The Brushtail Possum

Biology, impact and management of an introduced marsupial

Edited by T.L. Montague

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CHAPTER ONE

Anatomy of a Disastrous Success: The Brushtail Possum as an Invasive Species

Mick Clout and Kris Ericksen

The common brushtail possum (*Trichosurus vulpecula*) is a cat-sized Australian phalanger, weighing 2–4 kg. It is a solitary, nocturnal, arboreal marsupial that has a wide natural distribution in its native Australia and Tasmania, where it typically inhabits open eucalypt woodlands (Strahan 1983). In its native range the brushtail possum is only one of a suite of herbivorous arboreal marsupials. In New Zealand, where it has been introduced, it is the only possum present and has become a major invasive pest, causing severe damage to native ecosystems and acting as a vector of bovine tuberculosis. In this chapter, we explore how the possum became such a "disastrous success" in New Zealand.

History of introduction and control

The first successful introduction of brushtail possums to New Zealand was made in 1858 near Riverton, Southland (Pracy 1974), at a time when there was great enthusiasm among European settlers for the "artificial enrichment" of the fauna and flora (McDowall 1994). The prevailing view was that the native fauna, already depleted by recent extinctions, was largely doomed and that there was little value in what remained, other than as curiosities. The earliest deliberate introductions of animals by Europeans, starting with Captain Cook in the 1770s, were of domestic livestock. However, by the 1860s, settlers had organised themselves into "acclimatisation societies", dedicated to introducing new species to New Zealand (McDowall 1994). These societies institutionalised the previous informal process of introductions by individuals. They introduced animals such as deer, game birds, and trout for sport, a variety of European songbirds for nostalgic reasons, a range of other species for pure novelty value, and a few species for economic reasons. The introduction of the fur-bearing brushtail possum from Australia and Tasmania was in the latter category: it was motivated by economic profit.

By the middle of the nineteenth century, settlers in Australia had already discovered that brushtail possums had potentially valuable pelts, and were profiting from a fur trade. The American and Russian fur trades were very profitable at that time. It was therefore a logical step to attempt to establish a fur trade in New Zealand by introducing the fur-bearing brushtail possum. The very first possum importations, including an apparently unsuccessful one near Riverton in 1837 (Pracy 1974), were made by private individuals. The first successful introduction (also near Riverton) was evidently made in 1858. From the 1860s onwards most importations were made by acclimatisation societies, which imported many possums from Tasmania and Victoria, and encouraged and fostered their spread. There were at least 35 separate importations of possums, most of which took place during the 1890s (McDowall 1994). As possum populations became established, the acclimatisation societies not only continued to introduce them from Australia, but also spread New Zealand-bred animals throughout the country. From 1895 to 1906 the government also took an active role in the liberation of possums, so that in the 1890s, the acclimatisation societies and the New Zealand Government together made 86 separate liberations of possums (Pracy 1974). Between 1865 and 1926 a total of 127 recorded liberations were made by acclimatisation societies (108) and government agencies (19). Most of the liberations were of New Zealand-bred possums. A considerable number of other liberations made by private individuals should also be attributed to acclimatisation societies, since the individuals concerned were members of the societies and made releases of possums on their behalf (L.T. Pracy, retired, ex-Agriculture Pest Destruction Council, pers. comm.). The multiple liberations of possums throughout the country greatly supplemented and speeded up their natural spread. There was wide acceptance that having possums in New Zealand forests was beneficial.

By the early 1900s, the shooting and trapping of possums for furs had developed to the stage where

the acclimatisation societies were becoming concerned at over-harvesting of this asset. They lobbied the government, and in 1911 unlicensed hunting was prohibited by declaring the possum as "imported game" under the Animals Protection Act 1908 (McDowall 1994). However, the government was also under pressure from farmers, orchardists, and horticulturalists to allow unrestricted hunting, because of increasing reports of damage by possums to crops. There followed a series of confusing changes in restrictions on the taking of possums. In 1912 all protection was removed, but in 1913 it was reinstituted in native forest areas only. Concern grew at the continuing liberation and spread of possums, and so in 1920 the government commissioned biologist Harold Kirk to report on the impacts of possums on forests and orchards. Kirk (1920) concluded that, while damage to orchards and gardens was indisputable, "the damage to New Zealand forests is negligible". He recommended that possums be released in all forest districts away from orchards and gardens and that the government retain a hunting season for possums, issue licences to trappers, and collect a levy on all skins traded. The Kirk report formed the basis of the ensuing 25 years of government policy on possums. In 1921 new regulations were introduced permitting licensed hunting during a restricted season and a levy was placed on the sale of skins. Acclimatisation societies were empowered to enforce the regulations and they shared the income from levies with the government.

Throughout the 1920s and 1930s there was continuing controversy over the effects of possums on native forests. The fledgling conservation movement pitched itself against the acclimatisation societies, which were gaining substantial revenues from the levy on skin sales (McDowall 1994). No more liberations were officially permitted after 1922, but applications continued to be made by several acclimatisation societies (L.T. Pracy pers. comm.) and possums continued to be aided by people in their spread throughout New Zealand. It was not until the 1940s that the first scientific evidence of the impacts of possums on native forests was collected (Kean & Pracy 1953). There was then a radical change in official policy. In 1947 the government cancelled all restrictions on the taking of possums, instituted penalties for harbouring or liberating them, and legalised the use of poisons for possum control. From 1951 to 1961 the government ran a bounty system as an interim measure to encourage possum control. The national responsibility for possum control initially lay with the Department of Internal Affairs, but was transferred in 1956 to the New Zealand Forest Service. Increased numbers of possums were killed as a result of the bounty. About 1 million per annum were taken for this purpose in the late 1950s (Parkes *et al.* 1996), in addition to those harvested for pelts as part of the continuing fur trade. Despite this, the bounty scheme failed to prevent the continued spread of possums and appeared ineffective in controlling numbers (McDowall 1994). There were even reports that some possum trappers were deliberately spreading possums into new areas to provide a source of income from bounties. Reports of similar illegal releases by commercial possum trappers in Northland and Coromandel followed the rising skin prices of the 1970s (L.T. Pracy pers. comm.). The annual number of possums harvested commercially for fur is directly related to the price of skins, which peaked in the early 1980s (Parkes *et al.* 1996). After the withdrawal of bounties, large-scale control of possums was conducted on Crown lands by the New Zealand Forest Service, initially under the Noxious Animals Act 1956 and then under the Wild Animal Control Act 1977. Since 1987, the Department of Conservation (successor to the now-defunct New Zealand Forest Service) has continued to control possums under the Wild Animal Control Act 1977. In farming areas control was conducted by Agricultural Pest Destruction Boards under the Agricultural Pests Destruction Act 1967. Under the Biosecurity Act 1993, local authorities and other interested parties are now empowered to control possums, provided that they have been declared pests under local Pest Management Strategies (Livingstone 1993).

Possum control is conducted not only to protect forests and native wildlife, but also to prevent the transmission of bovine tuberculosis (Tb), for which possums were first implicated as vectors in the late 1960s (Ekdahl *et al.* 1970). Possums later became recognised as most important vectors of Tb in cattle and farmed deer in New Zealand (Ministry of Agriculture and Fisheries 1986), which stimulated heavy expenditure on Tb control and research (estimated at $33 million in 1991/92 (Livingstone 1993)). Widespread possum control is now mainly by the aerial distribution of carrot or pellet baits containing 1080 (sodium monofluoroacetate), with bait stations containing either 1080-poisoned pellets or anticoagulant poisons being used for ground control in some smaller, more accessible areas. Recent confirmation that possums not only damage forest vegetation and carry Tb, but also prey on the nests of some threatened native birds (Brown *et al.* 1993) has further emphasised the importance

of controlling possums on conservation lands. Possum control is now a major focus for the Department of Conservation, with Departmental expenditure for this purpose rising from $3 million in 1990/91 to $12 million in 1996/97 (Parkes *et al.* 1997).

Recent changes in distribution

The current distribution in New Zealand (Fig. 1.1) has changed little from that in 1984, as described by Cowan (1990a). The main changes in the past 15 years have been the complete colonisation of Northland, further spread in the south-west of the South Island, and the extermination of possums from some offshore islands (Table 1.1).

In Northland, possums were first reported at Te Kao in 1983, and at Te Paki, just south of Cape Reinga (Fig. 1.2) in late 1986 when possum droppings were found during a New Zealand Wildlife Service survey. In 1990, during a Department of Conservation survey of reserves at Te Paki, the only place at which a specially trained dog could not pick up the scent of possums was at North Cape Scientific Reserve (D. M. McKenzie, Department of Conservation, Whangarei, pers. comm.). The possum had effectively completed its century-long journey to the northern limit of New Zealand. On the Coromandel Peninsula, possums had

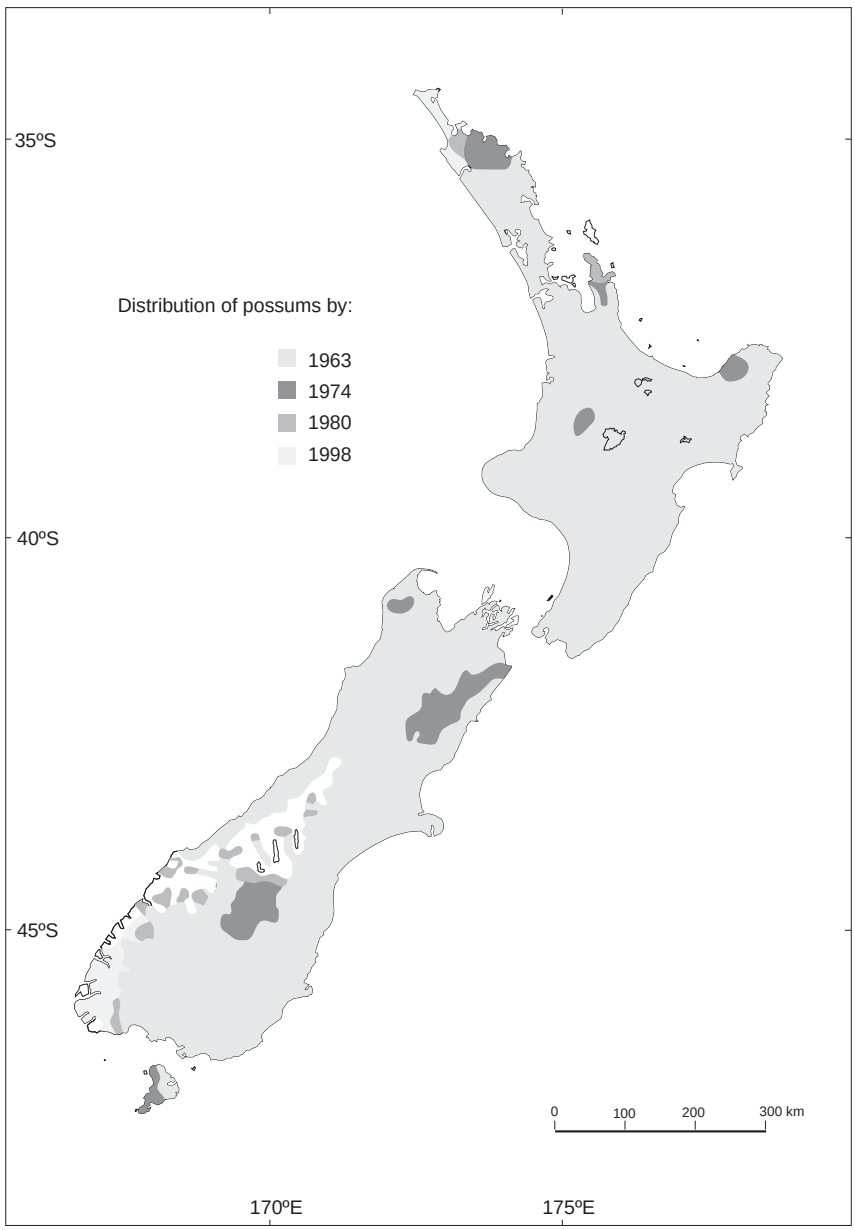

Fig. 1.1
Distribution of possums, at four stages of colonisation (after Cowan 1990a).

Table 1.1
New Zealand islands from which possums have been eradicated.

Island name	Area (ha)	Date possums introduced	Start year of eradication	Methods	Possum status in 1997	Sources
Northland						
Fortyseven	1	NA	1990	Talon in bait stations	Ongoing bait station operation	D. Taylor (Invercargill)
Harakeke	11	c. 1990	1992	Talon in bait station	Eradication confirmed 1994	R. Atkinson (Kerikeri)
Peach	11	NA	1990	Traps and Talon in bait stations	Unknown	R. Atkinson (Kerikeri)
Hauraki/Coromandel						
Rangitoto	2321	1868	1990	Poison, traps	Eradicated 1997	C. R. Veitch (ex Auckland)
Motutapu	1560	1868	1990	Poison, traps, and dog	Eradicated 1996	C. R. Veitch (ex Auckland)
Motutapere	50	c. 1902	1994	Aerial Talon 20P, then bait stations	Eradication confirmed 1997	R. Chappell (Coromandel)
Whanganui	220	c. 1902	1994	Cyanide, spotlighting, bait stations	Eradication confirmed 1997	R. Chappell (Coromandel)
Uretara (Bay of Plenty)	73.2	NA	1993	Pindone in bait stations	Ongoing bait station operation (close to mainland)	D. Williams (Rotorua)
Wellington/Marlborough						
Kapiti	1970	1892	1980	Poison, traps, and dogs	Eradicated 1986	Veitch & Bell 1990
Allports	16	<1980	1989	Poison	Eradicated 1990	D. Brown (ex Havelock Nth)
Tarakaipa	35	NA	1991	Poison, traps, and dogs	Eradication confirmed 1993	P. Brady (Picton)
Southern						
Pig (L. Wakatipu)	110	1975	1990	Poison and traps	Monitored annually for reinvasion	B. Barron (Wakatipu)
Pigeon (L. Wakatipu)	168	1975	1990	Poison and traps	Monitored annually for reinvasion	B. Barron (Wakatipu)
Stevensons (L. Wanaka)	40	<1993	1993	Bait stations	No sign since 1995. Monitored annually for reinvasion	J. Fleming (Wanaka)
Codfish	1396	<1925	1984	Poison, traps, and dogs	Eradicated 1987	Veitch & Bell 1990

NA = not available
Sources listed are/were Department of Conservation staff

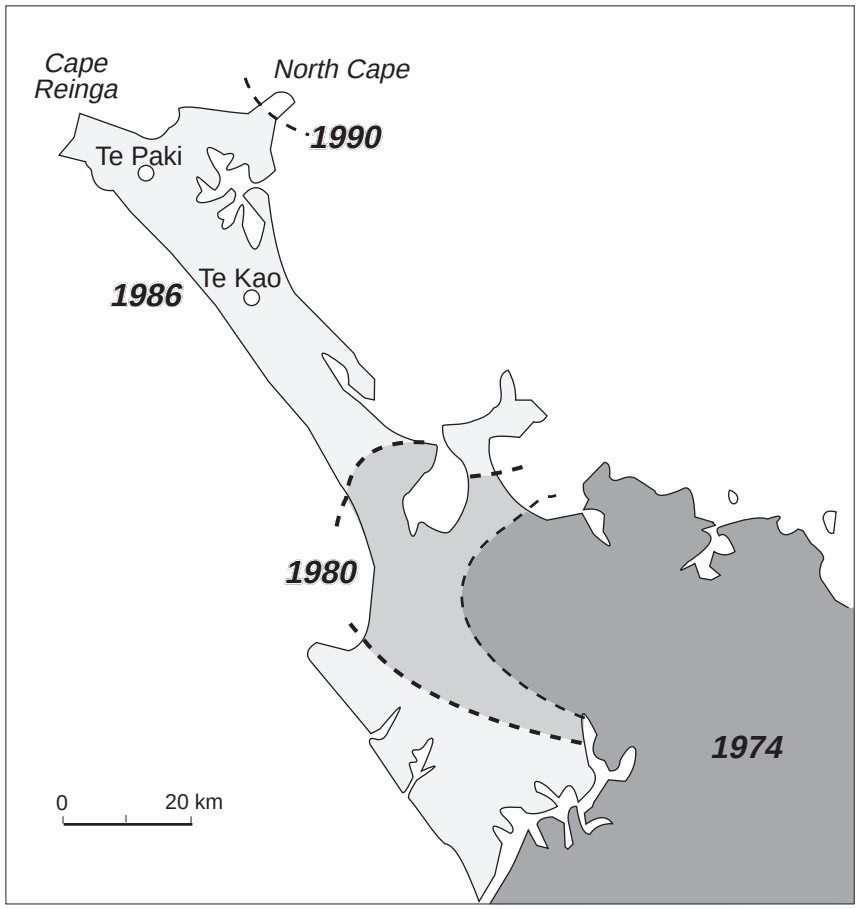

Fig. 1.2
Distribution of possums in Northland (after Cowan 1990a; D. M. McKenzie, DOC, Whangarei, pers. comm.).

reached its northern tip at Cape Colville by 1980 (Cowan 1990a,b). Here, as elsewhere, their spread was assisted over the years by a number of private liberations, the most northerly of which was at the base of Mt Moehau (R. Chappell, Department of Conservation, Coromandel, pers. comm.).

In Fiordland and South Westland it is possible that possums have been slowed in their spread both by the topography and by the wet and cold conditions. Cowan (1990a) noted that in the mid-1980s possums were still absent south of the Arawata River, apart from around Milford Sound. The range of possums in south-western New Zealand has expanded further since these previous reports were made (Fig. 1.3). Surveys carried out in southern Fiordland from 1995 to 1998 confirmed that a peninsula in Doubtful Sound and a large area around Long Sound remained possum free. Secretary Island is the largest offshore island in Fiordland known to be free of possums. The status of possums on Resolution Island is unconfirmed (P. Willemse, Department of Conservation, Invercargill, pers. comm.).

Possums have been recorded as present at some stage on at least 23 offshore or outlying islands. These include the 17 islands listed by Cowan (1990a), plus Motutapere Island, Uretara Island, Allports Island, and three small islands in Northland (Harakeke, Fortyseven, and Peach islands). Possums have also been recorded on Pig and Pigeon islands in Lake Wakatipu, and on Stevensons Island in Lake Wanaka (Table 1.1). They have now been eradicated from most of these named islands, in addition to Rangitoto, Motutapu, Whanganui, Kapiti, Tarakaipa, and Codfish islands (Table 1.1).

The possum as an invasive species: could its success have been predicted?

The question of which factors determine whether or not a species will be a successful invader has been addressed by several authors, albeit without much success at any synthesis (Williamson 1996). Apart from the obvious characteristic of previous success as an invader, attributes which have commonly been proposed to distinguish successful invaders from others include high intrinsic rate of increase, extensive

Fig. 1.3
Distribution of possums in Fiordland (after Cowan 1990a; P. Willemse, DOC, Invercargill, pers. comm.).

natural range, high abundance within this range, ecological distinctiveness in the invaded community, vacant niches in this community, and climatic matching with the natural range (Williamson 1996).

In the first respect the brushtail possum is an unlikely invasive species because it has an intrinsic rate of increase of only 0.2–0.3 per annum (Barlow 1991). Typical reproductive output is one young per female per annum, rising to an absolute maximum of two per annum under the most favourable conditions, such as in low-density populations during colonisation of new habitat or after control operations. There are, however, several other attributes which have contributed to the status of the brushtail possum as a highly successful invader in the New Zealand environment. Firstly, in its native Australia it is one of the most widely distributed native marsupials. It occurs naturally in a variety of habitat types in most parts of mainland Australia, although it is most abundant in dry woodlands of the south-east of the continent. It also occurs in Tasmania and on some offshore islands (Strahan 1983). This wide natural distribution suggests a broad environmental tolerance and was, in retrospect, an indication that the brushtail possum had the potential to become invasive in New Zealand. Brushtail possums are also more generalist and opportunistic in their feeding habits than most other arboreal marsupials, feeding not only on foliage, flowers, and fruits, but also insects, bird's eggs, and fungi (Strahan 1983; Cowan 1990a; Brown *et al.* 1993).

In addition to its broad environmental tolerance and generalist feeding habits, another factor that may have aided the success of brushtail possums as invasive species in New Zealand is the lack of competitors for food and shelter. In New Zealand it is ecologically distinctive and it has exploited a broad, essentially vacant niche for a large, nocturnal, arboreal herbivore. In Australia, brushtail possums have several competitors, including the marsupial gliders (*Petaurus, Petauraoides*) and other arboreal marsupials, about half of which use tree hollows similar to those required by brushtails and most of which have some dietary overlap with them in areas where they

coexist (Menkhorst 1984; Smith & Hume 1984). The congeneric mountain brushtail possum (*Trichosurus caninus*) normally replaces *T. vulpecula* in wetter forests in Australia (Kerle 1984), but in New Zealand common brushtail possums inhabit a range of wet forest types right up to the tree line (Clout & Gaze 1984).

The relative lack of parasites and predators may have been yet another factor in the success of brushtail possums in New Zealand (see Chapter 7). In Australia, 31 species of endoparasites and 35 species of ectoparasites have been recorded from brushtail possums (Viggers & Spratt 1995), whereas in New Zealand only 8 endoparasites and 6 ectoparasites (two of these not recorded from Australia) have been found (Viggers & Spratt 1995; Clark *et al.* 1997). Predators of possums in Australia that are absent from New Zealand include large carnivores such as feral dogs and dingos (*Canis familiaris*), foxes (*Vulpes vulpes*), wedge-tailed eagles (*Aquila audax*), powerful owls (*Ninox strenua*), lace monitors (*Varanus varanus*), and carpet pythons (*Morelia spilota*) (Cowan 1990a). In New Zealand the largest feral predator (also present in Australia) is the domestic cat (*Felis catus*), which can prey on young possums (Fitzgerald & Karl 1979) and is also present in Australia. Introduced ferrets (*Mustela furo*) and stoats (*Mustela erminea*) also feed on possums in New Zealand, although it is uncertain how much of this involves scavenging on carcasses (King 1990). Domestic dogs kill some possums, but by far the most significant predators of possums in New Zealand are humans. Fur trappers continue to harvest some possums when skin prices are high (Parkes *et al.* 1996), but most killing (by shooting, trapping, and poisoning) is for pest control purposes, to prevent damage to crops, native forests, and wildlife, and to reduce risks of transmission of bovine tuberculosis to domestic livestock.

In addition to the lack of competitors and a reduced burden of parasites and predators, the New Zealand environment holds other advantages for the brushtail possum. New Zealand forest ecosystems are generally more productive than those in Australia, where aridity and the generally low nutrient status of soils and vegetation (Attiwill & Leeper 1987) are important factors limiting the abundance of arboreal herbivores (Pausus *et al.* 1995; Braithwaite 1996). Foliage in Australian eucalypt forests is notoriously sclerophyllous and low in nitrogen and phosphorus (Attiwill & Leeper 1987; Cork 1996). The vegetation of New Zealand is generally higher in nutrients than that in Australia and forests can support higher densities of browsing mammals such as possums. Furthermore, since New Zealand plants have evolved in the absence of any mammalian browsers, they tend to have fewer chemical defences than equivalent Australian species. *Eucalyptus* leaves form the bulk of the diet of brushtail possums and other arboreal herbivorous marsupials in Australia, but high levels of phenolics, terpenoids, and other chemical defences in eucalypt foliage limit the intake of any one species (Freeland & Winter 1975) or individual tree (Lawler *et al.* 1998). In New Zealand forests a higher proportion of the vegetation is palatable (Brockie 1992) and possum diets include a wide variety of foliage (Fitzgerald 1976; Allen *et al.* 1997) and fleshy fruits (Cowan 1990b). The New Zealand plants most favoured by possums tend to be those producing foliage or fruits high in carbohydrate (Brockie 1992). Some highly palatable and chemically "unprotected" plant species are so preferred by possums that their selective browsing can result in local plant extinctions (Campbell 1990).

The final factor that has been influential in the disastrous success of the brushtail possum as an invader of New Zealand ecosystems is the sheer number of introductions from Australia and Tasmania and the subsequent widespread releases around New Zealand of locally bred stock (Pracy 1974). The probability of establishment of populations of introduced vertebrates rises significantly with the size and number of liberations (Veltman *et al.* 1996). It is therefore entirely possible that without repeated introductions possums would never have established in New Zealand. The first recorded introduction was apparently unsuccessful, as were some other releases (Pracy 1974), especially in Fiordland and south Westland. The climate of these latter parts of New Zealand is wetter and cooler than the natural range of brushtail possums, which may have reduced the probability of them becoming established there. The multiple introductions of possums not only served to increase the demographic chances of successful establishment, they also broadened the genetic base of the New Zealand population through separate importations from Victoria, New South Wales, and Tasmania. Finally, without the later releases of New Zealand-bred stock, the spread of possums through the country would undoubtedly have been much slower. Continued human assistance, through repeated importations and liberations, has undoubtedly been a critical factor in the success of the brushtail possum as an invader of New Zealand ecosystems.

Conclusions

It is clear that brushtail possums in New Zealand have experienced an "ecological release" from some of their natural controls.The net result of this is that possums achieve and maintain much greater population densities in New Zealand ecosystems than in Australia. Densities of 10–12 brushtail possums per hectare are common in New Zealand podocarp/broadleaf forest (Cowan 1990a), which is an order of magnitude greater than the densities of <1/ha prevailing in most Australian forests (Dunnet 1964). The ecological consequences of these sorts of densities of arboreal mammals in forests that have not evolved to accommodate them are severe, as are the economic consequences of the damage these invaders cause as vectors of disease.

The lesson to be learned from the possum example is a very simple one: the breaching of biogeographic boundaries by introducing alien organisms is something that should never be undertaken lightly. New Zealand ecosystems and the New Zealand economy would certainly be much better off without the brushtail possum.

Summary

- Brushtail possums were introduced to New Zealand from Australia in the mid-nineteenth century, with the motive of establishing a fur trade.
- Multiple importations and liberations of possums were conducted by private individuals, acclimatisation societies, and government agencies, with a peak of introductions in the 1890s.
- After an initial period of legislative protection, growing realisation of the adverse effects of possums led (in 1947) to their official recognition as a pest.
- It is now recognised that possums not only damage crops and native forests, but also carry bovine tuberculosis and prey on nests of native birds.
- Possums have now spread throughout the main islands of New Zealand, but have recently been eradicated from several small islands.
- The success of the brushtail possum as an invasive species is partially attributable to its generalist habits; the lack of competitors, parasites or predators; and the abundance of palatable, nutritious vegetation in New Zealand. Human assistance has also been a major factor in its success.

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