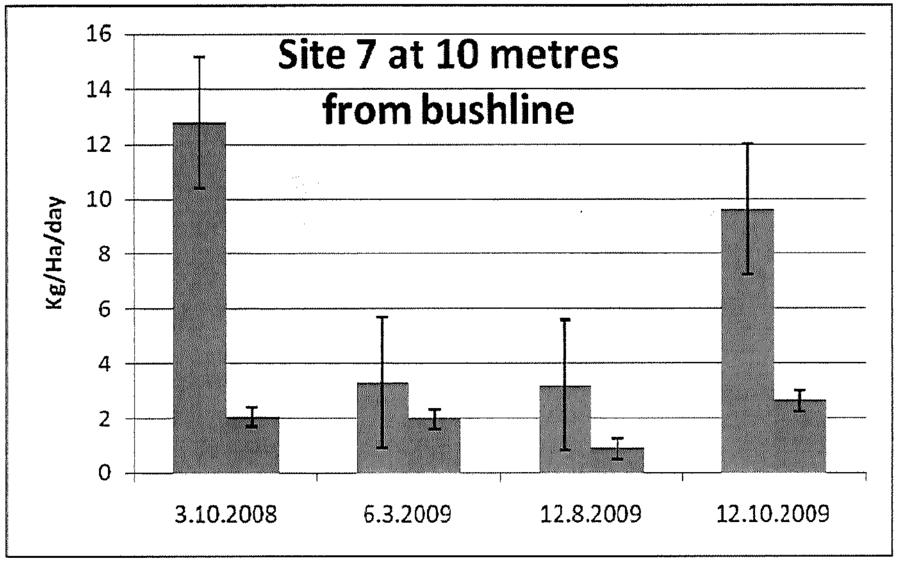

Site 5 at 100 metres from bushline
Mean pasture growth kg/day/ha
80
70
60
50
40
30
20
10
0
12.1.2009
4.3.2009
15.6.2009
23.9.2009
16.11.2009
18.1.2010
Harvest date

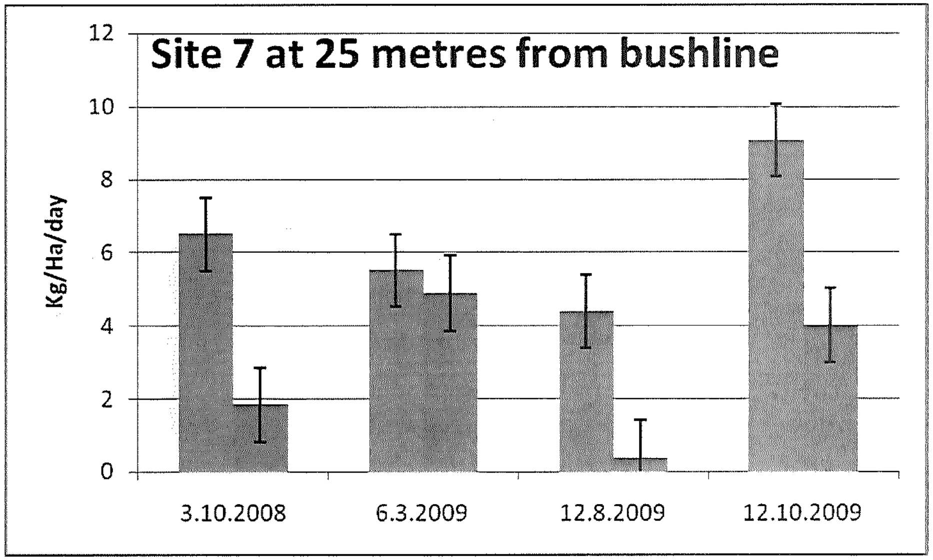

Site 6 at 10 metres from bushline
Mean pasture growth kg/day/ha
40
35
30
25
20
15
10
5
0
17.10.2008
5.2.2009
27.5.2009
12.8.2009
14.10.2009
10.11.2009
9.12.2009
Harvest date

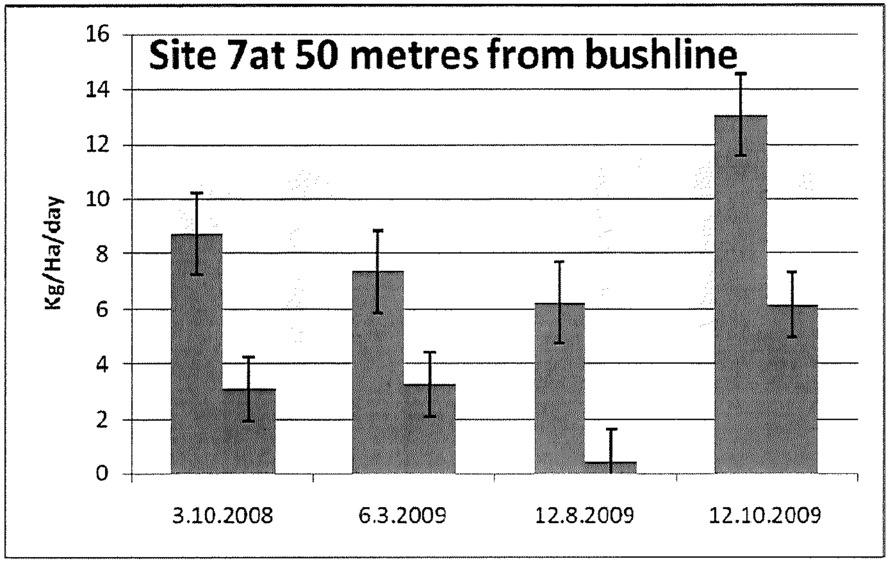

Site 6 at 25 metres from bushline
Mean pasture growth kg/day/ha
35
30
25
20
15
10
5
0
17.10.2008
5.2.2009
27.5.2009
12.8.2009
14.10.2009
10.11.2009
9.12.2009
Harvest date

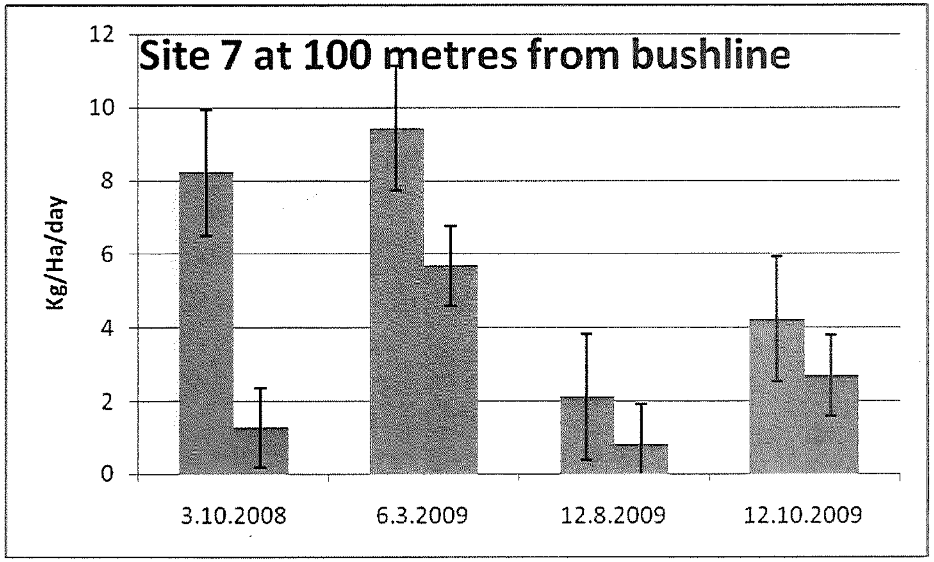

Site 6 at 50 metres from bushline
Mean pasture growth kg/day/ha
40
35
30
25
20
15
10
5
0
17.10.2008
5.2.2009
27.5.2009
12.8.2009
14.10.2009
10.11.2009
9.12.2009
Harvest date

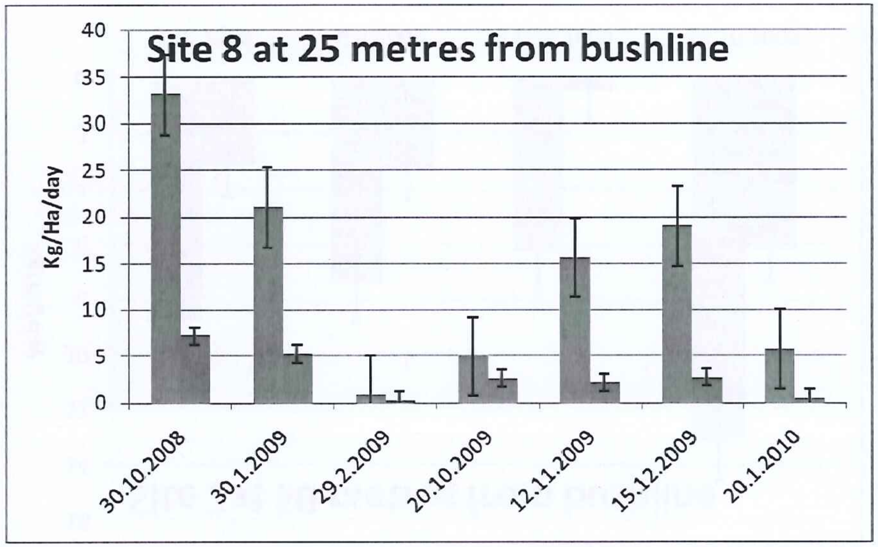

Site 6 at 100 metres from bushline
Mean pasture growth kg/day/ha
40
35
30
25
20
15
10
5
0
17.10.2008
5.2.2009
27.5.2009
12.8.2009
14.10.2009
10.11.2009
9.12.2009
Harvest date

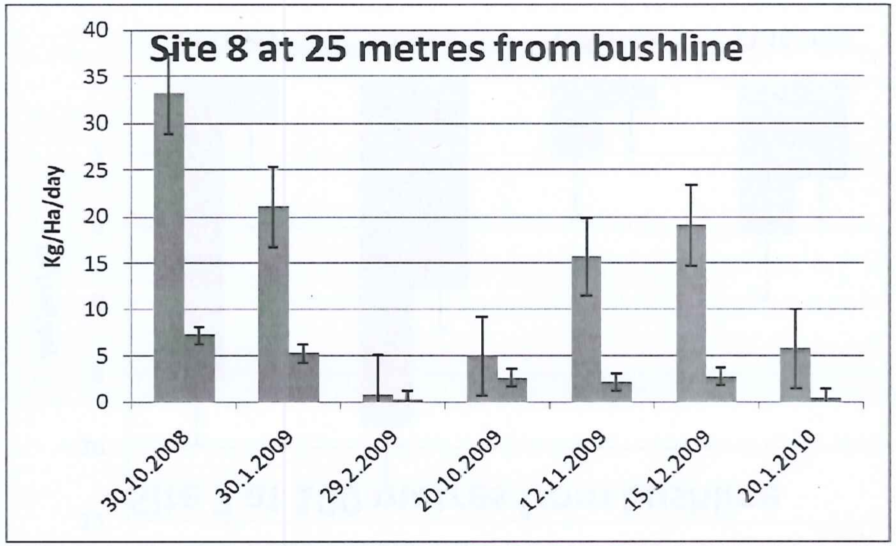

Site 7 at 10 metres from bushline
Kg/Ha/day
16
14
12
10
8
6
4
2
0
3.10.2008
6.3.2009
12.8.2009
12.10.2009

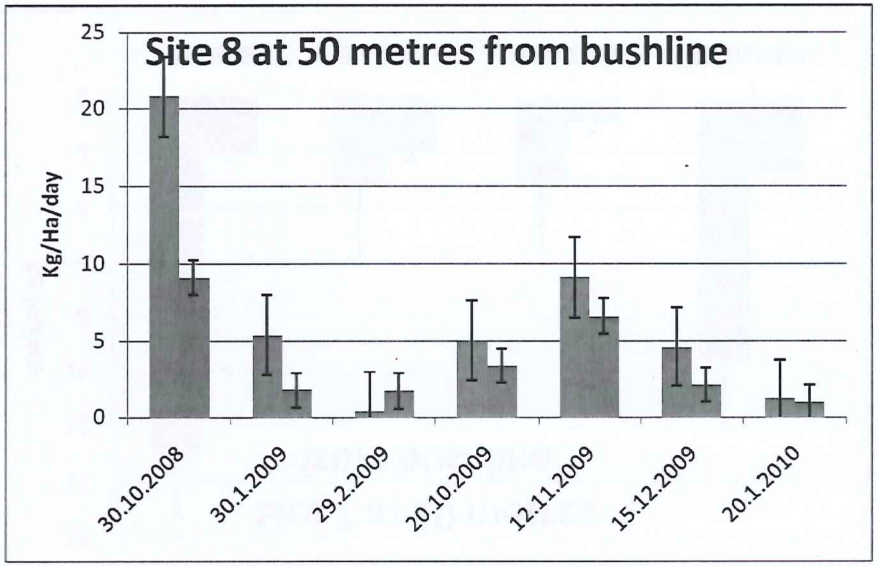

Site 7 at 25 metres from bushline
Kg/Ha/day
12
10
8
6
4
2
0
3.10.2008
6.3.2009
12.8.2009
12.10.2009

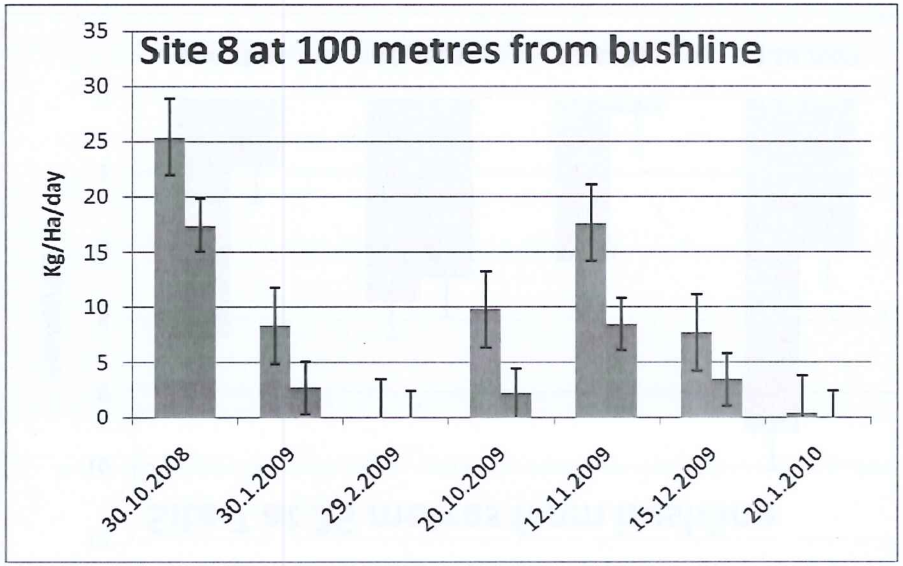

Site 7at 50 metres from bushline
Kg/Ha/day
16
14
12
10
8
6
4
2
0
3.10.2008
6.3.2009
12.8.2009
12.10.2009

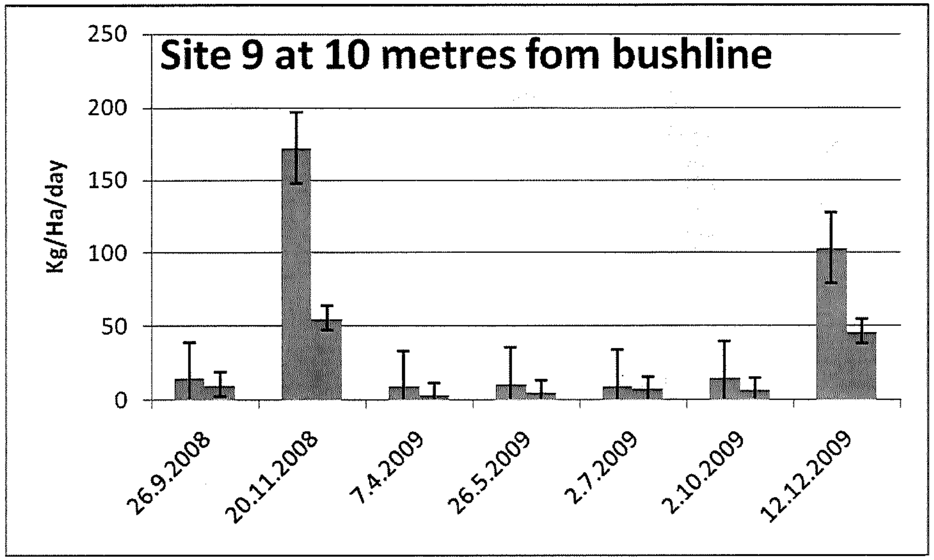

Site 7 at 100 metres from bushline
Kg/Ha/day
12
10
8
6
4
2
0
3.10.2008
6.3.2009
12.8.2009
12.10.2009

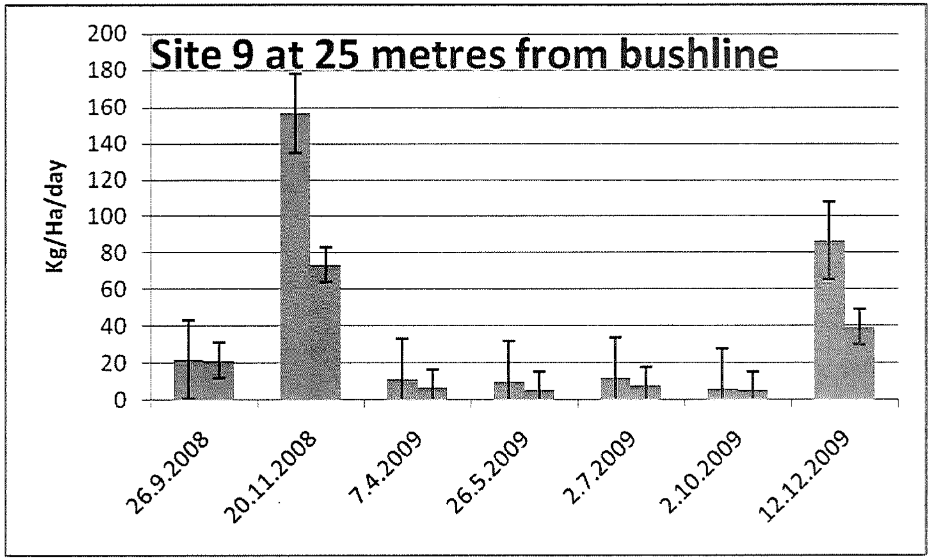

Site 8 at 25 metres from bushline
Kg/Ha/day
40
35
30
25
20
15
10
5
0
30.10.2008
30.1.2009
29.2.2009
20.10.2009
12.11.2009
15.12.2009
20.1.2010

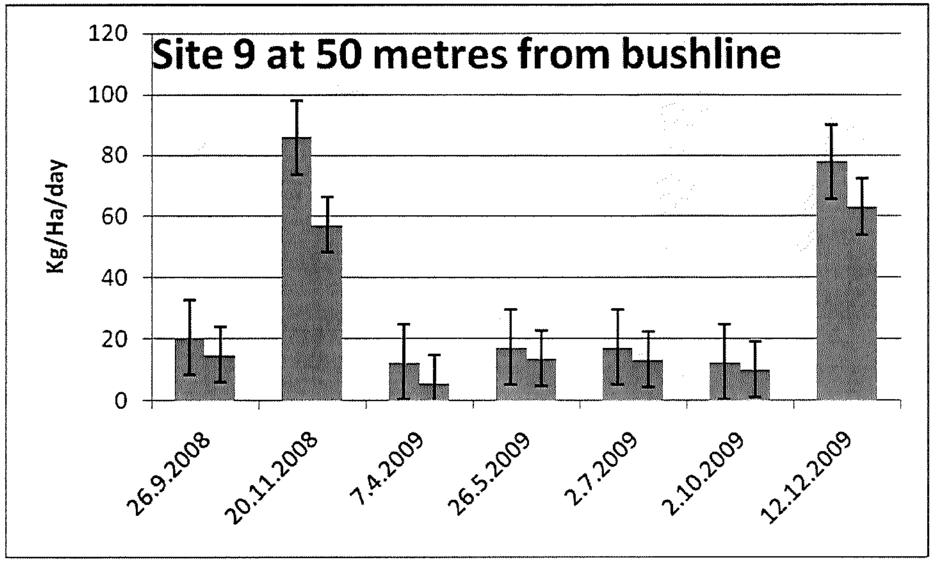

Site 8 at 25 metres from bushline
Kg/Ha/day
40
35
30
25
20
15
10
5
0
30.10.2008
30.1.2009
29.2.2009
20.10.2009
12.11.2009
15.12.2009
20.1.2010

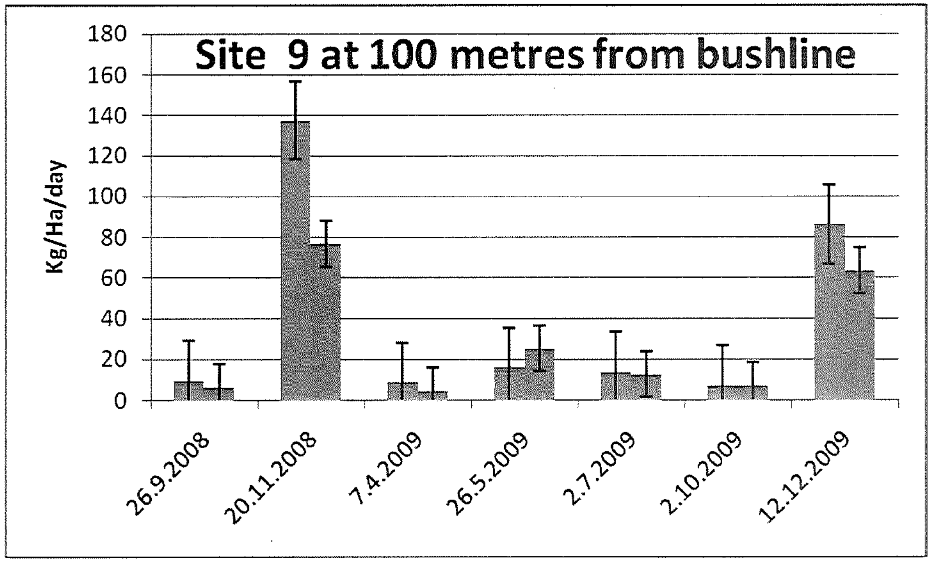

Site 8 at 50 metres from bushline
Kg/Ha/day
25
20
15
10
5
0
30.10.2008
30.1.2009
29.2.2009
20.10.2009
12.11.2009
15.12.2009
20.1.2010

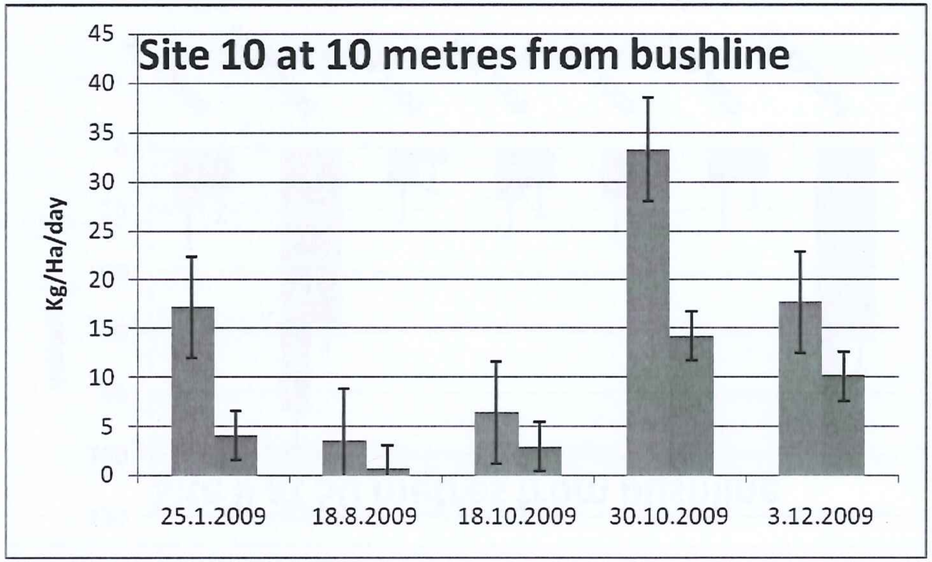

Site 8 at 100 metres from bushline
Kg/Ha/day
35
30
25
20
15
10
5
0
30.10.2008
30.1.2009
29.2.2009
20.10.2009
12.11.2009
15.12.2009
20.1.2010

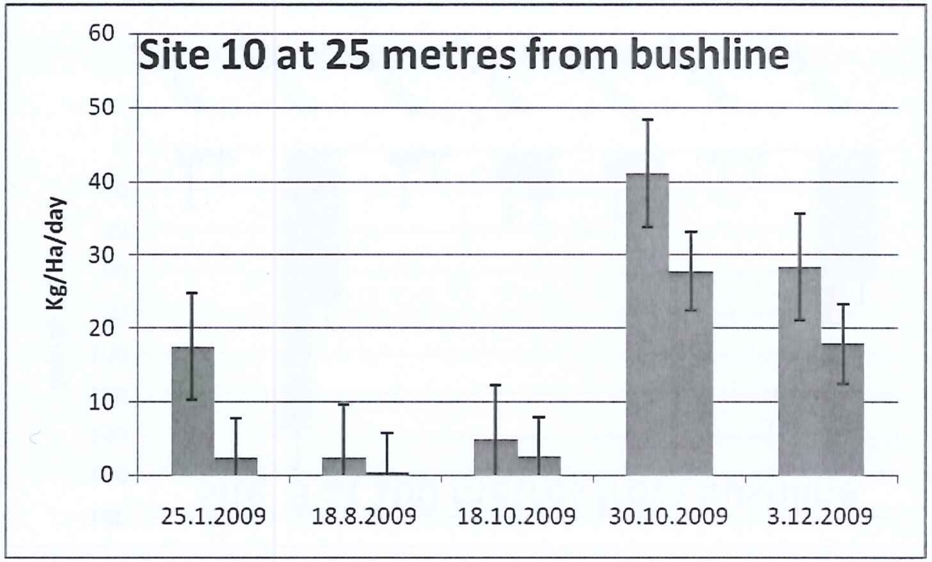

Site 9 at 10 metres fom bushline
Kg/Ha/day
250
200
150
100
50
0
26.9.2008
20.11.2008
7.4.2009
26.5.2009
2.7.2009
2.10.2009
12.12.2009

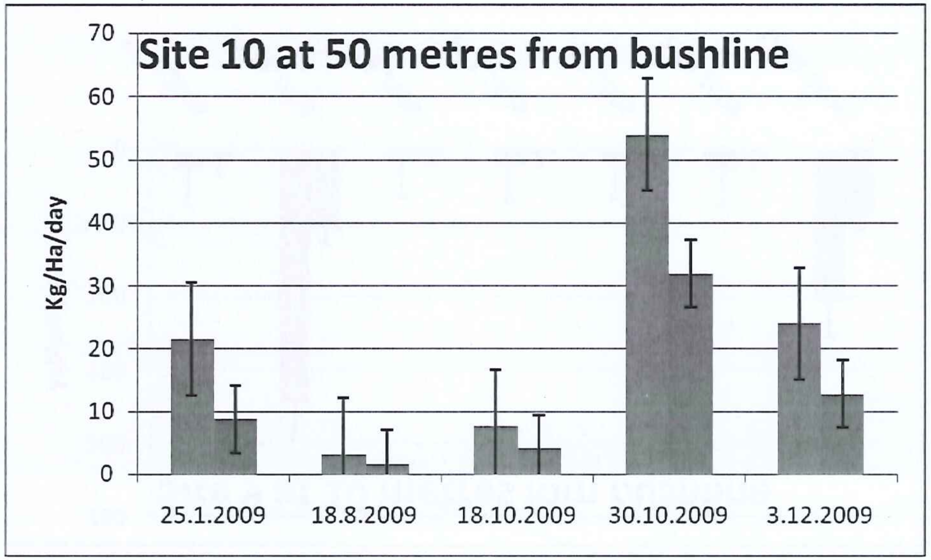

Site 9 at 25 metres from bushline
Kg/Ha/day
200
180
160
140
120
100
80
60
40
20
0
26.9.2008
20.11.2008
7.4.2009
26.5.2009
2.7.2009
2.10.2009
12.12.2009

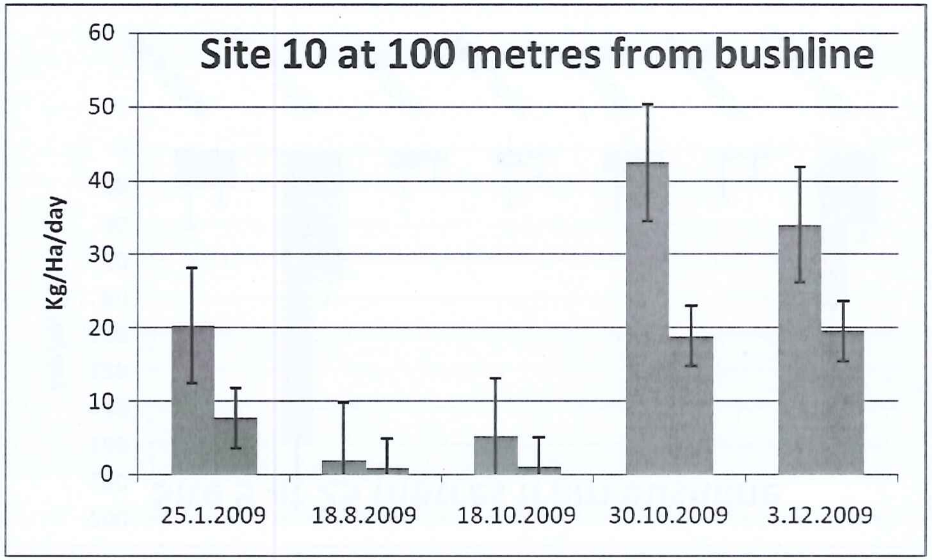

Site 9 at 50 metres from bushline
Kg/Ha/day
120
100
80
60
40
20
0
26.9.2008
20.11.2008
7.4.2009
26.5.2009
2.7.2009
2.10.2009
12.12.2009

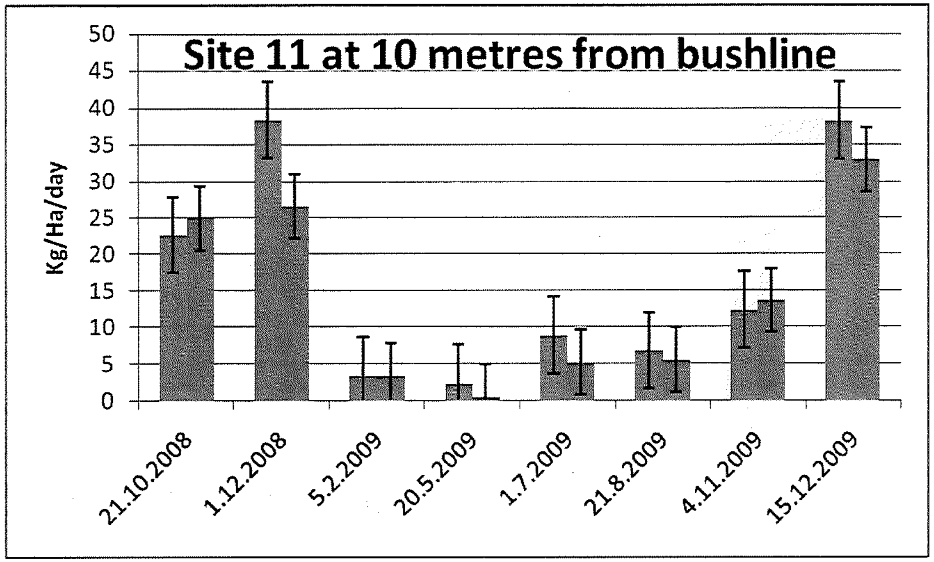

Site 9 at 100 metres from bushline
Kg/Ha/day
180
160
140
120
100
80
60
40
20
0
26.9.2008
20.11.2008
7.4.2009
26.5.2009
2.7.2009
2.10.2009
12.12.2009

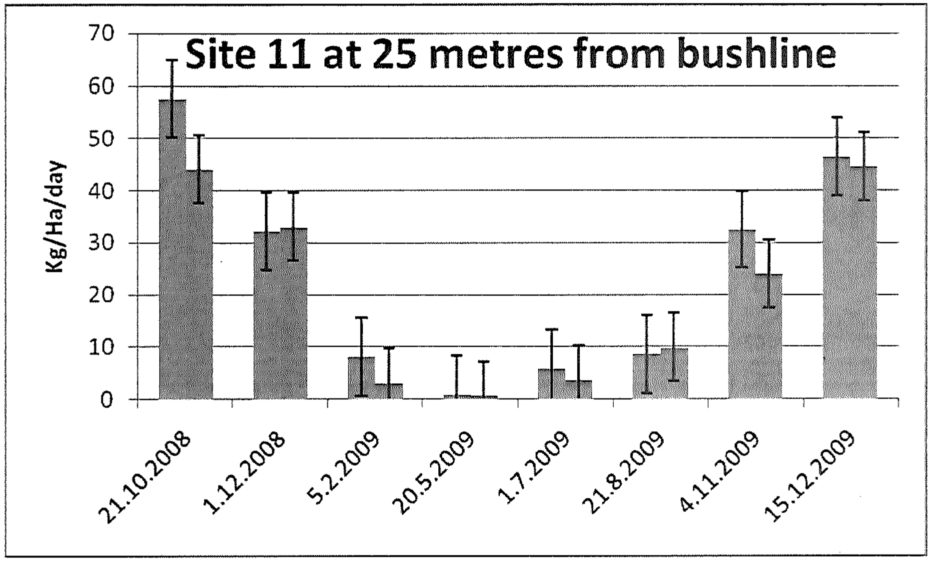

Site 10 at 10 metres from bushline
Kg/Ha/day
45
40
35
30
25
20
15
10
5
0
25.1.2009
18.8.2009
18.10.2009
30.10.2009
3.12.2009

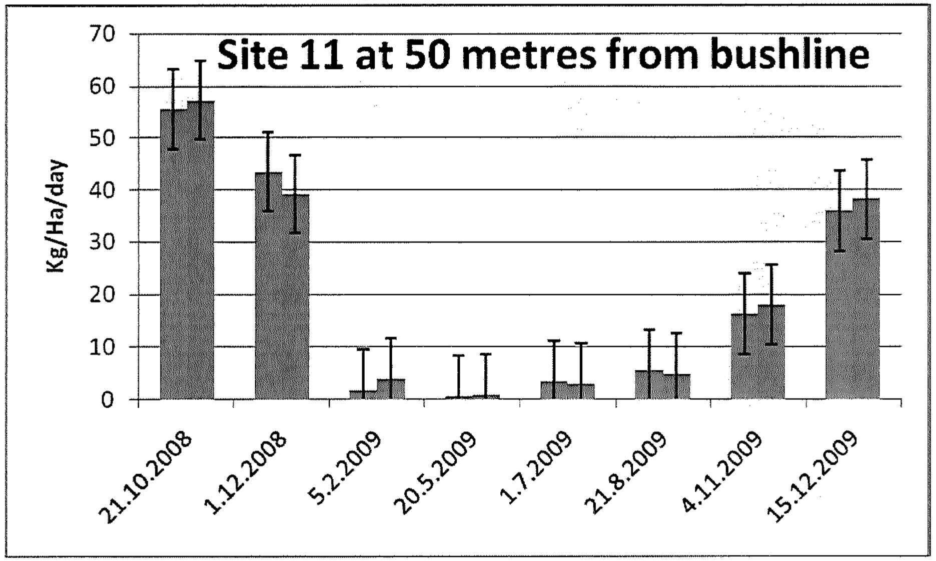

Site 10 at 25 metres from bushline
Kg/Ha/day
60
50
40
30
20
10
0
25.1.2009
18.8.2009
18.10.2009
30.10.2009
3.12.2009

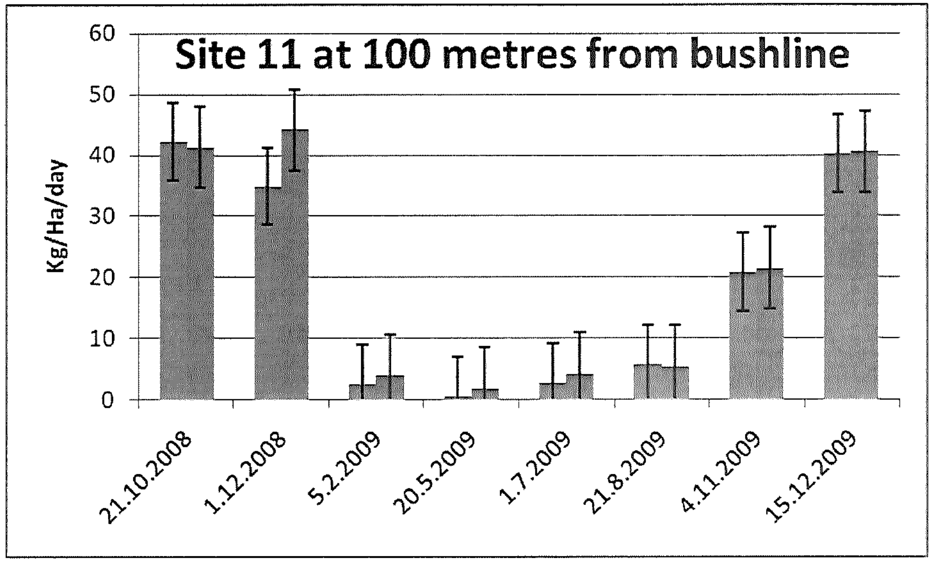

Site 10 at 50 metres from bushline
Kg/Ha/day
70
60
50
40
30
20
10
0
25.1.2009
18.8.2009
18.10.2009
30.10.2009
3.12.2009

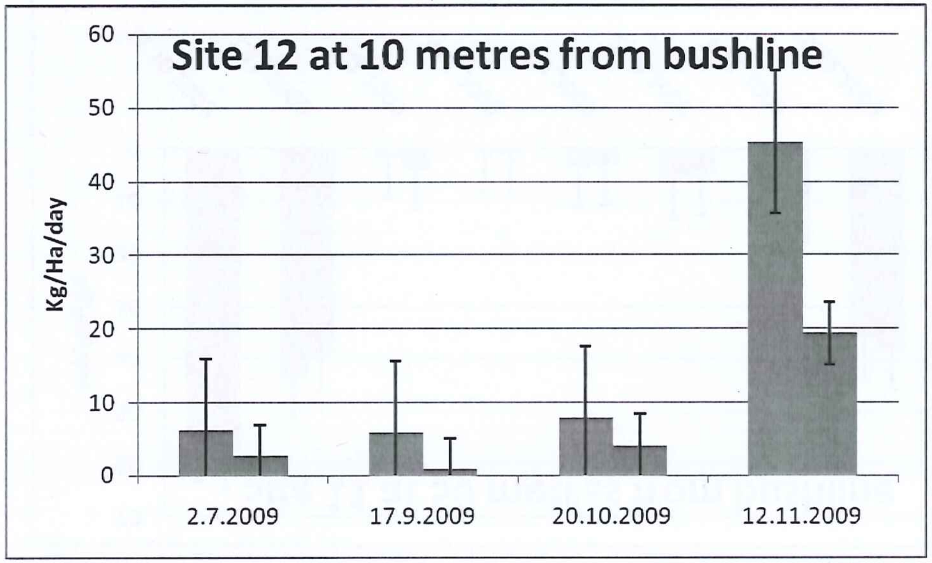

Site 10 at 100 metres from bushline
Kg/Ha/day
60
50
40
30
20
10
0
25.1.2009
18.8.2009
18.10.2009
30.10.2009
3.12.2009

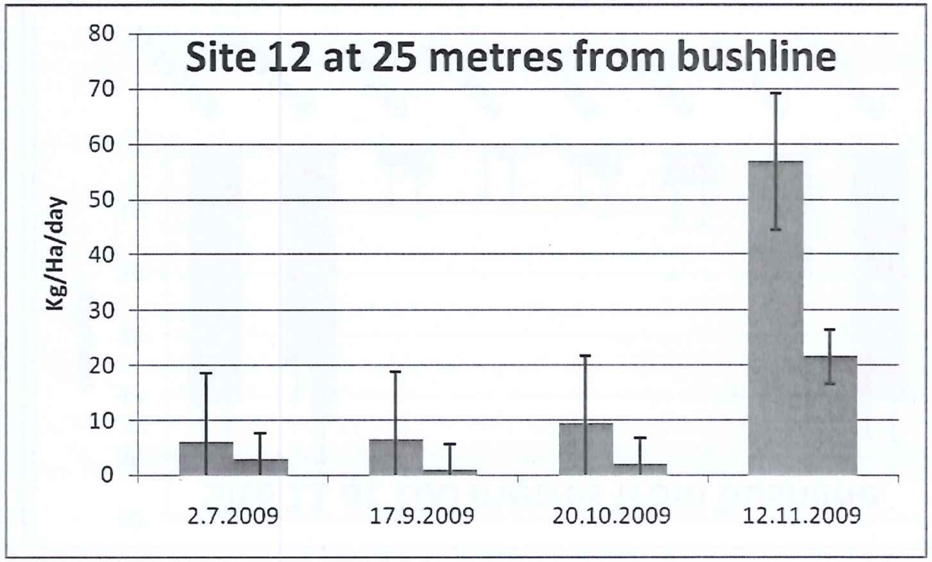

Site 11 at 10 metres from bushline
Kg/Ha/day
0
5
10
15
20
25
30
35
40
45
50
21.10.2008
1.12.2008
5.2.2009
20.5.2009
1.7.2009
21.8.2009
4.11.2009
15.12.2009

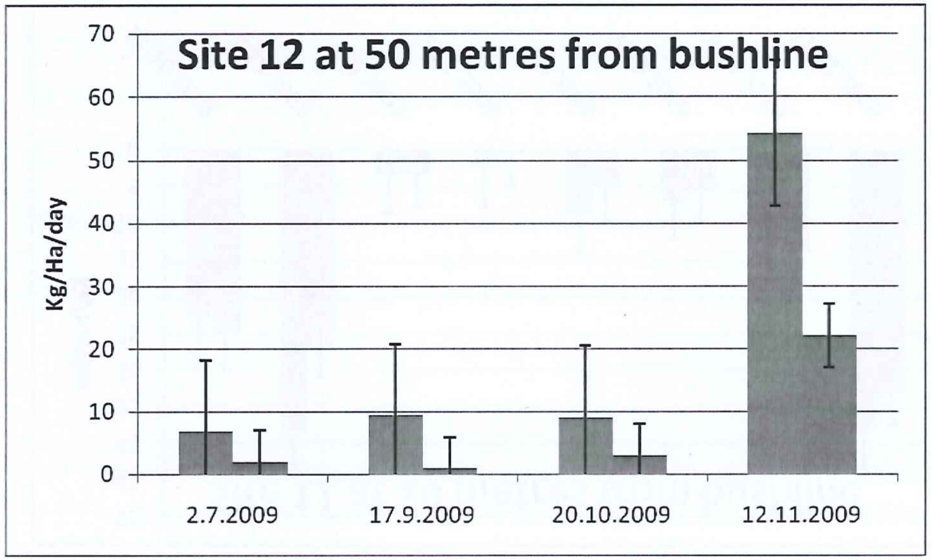

Site 11 at 25 metres from bushline
Kg/Ha/day
0
10
20
30
40
50
60
70
21.10.2008
1.12.2008
5.2.2009
20.5.2009
1.7.2009
21.8.2009
4.11.2009
15.12.2009

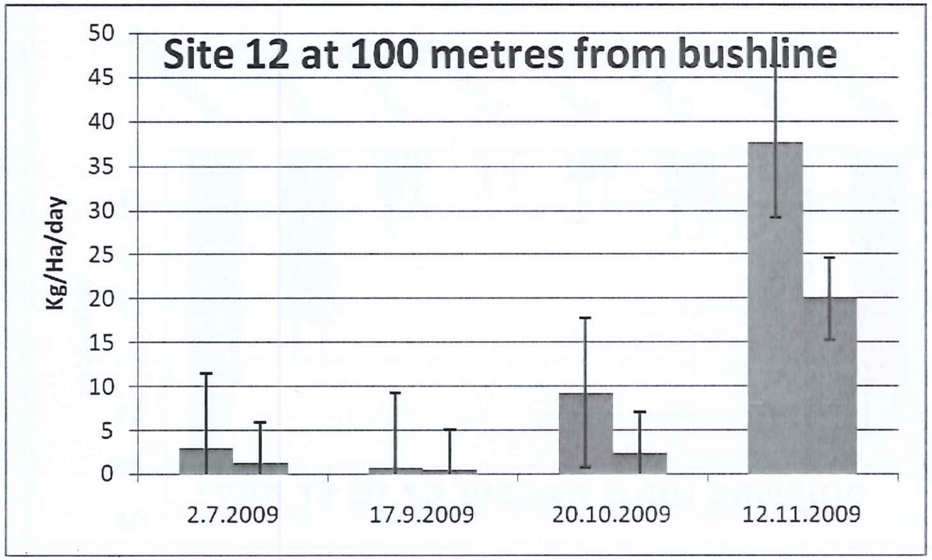

Site 11 at 50 metres from bushline
Kg/Ha/day
0
10
20
30
40
50
60
70
21.10.2008
1.12.2008
5.2.2009
20.5.2009
1.7.2009
21.8.2009
4.11.2009
15.12.2009

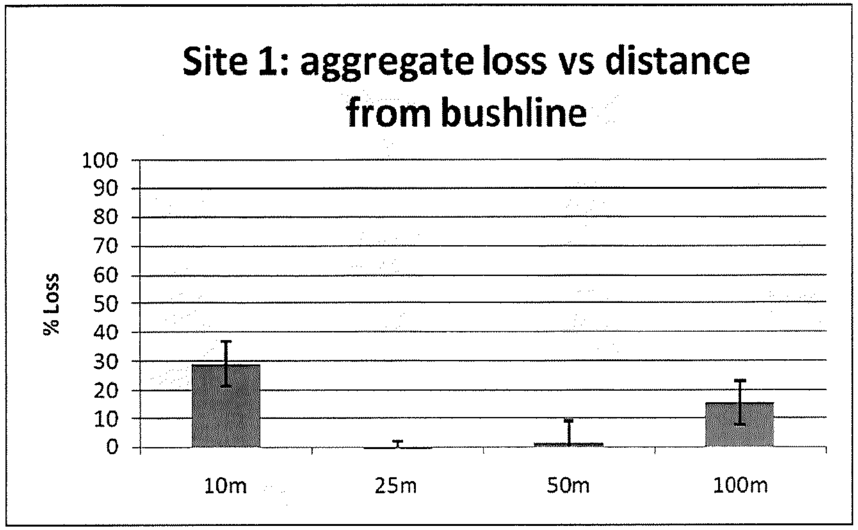

Site 11 at 100 metres from bushline
Kg/Ha/day
0
10
20
30
40
50
60
21.10.2008
1.12.2008
5.2.2009
20.5.2009
1.7.2009
21.8.2009
4.11.2009
15.12.2009

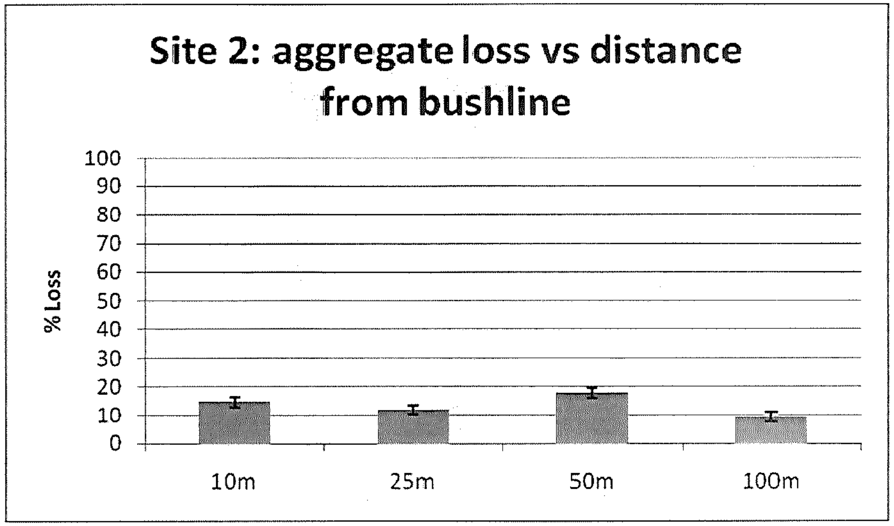

Site 12 at 10 metres from bushline
Kg/Ha/day
60
50
40
30
20
10
0
2.7.2009
17.9.2009
20.10.2009
12.11.2009

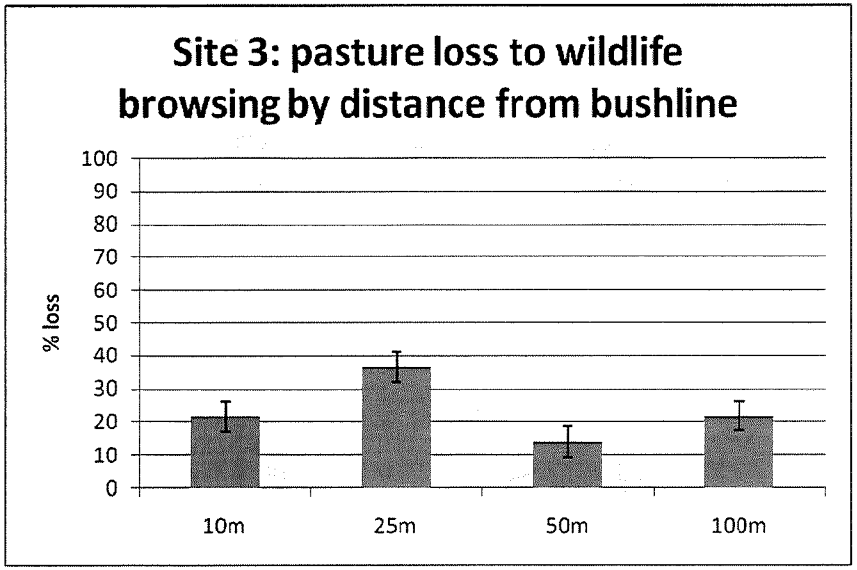

Site 12 at 25 metres from bushline
Kg/Ha/day
80
70
60
50
40
30
20
10
0
2.7.2009
17.9.2009
20.10.2009
12.11.2009

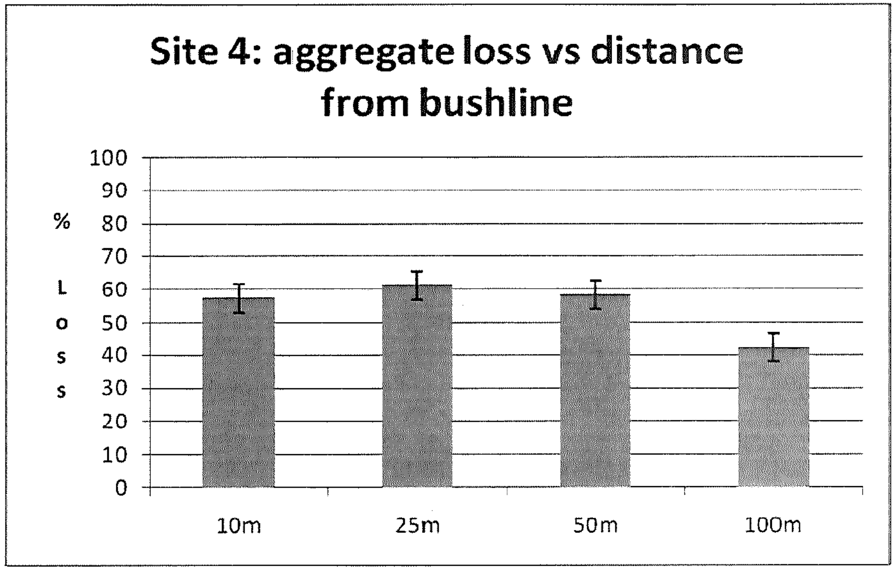

Site 12 at 50 metres from bushline
Kg/Ha/day
70
60
50
40
30
20
10
0
2.7.2009
17.9.2009
20.10.2009
12.11.2009

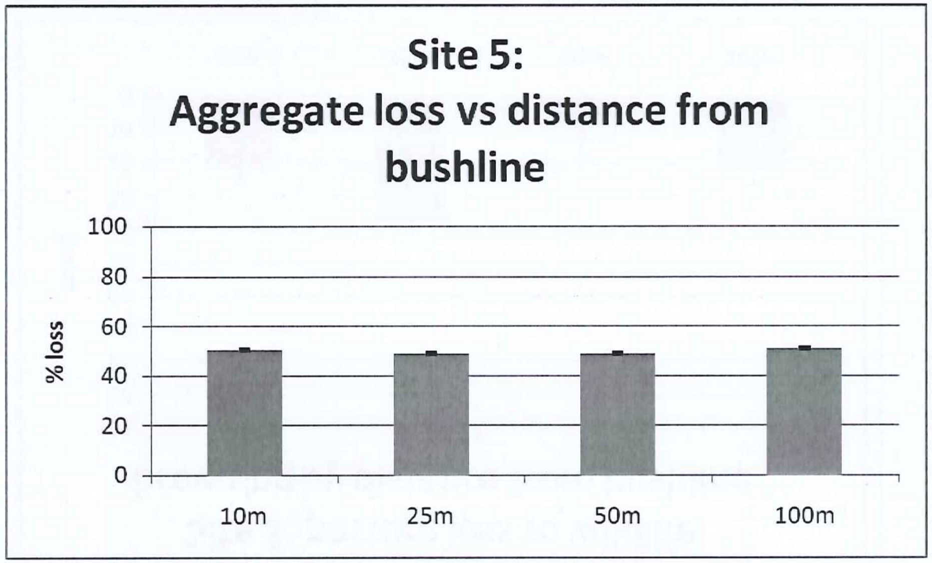

Site 12 at 100 metres from bushline
Kg/Ha/day
50
45
40
35
30
25
20
15
10
5
0
2.7.2009
17.9.2009
20.10.2009
12.11.2009

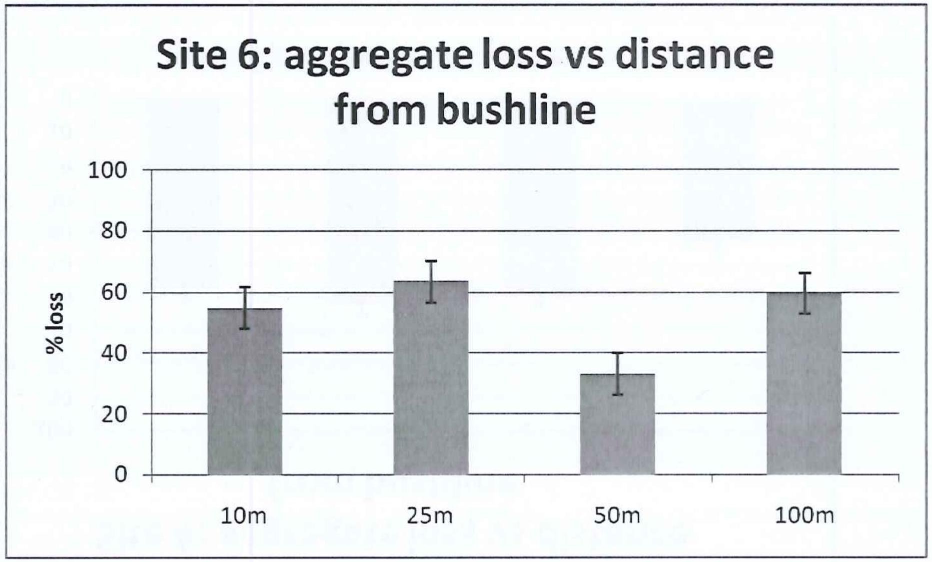

Site 1: aggregate loss vs distance from bushline
% Loss
100
90
80
70
60
50
40
30
20
10
0
10m
25m
50m
100m

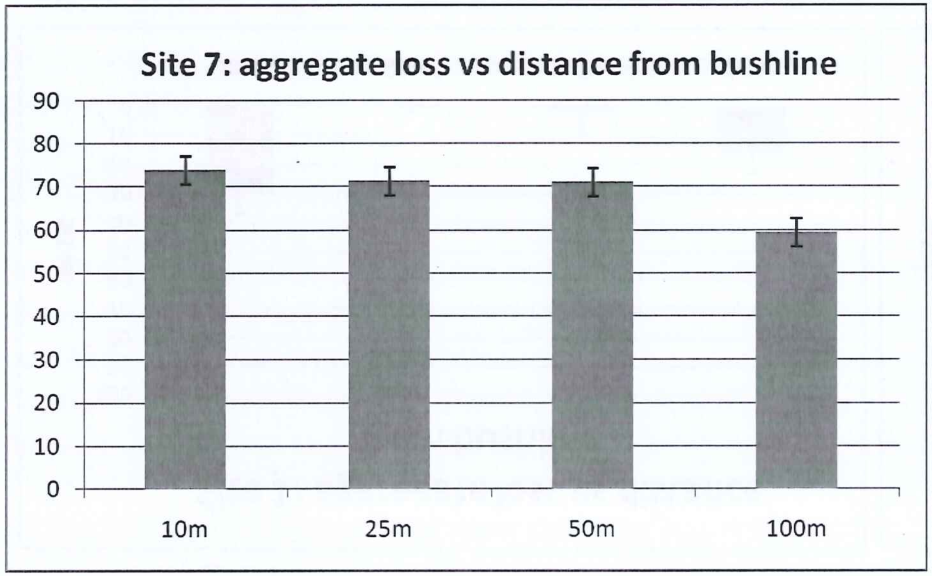

Site 2: aggregate loss vs distance from bushline
% Loss
100
90
80
70
60
50
40
30
20
10
0
10m
25m
50m
100m

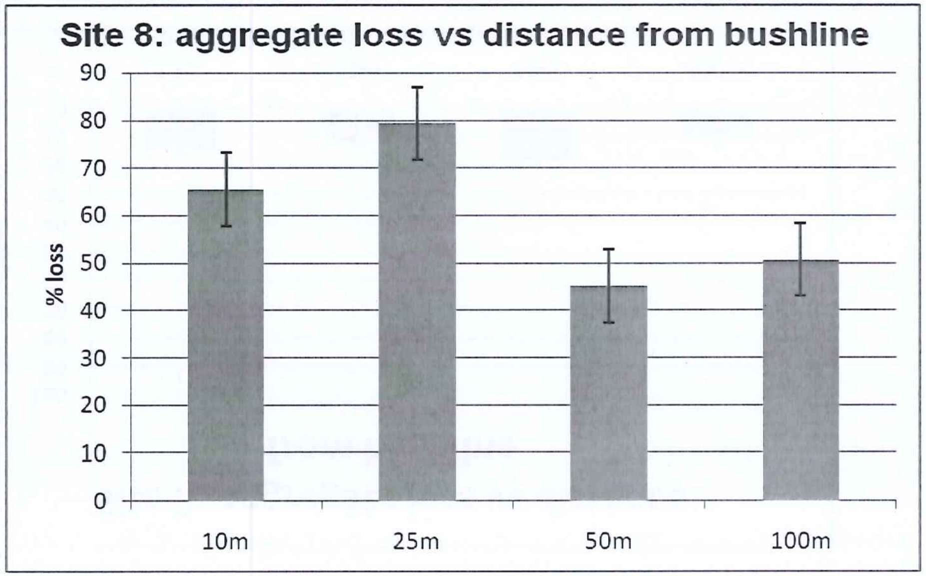

Site 3: pasture loss to wildlife browsing by distance from bushline
% loss
100
90
80
70
60
50
40
30
20
10
0
10m
25m
50m
100m

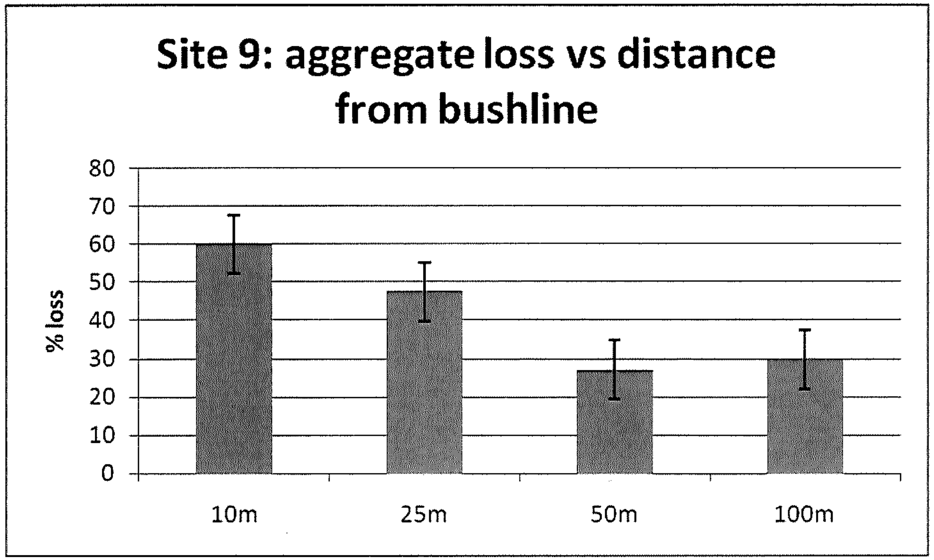

Site 4: aggregate loss vs distance from bushline
% Loss
100
90
80
70
60
50
40
30
20
10
0
10m
25m
50m
100m

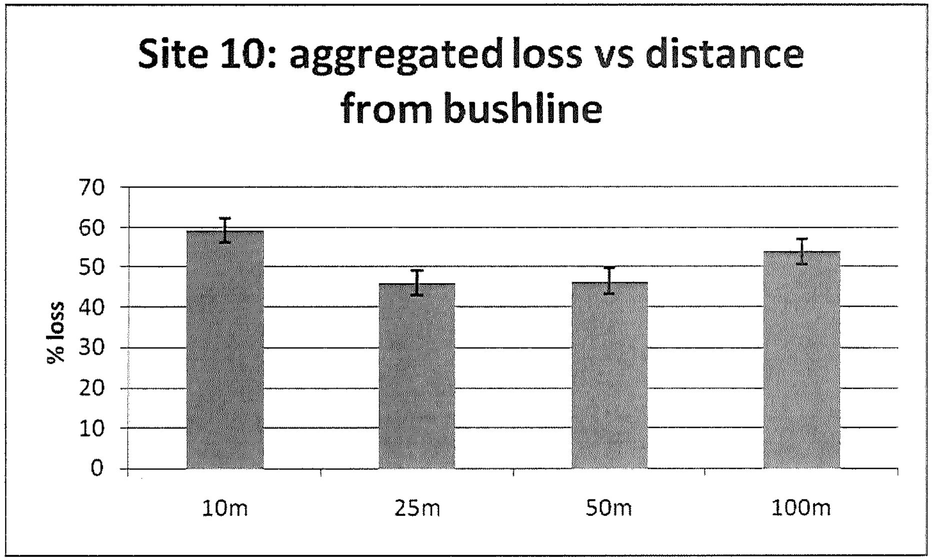

Site 5:
Aggregate loss vs distance from bushline
% loss
100
80
60
40
20
0
10m
25m
50m
100m


Site 6: aggregate loss vs distance from bushline
% loss
100
80
60
40
20
0
10m
25m
50m
100m

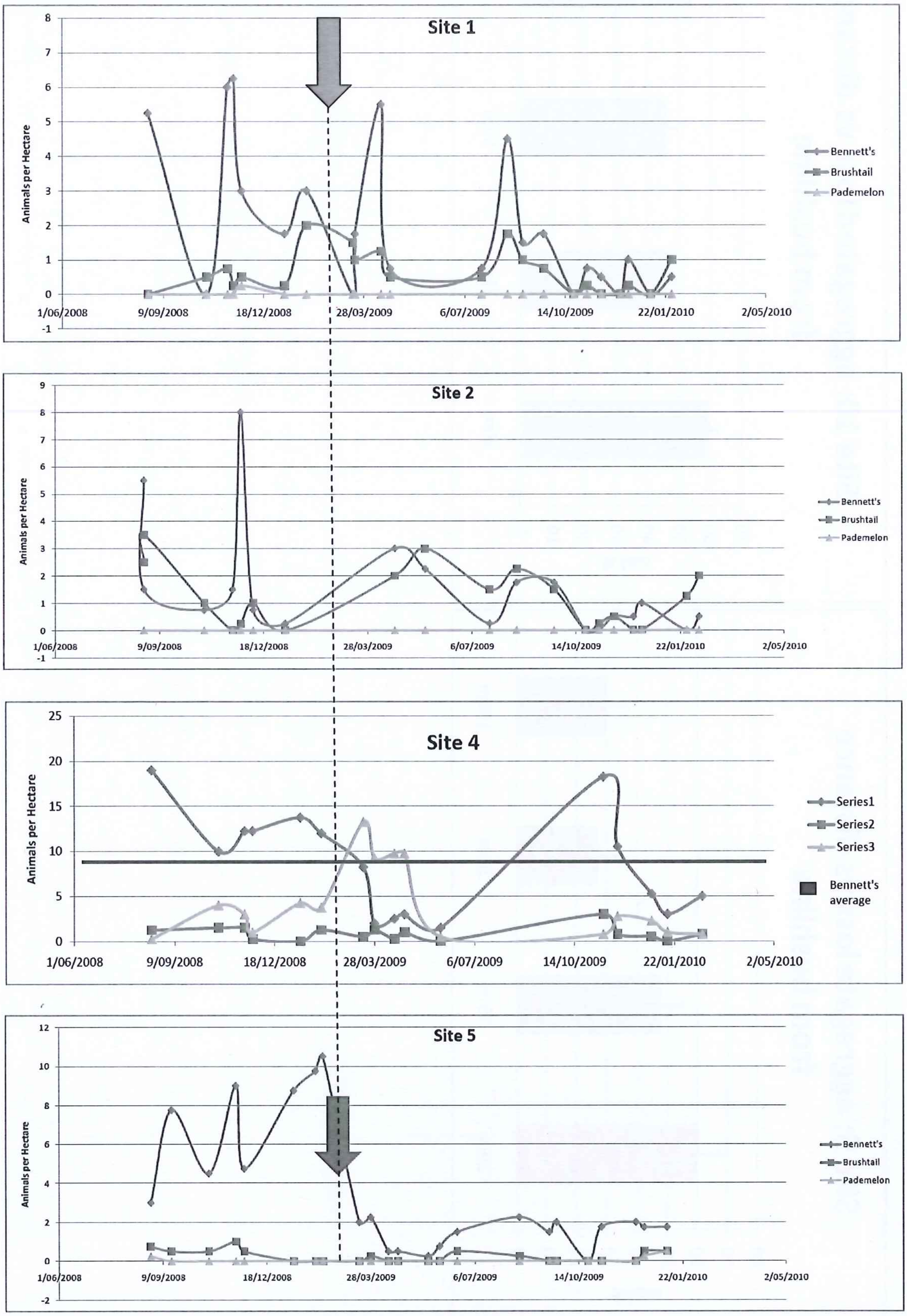

Site 7: aggregate loss vs distance from bushline
90
80
70
60
50
40
30
20
10
0
10m
25m
50m
100m


Site 8: aggregate loss vs distance from bushline
% loss
90
80
70
60
50
40
30
20
10
0
10m
25m
50m
100m


Site 9: aggregate loss vs distance from bushline
% loss
80
70
60
50
40
30
20
10
0
10m
25m
50m
100m


Site 10: aggregated loss vs distance from bushline
% loss
70
60
50
40
30
20
10
0
10m
25m
50m
100m

Appendix 4. Temporal changes in the relative abundance (animals ha-1) of Bennett's Wallaby, Brushtail Possum and Tasmanian Pademelon before and after commencement of intensive shooting regime (dotted lined) at sites 1, 2, 4, and 5 on King Island, Tasmania.



Appendix 5. Profile of Biodiversity Monitoring Plots established across King Island, Tasmania.

Site 1: Seal Rocks A

Description: Site is located adjacent to a laneway on the southwestern corner of the island, bordering the Seal Rocks Nature Reserve. Site is adjacent to wallaby-proof fencing. Dominant species around site are *Melaleuca ericafolia*, *Leptospermum scoparium* and *Boronia anemonifolia*. Monitoring site is heavily browsed with high percentages of bare ground and heavily browsed *Melaleuca ericafolia* plants.

Changes recorded since monitoring: An increase in the cover/abundance and biomass of *Melaleuca ericafolia* was observed in the exclosure plot. This was due to a combination of seedling regeneration and partial recovery of heavily browsed plants. There was no increase in biomass within the control plot. The single *Boronia anemonifolia* plant showed little signs of browsing suggesting it may unpalatable to browsing wildlife.

Summary of vegetation condition: Significant improvement.

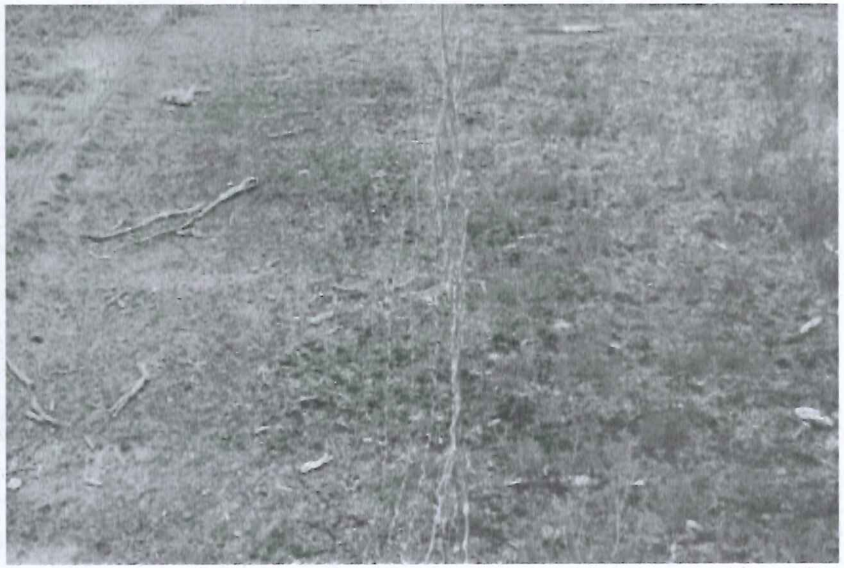
Before (left): shows heavily browsed *Melaleuca ericafolia* plants and compacted bare ground from habitat use by Bennett's Wallaby; After (right): Moderate recovery of *Melaleuca ericafolia* and some regenerating seedlings.

Site 2: Seal Rocks B

Description: Site is located within 5 m of wallaby-proof fencing adjacent to an area of pasture. Dominant plant species are *Melaleuca ericafolia* and *Leptospermum scoparium*. Close proximity to the fence means that the site is subject to heavy impacts from Bennett's Wallaby moving along the fence line. The exclosure and control plots have extremely low biomass levels with over 90% bare ground.

Changes recorded since monitoring: Within the exclosure there was strong regeneration of *Melaleuca ericafolia* and *Leptospermum scoparium*. The exclosure fence was within 1 m of the wallaby proof fence line. A clear difference could be observed with regeneration only occurring within the exclosure. There was regeneration of *Melaleuca ericafolia* in the control plot, however cover/abundance and recovery of *Leptospermum scoparium* was considerably lower than compared to plants in the exclosure. Regeneration within the control plot may be linked to the fact that this plot was further away from the fence-line. Lack of regeneration along the fence-line may be attributable to ground compaction instead of direct browsing. Relative abundance of animals remained stable.

Summary of vegetation condition: Significant improvement.

Before (left): Shows extremely limited plant species richness and biomass. This site is adjacent to wallaby-proof fencing and therefore high levels of wildlife movement; After (right): The same exclosure at the end of the trial shows regenerating *Melaleuca ericafolia* and *Leptospermum scoparium* inside exclosure. Bare ground remains outside.

Site 3: Currie A

Description: Site is located within a stock excluded (no wallaby-proof fencing) area of regenerating coastal grasses, shrubs and trees, interspersed with areas of pasture grasses. Dominant native species are *Leucopogon parvifloris, Leptospermum laevegatum, Isolepis nodosa, Calytrix tetragona* and *Dichondra repens*. Site is sloping with interspersing areas of bare ground due to movement of wildlife.
Changes recorded since monitoring: An increase in presence of *Leucopogon parvifloris* seedlings (>100) was observed in the exclosure due to the presence of a mature tree. Evidence of browsing of individual *Leptospermum laevegatum* plants was also observed outside but not inside the exclosure. Increased cover/abundance of *Dichondra repens* was observed inside the exclosure (55 individual plants inside compared to 4 outside). Increased biomass and reduced areas of bare ground (wallaby tracks) was observed inside the exclosure whereas there was no recovery outside.
Summary of vegetation condition: Significant improvement.

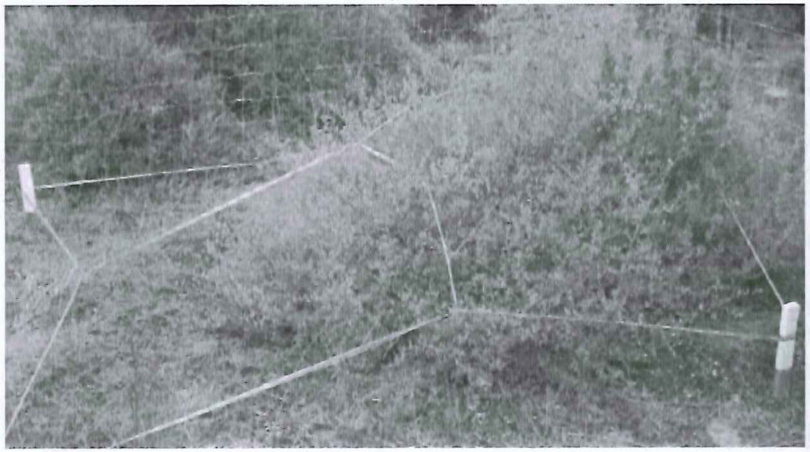
Significant improvements were observed in vegetation condition at Site 3 within the exclosure. For example, individual plants such as *Leptospermum laevegatum* showed significant recovery from intensive browsing (left) compared to the on-going intensive browsing and decline of individuals of the same species in the control plot (right).

Site 4: Currie B

Description: Site is located within a stock excluded (no wallaby-proof fencing) area of regenerating coastal grasses, shrubs and trees, interspersed with areas of pasture grasses. Dominant native species are *Leucopogon parvifloris, Leptospermum laevegatum, Isolepis nodosa, Calytrix tetragona* and *Dichondra repens*.

Changes Observed Since Monitoring: This site showed little evidence of a response to wildlife exclosure. Some recovery of wallaby tracks was observed within the exclosure with a general increase of leaf litter over tracks. Appears to be too early to detect changes in vegetation condition as site was heavily disturbed from wildlife use prior to the establishment of the exclosure.

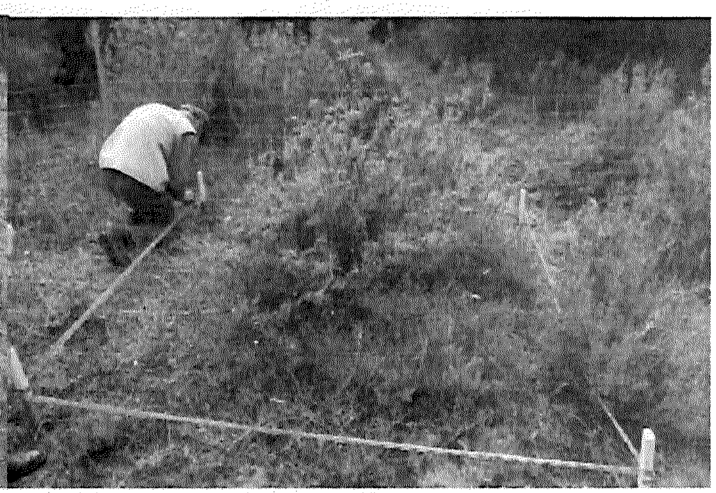
Summary of vegetation condition: No change detected.



Before (left) and After (right) showing *Leptospermum laevegatum* as dominant.

Site 5: Currie C

Description: Site is located within a stock excluded (no wallaby-proof fencing) area of regenerating coastal grasses, shrubs and trees, interspersed with areas of pasture grasses. Dominant native species are *Leucopogon parvifloris*, *Leptospermum laevegatum*, *Isolepis nodosa*, *Calytrix tetragona* and *Dichondra repens*. This site is shaded by *Calytrix tetragona,* the dominant species.
Changes recorded since monitoring: Recruitment and growth of *Leptospermum laevegatum* seedlings observed within the exclosure. *Calytrix tetragona* does not appear to be browsed in the exclosure or control. Appears to be too early to detect changes in vegetation condition as site was heavily disturbed from wildlife use prior to establishment of the exclosure.
Summary of vegetation condition: No detectable change.

Before After

Before and after images of the exclosure. Few detectable changes were recorded.

Site 6: Currie D

Description: Site is located within a stock excluded (no wallaby-proof fencing) area of regenerating coastal grasses, shrubs and trees, interspersed with areas of pasture grasses. Dominant native species are *Leucopogon parvifloris, Leptospermum laevegatum, Isolepis nodosa, Calytrix tetragona* and *Dichondra repens*. Both the exclosure and control plots have high levels of exposed sandy ground and low levels of plant biomass.

Changes recorded since monitoring: Little regeneration/change in species composition and cover/abundance of plants observed in the exclosure. Increased area of bare ground/erosion observed in the control plot as a result of trampling by wildlife. Disappearance of ground cover of mosses also observed on control plot. Overall, no improvement or decline in vegetation condition detected within exclosure, but further decline occurring on control plot.

Summary of vegetation condition: No detectable change inside exclosure, further decline of condition of vegetation outside (control plot and elsewhere).

Exclosure Before (left) and After (right): Several *Isolepis nodosa* plants and one *Calytrix tetragona* (near middle of plot) have experienced significant growth.

Control Plot Before (left) and After (right): Further degradation of the control site has continued. *Isolepis nodosa* and *Poa* spp. have been heavily browsed and area of bare ground has increased significantly. Note wallaby tracks in left hand side of 'after' image.

Site 7: Black Point A

Description: Site is located in an area open of pasture grasses and regenerating native grasses, rushes etc. Exclosure and control plots contain areas of exposed sand/erosion/wallaby tracks.

Changes recorded since monitoring: Increase in presence of *Lagurus ovatus* inside exclosure (see image). Overall increase in ground cover and plant biomass within the exclosure. Percentage of bare ground within the exclosure decreased from 30% to 15%. This was also evident visually with a distinct presence of flowering *Lagurus ovatus* inside exclosure, but none present outside on the control plot. Area of bare ground in the control plot increased from 35% to 60%. Evidence of browsed *Isolepis nodosa* in control plot.

Summary of vegetation condition: Significant improvement.


Before (left): shows heavily browsed *Isolepis nodosa*, *Poa* spp. and intersecting wallaby tracks on control plot.
After (right): shows general increase in biomass within the fenced area. There is some recovery of *Isolepis nodosa*, *Lagerus ovatus* (shown flowering in exclosure) and *Lepidosperma concavum* within exclosure whilst browsing and soil compaction remain outside.

Site 8: Black Point B

Description: Site is located in open of pasture grasses and regenerating native grasses and rushes. The site is in poor condition, heavily intersected by wallaby tracks (exposed sand) and initial assessment revealed few seedlings and young plants.

Changes recorded since monitoring: No signs of early plant recovery in exclosure.

Summary of vegetation condition: No detectable change.

Control Plot

Before (above left): shows heavily browsed *Isolepis nodosa, Lepidosperma elatius* and wallaby tracks in the control plot.
At the end of the trial (above right) there is a dramatic increase in the area of bare ground and further browsing of vegetation.

Exclosure

Before After

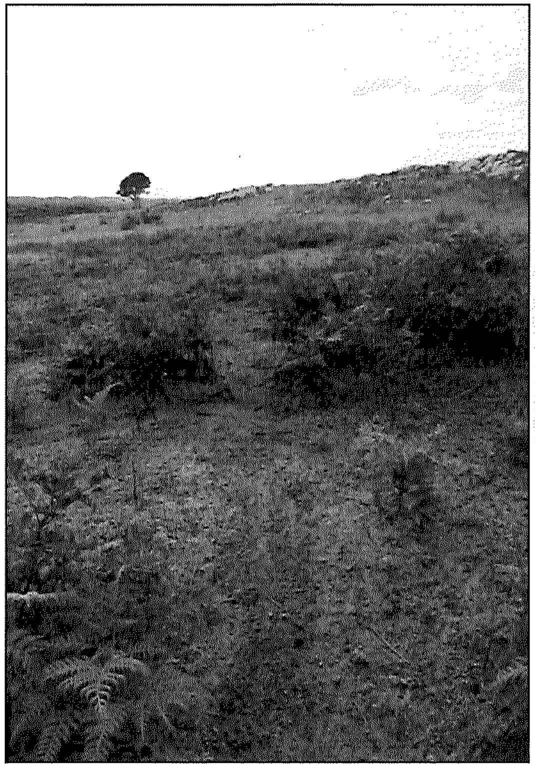
Plant biomass has increased whilst area of bare ground has decreased within the exclosure plot.

Site 9: Red Hut A

Description: Site is located adjacent to a wallaby-proof fenced area of pasture. Evidence of browsing damage is moderate with wallaby tracks intersecting the exclosure and control plots. Dominant species are *Melaleuca ericafolia, Bursaria spinosa*, and *Boronia anemonifolia*. Ground cover is a mixture of native and non-native grass species. Site is heavily interspersed by wallaby tracks.

Changes recorded since monitoring: Evidence of wildlife browsing was observed between the second and third monitoring round. Unfortunately, no quantitative or qualitative changes were recorded in the three-month period between the first and second observations.

Summary of vegetation condition: No detectable change.



No detectable improvements in vegetation condition were recorded during the study period. The area remained intensively used by native wildlife outside of the exclosure plot.

Site 10: Red Hut B

Description: Site is located adjacent to a wallaby-proof fenced area of pasture. Dominant species are *Melaleuca ericafolia*, *Bursaria spinosa*, *Boronia anemonifolia*. Ground cover is a mixture of native and non-native grass species. Site is heavily interspersed by wallaby tracks.

Changes recorded since monitoring: Significant increase in palnt cover/abundance and biomass within the exclosure. Fifteen new *Melaleuca ericafolia* seedlings observed within the exclosure. *Melaleuca ericafolia* not recorded in control plot. An increase from 5 to >50 individual Dandelion spp. plants was recorded in the exclosure. Numbers in the control remained stable at <10.

Summary of vegetation condition: Significant improvement.

Significant improvement was observed in the exclosure plot over the study period including the recruitment of new plant species and recovery of ground cover (above).

Site 11: Reekara A

Site description: Fenced. Dominant species include *Eucalyptus brookerianii, Eucalyptus viminalis, Leptospermum scoparium* and *Melaleuca ericafolia*. This site appears to be in reasonable condition although some evidence of ringbarking by wallabies.

Changes recorded since monitoring: Increase in *Melaleuca ericafolia* seedlings inside and outside exclosure but more prevalent within. Higher numbers of *Leptospermum scoparium* and ground cover species such as *Lagenophora stipitate* and *Viola* spp. observed within exclosure between first and second rounds of monitoring.

Summary of vegetation condition: Improvement.

These images compare the exclosure plot before (left) and a smaller section of the plot after establishment (right). Recovery of *Melaleuca ericafolia* and several native herb species can be observed looking at the close up image (right).

Site 12: Reekara B

Site description: This site has wallaby-proof fencing on three sides. Dominant species include *Eucalyptus brookerianii, Eucalyptus viminalis, Leptospermum scoparium* and *Meleleuca ericafolia*. The site appeared to be in reasonable condition.
Changes recorded since monitoring: Second round monitoring revealed high numbers of *Nematolepis squamea*, and *Acacia mucronata* seedlings in the exclosure with very few in the control plot. Evidence of wildlife ringbarking several tree species was present around the site.
Summary of vegetation condition: Improvement.

Little improvement was observed within the exclosure plot (Before shown at left; After shown at middle) with the exception of the regeneration of *Pteridium esclulentum* (middle). Ringbarking of trees by Bennett's Wallaby was frequently observed outside of the exclosure plot (right).

Site 13: Reekara C

Site description: Poorly-drained site that is wetter than Reekara A and B; dominant species are *Melaleuca ericafolia* and *Monotoca glauca*. Evidence of wallaby tracks was present throughout the area, but there were few signs of browsing damage.

Changes recorded since monitoring: Six *Melaleuca ericafolia* plants have regenerated in the exclosure with none in the control plot. *Pomaderris* spp. have regenerated well in both exclosure and control.

Summary of vegetation condition: Significant improvement in exclosure and limited improvement in control plot.

Comparing Before (top) and After (bottom) within this exclosure shows an increased number of *Gonocarpus tetragynus* seedlings. These were present in the control plot at very low number.

Site 14: Reekara D (Stump 2)

Site description: Poorly-drained site that is wetter than Reekara A and B and similar to Reekara C. Dominant species are *Melaleuca ericafolia* and *Monotoca glauca*. Evidence of wallaby tracks was present throughout the area, but there were few signs of browsing damage.

Changes recorded since monitoring: Little change observed at this site.

Summary of vegetation condition: Few detectable changes.

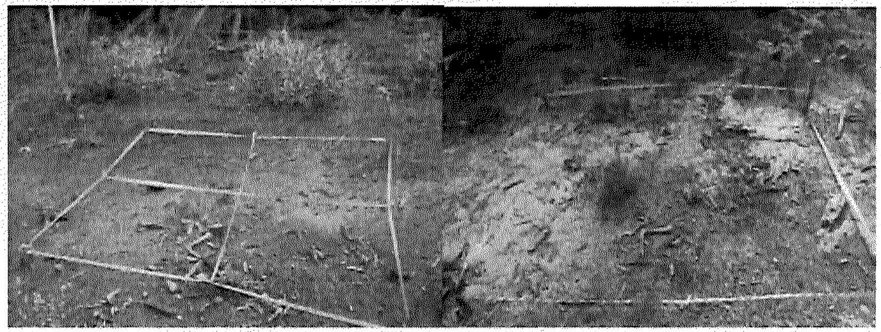
During the second round of observations in November, several orchid spp. plants (unidentified) were observed within the Exclosure, but none were found in the control plot during the study.

Site 15: Wickham A

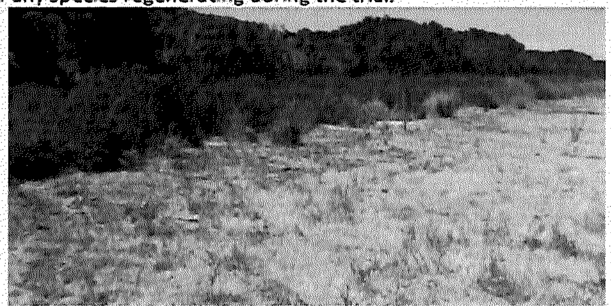
Site Description: Site adjacent to an area unfenced coastal pasture. Dominant species include *Boronia anemonifolia* and *Leptospermum laevegatum*. Site has a high relative abundance of Bennett's Wallaby (average 14 animals ha^{-1}). Numerous wallaby tracks were observed going in and out of the pasture area. Area directly adjacent to pasture inside the stock exclusion fencing had high % of bare ground and serious soil compaction most likely due to the movement of Bennett's Wallaby.

Changes recorded since monitoring: Little recovery during period of the study.

Summary of vegetation condition: No detectable changes.



Before (left) and After (right) showing that there was little recovery within this exclosure over the trial period. One small *Boronia anemonifolia* plant has grown slightly, but there have been no seedlings of any species regenerating during the trial.



The exclosure plot was situated just behind the fenceline shown in this image. Extensive wallaby tracks between the native vegetation and pasture areas demonstrate the high levels of wildlife abundance at this site. Soil compaction in and around the exclosure plot may so extensive that it could prevent any plant regeneration for several years if wildlife abundance remains at current levels.

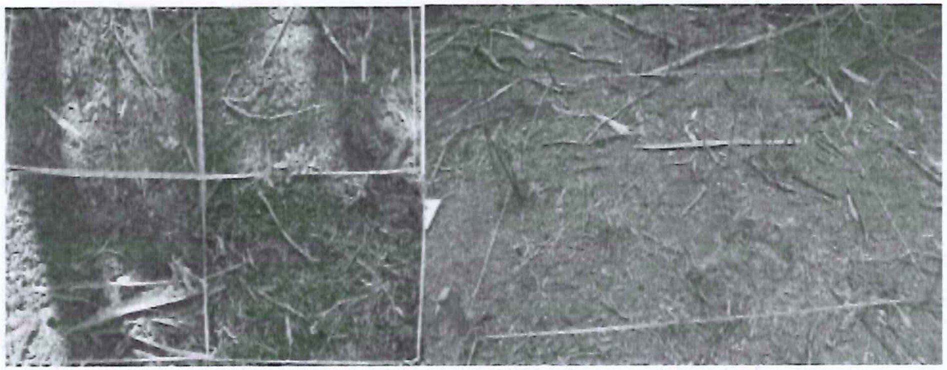
Site 16: Wickham B

Site Description: Site adjacent to an area unfenced coastal pasture. Dominant species include *Boronia anemonifolia* and *Leptospermum laevegatum*. Site has a high relative abundance of Bennett's Wallaby (average 14 animals ha^{-1}). Numerous wallaby tracks were observed going in and out of the pasture area. Area directly adjacent to pasture inside the stock exclusion fencing had high % of bare ground and serious soil compaction most likely due to the movement of Bennett's Wallaby.

Changes recorded since monitoring: Seedling recruitment of existing and new plant species, and regeneration of plants.

Summary of vegetation condition: Improvement.

Before (left) and After (right) images of the exclosure plot show that heavily browsed *Melaleuca ericafolia* plants have recovered. There are several new seedlings of the same spp.



Before (left) and After (right) images of the control plot show regeneration of Senecio sp. but no regeneration of *Melaleuca ericafolia*.