Brush-tailed Rock-wallaby

Petrogale penicillata

The Brush-tailed Rock-wallaby belongs to the *Macropod* family, which includes kangaroos, wallabies, tree kangaroos, pademelons, potoroos and bettongs. Australian has 15 different species of rock-wallaby, which equates to a third of all our macropod species.

A hundred and fifty years ago, hundreds of thousands of Brush-tailed Rock-wallabies lived throughout the Great Dividing Range, from southern Queensland to Victoria. Now, this shy and mysterious macropod is listed as *Vulnerable* under the Federal *Environment Protection and Biodiversity Conservation Act 1999.*

Through genetic research scientists have determined there are three genetically distinct forms of Brush-tailed Rock-wallaby. As with many Australian natives, the range and abundance of the Central and Southern forms have been gravely impacted since European settlement.

The table below describes the current range, the classification status in terms of each State or Territories Relevant Legislation, and total population estimates of the three recognised forms of Brush-tailed Rock-wallaby, known as *Evolutionary Significant Units*:

Evolutionary Significant Unit (ESU)	Current Range	Various State/ Territory Government Legal Status	Total Population Guesstimate
Southern Form	south eastern Victoria – East Gippsland (Farm Creek, Little River and West Gully) and teetering on extinction in the Grampians	Listed Vulnerable under the *Flora and Fauna Guarantee Act 1988* and Critically Endangered under the *DSE Advisory List of threatened vertebrate fauna in Victoria 2007*	Up to 20 left in the wild and 20 in captivity
Central Form	south eastern NSW – ranging between the Hunter and Kangaroo Valleys	Listed as Endangered under the *Threatened Species Conservation Act 1995* Listed as Endangered under the *Nature Conservation Act 1980*	500
Northern Form	north eastern NSW and south eastern QLD - ranging from100km west of Port Macquarie to 100km north west of Brisbane	Listed Vulnerable under the *Nature Conservation (Wildlife) Regulation 1994*	10,000

Dramatically reduced, fragmented populations are all that survive … isolated remnants dotted throughout the species' original range.

Before we discuss their *Brush with Extinction*, let's get to know these captivating acrobats.

The Brush-tailed Rock-wallaby is often confused with the common Swamp wallaby (*Wallabia bicolour – not shown here*), as both species feature a light-coloured cheek stripe and a black stripe over the centre of their forehead. Both species are relatively solitary in nature, although they also share company with mates and relatives. Neither species hops like a kangaroo – they bound with their head low.

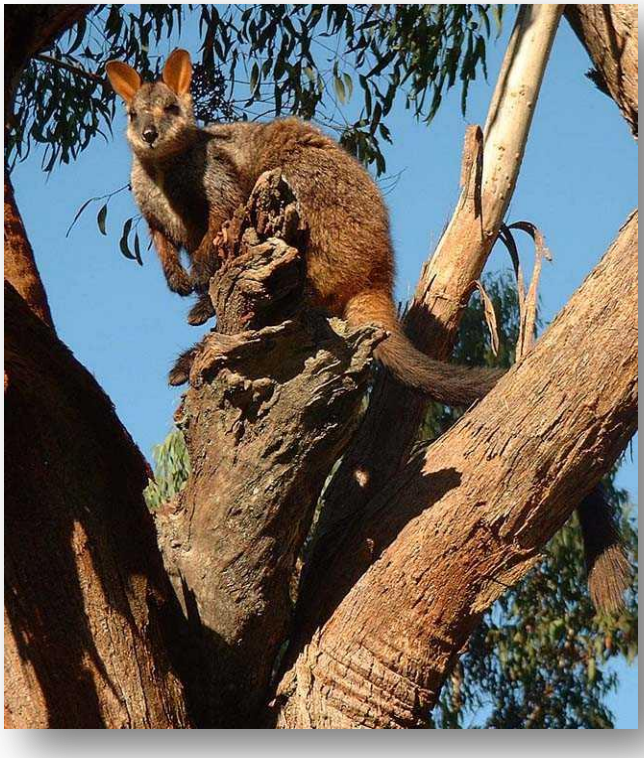
The most notable difference between these wallabies is their size. As with most marsupials, the males of both species are slightly larger than the females and exhibit greater shoulder and arm muscularity.

The adult male Brush-tailed Rock-wallaby weighs 5-10kg with a maximum body length of 60cm. Swampies are larger than Brushies, 5-10kg heavier, and more cumbersome and noisy in their movement. Although they share a similar range, the Swamp wallaby prefers moist habitats, but not necessarily swamps, as its' name suggests. While the *Swampy* is frequently observed along forest margins and road verges, the illusive Brush-tailed Rock-wallaby lives only in rugged rocky outcrops.

The upper body of the Brush-tailed Rock-wallaby is brown, with grey shoulders and a red-tinged rump. The chest and belly are paler and some individuals sport a white blaze on their chest or neck. Their paws are dark, as is the outside of their ears. Their fur is long and thick, especially in winter, and particularly about the rump. Brushies are distinguishable by their unique tail which ends in a *brush* of coarse dark hair.

Rock-wallabies' adaptation to cliffs, gorges, steep rocky slopes, loose boulder-piles and isolated rock stacks is their main form of defence against predators and competitors. These agile creatures have skin ridges, resembling finger prints, on their hind footpads. This specialised grip - on flexible feet with a reduced fourth toe claw - allows them to hop on near-vertical surfaces.

In fact, Brush-tailed Rock-wallabies even bound up trees to perch on high branches! Their brushy tail is longer than their body and provides balance as they make their gymnastic leaps. While other macropods use their five-fingered forelimbs to manipulate food and to fight, Rock-wallabies also use their *arms* to assist with climbing.



Brush-tailed Rock-wallabies are known to occupy a diverse array of habitats: from rainforest gullies to dry ridges, from vine thickets to dry open forest, from riverbanks to rocky hills far from water sources, and refuges adjacent to and far from cleared pasture.

Dense vegetation cover, such as that provided by fig trees, on and below a cliff appears important to this species, both as a food source and for protection from predation and weather extremes.

Brush-tailed Rock-wallabies don't like the cold. They favour north-facing rocky slopes and escarpment to assist with *thermoregulation* (body temperature control). They seek sunny ledges when they want to warm up and cool crevices on hot summer days.

They are *crepuscular* (most active at dusk and dawn), feeding on a variety of plants including grasses, forbs, orchids, fruits, flowers and ferns. Brushies are also known to consume stringy bark from certain eucalypts.

Studies have shown that they forage along, below and above 0.5-1km of cliff line, occupying a home range of 5-25ha, depending on the habitat richness, predation pressures and competition for food.

Within their home range, Rock-wallabies both share, *and* vigorously defend, refuges, sunning spots, feeding areas and pathways.

Lookout vantage points and *predator-proof* escape routes seem to be an important component of habitat use. They may stray further from safe refuge areas under the cover of darkness.

Here, the term *population* describes a group of individual Rock-wallabies occupying a defined area and potentially interbreeding. It is extremely rare for Brushies from *different* populations to exchange individuals or interbreed, so populations can be readily identified genetically.

A population can be made up of one or more *colonies*, or groups, living in separate but neighbouring patches of suitable habitat. Where physically possible, males move to neighbouring colonies and propagate genetic diversity.

Disturbance by fire, drought, goats, humans or predators may motivate Rock-wallabies to move away from their refuge and foraging sites, although colonies generally demonstrate high site fidelity. Each discrete colony is susceptible to local extinction, although, where multiple colonies exist within a population, re-colonisation can occur through dispersal.

Colonies of Brush-tailed Rock-wallabies tend to subdivide again into even smaller family units, comprising one very territorial dominant male and 1-5 mature females, plus sub-adults and juveniles.

Both sexes establish home ranges, with the dominant male range overlapping the smaller home ranges utilised by females within the colony or group. Mature females can show dominance over other females and claim their own share of the groups range. Mothers and daughters tend to remain close and even share territory, while young males disperse.

Mature males fight for group dominance. Weaker males are physically expelled into less favourable habitat outside the territory, where there is reduced protection against predation. It is likely that many young males from small, remnant, geographically isolated populations perish in their futile search for available females. Otherwise, in the wild, Brush-tailed Rock-wallabies have a life span of up to ten years.

Females reach sexual maturity at 18 months of age and males at 20-24 months. There is a gestation period of 31 days after which a single *jellybean-sized* embryo is born and climbs through the mothers' fur to the pouch.

Joeys remain in the pouch for about 6-7 months, suckling from 1 of 4 nipples. Joeys gradually spend more time playing and feeding out of the pouch, but continue to suckle up to 9 months of age.

As with many other macropods, females may *pause* the development of a second fertilized embryo until sucking from the previous joey decreases.

Brushies are very vulnerable to predation at 6-12 months of age. The lactating mothers are forced to hide their *gangly dependents* in small rock crevices, simply because it becomes too risky to navigate the

precipitous habitat with an *unbalancing* weight in their pouch while they satisfy their extra appetite.

Yet, when these small *pouch young* are not tucked safe in their mothers' pouch they are easy prey for foxes, dogs and cats as well as their native predators - Pythons, Wedge Tailed Eagles and Eastern Quolls. Then, as the weaned young begin to disperse their *inexperience* leaves them susceptible to feral predation. The photo opposite shows an introduced fox hunting for stashed joeys in a Shoalhaven Rock-wallaby colony.

It is not surprising, therefore, that the strongholds of surviving Rock-wallaby colonies are characterised by complex habitat, incorporating boulder piles, caves, ledges and cliffs, to provide adequate *refuge* areas for the protection of young from feral foxes and cats.

So how did the most abundant species of Rock-wallaby –and one of the most common of all wallaby species – fall into an *extinction vortex* in 130 years?

Previously widespread in the southern Victorian Grampians, distributed up the coast to central Queensland and as far west as Bourke, the Brush-tailed Rock-wallaby appears to have once occupied less complex habitat than it does today. They were even recorded at Middle Head and Pittwater near Sydney. It is in *marginal* habitat that the first impacts from hunting and sheep grazing *rocked* their numbers.

During the late 19th Century and early 20th Century hundreds of thousands of Brush-tailed Rock-wallabies were shot for sport, skin sales and government bounties. Those in *treeless* terrain or dotted along open cliff faces were easy targets. The Pastures Protection Board paid hunters a bounty for every skin up until 1914, and companies exported their prize skins by the *bale* to the London markets.

Sheep grazing influenced the retreat of Brushies along the western slopes and there is evidence that increasing numbers of goats affected the Rock-wallaby decline in the Warrumbungles and at Mount Kaputa. In 1918 the Brush-tailed Rock-wallaby was finally afforded protection under the *Native Animal Protection Act*, but shooting for sport continued both *illegally* and during declared *open seasons*.

Then, as the introduced fox population exploded from the south, the hunting-diminished populations of Brush-tailed Rock-wallabies suffered further decimation. Unfortunately the fox is also very agile.

Feral animals are a perilous artificial addition to an ecosystem by humans. They are a human impact.

The demise of the Brush-tailed Rock-wallaby was greatest in the southern and settled districts. Small populations became fragmented, with *islands* of suitable habitat becoming isolated amongst ever-expanding cleared farmland. The remaining substantial populations, such as those in the New England and the Border Ranges, owe their preservation to steep, rugged and remote habitat containing predator-proof refuges.

The factors that continue to threaten the survival of this species are common to the decline of many Australian small mammals. These threats include: predation by foxes and cats; habitat degradation and modification; weed invasion; population fragmentation; bioclimatic factors; drought; fire; disease; competition by introduced herbivores.

The greatest threat to the Brush-tailed Rock-wallaby, and many other endangered marsupial species, is the small size of the remaining populations and their geographical isolation from each other.

Tiny fragmented populations are highly vulnerable to local catastrophes, predation, inbreeding and the associated loss of genetic variation through low migration rates.

A number of Southern and Central ESU Brush-tailed Rock-wallabies populations are now *so low* that, even with targeted fox control, *occasional* predation is preventing juvenile recruitment into the adult population. This *predator pit* phenomenon results in an *extinction vortex* where colony sites are blinking out, especially at the limits of their range.

Catastrophic events, like the drought and bushfires experienced by the Victorian East Gippsland Rock-wallabies in 2002-3, have a massive impact on the overall population size when there are so few colonies left. Following wildfire, Rock-wallabies have been reported to both disappear from *and* remain in their colony habitat. The frequency and intensity of fire alters the structure, composition and, quite probably, the suitability of the vegetation. Immediately after fire and during periods of drought, Rock-wallabies may have to forage further afield for food, increasing the risk of predation. However, fire also stimulates fresh plant growth and may even improve the availability of food.

The trend to locate rural, residential and tourism developments adjacent to escarpment in order to maximise scenic opportunities, continues to impact Brush-tailed Rock-wallabies through an increase in feral and domestic animal predation and weed invasion, the removal of native vegetation, fragmentation of colonies *and* permanent changes to dispersal corridors.

Two diseases are known to cause mortalities in Brushies: Toxoplasmosis carried by cats, and Hydatidosis with foxes, dogs or sheep as hosts.

A number of the threats to the Brush-tailed Rock-wallabies are being addressed with the coordination of both State and National Recovery Teams and the implementation of their Recovery Plans.

Scientists are investigating the breeding biology and conservation genetics to understand the causes and consequences of their small population size, and how best to counteract these processes. This research involves genetic surveys, captive breeding and assisted reproduction strategies, establishment of protected breeding colonies and reintroduction trials. A Threat Abatement Plan (TAP) for predation of threatened fauna by the Red Fox was prepared by the NSW NPWS in 2001. The National Parks and Wildlife Service (NPWS) undertakes fox control programs designed to protect Brush-tailed Rock-wallabies in a number of NSW Reserves, including Warrumbungle, Wollemi, Yengo and Goulburn River National Parks.

The intensive fox control program to protect the Shoalhaven Brush-tailed Rock-wallabies provides a successful model of a community-supported, *cross-tenure* program implemented by NPWS. Professional fox shooting complements 120 permanent 1080 fox bait stations to minimise fox numbers around the three remnant colonies in the Kangaroo Valley area.

Fox baiting commenced around two of these colonies in 1994 and around a third in 2001. The efforts have helped save these three colonies, while others have disappeared. The NPWS monitors the effectiveness of several of their fox baiting programs targeted at protecting dwindling Central ESU populations.

Ongoing goat control specific to Brush-tailed Rock-wallaby conservation is undertaken by NSW NPWS at the Warrumbungle National Park. Goat control has also occurred in the core Brush-tailed Rock-wallaby habitat of Oxley Wild Rivers National Park.

Many surviving colonies are *not* located within National Parks. Community fox control, habitat protection by Landcare and Bushcare groups and Voluntary Conservation Agreements (VCA) on private properties will continue to make an important contribution to the survival of many Brush-tailed Rock-wallaby populations.

Throughout their range, Brush-tailed Rock-wallaby populations are notoriously difficult to monitor due to the inaccessibility of the species' habitats, particularly in the north where numbers are greater.

Well over 95% of all Brushies belong to the Northern ESU with over 100 colonies estimated in the north-

eastern region of NSW. These populations are less fragmented than in southern NSW. Interbreeding colonies along the Apsley-Macleay River and the Clarence Rivers form near-continuous populations.
In Victoria, where the Southern ESU represents only 1% of total Brush-tailed Rock-wallaby numbers, the near-extinct population in the Grampians is 550 km away from the nearest population in East Gippsland. Regarded as extinct in 1916, the Southern ESU has been closely monitored by the Victorian Brush-tailed Rock-wallaby Recovery Team since 1996.

Brush-tailed Rock-wallaby *scats*, or pellets, have a unique appearance and finding fresh pellets obviously indicates the presence of this species. Old pellets have been known, however, to persist in protected rock shelters many years after the extinction of a colony.

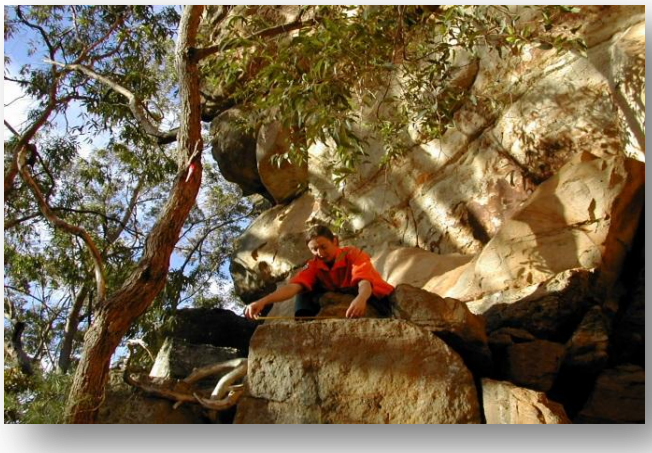
Surveys for Brush-tailed Rock-wallaby fresh and old pellets have provided information on changes in distribution and habitat use. Rock surfaces worn smooth (polished) within shelters have also helped detect the past presence of Rock-wallabies.

Surveys in 1993 located 47 extant (living) Central ESU Brush-tailed Rock-wallaby colonies in NSW, most of these being isolated populations.

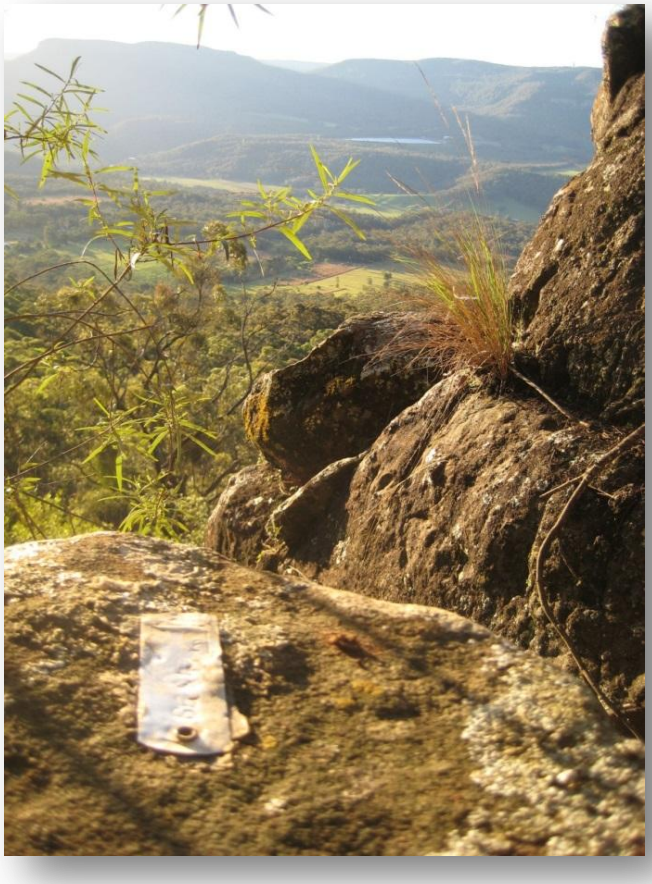
While some populations are located within NPWS Reserves - Blue Mountains (60km west of Sydney), Kanangra Boyd (100km west of Sydney), Watagans (30km west of Newcastle), Wollemi (100km south west of Newcastle), Yengo (100km north west of Newcastle), Oxley Wild Rivers (100km north west of Port Macquarie) and Guy Fawkes River (100km west of Coffs Harbour) National Parks and Jenolan Caves Reserve – many are on a combination of Private, Crown or Council Land, such as the Shoalhaven population (100km south of Sydney).

The species is now extinct across the western slopes and plains of NSW except for the struggling population in Warrumbungle NP (400km west of Port Macquarie).

The NSW Brush-tailed Rock-wallaby Recovery Team manages the conservation of the Central ESU. Accurately estimating their abundance remains one of the challenges in recovery planning.



As part of the NSW Fox Threat Abatement Plan, hundreds of $2m^2$ pellet plots within selected colonies were methodically monitored to measure the relative abundance of Brush-tailed Rock-wallaby colonies. Repeated pellet counts of these tagged rock ledge and boulder plots detected broad trends in populations. This technique has proved helpful in comparing large populations and in warning of the imminent demise of small colonies.



Advances in DNA *fingerprinting* has enabled the minimum population size of a colony to be

established with greater accuracy. Individuals and their sex are distinguished by genetic microsatellite analysis of DNA obtained from epithelial cells on the surface of collected fresh pellets. The genetic data analysis is able to detect birth and recruitment over time.

An added advantage of this survey method is that genetic variability within and between colonies and populations can be measured, enabling dispersal patterns and population structure to be inferred.

This conservation science saved a Shoalhaven colony from extinction in 2007, when it was discovered that only one individual female remained. A mate from a stable wild population was relocated to the site and their breeding has since helped to rebuild this most southerly Central ESU colony.

The cage trapping and micro-chipping of Brush-tailed Rock-wallabies has also aided the determination of population size and demographics. However, the disturbance of setting and repeatedly checking multiple traps in remote and rugged terrain makes this technique less desirable than other non-invasive methods of population monitoring.

Some small Rock-wallaby colonies are now effectively monitored using infrared-triggered digital cameras located at a water or food source. Individuals in the Victorian, Shoalhaven and Warrumbungle populations, distinguishable by subtle identifying features, have been monitored for condition, interactions, breeding and recruitment.

Each of the thirty known adult Rock-wallabies within the three Shoalhaven populations are individually recognised by NPWS staff on the monitoring cameras. They all have names and undergo a monthly *roll call*.

The Southern and Central genetically distinct forms of Brush-tailed Rock-wallabies (or ESUs) are managed in captivity through the Australian Species Management Program (the species management arm of the Australasian Regional Association of Zoological Parks and Aquaria, ARAZPA).

Captive populations at Waterfall Springs Sanctuary (NSW), Tidbinbilla Nature Reserve (ACT), Adelaide Zoo (SA), Taronga Zoo (NSW), Healesville Wildlife Sanctuary (VIC) and Mount Rothwell Sanctuary (VIC) have been used to develop husbandry protocols, to establish and refine techniques for rapid population expansion, for behavioural studies, and to generate public awareness.

Captive breeding programs and intensive introduced predator management are vital to the survival prospects of small isolated populations of many threatened Australian mammals.

In addition to the *predator pit* phenomenon, small wild populations are at great risk from *genetic bottlenecks*, catastrophic natural events such as drought and fire as well as disease and annual fluctuations in sex-ratios. Captive breeding isolates animals from most negative factors that periodically affect survivorship.

The NSW and Victorian Brush-tailed Rock-wallaby Recovery Projects have focused on supplementing peripheral colonies to pull them out of the *predator pit.* Artificially reinforcing numbers to self-sustaining levels enable colonies to tolerate occasional predation.

In NSW the Shoalhaven and Warrumbungle populations represent the limits of the known range of the Central ESU, are extremely isolated from other populations and buffered by intensive fox control. In this context, conservation of these particular wild colonies is a priority for management.

The Recovery teams have delivered mixed success in their endeavour to build up viable and genetically robust populations of this species in priority locations through the release of captive breed Brushies.

Individuals are radio-collared, micro-chipped and sampled for DNA and blood analysis prior to release at their new wild colony. They are closely monitored by dedicated NPWS staff using radio-tracking equipment and infra-red cameras. While many individuals settle-in well and commence breeding, some individuals meet with stress, health complications and mortality.
Autopsy results guide adjustments to the relocation process, ultimately improving the success rate.

The first release of a male Rock-wallaby in 2007 literally saved a Shoalhaven colony from extinction and preserved the genetics of the surviving female. Further releases in this colony have introduced a range of genetics in individuals strategically bred from several different Central ESU populations.

Brushies have demonstrated their ability to rebuild significant populations from small numbers. A temporary predator-proof fence rescued the Jenolan Caves population from extinction. The population was able to recover to a level that could sustain low fox and cat predation rates encountered under the implementation of ongoing NPWS feral control.

A Brush-tailed Rock-wallaby pair introduced to the island of Oahu in Hawaii in 1916 successfully bred up to a stable population. The Brush-tailed Rock-wallaby reached pest proportions on Kawau Island in New Zealand, where it was introduced in the 1870s. Kawau Island individuals, preserving otherwise lost genetics, were repatriated early this century and included in the captive breeding program.

Waterfall Springs Wildlife Sanctuary breeds the Brush-tailed Rock-wallaby in captivity for the purpose of population reinforcement of priority NSW colonies.

While the NSW Recovery Team coordinates the captive breeding genetics and releases, the successful breeding rates at Waterfall Springs can be attributed to large naturalistic enclosures, minimal human interference, the assistance of dedicated volunteers and the skilled animal husbandry and veterinary care provided by Celia Thomson, Sanctuary Curator.

The aim in the Shoalhaven is to bolster the three colonies to at least thirty adults each. At that size they should continue to gradually grow with continued feral animal control, despite occasional predation.

Landholders, Volunteers and Partnerships

The involvement of local communities is a vital component in this and other threatened species' recovery. *The Friends of the Brush-tailed Rock-wallaby Incorporated* is a community group based in the Shoalhaven that is dedicated to raising funds and public awareness for the conservation of this graceful and timid species. The Friends work together with the NSW Office of Environment and Heritage, National Parks and Wildlife Service, Waterfall Springs and the Kangaroo Valley community. This collaborative work has far reaching conservation outcomes beyond rescuing the Brush-tailed Rock-wallaby from an *extinction vortex*, including:

- engaging and consolidating rural communities in sophisticated and responsible 1080 fox poisoning
- protecting a broad range of native fauna that share Brush-tailed Rock-wallaby habitat and surrounds through the control of foxes, introduced herbivores and invasive plants
- increasing community knowledge and appreciation of threatened fauna and biodiversity

How can *I* help?

- Become a member of, or donate to, *The Friends of the Brush-tailed Rock-wallaby Inc.* and/or *Waterfall Springs Foundation*
- Symbolically adopt a Brush-tailed Rock-wallaby
- You can report NSW BTRW sightings via an online species sighting form at www.btrw.org/
- If you own land, there are numerous suggestions at: www.btrw.org/help/landholders/
- Educate yourself and others on *the importance of biodiversity and how to minimise your ecological footprint* and relieve the pressures that are driving so many native species to extinction
- Join a local Landcare or Bushcare Group

The information in this brochure was compiled by National Parks Technical Officer Juliet Dingle from first-hand field observations and a comprehensive appraisal of the recovery plan and scientific literature, which can be researched in detail from reference lists on the following rock solid websites:

- www.rockwallaby.org.au
- www.environment.gov.au
- www.environment.nsw.gov.au
- www.btrw.org/
- www.vicrockwallaby.com/
- www.waterfallsprings.org
- www.tidbinbilla.com.au
- www.mtrothwell.com.au/index.php/BrushTailedRockWallaby/
- www.fnpw.org.au

Recognition for the Friends

The Friends of the Brush-tailed Rock-wallaby received a *Special Commendation* in the *Community Award* category of the prestigious United Nations Association of Australia 2015 World Environment Day Awards for "their amazing longevity in their commitment to the preservation of the Brush-tail Rock-wallaby in southern NSW … their work across education, pest control, monitoring and partnerships."

This is the judges' comments: "This group has spent the last 20 years educating the public and engendering community support to protect and increase the population of this endangered species in the Shoalhaven area of NSW. Working in long-term partnership with local community, landowners and the National Parks and Wildlife Service, the group's efforts have begun to bear results. Numbers of the Brush-tailed Rock-wallaby in the area are now increasing."

The Friends of the Brush-tailed Rock-wallaby **and the** ***NSW National Parks & Wildlife Service*** **have partnered with many schools to give the next generation hands-on experience in biodiversity science and conservation**