Rabbit Distribution and Abundance: Information Sheet

Controlling factors

Rabbits are adapted to the 'Mediterranean' climate of their Iberian homelands - a climate with cool, wet winters and hot, dry summers. They do well in similar regions in Australia, but not in the hot, humid tropics.

The primary environmental factors that influence rabbit distribution and abundance are:

- *Temperature.* Rabbits are stressed by heat and humidity. Some thresholds seem to be:
    - A mean annual minimum temperature of 10°C, with higher mortality rates and reproductive stress above that. Rabbits suffer reproductive stress in the tropics because, when high-quality food is available, it is too hot and humid for rabbits to dissipate the heat-load of lactation. The threshold roughly coincides with the Tropic of Capricorn; rabbits are distributed more patchily and at lower densities to the north.
    - A mean temperature for the warmest month of the year of 25°C, with reduced rates of reproduction in areas warmer than that. Rabbits can lactate in summer, but they use their fat reserves instead of getting energy from freshly ingested food. They produce fewer litters at longer intervals because they must rebuild energy reserves between each one.
- *Water.* Rabbits usually get all the water they need from the plants they eat except during drought, when there is less vegetation available and its moisture content may be lower. They then need to drink and require access to water within approximately 0.4 km of their warren.
- *Food.* The availability of food is an ephemeral factor.
    - Distance from agricultural lands can be used as a proxy measure for the availability of reliable and nutritious feed.
    - Rabbit densities are generally highest where the total rainfall the year prior was more than about 400mm and the winter temperature was above 4°C, creating good conditions for pasture growth.
    - Irrigation areas can support higher numbers of rabbits than the same area would without irrigation.
- *Soil type.* Soils with 20-50% clay content are good for burrows and, subject to rainfall, can be associated with the persistence of food plants throughout the year. Deep, sandy soils are also preferred burrow sites.

Other factors affecting rabbit distribution and abundance are the presence of predators and diseases, including bio-controls (like calicivirus and myxomatosis and the insects which spread them), and the rabbit-control activities of land managers.

- *Predators*: Rabbits can be a significant food source for foxes, cats, and dingoes. In some situations (e.g. when rabbit density is low or when biological controls are active) predators can help constrain rabbit numbers, but in good conditions rabbits outbreed predation.
- *Bio-controls*: Myxomatosis and RHD (rabbit haemorrhagic disease) viruses were introduced into Australia in 1950 and 1995 respectively, causing massive reductions in rabbit numbers (around 95%) in affected populations.
    - Myxomatosis is most effective in the wetter regions of Australia. It was not a reliable biocontrol in arid Australia in dry years due to the lack of mosquitoes to transmit it and because European rabbit fleas fared poorly in areas where average annual rainfall was below about 200 mm.
    - RHD is more effective in drier areas – partly because it is transmitted by flies. In wetter areas it can be limited by the presence of a related non-pathogenic virus (RCV-A1), which offers some immunity against RHDV, although the RHDV1-K5 strain can overcome that partial protection.
- *Conventional control*: Land managers control rabbits by removing their shelter (e.g. ripping warrens) and reducing their numbers (e.g. baiting, fumigating, shooting and trapping).

Warren destruction can have long lasting results, while shooting may be a shorter term solution (Mutze 1991, McPhee & Butler 2010, Lurgi *et. al.* 2016).

Challenges in monitoring

Recording the distribution and abundance of rabbits is not a simple matter.

Rabbit abundance fluctuates dramatically within and between years. Typically, rabbits breed rapidly with good seasonal conditions, followed in turn by a crash as they either eat themselves out of food or are affected by a control factor such as a bout of myxomatosis or rabbit haemorrhagic disease. Long-term monitoring is therefore essential to understand the true story of rabbit abundance at any location.

Collecting the data can, however, be time-consuming, costly, and logistically challenging as rabbits are nocturnal and live in burrows (concealing the extent of their presence from many would-be observers), and occur everywhere from urban areas to extremely remote, rarely visited sites.

The task of understanding rabbit abundance nationally is made more difficult by the lack of consistency in available data. Different survey methodologies are used across the country (e.g. warren counts, dung counts or spotlighting), at different scales and different frequencies. Furthermore, an apparent absence of rabbits may be because they are absent, the were present but not observed, or the area was not surveyed.

Rabbit distribution (i.e. the areas they may be found) is thought to be relatively stable across Australia, although in some regions their distribution can vary across seasons. As an example, in semi-arid zones sporadic vegetation growth follows good rain events, resulting in a local expansion of rabbit distribution. Distribution may also change at a local scale following introductions of new control methods. The Riverina in New South Wales provides an example - when myxomatosis first spread through the area, rabbits contracted from the heavier soils and became confined to sandhill and rocky habitats (Myers, 1960).

In spite of these difficulties, it is important to understand the distribution and abundance of rabbits as best we can. Australia has over 50 years of survey data, which has been compiled in the Australian National Rabbit Database (Roy-Dufresne *et al*., 2019). The database amassed information from over 120 studies across all States and Territories (including citizen science sources such as RabbitScan) into a consistent and unified framework. It eliminated potential disparities arising from different monitoring and reporting methods used for data collection.

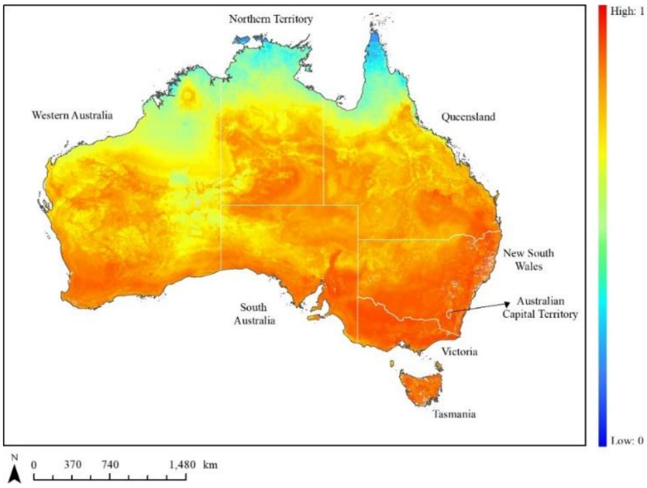
Nonetheless, there are still large areas in Australia without sufficient data for analysis. This inherent bias arises because not all areas are equally surveyed – sites with higher human populations, active rabbit control programs, abundant rabbits, or easy access are surveyed more than others.

Modelling rabbit distribution and abundance

Models have been developed to build on this patchwork of data and effectively ‘fill the gaps’ with predictions of distribution and abundance. Models also help analyse the key factors controlling rabbit populations. Every model has shortcomings of some kind but there are some consistent patterns and interesting differences in their outputs, providing useful insights into rabbit distribution and abundance in Australia.

A recent modelling exercise used species distribution models, which draw on available occurrence data and the associated climatic and environmental information for sites site where rabbits were observed (Roy-Dufresne *et al.* 2019). It reduced issues of spatial bias in the occurrence data, and provided insights about the geographic range limits of rabbits and habitat suitability in Australia.

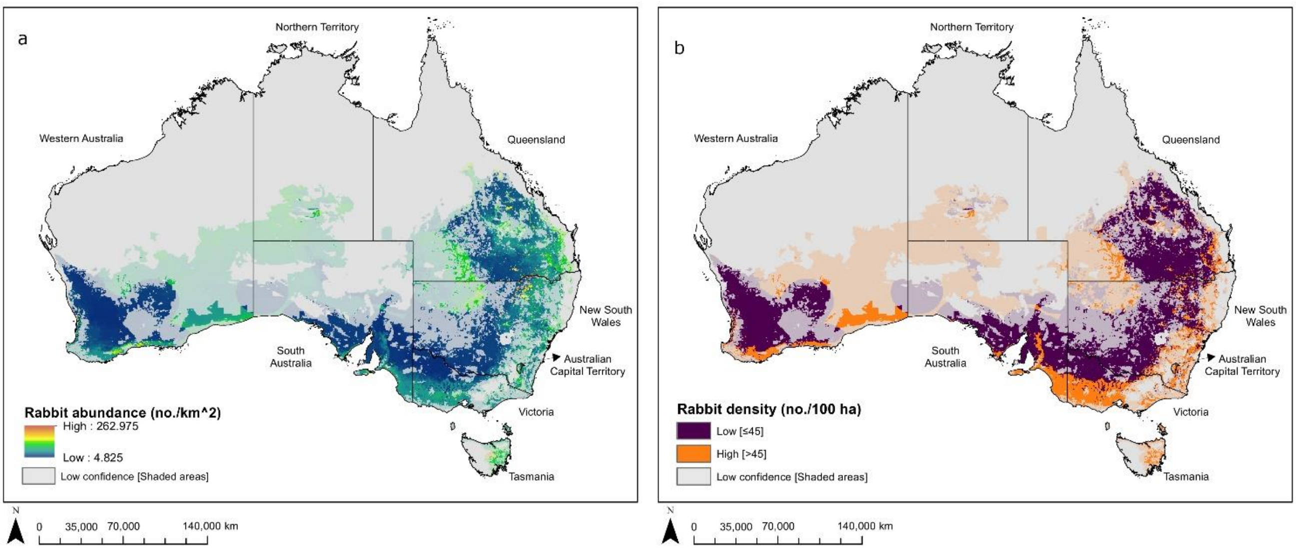
Outputs highlighted the importance of having occurrence data from across the entire range of a species for accurate results. In this case, a combination of expert and citizen science data was used to broaden the sampling effort spatially and temporally, enabling extrapolation across Australia.



Averaged probability of occurrence of rabbits across Australia. (Roy-Dufresne et.al. 2019)

Brown et al. (2020) combined climatic and environmental data, biological thresholds, and the long-term abundance datasets from the Australian National Rabbit Database to model the abundance of rabbits at a continental scale. That work enabled the production of maps showing the mean abundance of the rabbits in different regions of Australia, regions where the rabbit density is greater than 45 rabbit/100 ha (approximately 1 rabbit/2 ha) at which rabbit damage to vegetation is evident, and finally, 'hot spots' regions where rabbit abundance is persistently high based on the modelled interannual variation in rabbit abundance.

These results provide a clearer understanding of the factors controlling rabbit abundance in Australia (as discussed previously), but highlighted the complexity of integrating datasets from disparate sources with varying spatial and temporal scales. While correcting for observation error and seasonal bias in the datasets, the authors were limited to using only a subset of available datasets (due to limited sampling information) and to constrain predictions to regions within the bounds of the climatic conditions where abundance datasets were collected.



Figures modified from Brown et.al. 2020. (a) Mean corrected abundance (no. rabbits/km of transect) between 1973 and 2012, (b) Spatial prediction in rabbit densities between 1972 and 2012 based on rabbit impact. Muted colours represent areas with low prediction confidence.

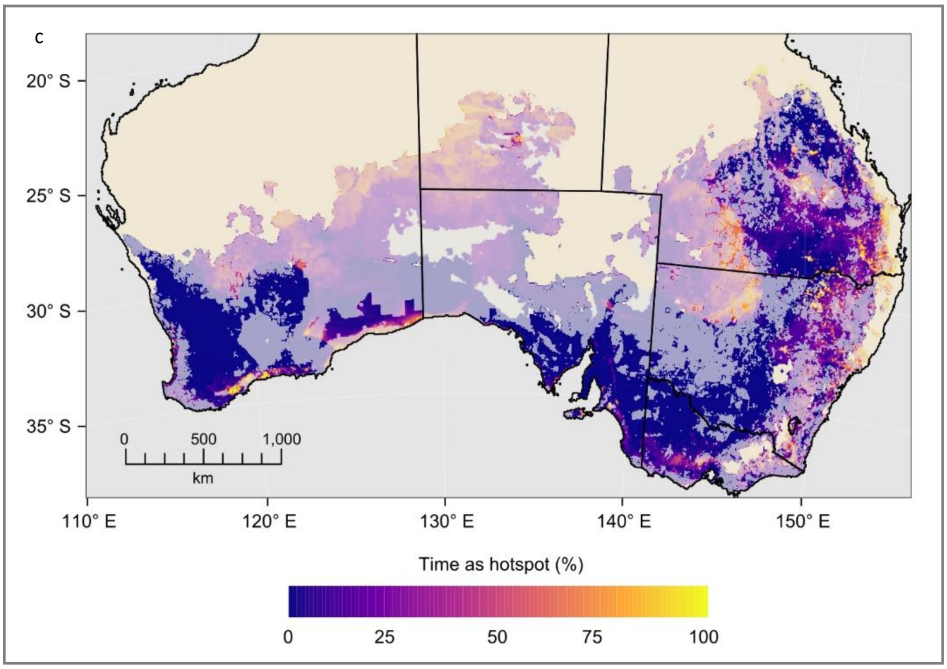
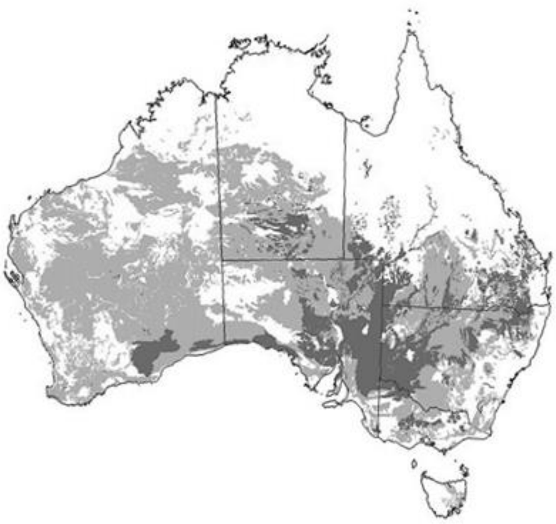


Figure modified from Brown et.al. 2020. (c) Percentage of time in hot spot conditions for high rabbit abundances. The muted colours represent areas with low prediction confidence (i.e. the model results were extrapolated beyond the climatic and environmental envelope used in the analysis).

Another approach under consideration to model rabbit impacts is based on the Australian soils map and the number of localities within each soil polygon where rabbits had been recorded (using data from sources as varied as rabbit study sites, flea release sites, RabbitScan, plant surveys, and recovered RHD rabbit carcasses). While not a measure of rabbit density per se, the map potentially integrates information on the damage rabbits cause (soil erosion, seedling loss, competition with livestock) and may complement rabbit density estimates when determining rabbit control priorities.

This approach, like those discussed above, has the limitation that extrapolating information across whole soil polygons might give a false impression where one soil-type covers a large area. In this exercise the data sources were biased toward sites where rabbits were perceived as problematic and therefore more closely monitored.



Perceptions of where rabbits are most problematic. (Berman & Cooke 2008). Darker shade indicates where most economic or ecological damage is thought to occur.

Future projects

To address the challenges in monitoring and modelling pest animal distribution and abundance, ABARES is working on a collaborative project to determine what is required to build and maintain national distribution datasets for invasive species in Australia (with projected work on rabbits). The work will include developing modelling methods to provide reliable pictures of national pest animal and weed distributions from disparate data sources. The project is expected to be completed in 2023.

Citizen Science - RabbitScan

Several of the models discussed above have found data from citizen science sources invaluable to their operation. RabbitScan is a very useful way for individuals and groups to record their data for their own use, and to make it available to researchers and people designing national rabbit control initiatives.

It enables the recording of:

- Rabbit activity, such as sightings and warrens.
- Damage, such as soil erosion.
- Control activities, such as warren ripping.
- Disease in rabbit populations (such as RHDV).

For more information see: feralscan.org.au/rabbitscan/

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Foundation for Rabbit-Free Australia Inc (2021)
PO Box 145, Collinswood, SA, 5050
www.rabbitfreeaustralia.org.au

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