



Figure 5 Brazilian buttercup lining the road behind Low Flat, 1966 (Photo: W.R. Sykes).



Figure 6 A dense mass of Brazilian buttercup seedlings being hand pulled by some of the volunteers in August 1993.

shorter and stubby with a thick stem and seedlings were few. In 1990, Sykes noticed that the Brazilian buttercup shrubs on North Meyer were under stress and had fewer leaves than the plants on Raoul. He also observed a general lack of Brazilian buttercup seedlings on North Meyer, in contrast to Raoul where seedlings were more abundant. However, Clapham (1991a) observed that the bushes on the Meyers, although smaller than those on Raoul, had seeded prolifically, and he collected five large freezer bags full of seeds from five small to medium sized bushes on North Meyer. Fastier (1994) and his team removed hundreds of mature Brazilian buttercup trees from the western slope of North Meyer and the north-western slope of South Meyer.

The original listing of category A species did not include Brazilian buttercup (Devine 1977) and eradication was not begun until 1978 after initial poisoning trials which commenced in 1975 (Anon. 1982a). Champness (1975) warned that this species was spreading rapidly and that germination success was very high. After control commenced, Sykes (1980) noted the obvious decline of the species around Low Flat, the Orchard, Denham Bay and the crater, as a result of spraying. However, Selby (1980) observed an increase in the number of young seedlings and suggested that this could be related to the low goat numbers. He thought that Brazilian buttercup seedlings would have been eaten by goats. In 1984, one small bush was found on the ridge between Mahoe and Darcy Point (Sykes 1984). This plant was removed, but could have resulted in a considerable increase in the range of Brazilian buttercup on the island if it had seeded. Bracefield (1987) killed 64,365 plants and sprayed four areas, mainly on Low Flat and between Bell's Ravine and Ravine 6. Gardner (1988) killed 16,920 seedlings, from a wide range of sites. In a sweep of the Orchard from Denham Bay track to the edge of Bell's Ravine in October 1990, 436 Brazilian buttercup plants were removed (Crawley 1990). Very few of the plants seen by Sykes in 1990 were mature and those with pods were depodded and the seeds destroyed.

In January 1993, 12 mature trees and >1700 seedlings were killed around Blue Lake and several large trees and >6000 seedlings were removed from the bluffs and ravines above the airstrip (Samson 1993b). During the 1993-4 season, mature, seeding plants, some of which were estimated to be up to 10 years old, were located (or historic plots relocated) from near Western Spring as far east as Rayner Point spur on the north side of the island, around Blue Lake and extending 100 m up the lower slopes of Moumoukai, on the lower slopes of Mt Campbell and around Green Lake - especially the eastern side. Seedlings were recorded from Tui Lake and the vicinity of the swamp in Denham Bay (Fastier 1994). Several areas which required grid searching were indicated by Fastier (1994) and Uren (1995a) reported that 90 mature seeding plants, >1600 adolescents and >99,000 seedlings of Brazilian buttercup were killed from the crater area alone. In all cases seed pods were removed from mature plants and burnt at the Hostel, and the vegetation in the area of each infestation was cleared to provide more light and hasten the germination of Brazilian buttercup seeds. This latter strategy was suggested by Bill Sykes during his visit to the Island in 1994 (Sykes 1994).

Currently the species is scattered along the Northern Terraces from Western Spring in the west to Rayner Point in the east. In the crater it is scattered around all lakes but commonest around Blue Lake, and seedlings are occasionally

found at the northern end of Denham Bay. Thus, the species has extended its range since the late 1960s (Sykes 1977a). Mature seeding plants are still present and adding to the seed bank but are much less abundant than when the eradication programme commenced (Sykes 1994).

5.2.2 *Ecology*

Brazilian buttercup is a shrub, up to 4 m tall, with pinnate leaves and is in the same family as Mysore thorn (Fabaceae). The flowers are bright golden yellow and flowering is from November through to May (Rees 1982). Small green seeds (about the same size and shape as mung bean seeds) average 30 per pod (Champness 1975). Pods are clumped on the branches and seed production is prolific, e.g., Uren (1994) records that 2.5 kg of seed was taken from 11 mature flowering plants.

Like Mysore thorn, Brazilian buttercup is light-demanding and grows in light gaps in the forest or at the forest edge. When a mature bush is killed, hundreds of seedlings germinate in the space that the parent occupied (Crawley 1991b) (Figure 6). The greater part of this flush of germination is related to increased light levels once the parent canopy is removed. However, it is possible that the parent plant may also leach chemicals into the soil which inhibit seed germination.

The plants grow rapidly, and it is likely that plants in the forest which are two years old could flower and set seed (Sykes 1990). Flowering of plants is related to the amount of light received and can be a function of plant size. Plants do not flower in their first year, but those in high light environments could flower in the following year. In canopy gaps in the forest, plants are usually 2 m tall before they flower and set seed (Figure 7). As Uren (1995a) has observed "the life span of the Brazilian buttercup seems to be a short but fertile one".

Most seed is dispersed only a short distance from the parent plant, by the explosive opening of the seed pod. However, some seeds are carried long distances, e.g., the isolated young plant on Mahoe ridge and the infestations on the Meyers. Sykes (1977a, 1984) has suggested that birds are responsible for the long-range dispersal which has happened. Human visits to the Meyers are very infrequent, and Brazilian buttercup was already established there by the time of the Ornithological Society Expedition in 1966-7 which is when the islands had their most intensive period of human use. Birds could have dispersed the seeds in mud attached to their feet or feathers, or possibly as ingested seed. The seed is not likely to be eaten by the major seed dispersing birds though, because it is dry and not attractive to the disperser. It is possible that seed destroyers, such as kakariki which live on the Meyers but are recorded visiting Raoul (Veitch 1994), could disperse intact seeds. However, humans as a dispersal agent of Brazilian buttercup cannot be ruled out.

Because of the normal mode of dispersal, by explosion of the pod, spread of Brazilian buttercup is predictable. The extension of its range, since first recorded by Sykes (1977a) is a result of normal incremental spread. The seeds will persist in the soil for a number of years (a characteristic of many legumes). Therefore, any light gaps formed in previously infested sites are likely to have abundant germination of Brazilian buttercup. Numbers of seed buried in the soil are likely to be greater downhill of infestations, and will decrease with increasing distance from infestations.



Figure 7 Young Brazilian buttercup shrubs in a forest light gap which have flowered and set seed for the first time, August 1993.

As with Mysore thorn, the practicable point of control is before the plants set seed for the first time. Plants are more easily seen when in flower. Where seedlings have come up densely where the parent plant was, the seedlings can be left to self-thin and pulled before they flower. As suggested by Sykes (1994) and implemented by Simon Uren and his team, clearance of the understorey vegetation where mature seeding plants have been killed should hasten the germination of seeds and theoretically reduce the number of seeds remaining dormant in the soil.

5.2.3 *Control methods*

Brazilian buttercup is very susceptible to the Tordon group of sprays (Sykes 1980) and Crawley (1991b) established that Escort effectively killed Brazilian buttercup trees. In 1991-92, seedlings were hand-pulled and the larger plants were cut and the stumps sprayed with Escort from 500 ml bottles (Clark 1992).

Currently, large plants are poisoned with Tordon 2G granules and adolescent and seedling plants are hand-pulled. Seed pods are removed from all fruiting trees and burnt back at the Hostel. Understorey vegetation is cleared in the vicinity of mature plants once they have been removed to encourage germination of seed in the soil.

5.2.4 *Future work*

The location of all known sites of Brazilian buttercup should be checked annually for regeneration from seed. Areas in the vicinity of each infestation should be grid-searched and more remote locations should be scanned at every opportunity. Part of the problem with the current abundance of Brazilian buttercup is that previously treated sites have not been visited for several years

and mature plants are now present on those sites. Incremental spread from the original sites has also resulted.

On the Meyer Islands a check should be made for flowering plants annually but (apart from flowering plants) destruction of plants should be undertaken every second year in order to minimise the damage to the fragile, burrow-ridden soils. The best time of year for control is late August-early September to avoid disturbing the majority of nesting or fledgling birds.

Because Brazilian buttercup has occasionally been dispersed long distances, e.g., Mahoe ridge, and many parts of the island are difficult of access and infrequently visited, it is suggested that helicopter surveillance during the flowering season of Brazilian buttercup could be a cost-effective method of determining the extent of this species. Further west towards Hutchisons Bluff, further east from Rayner Point and along both sides of Mahoe ridge are places which should be searched by helicopter. Surveillance by boat is another method which teams often try but this is weather dependent and only part of the coast and bluffs are visible.

5.3 *Passiflora edulis* - BLACK PASSIONFRUIT

5.3.1 *History*

This common edible fruit has probably been on Raoul since the days of occupation by the Bells. Black passionfruit was first recorded for Raoul Island by Sorensen (1944) and was well established by the time of his visit. Most of the original dispersal of naturalised plants was probably accidental by humans (Sykes 1977a), as black passionfruit seems to have spread out from foci where most human activity has been, e.g., Low Flat, Boat Cove and the crater. Some deliberate planting of passionfruit may have been undertaken by coast watchers. Grapes were planted near the observation hut on Trig V (Expedition Hill) and it is likely that the passionfruit observed at this location by Sykes (1977a) resulted from similar earlier plantings. One large vine was removed from among Mysore thorn in Denham Bay (Trotter 1976).

Both Selby (1980) and Sykes (1980) state that black passionfruit had spread considerably in the last decade and recommended that it be transferred from a category C weed to a category A weed. Ombler (1977) had also made this recommendation. Many plants had been destroyed in the Low Flat and Orchard areas by weed teams but there were still a number of mature vines and seedlings present. The species was subsequently transferred to category A and concerted efforts at control were commenced in 1980 (Anon. 1982a).

By 1984, when Sykes visited the Island again he observed a considerable amount of this vine especially in the area from Low Flat to Bell's Ravine. He also noted outliers near Fishing Rock road and at Blue Lake (Sykes 1984). Bracefield (1987) killed 7069 black passionfruit vines, from Boat Cove to Ravine 6 but mostly from Low Flat and Gardner (1988) killed 26,647 passionfruit, mainly from Low Flat. On his next visit, Sykes (1990) saw few black passionfruit plants but most were large. The distribution was similar to that known from past



Figure 8 Black passionfruit flowers and foliage, 1944 (Photo: J.H. Sorensen).

years, but the density was much lower, and the plant he had previously seen at Trig V was gone. This plant had been destroyed in 1975 by Champness, much to the distress of the Meteorological Service staff on the Island at the time. Clapham (1991a) found plants up to 160 m altitude on Mt Campbell and recorded the spread of black passionfruit further west to Ravine 6. By 1994, passionfruit had moved further east and was above and below the road from Fishing Rock to Rayner Point and was also near Boat Cove Hut (Fastier 1994).

5.3.2 Ecology

Black passionfruit is a vigorous vine in the passionfruit family (Passifloraceae) which climbs with the aid of tendrils. The leaves are glossy and divided into three lobes. An important point to note is that the first 6-8

leaves of seedlings are undivided. Like Mysore thorn this vine climbs to the top of the trees which support it, and smothers them. The species is light-demanding and vines which germinate in a light gap send out several stems from ground level and these climb up stems when they encounter them. The flowers are produced singly and are large and showy (Figure 8). Flowering is from July to March. Fruits are dark purple when ripe and contain numerous black seeds which are surrounded by sweet pulp. The seeds are mature enough to germinate before the fruits turn purple (Sykes 1990). Fruiting is from January to April.

Fruits are eaten by rats (Norway and kiore) and birds (e.g., tui). Rats tend to destroy most of the seeds eaten whereas the birds disperse the seeds because they swallow the seeds whole with the pulp.

Vines are fast growing and are capable of flowering and fruiting within three years. Seedlings germinate in light gaps and light flecks and can be found scattered through the forest. Seedlings will often be found in tight clumps because they have germinated from a single bird dropping or the occasional whole fallen fruit which has not been eaten by rats. The pattern of spread of black passionfruit is not as predictable as the two legumes already mentioned, although to date, it appears to have steadily spread from the main focal point at Low Flat. New infestations could appear at locations remote from the current distribution, as a result of bird movements. For example, Mahoe ridge could be affected.

5.3.3 Control methods

Plants were hand-pulled or cut, but herbicides were not required for control (Clark 1992). Currently, mature vines are cut and the roots either pulled out or treated with Tordon 2G granules. Seedlings and young vines are pulled up and left to desiccate.

5.3.4 Future work

All sites from which passionfruit has been recorded should be checked annually. The range of this species overlaps considerably with that of Brazilian buttercup, so the two species can be checked and searched for in tandem.

Aerial reconnaissance, as recommended for Brazilian buttercup, will be useful to determine the extent of this species. It has tended to spread from foci of human activity, but because of its fruiting habit, seeds are likely to be spread to remote sites. Mature vines should be easy to spot from the air because of the large glossy yellow-green leaves which will be in the pohutukawa canopy.

5.4 *Anredera cordifolia* - MADEIRA VINE

5.4.1 *History*

Sykes (1977a) suggests that Madeira vine has recently become established on Raoul and notes that in 1967 it was growing in a ravine near the Meteorological Station - near a rubbish dump and further down near the beach. Champness recorded two plants in 1975 - one in Bell's Ravine and one near the Norfolk Pines at Denham Bay, and observed that both plants had run very wild. Time did not permit the removal of the Denham Bay plant - and there has been no record of it subsequently (it is likely that the Denham Bay plant was misidentified because it was never recorded there by anyone else). In 1976 Sykes (1977b) noted that the population in Bell's Ravine was decimated by floods which washed the plants out to sea and in the same year he reported Madeira vine from the open slopes immediately east of Fishing Rock where ten years earlier it was not observed to be present. From this time this vine was recognised as a potentially serious threat to vegetation on Raoul and attempts were made to control it with herbicides. In 1980, Sykes (1980) observed that there had been little spread of this species since 1978 and in 1984 he affirmed that there had been little change in the status of this species in the past decade as it was still present in both sites (Sykes 1984). This plant was added to the category A list in 1985 and the search for a herbicide which would kill it continued (Anon. 1985). Presumably, the persistent efforts to control this species had kept it more or less in the same places. Sykes (1990) recorded no significant change since 1984. Clark (1992) noted the presence of both infestations but Samson (1993a) did not find Madeira vine in Bell's Ravine. However, Fastier (1994) did locate Madeira vine there. Thus, the species still persists at both locations and has been reported as spreading further west from the Fishing Rock site (E.K. Cameron, pers. comm., Uren 1994).

5.4.2 *Ecology*

This plant is a soft-leaved vine, in the family Basellaceae, whose leaves become more succulent when exposed to salt spray. Madeira vine has racemes of small white flowers on Raoul (from January to March) but has not been observed to set fruit. However, it is a threat because it disperses vegetatively by knobbly tubers (Figure 9) which are produced frequently in the leaf axils along the stems. The tubers are easily dislodged and roll down slopes. It is also possible