# PROPERTY-LEVEL RABBIT CONTROL USING HARBOUR DESTRUCTION RESTRICTS BREEDING SUCCESS

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## ABSTRACT

The European rabbit is a significant economic, environmental, and social pest animal in Australia. Best management strategy for managing the impacts of rabbits involves integrated control techniques to reduce rabbit numbers and prevent re-invasion. In Queensland, rabbit populations have become isolated and sporadic as a result of biological control activity and on-going strategic control programs. This provides opportunity for land managers to have significant positive outcomes on individual properties with greatly reduced risk of re-invasion. Four case studies are presented where individual or small neighbouring properties have used harbour removal as the primary control tool following natural virus outbreaks to achieve greatly reduced rabbit numbers. In two of the case studies, rabbit breeding and survival was assessed using remote monitoring cameras to track kitten emergence from breeding harbour and subsequent survival (or not) to adulthood. In all cases, only one kitten per breeding season and location survived to adulthood, but overall, the adult numbers declined, and by up to 88 percent. Rabbit declines following the harbour removal were greater than those seen following virus outbreaks, highlighting that virus outbreaks on their own will not achieve satisfactory control outcomes. Harbour removal provides greatly reduced rabbit numbers and longer-term benefits than other control techniques and when used in an integrated process with other control tools provides excellent outcomes for land managers.

**Keywords**: Rabbit, harbour destruction, IPM, breeding, survival

## INTRODUCTION

Australian land managers have been battling the damage caused by European rabbits (*Oryctolagus cuniculus*) for over 170 years. It is often considered that the best outcome for controlling any vertebrate pest is an integrated pest management (IPM) program. The modern idea of IPM has been around since the 1970's and encourages multiple control techniques in a short period of time to remove as many of the pest species as possible (Kogan 1998). For rabbit management, there are many control tools available as well as natural conditions that can be used to achieve excellent outcomes (for examples see Cooke 1981, and Williams and Moore 1995).

Rabbit numbers in Australia increased through the early 1900's to levels where individual property management was unrealistic. The sheer number of rabbits throughout the landscape meant that any effort to remove rabbits from a single property would be undone by immigration from nearby populations. This changed with the release of biocontrol agents that kill rabbits – first myxoma virus in 1950, then Rabbit Haemorrhagic Disease Virus (RHDV-Classic) in 1995 and finally RHDV2 and RHDV-K5 in 2014 and 2017 respectively (Fenner and Ratcliffe 1960, Cooke and Fenner 2002, Cox *et al.* 2019, Ramsay *et al.* 2020). The success of these viruses in Queensland has meant that rabbit populations are now

sporadic and greatly reduced. This provides an opportunity for land managers to have meaningful impact on rabbit populations on their own property, or with neighbouring properties, with long-term results.

Here, four case studies of control programs that reduced rabbit populations and their impacts for individual or neighbouring land managers are described. These studies all used harbour removal as the key control technique and were integrated with natural environmental conditions, virus outbreaks and/or fumigation and shooting. The removal of rabbit harbour is considered to expose rabbits to predation risk and weather extremes reducing their survival (Williams *et al*. 1995). The success of harbour removal in the first two case studies discussed, and other control programs, led to questions about how well rabbits breed and survive in the harbour that remains. The final two case studies address this question.

## CASE STUDIES

### Case Study 1 – Whetstone

Whetstone is a cattle feedlot and grazing property located near Goondiwindi in southern Queensland. It was a release and monitoring site for RHDV1-Classic in 1996 and monitoring continued consistently until 2003 (with a final survey in 2006). Monitoring consisted of a 10 km spotlight transect and opportunistic shooting of at least 20 rabbits for breeding status and evidence of virus activity. Rabbit numbers were quite high prior to the release of RHDV and declined by about 70% following the release (Figure 1). An outbreak of myxomatosis and a second outbreak of RHDV in 1998 reduced numbers further (below 2 rabbits per spotlight km) and they remained low before beginning to increase through the spring of 1999. At this time, the paddocks with the highest density of rabbits were ploughed as part of pasture improvement for cattle. This activity was not actually aimed at controlling rabbits but by fortune it removed the key breeding warrens on the property. Rabbit numbers declined even further (below 0.5 rabbits per spotlight km) and remained at that level at least until monitoring ceased in 2006.

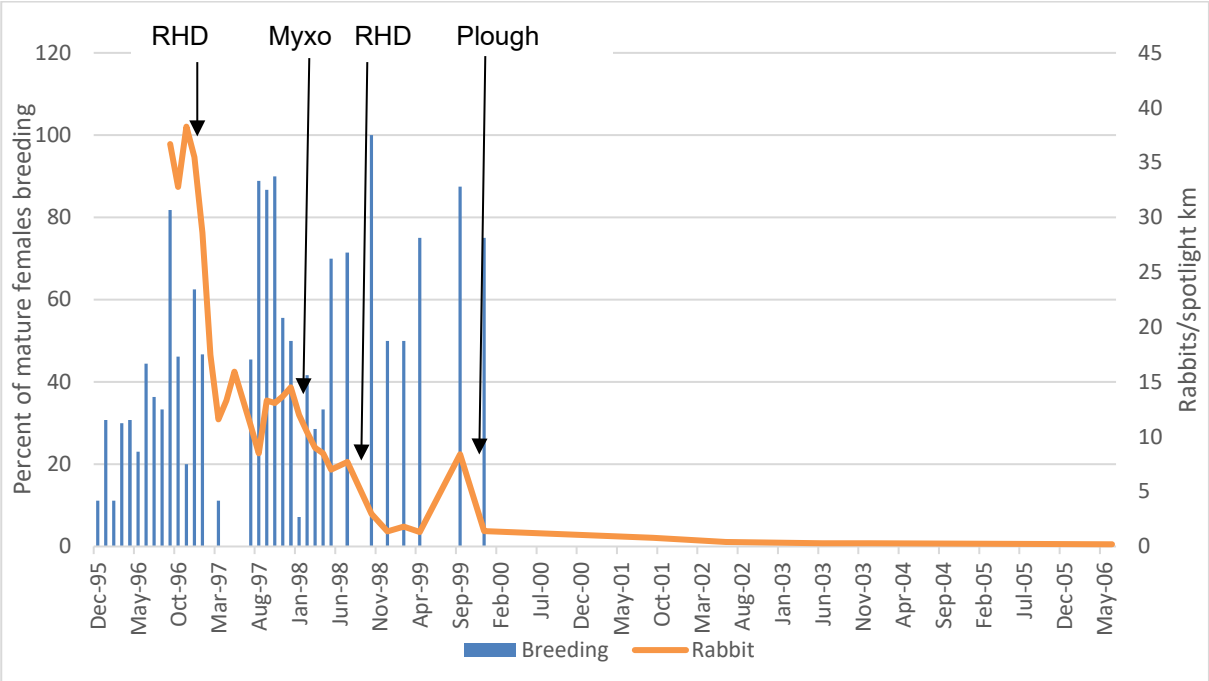


**Figure 1.** Rabbit numbers and percentage of mature females breeding at Whetstone.

During the decline of rabbit numbers, breeding effort was still being maintained. The percentage of mature females that were pregnant or lactating at each sampling period did not decrease and was higher than pre-RHD release in comparable months (Figure 1.).

### Case Study 2 – Highfields

Two adjoining small-acreage properties outside the township of Highfields in southern Queensland were found to have relatively high density of rabbits for the region in 2017. One property was a lifestyle block and the other was an unoccupied grazing block. Both properties were infested with lantana which was providing harbourage for rabbits to dig warrens under. In early 2018, RHDV1-Classic was released by injecting 16 rabbits trapped on the sites and releasing them. Ten of those injected rabbits were affixed with radio-tracking collars to determine their fate. At the time of the RHDV1-Classic release it was noted that RHDV2 was active on the site. Six carcasses were recovered within seven days of injection and blood samples confirmed they died of RHDV1. The remaining four collars were found removed from the rabbits within 5 days of injection and it is unclear if they were removed by the rabbits or lost due to predation. One collar was found approximately 1 km away from the collared site suggesting it had been moved by a predator. A reduction in rabbit numbers of 6 percent was seen at the time of the RHDV1-Classic release, however, as noted, RHDV2 was active at the same time (Figure 2).

In February of 2019, across both properties the lantana harbour was removed and all warrens (n = 62) and burrows (n = 45) were ripped using an excavator with a bucket and a single tine. Log piles and lantana piles were then burnt in March 2019. Rabbit numbers declined by 96 percent as a result of the harbour removal. Follow-up monitoring in 2022 and 2023 saw no rabbits and only some fresh sign near the boundary probably from a rabbit that has come in from off the site.

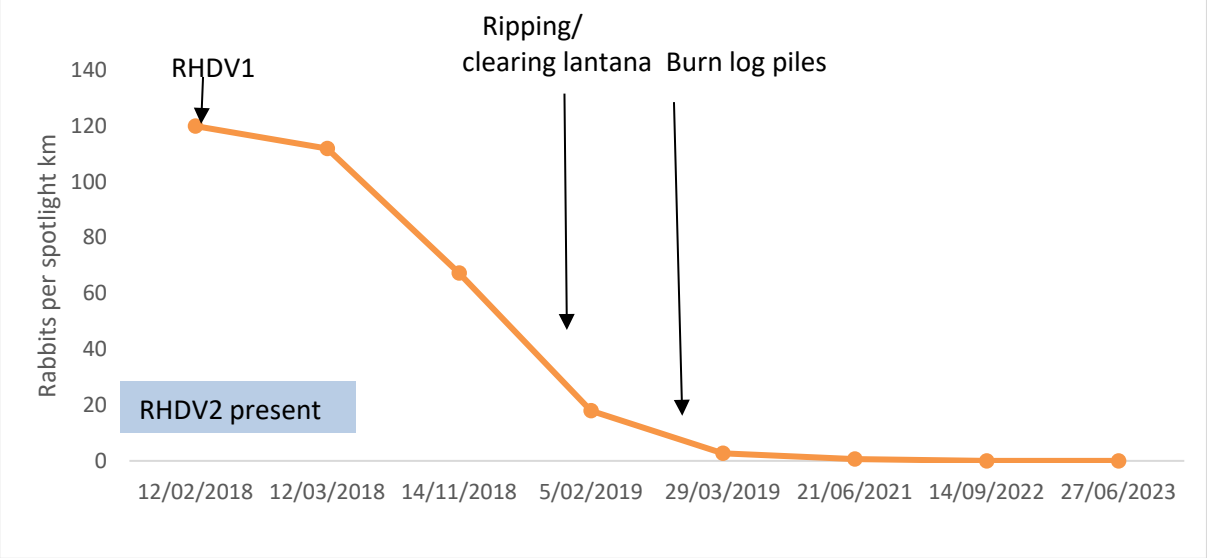


**Figure 2.** Rabbit numbers at the Highfields sites in relation to control works.

### Case Study 3 – Dalveen

The site outside the township of Dalveen was a 2000-acre cattle grazing property. Rabbits had been present for many years without being reported and had established a large number of warrens (n = 100), burrows (n = 242) and other breeding sites around log-piles, rubbish piles, sheds and houses, rocks and blackberry bushes (n = 354). Monitoring was undertaken using spotlight counts over a 6 km transect through the property. Control works

were undertaken through spring of 2019 and involved clearing and burning blackberry bushes, burning log-piles, moving rocks, ripping exposed warrens and burrows, and netting sheds. In total, 652 breeding places were treated, with 1 warren, 10 burrows, 1 log-pile, 1 tree-base, 5 blackberry bushes, 6 rocks, 1 soil mound and 1 hay shed un-treated for various reasons including accessibility, unwillingness from the landowner, and difficulty of removal (e.g. warren on a dam wall, or granite rock slab). Rabbit numbers declined by 87.5 percent and have remained low (Figure 3).

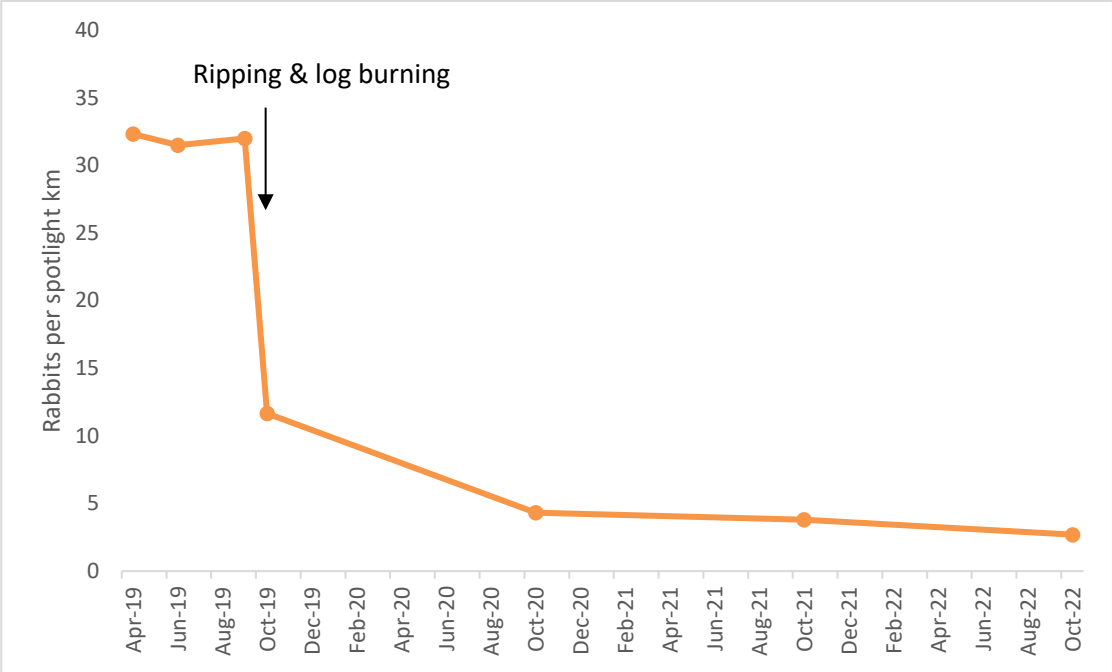


**Figure 3.** Rabbit numbers at the Dalveen site in relation to control works.

In June of 2021, the un-treated breeding sites were examined, and remote monitoring cameras were deployed and those sites that had rabbit activity to assess the survivability of rabbits when the key breeding locations had been removed and only difficult to control locations remained. Cameras were deployed at 1 warren, 1 burrow, 3 hollow logs, 1 tree-base, 2 rocks, 2 blackberry bushes and the hay shed. Enough cameras were placed at each location to capture activity at every entrance to the structure. Cameras were deployed from July 2021 to February 2022 to cover the expected breeding season. Images were downloaded every three weeks. The maximum number of adult, juvenile and kitten rabbits was recorded as well as any other animals and any interactions between rabbits and predators. The adult population at the monitored sites was 24 individuals at the start of the breeding season and five kittens were present at the hay shed. In September 2021 the hay shed floor was covered with wire netting and corrugated iron sheets and thereafter, no rabbits were captured on cameras at that location. In total, 34 kittens were born at the monitored sites with only one surviving to adulthood (at the warren). Breeding was observed at the hay shed, the warren, the burrow, and one rock location. At the end of the breeding season at the monitored sites, six adults and zero kittens were present, meaning an overall decline of 75 percent in the rabbit population despite the on-going breeding at those locations (Figure 4.). Predation was captured on cameras on 19 occasions (cats n = 7, dogs n = 7, raptors n = 4, quoll, n = 1). Signs of myxomatosis were observed on camera images and another possible factor for the decline of rabbit numbers was the weather (it was a wet spring and early summer).

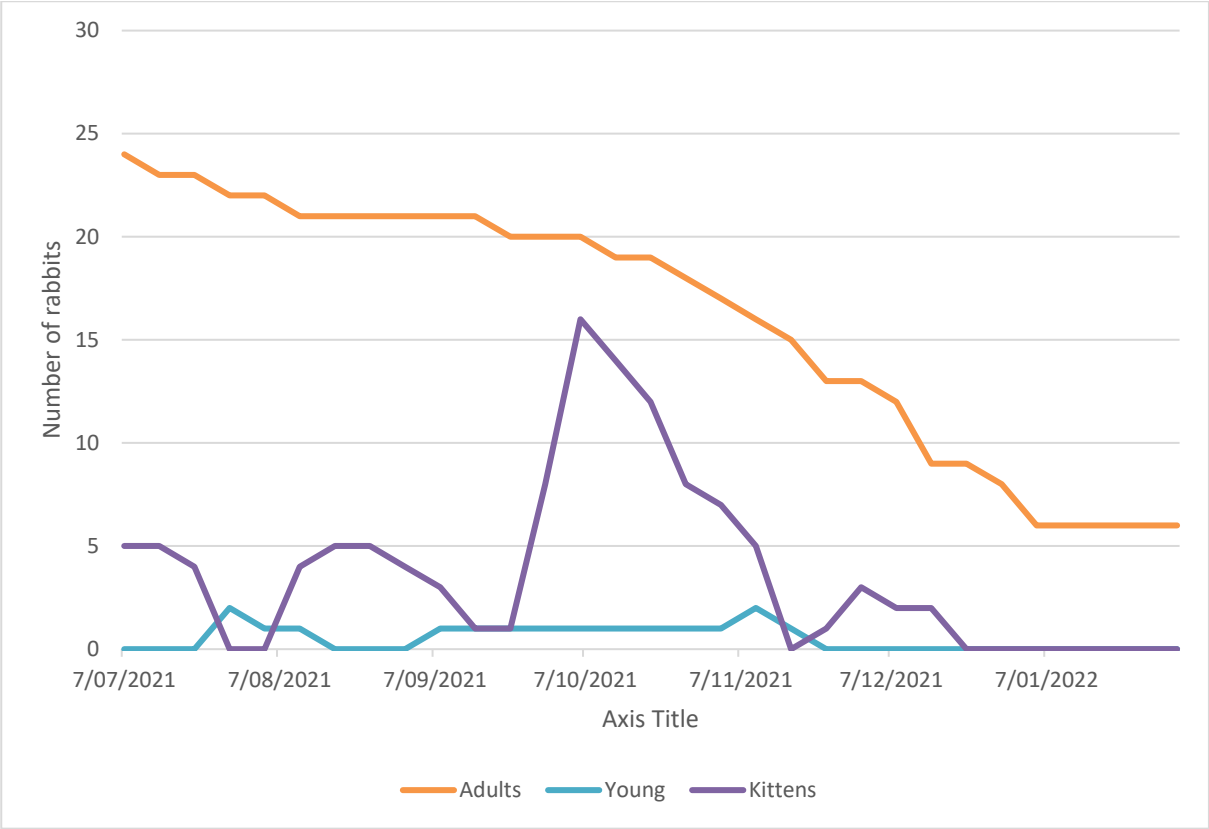


**Figure 4.** Number of rabbits by adults, young and kittens, captured on cameras at Dalveen through the 2021/2022 breeding season.

### Case Study 4 – Wallangarra

Two peri-urban properties (cattle and sheep grazing) were monitored as part of the RHDV1-K5 release in 2017. Spotlight counts began in 2013 to monitor the impact of the virus release and was continued to monitor impact of further management. On property one (45-acres), almost 100 warrens were ripped in May 2017 following the RHDV1-K5 release in March. Shooting of surface rabbits was undertaken through May and June 2017 and any burrow re-openings were fumigated and collapsed. On property two (4-acres), 14 warrens (although some of these may have been connected underground) were ripped in June 2017. No follow-up management occurred. Across the two properties rabbit numbers declined by 88 percent following the RHDV1-K5 release and warren ripping programs, with the ripping having the largest impact. Rabbit numbers on these properties had been significantly higher in 2016 and crashed following the arrival of RHDV2 (Figure 5.).

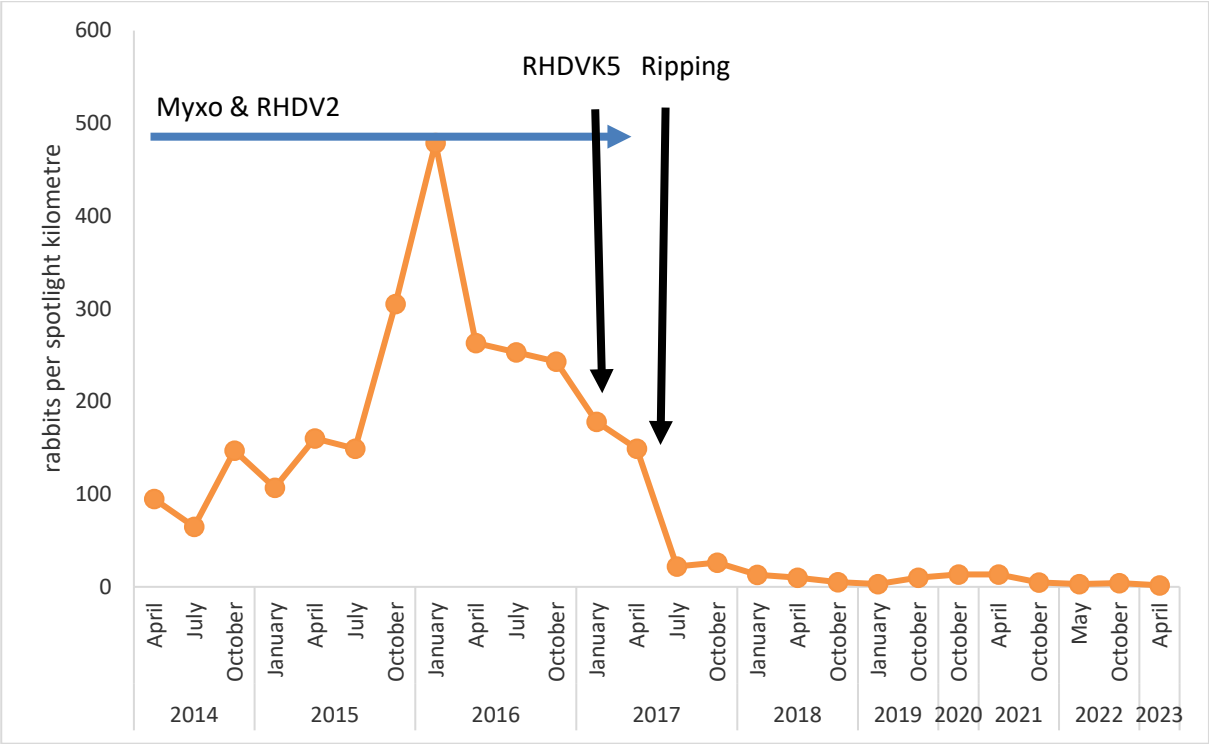


**Figure 5.** Rabbit numbers at the Wallangarra sites in relation to control works.

In June 2021, property one was examined for breeding sites and cameras were deployed to monitoring survivorship at two warrens, six burrows and one shed. Enough cameras were placed at each location to capture activity at every entrance to the structure. Cameras were deployed from July 2021 to February 2022 to cover the expected breeding season. Images were downloaded every three weeks. The maximum number of adult, juvenile and kitten rabbits was recorded as well as any other animals and any interactions between rabbits and predators. The adult population at the monitored sites was 18 individuals at the start of the breeding season. In total, 36 kittens were born at the monitored sites with only one surviving to adulthood (at a warren). Breeding was observed at the two warrens, three of the burrows, and the shed. At the end of the breeding season at the monitored sites, six adults and zero kittens were present, meaning an overall decline of 83 percent in the rabbit population despite the on-going breeding at those locations (Figure 6.). Predation was captured on cameras on 19 occasions (cats n = 2, raptors n = 6, fox, n = 1). All warrens and burrows were fumigated and collapsed following the monitoring period.

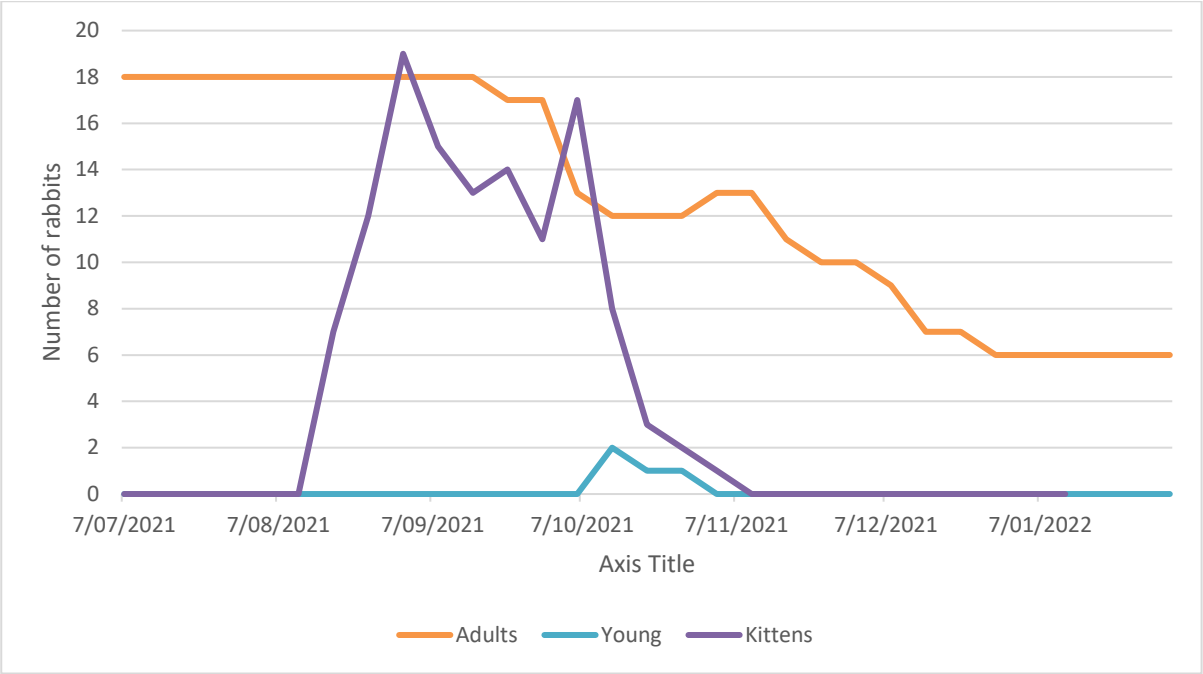


**Figure 6.** Number of rabbits by adults, young and kittens, captured on cameras at property one at Wallangarra through the 2021/2022 breeding season.

In June 2022, both properties were monitored through the breeding season as described above. Property one only had rabbit activity at the two warrens which had re-opened with two holes each (previously four and five holes respectively). Property two had 4 warrens and 2 burrows. The adult population at the monitored sites was four and 19 individuals respectively at the start of the breeding season. In total, six kittens were born at property one, and 31 kittens were born at property two with only one surviving to adulthood (at a warren). Breeding was observed at all warrens only. At the end of the breeding season at the monitored sites, at property one, the four adults and one kitten were present, and at property two, 16 adults and one kitten were present (Figure 7). Predation was captured on cameras on 12 occasions (cats n = 8, raptors n = 1, fox n = 3). All warrens and burrows were fumigated and collapsed following the study period and cameras remained in place for four weeks to monitor the impact. On property one, there were no re-openings and no rabbits seen on the cameras. On property two, three holes re-opened in the first week and were re-treated after which no more re-openings were seen. Seven occasions of a single adult rabbit were seen on cameras but only on those closest to the property boundary suggesting the rabbits were not residing on the property.

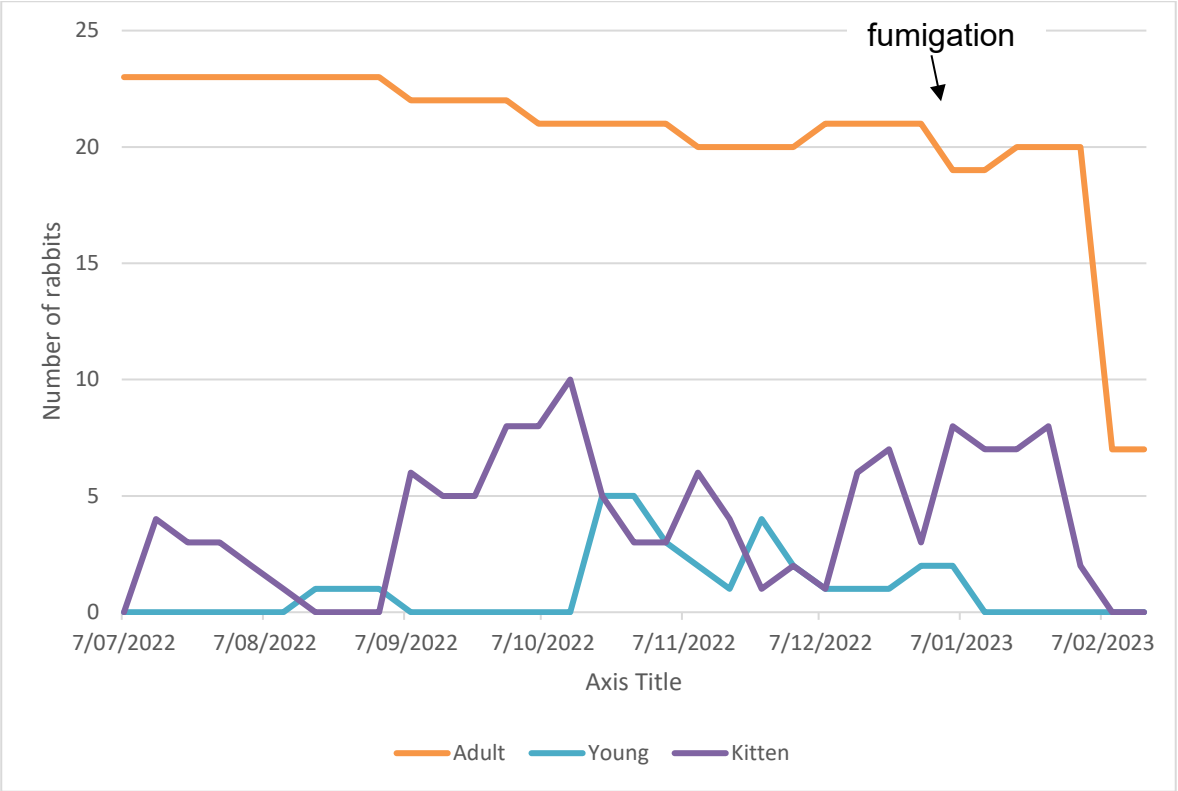


**Figure 7.** Number of rabbits by adults, young and kittens, captured on cameras at two properties at Wallangarra through the 2022/2023 breeding season.

## DISCUSSION

Rabbit survival depends on a number of factors. Bottom-up factors such as climate, soil, food availability, harbour and land use can provide favourable or unfavourable conditions for population breeding and survival, while top-down factors such as virus outbreaks, warren flooding, competition, predation, and human hunting have direct survival implications for individual animals (Norbury and Jones 2015). Land managers have access to many tools from the top-down suite of factors, however, these target individuals rather than populations. Of the bottom-up factors, harbour is the only one that can be directly impacted by land managers. Breeding and shelter locations such as warrens, burrows, log-piles, woody weeds, rubbish piles and structures can be removed or destroyed.

In the two case studies where breeding success and survival were monitored after harbour removal programs, the populations either declined significantly, or did not increase, despite many kittens being born. The properties in all the case studies presented achieved significant reductions in rabbit populations to levels below which regeneration of many trees and grasses can occur (Cooke 1987, Sandell 2002, Bird *et* al. 2012, Cooke 2012). In all cases, the harbour removal followed either natural virus outbreaks of RHDV and in some cases myxoma virus as well. In Queensland, natural virus activity is very prevalent and has reduced rabbit populations across the state. This removes the need for deliberate virus releases and allows mechanical control work to be more effective as it is already being integrated with virus activity. In three of the case studies, harbour removal was a multi-faceted approach with warren ripping, burning of woody weeds and log-piles, and fumigation and burying of burrows at the time of control or as follow-up management. By removing the breeding and shelter harbour, the land managers have not only reduced the rabbit populations significantly; they have also reduced the potential for re-invasion. Rabbit

populations are more sporadic across the state due to virus activity and on-going control works meaning that there are fewer rabbits looking to invade new areas and areas that do not have ready-made harbour are less desirable (Williams *et al* 1995). Property-level management of rabbits is achievable through harbour removal which reduces breeding success and will provide the best long-term benefits.

## ACKNOWLEDGMENTS

The Darling Downs and Moreton Rabbit Board (Nathan Ring and Greg Wilson) coordinated control works at Highfields and Dalveen and provided data for those control programs. The control works at Wallangarra were assisted by Southern Downs Regional Council and the Queensland Murray-Darling Commission (now Southern Queensland Landscapes) through funding from the Queensland Feral Pest Initiative. Whetstone data prior to 1999 was collected by DAF staff Georgianna Cunningham, Wanda Gould and David Berman. Landholders allowed access to their properties and undertook control works under the direction of the aforementioned bodies.

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