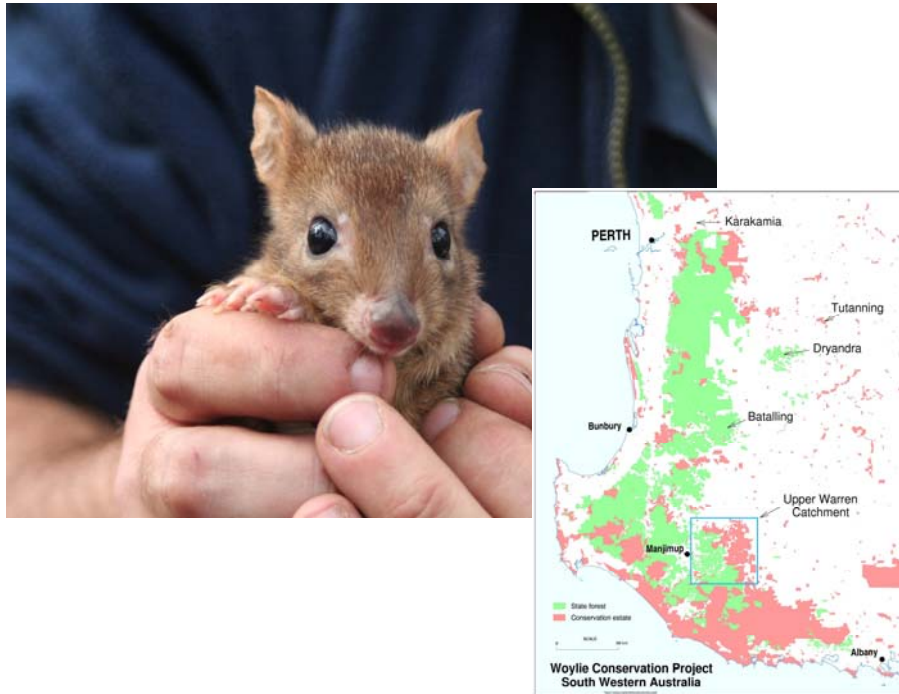


Where's the Woylie?

Possible factors affecting post-decline Woylie (*Bettongia penicillata ogilbyi*) abundance in the Upper Warren Region of South West Australia



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Abstract:

The woylie (*Bettongia penicillata ogilbyi*), also known as the Brush-tailed Bettong, has been declared as “fauna that is rare or likely to become extinct” not once, but twice. The woylie used to cover over 70% of the Australia, but over the past century the population has declined to populate only 1% of Australia. It currently exists predominantly in the Upper Warren Region of the south west region of Western Australia. Studies involving the factors causing woylie population declines began in the 1970’s. These studies examined woylie habitats and established which vegetation types, groups and landscapes were preferred by woylies. While these studies were being conducted, a fox baiting program in the 1980’s was established and the scientific and conservation community saw a miraculous increase in woylie abundance in the 1990’s. But in 2001, woylie populations declined once again and declined farther than they did in the 1970’s. The main factors thought to be the cause of the second population decline are disease caused by two parasites *Toxoplasma* and *Trypanosoma sp. nov.* and increased mortality of adult woylies. In response to these drastic population declines, the Warren District Western Australia Department of Environment and Conservation (D.E.C.) developed the Woylie Conservation Research Project which involves a wide range of disciplines to determine the main factor or factors affecting woylie abundance. Recently, D.E.C. developed a Woylie Translocation Project which involved construction of the Perup Sanctuary. The goal of the project is to translocate 40 individuals into the sanctuary.

For my Independent Study Project (ISP), I worked with D.E.C. in Manjimup, Western Australia for three weeks on the Woylie Translocation Project. I collected primary data which included trapping data and habitat surveys for 50 trapping sites in 13 transects equaling 650 data points. I asked the question: What factors may be affecting post-decline Woylie (*Bettongia penicillata ogilbyi*) abundance in the Upper Warren Region of South West Australia? I investigated this question by looking at several possible factors including habitat surveys used to observe any woylie habitat preferences, the presence of other mammals, distance from paddocks and private property, vegetation groups, landscapes, and category of forest. Several trends were noticed, but none of the study factors were claimed as a major factor affecting the present decline in woylie abundance. My study verified previous studies involving habitat preferences, vegetation groups and landscapes suited for woylies. Also in my study, possible competition between brush-tail possums (*Trichosurus vulpecula*) was observed, but no solid conclusions were made about brush-tail possums being a major factor for population decline. Many woylies were trapped in trap sites that were in close proximity to paddocks and private property. This trend is interesting since paddocks are becoming universally understood as a habitat that provides resources for a variety of species. Woylie abundance was high in both National Park and Nature Reserves which is worthy to note, since National Parks are claimed to have the highest abundance of woylies.

It has been a difficult process, in the past and presently, to find one solid factor affecting woylie abundance. It is something that may take many more years to solve. Currently, the best efforts are being made by scientists and conservations to find an answer. It is important to not disregard any of the study factors but to continuously investigate multiple factors as a change in habitat preferences or the presence of other small mammals may affect woylie population declines.

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Introduction:

1.1 Woylie Ecology and Habitat Preference

The woylie (*Bettongia penicillata ogilbyi*) is a nocturnal rat-like kangaroo. It is commonly called a brush-tail bettong and woylie refers to its name from the Nyoongar, indigenous south west Australians. Other common and indigenous names include Brush tailed Bettong, Rat Kangaroo, Brush trailed Rat Kangaroo, Woylyer, and Karpitchi (De Torres 2008). There are two currently recognized subspecies *Bettongia penicillata ogilbyi* which populates south west Australia and has been reintroduced into parts of South Australia and New South Wales and *Bettongia penicillata penicillata* which is an extinct woylie originally endemic to south-eastern Australia (Department of Environment and Conservation 2002). The woylie has a brown dorsal side and a yellow-grey ventral side with a black crest on its tail which is the meaning of *penicillata* ('black crest') (Troughton 1941). When the woylie moves, it bounds with its head held low, back arched and the tail is held straight behind it. The tail is used for digging and collected nesting materials. The woylie diet consists of tubers, bulbs, and grain/seeds and sometimes resin exudate from *Hakea* species (De Torres 2008). Woylies are typically known to be mycophagous, feeding primarily on underground fruiting bodies of ectomycorrhizal fungi (Christensen 1980, Lamont et al. 1985, Malajczuk et al. 1987, Claridge & May 1994). A main part of their diet includes a common native truffle of south west Australia called *Hysterangium* (Mitchell et al 2008). The digging involved in finding these truffles, increases water infiltration and traps seed and organic matter which aids in dispersing fungal spores and seeds (De Torres 2008). These various contributions to significant environmental services hails the woylie as a keystone species to the Jarrah woodlands of south west Australia (Garkaklis 2001).

Different sources note the *bettongia penicillata ogilbyi* lives in various habitats. In a population of *B. penicillata ogilbyi* in Western Australia, scrub density and bare ground were identified as important characteristics of the preferred habitat for this species, with animals absent from open areas and areas with extremely dense ground cover (Christensen 1980). Woylies are known to inhabit areas where *Xanthorrhoea* (grass trees) (De Torres 2008), *Gastrolobium* (Christensen 1980; Mitchell 2008), various types of *Leucopogon* (Christensen 2008), *Hakea* (Straham 1984), *Pteridium esculentum* (bracken fern) and *Bossi ornata* (A. Wayne pers. comm.). Woylies use these types of vegetation for nesting, nutrients, and protection. *Pteridium esculentum* (bracken fern), *Bossi ornata*, and *Gastrolobium* are thought to be classic indicators of a good woylie habitat (A. Wayne pers. comm.).

1.2 Woylie Population Declines

Evidence from Aboriginal people and early settlers' records suggest the woylie was abundant throughout most of Australia as they once occupied south-eastern Queensland, eastern and southern New South Wales, western Victoria, most of South Australia, much of the Northern Territory outside the Wet Tropics and the south-west of Western Australia. In the 1880's woylies were quoted to be 'swarming'. In the early 1900's the number of woylies in South Australia were so high, people sold them by the dozen for coursing (hunting) using greyhounds (Wood-Jones 1925). Within the last century woylies have had numerous peaks and lows in their abundance (Figure 1).

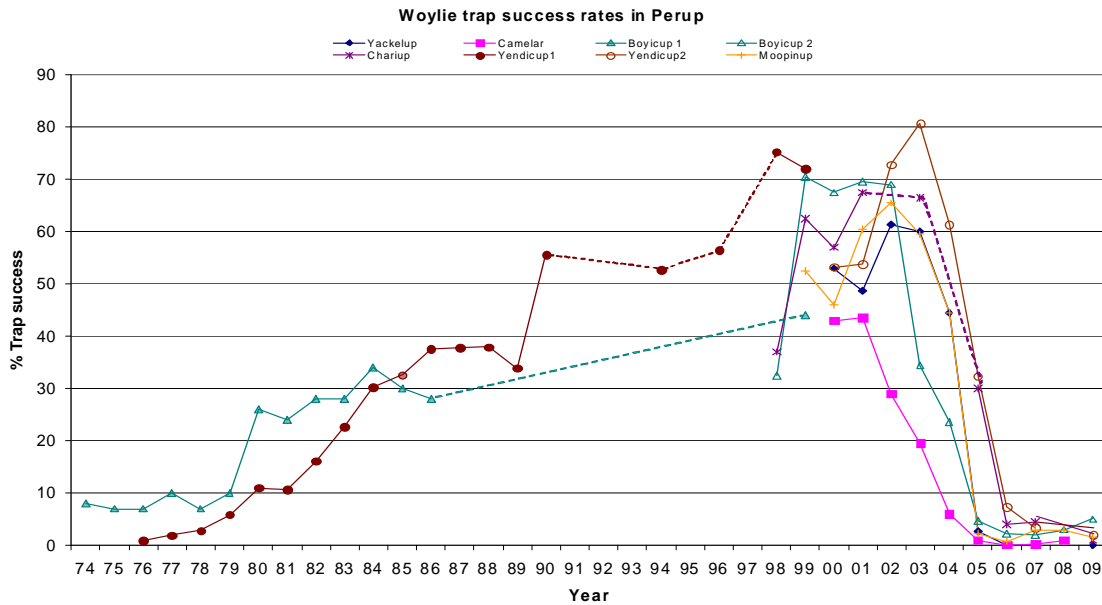


Figure 1: Trap success of woylies from the first population decline in the 1970's and second population decline, in the early 2000's.

In the 1970's a new interest in the woylie populations was sparked by a Conservation and Land Management (C.A.L.M.) scientist, Per Christensen. Christensen determined exotic diseases, land clearing and the spread of the introduced fox led to accelerated declines and by the 1960's, the woylie became restricted to three areas in southwestern Australia ---Dryandra, Tutanning and Upper Warren (Christensen 1980). In 1973, the woylie was listed as a threatened species in Western Australia (Wayne J. 2010). It was suspected that foxes were a factor in the decline of woylie populations. In 1977, D.E.C. and C.A.L.M. started a fox baiting program using 1080. After the fox baiting program started, a dramatic increase in the numbers of woylies and other medium sized marsupials was observed in 1996 (Wayne J. 2010). The recovery of the woylie was hailed as a resounding success. Populations of this native marsupial had recovered to the extent that it was removed from both State and Commonwealth threatened species categories-

the first species in Australia to be de-listed. The woylie became the ‘pinup’ animal for other conservation efforts throughout Australia (Mitchell *et al* 2008).

But in 2001 as the population was thought to continue increasing, woylie numbers were observed to have once again plummeted. Statistical analysis’ predicted that populations declined by 93 per cent at Dryandra, 95 per cent in Upper Warren River Catchment east of Manjimup and 97 per cent at Batalling (Mitchell *et al* 2008). Overall, the woylie population has declined by more than 80 per cent since 2001 (Wayne J. 2010) as the number of woylies have decreased any where from 25 to 95 per cent each year. Currently there are estimated to be less than 1,300 woylies remaining within the last four local populations- Perup, Kingston, Dryandra and Tutanning (Wayne J. 2010). As a result, in 2008 the Western Australia Wildlife Conservation Act re-listed the woylie as “*fauna that is rare or likely to become extinct*” as was written in the Wildlife Conservation Act of 1950 (Department of Environment and Conservation, “Minimum Standards” 2008). The Australian Federal conservation status has the woylie listed as *Endangered* and the World Conservation Union lists the woylie as *Critically Endangered*.

In response to these most recent population declines, the Department of Environment and Conservation established a recovery team and a project called the Woylie Conservation Research Project. The project speculates the most recent decline is due to several factors. One is the increased rate of adult mortality and whether reduced recruitment into the adult breeding population involved can not be established (Department of Environment and Conservation, Woylie Conservation Project Report 2008). Other possible causes of the recent population decline include a disease carried by two parasites called *Toxoplasma* and *Trypanosoma sp. nov.* as well as the increased predation of feral cats (Department of Environment and Conservation, Woylie Conservation Project Report 2008). Although it is not certain, there may

be a synergistic effect between the two parasites and various stressors are thought to trigger the disease (Department of Environment and Conservation, Woylie Conservation Project Report 2008). Climate and extreme weather conditions are also thought to be an agent of decline. Habitat loss, habitat modification, fire, direct human interference from trapping and lack of food resources have been dubbed as unlikely factors effecting recent population declines (Department of Environment and Conservation, Woylie Conservation Project Report 2008).

1.3 Woylie Translocation Project

In response to drastic woylie declines, government and national park groups have organized re-introduction or translocation projects. In 1983 the woylie was reintroduced and monitored in the Perup River Fauna Priority area and the same was done in 2001 in the Gammon Ranges National Park of South Australia. A successful woylie translocation project was conducted in the Karakamia Wildlife Sanctuary in 2008 (Richards et al 2009). The current Woylie Translocation Project run by the Department of Environment and Conservation aims to “translocate woylies (*Bettongia pencillata ogilbyi*) from wild populations within the Upper Warren Region (Greater Kingston and Perup areas) to the Perup Sanctuary, Perth Zoo and Malaga Native Animal Rescue in an attempt to establish and secure ‘insurance’ populations of the species and to further investigate the factors involved in the species decline” (Wayne J. 2010).

The goal of the project is to re-introduce at least 40 woylies into the Perup Sanctuary, 25 to the Perth Zoo and 8 to the Malaga Native Animal Rescue. The Perup Sanctuary was recently constructed for the purpose of securing an ‘insurance population’ of woylies. The translocation project is important to “securing critically important woylie populations from extinction” (Ordell

et al., 2009). The sanctuary is a 400 hectare (ha) predator-free enclosure in a forest block of Yackelup which was home to a large woylie population prior to the population declines in 2005 (Wayne J. 2010). The individuals translocated to the Perup Sanctuary will be tagged with radio collars and monitored to determine whether the woylies have an increased survival rate. I was involved in the first three weeks of the translocation project. At the end of three weeks 27 woylies were successfully translocated to Perup Sanctuary, 7 to Malaga and 3 to the Perth Zoo (e-mail from Adrian Wayne 1/12/2010).

1.4 My ISP

My Independent Study Project (ISP) involved me volunteering for three weeks with the Warren District Department of Environment and Conservation during the Woylie Translocation Project. My work lead me to the Shire of Manjimup in Western Australia and into the Bush, or forest, of the Upper Warren Region. I was a nomadic member of the trapping teams. I helped find, measure, GPS record and clear various transects. I also helped teams set, collect and clean traps . During the translocation project, I helped trap and process woylies and other species such as brush-tail possums, chuditchs, bobtails and quendas. In the field, I collected data on habitat surveys and tree basal areas. At the end of each trapping day, I recorded all the data collected at each transect and infiltrated it into my study. Throughout the course of three weeks I reviewed literature about woylies and the various factors affecting their population declines. I used both field data and various woylie resources to investigate the question of: *What factors may be affecting post-decline Woylie (Bettongia penicillata ogilbyi) abundance in the Upper Warren Region of South West Australia?* The possible factors studied included habitat surveys used to

observe any habitat preference, the presence of other small mammals, distance from paddocks and private property, vegetation group, landscape, and category of forest.

Methods:

2.1 Transects, Sites and Trapping

Woylie trapping for the translocation project officially began on November 8th, 2010 and will continue for 8 weeks. Multiple transects were established throughout the Upper Warren Region (in the Greater Kingston and Perup areas) which were set at least 1-2 km away from the already existing Upper Warren woylie population monitoring sites. This was done to maximize genetic diversity and capture woylies in areas suspected to have high population densities. Each trapping transect was at least 10 km in length with 50 trap sites, 2 m apart. Fifty Sheffield wire cage traps and a peanut butter-based bait was used at all sites. During the three weeks I volunteered, multiple trapping transects were run concurrently. Each site was trapped for up to four consecutive nights. At 5:30 A.M, four to five teams (made up of a scribe and an animal handler) drove out to a designated transect, collected and recorded all trapped animals before 10 A.M. All animals captured, including woylies and non-target species (i.e. Common Brush-tail Possums and Southern Quolls), were processed and recorded with standard trap monitoring protocols. These protocols include recording species, weight, sex, breeding condition, age, standard body measurements and individual identifiers (i.e. ear tags). Woylies that were not female with dependent young, were processed, recorded and sent to the Perup Ecology Center for further processing. This collected data will be used to explore how woylie populations may be effected by the presence of brush-tail possum and chuditch populations.

2.2 Habitat Surveys

Many studies involving woylie population declines have involved habitat site-vegetation studies or habitat surveys. Per Christensen did a habitat site-vegetation study in the 1980's involving woylies and tammars. He hypothesized woylie populations are “centered around certain site types which may be defined by distinctive plant associations” (Christensen 1980). Per Christensen did habitat surveys to determine if suitable habitats was an important factor in woylie abundance and distribution. Christensen’s methods included a principal component analysis, (P.C.A.), to reveal any associations between the study species and site-vegetation types. A P.C.A. was also done in this study to analyze any associations present between woylies and the basal areas of Jarrah (*Eucalyptus marginata*), Marri (*Eucalyptus camaldellensis*), Wandoo (*Eucalyptus wandoo*) and other species identified in the 13 transects.

Over the course of three weeks, I did habitat surveys for all 13 trapping transects at all 50 sites equaling 650 data points at the end of the study. The forests of the Upper Warren Region are mostly Jarrah and Marri Forests with low under story scrub, and open Wandoo woodland. Tree basal area measurements using a Factor 2 prism were made for Jarrah (*Eucalyptus marginata*), Marri (*Eucalyptus camaldellensis*), and Wandoo (*Eucalyptus wandoo*) trees as well as other species identified such as Flooded Gum (*Eucalyptus grandis*) and *Bull banksia* trees. The amount of prism contacts were recorded and these numbers were multiplied by two to give the value of m²/ha. I also recorded which vegetation was present in both the middle and lower canopy of the forest. One part of Christensen’s study involved him taking note of the density and sparseness of vegetation present. Density and sparseness in my study was also noted, but inconsistently and only in when very obvious density and sparseness was observed. Obvious can

be denoted as 'dominant flora covering 40-60% of the ground.' The soil color and type (brown/red/grey/yellow and sand/gravel) was also noted, but not used in the final analysis.

2.3 Other Possible Factors

At every trap site, the different types of vegetation were recorded. After all the vegetation was recorded, eight dominant types of vegetation was chosen out of the habitat surveys completed at each transect. These eight types of vegetation were chosen due to the *Bossiaea ornata*, *Eucalyptus wandoo*, *Hakea*, *Gastrolobium bilobum*, *Leucopogon capitalatus*, *Leucopogon juniperinus*, *Pteridium esculentum* and *Xanthorrhoea preissii*. Each of the eight floral types were given one mark as a means to denote that the vegetation was present. The other data including landscape, vegetation group, category of forest and the distance from paddock was collected by a colleague using a variation of computer programs and DEC corporate data bases. All trap sites were matched up using an ARCH Pad GPS system and ARCH view GSI which are E.S.R.I. programs. All 650 GPS points were matched up with DEC Corporate data bases.

During analysis, the data was separated into sites that did and did not trap woylies. They are classified as captured and non-capture sites. This was done to determine any trends or patterns in the possible factors affecting woylie abundance.

Results:

3.1 Habitat Surveys

Per Christensen's P.C.A. run on his habitat site-vegetation studies revealed woylies favored sites with a variety of vegetation including *Leucopogon capitellatus*, *Eucalyptus marginata*, a variety of *Hakea* and other varieties of *Leucopogon* present in well drained areas and deep soils. The P.C.A. run for this study (Table 1) reveal woylies had a negative correlation with transects with high basal areas of Marri, Wandoo and Other identified species and a positive correlation with those areas consisting of a high Jarrah basal area.

	PC1	PC2	PC3	PC4
Jarrah	0.5304	-0.33589	0.57979	0.51932
Marri	0.48211	0.34981	-0.65494	0.46505
Wandoo	-0.61634	-0.42104	-0.23705	0.62182
Other	-0.32614	0.76651	0.42274	0.3569

Table 1: P.C.A. results for Tree basal area of Jarrah, Marri, Wandoo and other species identified.

In Figures 2 and 3 it reveals the amount of each vegetation recorded at sites where woylies were and were not captured. The results of this particular study revealed woylies were captured in sites with high levels of *Leucopogon capitalatus*, *Hakea* and *Bossinea ornata*. Where woylies were not caught, high levels of a varying type of *Leucopogon*, *Leucopogon juniperinus* was observed. The ground cover density of various types of vegetation was recorded as dense in different transects (Table 2).

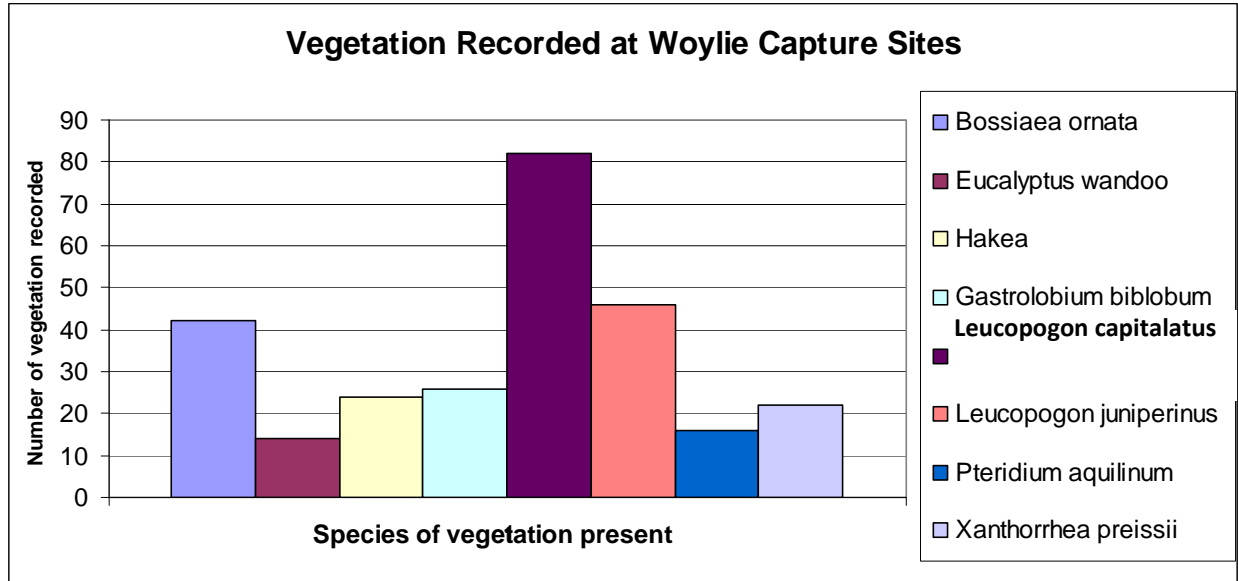


Figure 2: Graph of the 8 dominant vegetation species present at woylie capture trap sites.

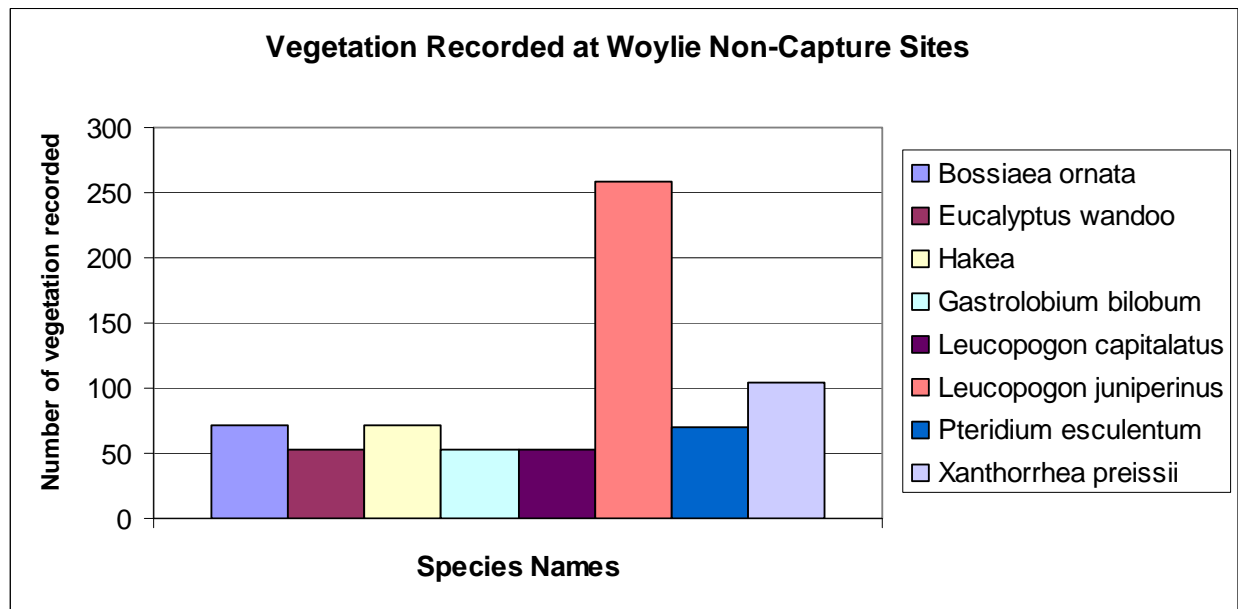


Figure 3: Graph of the 8 dominant vegetation species present at woylie non-capture trap sites

Vegetation Type	Coverage	Transect Name
<i>Leucopogon capitalatus</i>	Dense	Dwalgan, Corbal and Boyicup 2 and Yackelup 3

<i>Gastrolobium bilobum</i> (heartleaf)	Dense	Kenninup 2
<i>Xanthorrhoea</i>	Dense	Kingston 9
<i>Pteridium esculentum</i> (bracken fern)	Dense	Coonan, Coonan 2, Corbal
<i>Bossiaea ornata</i>	Dense	Dwalgan, Boyicup 2, Yerramin

Table 2: Dense vegetation at various transects. Notice that Dwalgan and Boyicup 2 have high densities of *Leucopogon capitalatus* and *Bossiaea ornata*.

3.2 Presence of Other Small Mammals

Figure 4 displays how many woylies, brush-tail possums and chuditchs were caught in three weeks at all 13 transects. Generally transects where high numbers of woylies were trapped, trapped fewer brush-tail possums and fewer or equal numbers of chuditchs. The amount of brush-tail possums trapped were more than double the amount of woylies trapped. Overall, the brush-tail possum had the greatest abundance in all 13 transects.

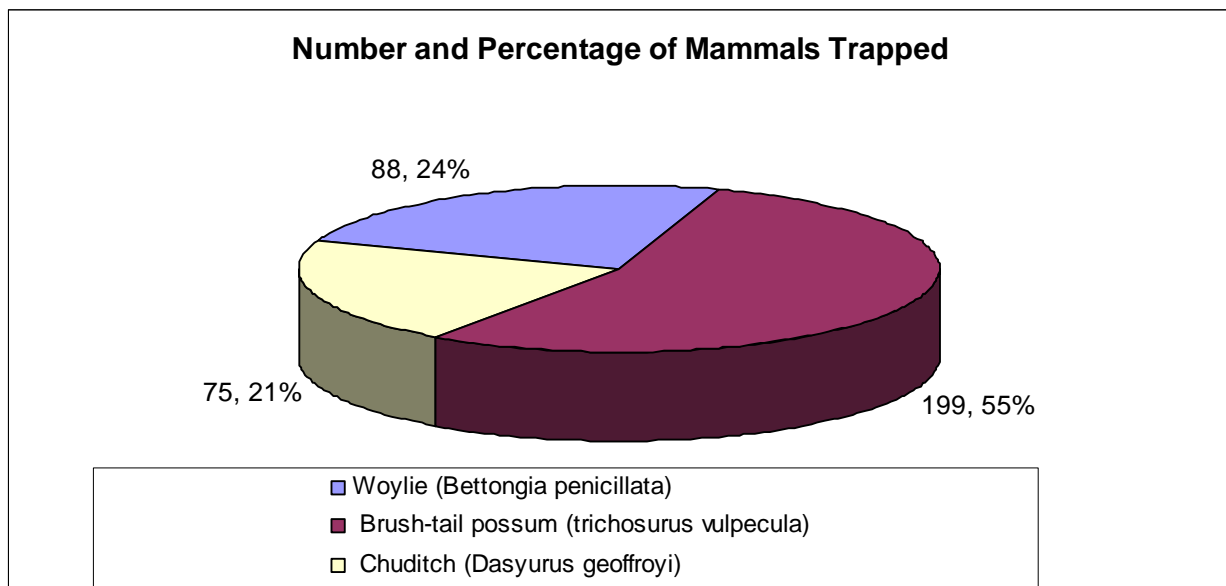


Figure 4: Pie chart showing how many woylies, brush-tail possums and chuditchs were caught in all 13 transects.

Transect Name	Woylie (<i>Bettongia penicillata</i> oygli)	Brush-tail Possum	Chuditch
Balban 2 (BAL2)	4	6	17
Boycup 2 (BOY2)	19	12	1
Coonan (COO)	0	5	4
Coonan 2 (COO2)	0	12	1
Corbal (CORBAL)	7	34	6
Dwalgan (DWAL)	28	12	4
Kenninup 2 (KEN2)	5	16	12
Kenninup 3 (KEN3)	8	23	1
Kingston (KING)	3	25	14
Meribup (MER)	3	9	1
Yackelup 2 (YAK2)	1	13	2
Yackelup 3 (YAK3)	1	14	5
Yerramin (YER)	9	18	7
TOTAL	88	199	75

Table 3: Total number of mammals caught at each transect. Dwalgan and Boycup 2 are in bold to emphasize the high number of woylies captured at that site.

3.3 Distance from paddocks

A great majority of the transects (~43%) were within 100-500 m to a paddock or some form of private property (Figure). 41% of the woylies captured were within this same distance from paddock.

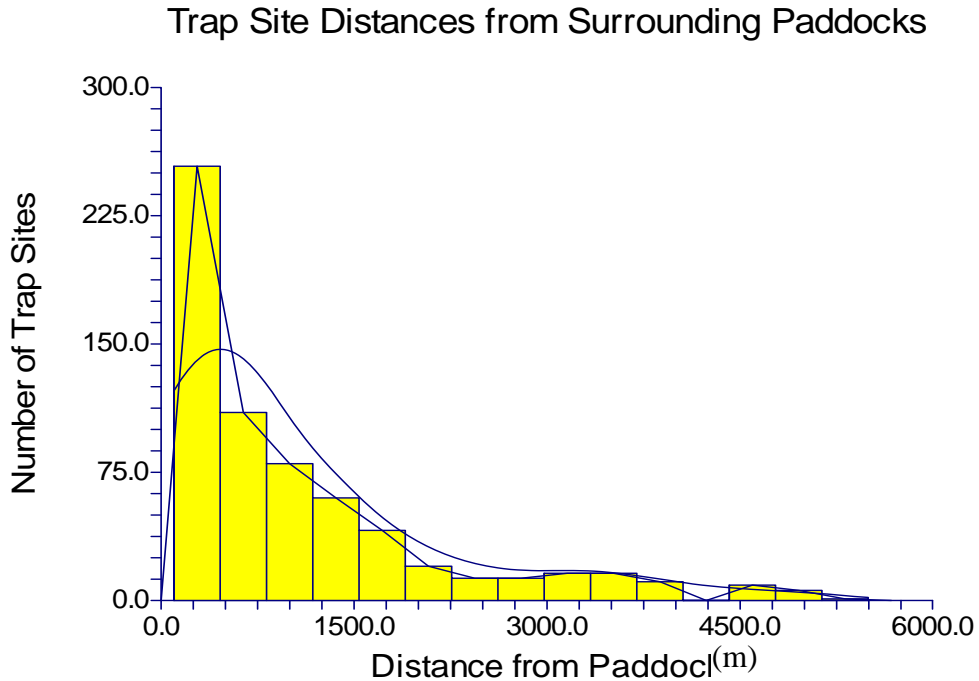


Figure 5: Chart displaying the distances each trap site was from paddock or private property.

3.4 Vegetation Groups

The vegetation groups of each trap site fell underneath the category of depressions/swamps, Jarrah uplands, Jarrah Valleys, Wandoo uplands and Wandoo Valleys. As was previously stated, the data was separated into sites that did and did not trap woylies. They are classified as captured and non-capture sites. The per cent of each vegetation type was calculated for capture and non-capture sites. They are the following: Captured sites: Depressions/swamps: 29%, Jarrah uplands: 43%, Wandoo uplands: 8.3 %, Wandoo valleys: 15.7% Non-captured sites: Depressions/swamps: 22.1%, Jarrah Uplands: 34.9%, Jarrah Valley: 11%, Wandoo uplands: 12%, Wandoo valleys: 18.8%

3.5 Landscape

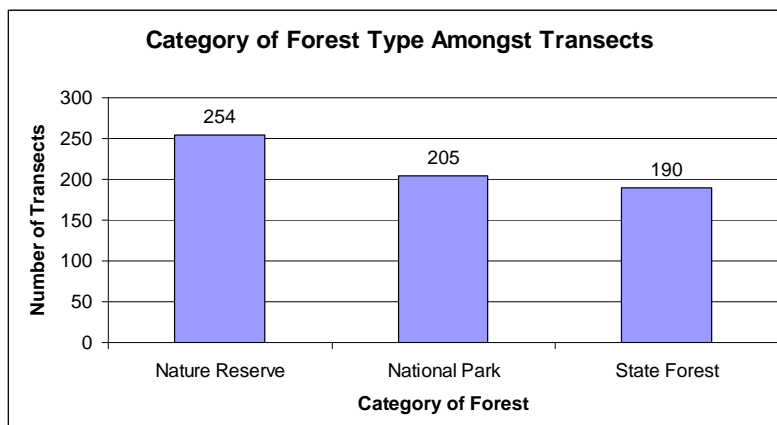


Figure 6:

Simple bar

graph showing the how many transects were in each category of forest.

The landscapes included depression, uplands and valleys. The percentage of these land forms present in woylie capture and non-capture sites was calculated. The results are the following:

Captured: Depression: 29%, Uplands: 48.6%, Valleys: 19.4% and Non-captured sites:

Depressions: 29%, Uplands: 48.6%, Valleys: 19.4%.

3.6 Category of Forest

There were three different categories of forest including National Park, Nature Reserve and State Park (Figure) Again, the percentage of these categories were calculated for woylie capture and non-capture sites. The results are the following: Captured: National Park: 53%, Nature Reserve: 38.8 %, State Forest: 5.5% and Non-Captured: National Park: 33%, Nature Reserve: 36%, State: 31%.

Discussion:

4.1 Habitat Surveys and Habitat Preference

The results of my habitat surveys and tree basal areas revealed similar results to Per Christensen's habitat site-vegetation studies. Both Christensen's and my study revealed that woylies are found in habitats with high levels of Jarrah, *Gastrolobium bilobum* and *Leucopogon capitalatus*, *Bossi ornata* and *Hakea*. The results of my study are evidence that woylie habitat preference is the same as it was 30 years ago.

4.2 Presence of Other Mammals

During the translocation project trapped other mammals including brush-tail possums (*Trichosurus vulpecula*) and chuditch also known as Western quolls (*Dasyurus geoffroyi*). The abundance woylies, brush-tail possums and chuditch are all low to moderate in the Upper Warren Region (Wayne J. 2010). The fox baiting program established in the 1980's saw an increase in all Upper Warren small mammal populations, especially the woylie and the chuditch (Start *et al.* 1996). The chuditch, like the woylie, used to populate about 70% of Australia but is now reduced to the South West corner of Australia. The chuditch is a natural predator to the woylie but its main diet consists of invertebrates and plants. According to the data collected in this study, chuditch numbers were either equal or less than woylie numbers. Therefore, chuditch do not seem to be a major factor in the post decline woylie populations.

Usually the densities of small mammal populations have tended to fluctuate together, but recently a new trend has arisen between woylie and brush-tail possum abundance. It has been observed that when woylie populations are low, brush-tail possum populations tend to increase (A. Wayne per. comm.). This trend was evident in the trapping data collected during the translocation project. There is no published literature discussing this recent trend, but it may be due to the brush-tail possums' ability to adapt to a variety of habitats ranging from forests, woodlands, ground hollows, hollow logs, ground with no trees and cities (How 1995) therefore adding an element of competition to woylies in preferred habitats.

4.3 Distance from Paddocks

A recent study in the Upper Warren Region involving Western Ring-tail possums (*Pseudocheirus occidentalis*) found an increased abundance associated with cleared land that was agricultural or an exotic tree plantation. A variety of animal populations across the world have had increased abundance due to increases in forest edges (Wayne 2006). This is thought to be explained by the selective nature of agricultural development (Finlayson 2008; A. Wayne per. comm.). Cleared land for agriculture is generally picked due to its close proximity to water sources and good soil quality. The high percentages of woylie captures were close to paddocks and some woylies upon release were observed to retreat into blue eucalypt farms. Studies of the wildlife values of blue eucalypt plantations concluded that blue gums provide a habitat or resources for a range of species (Lindenmayer 2004) including woylies which helps explain the high percentage of woylie capture sites near paddocks.

4.4 Vegetation Groups and Landscape

The majority of woylies caught were in the Jarrah uplands and depression/swamp vegetation groups and in upland landscapes. Christensen's study found woylies prefer well drained areas and deep soils which consists of uplands and depressions. Woylies are generalists in that they prefer drier open woodlands which include upland Jarrah forests. Therefore, this data is further evidence that woylie habitat preference remains the same.

4.5 Category of Forest

The Conservation Commission of Western Australia is the vesting body for State forest, national parks, conservation parks and nature reserves and the Department of Environment and Conservation (D.E.C.) (Australia's Forest 2009). In 2001, the Forest Management Plan 2004-2013 (F.M.P.) was established by the State Government of Western Australia. With the F.M.P. the State Government implemented the *Protecting our old-growth forests policy* which brought an end to logging in all old-growth forests managed by DEC. These areas include the National Park areas of Dwalgan and Perup which were transects included in the translocation project. These areas were chosen due to the high abundance of fauna, such as woylies, while Nature Reserve and State Forest have lower fauna abundance. This explanation may give the impression logging is a major effect of low woylie abundance, but many studies have proved logging is not a major factor in woylie population declines (A. Wayne per. comm.).

Conclusion:

In conclusion, the study did not verify any of the possible factors to be a main factor affecting woylie abundance. The study did ensure that woylie habitat preference has not changed and remains to be arid upland habitats consisting of Jarrah. Also, the collected data verified woylies continue to prefer ground vegetation consisting of *Bossiaea ornata*, *Hakea*, *Gastrolobium bilobum*, *Leucopogon capitalatus*, and *Eucalyptus marginata* (Jarrah). Woylie abundance may be affected by competition with brush-tail possums for preferred habitats. Competition may be amplified in areas where woylie habitat preference is enclosed or bordered by a variety of habitats suitable for possums.

The transects with the highest numbers of trapped woylies were Dwalgan and Boyicup 2. Both of these transects contained habitats preferred by woylies. There was not an immense amount of trap sites in Dwalgan and Boyicup 2 that were close to paddocks but it is important to note that about 50% of the trap sites in Dwalgan and Boyicup 2 were 100-500m away from paddocks. Another interesting observation is all Dwalgan trap sites were in National Park while Boyicup 2 trap sites were predominantly in Nature Reserve. Perhaps woylie abundance in Boyicup 2 are recovering in Nature Reserves where abundance is thought to be low.

Although no factors led to any definite conclusions, none of the studied factors should be completely disregarded. The collected data may have been more useful if a more in-depth statistics analysis was conducted. In the end, looking at multiple factors is important especially when developing a successful conservation plan for endangered species. Many studies that investigate multiple factors affecting rare animal abundance, speculate many factors tend to have a synergistic effect on the abundance of the threatened species. The Department of Environment and Conservation woylie translocation project plans to do habitat surveys for the remaining trapping transects and sites so as to investigate further whether woylies have changed their habitat preferences. Currently, the main factor is most likely due to disease and increased mortality of adult woylies.

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