Conservation status of the giant endemic landsnail *Placostylus bollonsi* on Three Kings Islands

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ABSTRACT

Surveys were carried out between 1995 and 2001 to determine the conservation status of the endemic landsnail *Placostylus bollonsi* (Pulmonata: Bulimulidae) on the Three Kings Islands, northern New Zealand. Two extinct and five extant local populations of this species are recorded. The extant populations all had highly restricted geographic distributions, ranging from c. 0.5 to 4.7 ha. However, none of these populations appeared to be threatened, and none required conservation assistance. The distributions of two populations on Great Island had increased substantially over a 10-year period since an earlier survey in 1991, whereas another population on that island had more or less the same distribution as in 1991. The populations on North East and West Islands had not been surveyed prior to this study. In the period from 1995 to 1997, snails were common and widely distributed on the former island, but were much less common and had a patchy distribution on the latter.

Keywords: *Placostylus bollonsi*, landsnails, Three Kings Islands, conservation status, anthropic impacts, population recovery, species translocation

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1. Introduction

Placostylus (*Basileostylus*) *bollonsi* Suter, 1908 is a large terrestrial herbivorous landsnail with an elongate shell up to 122 mm high. This species, which is in a monotypic subgenus, is endemic to the Three Kings Islands off northern New Zealand (Powell 1979). There are five extant local populations of *P. bollonsi*: three on Great Island; and one each on North East and West Islands. In addition, there are two extinct populations on Great Island.

Since 1980, *P. bollonsi* has been fully protected under of the Wildlife Act (Section 7b, Seventh Schedule). In addition, the Three Kings Islands are designated as Nature Reserves, and landing is prohibited except by permit from the Department of Conservation.

Before the arrival of humans, *P. bollonsi* was probably widely distributed and common in broadleaved forest and shrubland on the four largest islands in the Three Kings group (Great, South West, West, North East: Fig. 1). However, human-related forest clearance, which began at least 400 years ago and continued until the mid 19th century, is inferred to have caused extinction of *P. bollonsi* on South West Island, and the fragmentation and dimunition of snail populations on Great, North East and West islands (Brook 1999, 2002a). Populations of *P. bollonsi* on Great Island declined further between 1889 and 1946, and at least two became extinct as a result of habitat deterioration caused by feral goats (Powell 1935, 1948; Turbott 1948). However, since goats were eradicated in 1946, the three surviving Great Island populations have all increased in size (Climo 1973; Brook & Laurenson 1992; Brook 2002a).

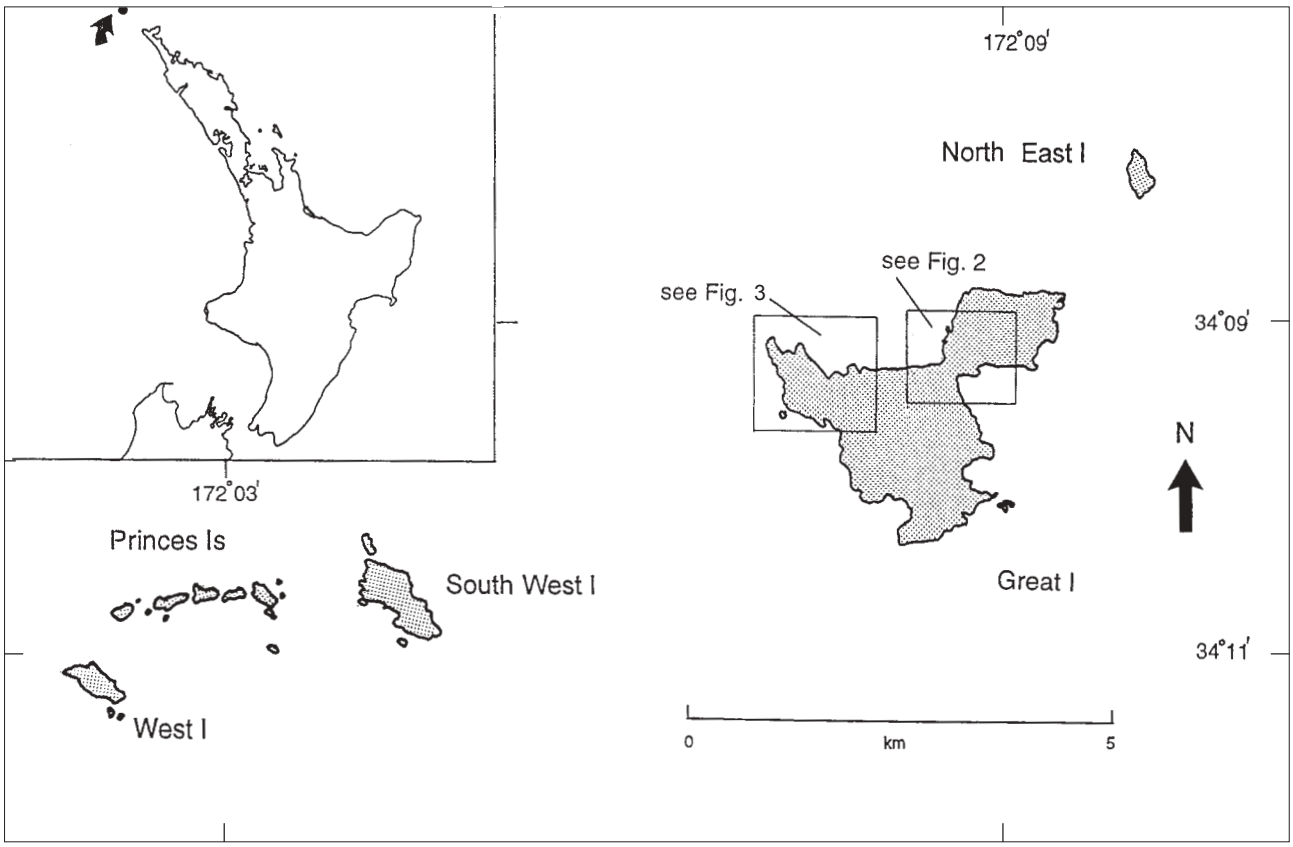

Figure 1. Location of Three Kings Islands. Areas on Great Island enclosed in boxes are shown enlarged in Figs 2 & 3.

Despite evidence of recovery, *P. bollonsi* has generally been regarded as a threatened species because of the restricted geographic distribution and small size of its constituent populations. For example, a classification of New Zealand wildlife by Bell (1986) equated the conservation status of *P. bollonsi* with the 'vulnerable' category designated by the International Union for the Conservation of Nature and Natural Resources (IUCN). Subsequent classifications of national priorities for species conservation in New Zealand prepared by the Department of Conservation (Molloy & Davis 1992; Tisdall 1994), identified populations of *P. bollonsi* as second priority threatened species. These authors noted that no *P. bollonsi* populations were actually threatened, but their localised distributions and relatively small size made them especially vulnerable to future catastrophes.

In 1995, a recovery plan was published by the Department of Conservation identifying management priorities for some giant landsnail species in northern New Zealand (Parrish et al. 1995). It concluded that *P. bollonsi* did not require intensive conservation assistance, but identified two management tasks necessary for conservation of the species: maintenance of island security to prevent establishment of exotic predatory mammals on the Three Kings Islands; and regular monitoring of the status of populations of *P. bollonsi*.

The *P. bollonsi* populations on Great Island were surveyed in 1991 by Brook & Laurenson (1992). There is no comparable recent historical information for the populations on North East and West Islands, although Brook & Laurenson (1992) provided brief accounts of the distribution and abundance of snails based on observations made during field visits in 1982–83. The present study was undertaken to assess the current conservation status of all known populations of *P. bollonsi*, to identify limiting factors and threats to these populations, and to identify management options for the species.

1.1 FIELD SURVEYS

Field visits were made to North East Island in 1995–96, to West Island in 1996–97, and to Great Island in 2001. The distribution area of each population of *P. bollonsi* was determined by searching for live snails and shells of recently dead snails, and recording their distribution on a 1:10 000 scale topograhical map (i.e. an enlargement of NZMS 260 sheet L01). Brief field notes were made on the distribution of the main vegetation types within and adjacent to each snail colony, and abundances of live snails in the various habitat types present were qualitatively assessed. In addition, quantitative abundance and size frequency data were obtained for live snails and empty shells in eight randomly placed 10-m^2 quadrats within broadleaved forest on North East Island. Within each of these quadrats a thorough search was made for all live snails and empty shells, and shell heights of all the individuals found were measured on site. A distinction was made between living and dead specimens, and between specimens possessing a labial varix and those with an unthickened outer lip. Callus deposition around the apertural margin in *P. bollonsi* does not begin until an individual has almost attained maximum shell height, and thus the presence of a varix is useful for distinguishing 'adult' and 'juvenile' shell morphological types.

1.2 TAXONOMIC NOMENCLATURE

Placostylus bollonsi was originally described by Suter (1908) from specimens collected in South East Bay on Great Island. Powell (1948) subsequently described three subspecies of *P. bollonsi* on Great and North East islands based on differences in shell morphology: *P. b. bollonsi* incorporated the type population (by then extinct), another (extant) population above South East Bay, and one on North East Island; *P. b. caperatus* included an extant population above North West Bay on Great Island; and *P. b. arbutus* incorporated an extant population west of the trig on Great Island, and an extinct population near Hapuku Point on the same island. Powell (1951, 1979) later also included the extant population on West Island in subsp. *bollonsi*. A multivariate analysis by Brook & Laurenson (1992) also found consistent morphological differences between extant populations of subspp. *bollonsi*, *caperatus* and *arbutus* on Great Island, but showed that there were significant differences in shell morphology between populations on North East and West islands, and between these populations and the *P. b. bollonsi* populations on Great Island. However, although these morphological differences were probably at least in part hereditary (Brook & Laurenson 1992), a study of allozyme genetic diversity by Triggs & Sherley (1993) found very little overall genetic differentiation among the four extant populations of *P. bollonsi* from Great and North East islands.

On the basis of this genetic evidence there seems to be little taxonomic justification for continued recognition of formal subspecies within *P. bollonsi*. Instead, in this report, six informal names are used for morphologically distinct local populations: *P. bollonsi* "bollonsi" for the extinct type population and the extant population on north-eastern Great Island; *P. bollonsi* "caperatus" for the population on the North West Bay landing slope on Great Island; *P. bollonsi* "arbutus" for the extant population on north-western Great Island; *P. bollonsi* "North East" for the population on North East Island; *P. bollonsi* "West" for the population on West Island; and *P. bollonsi* "Hapuku Point" for the extinct population at Hapuku Point.

2. History, distribution and status of populations of *P. bollonsi*

The locations of the two extinct and five extant populations of *P. bollonsi* are shown in Figs 2, 3 and 4.

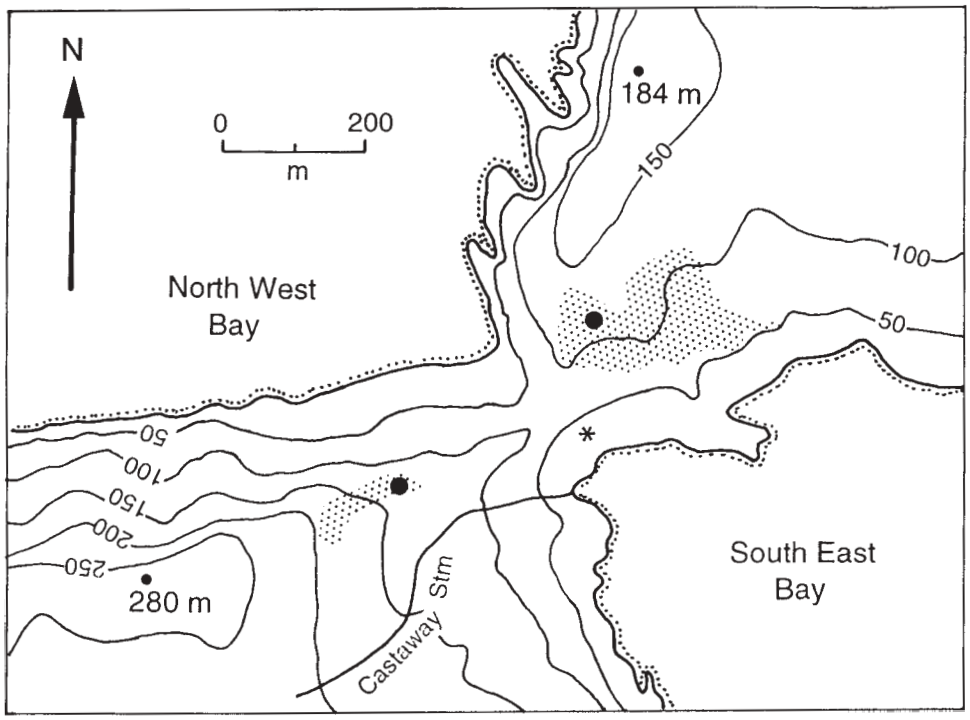

Figure 2. Distribution of *Placostylus bollonsi* on eastern Great Island. Locations of extant "bollonsi" (eastern) and "caperatus" (western) populations in 1945–46 indicated by filled circles. Geographic ranges of populations in 2001 indicated by stippled areas. The asterisk denotes the approximate location of the extinct type population. Contours at 50-m intervals.

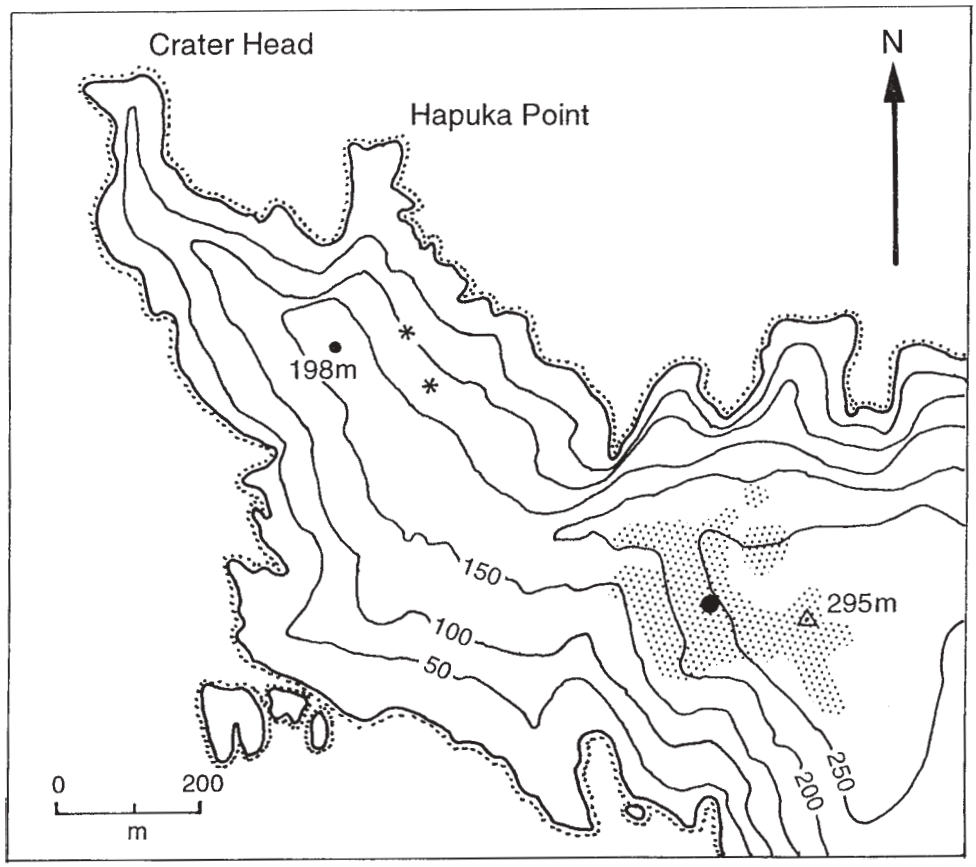

Figure 3. Distribution of *Placostylus bollonsi* on north-western Great Island. Location of "arbutus" population in 1946 and its geographic range in 2001 indicated by filled circle and stippled area respectively. Asterisks denote locations of extinct *P. bollonsi* population(s) near Hapuka Point. Contours at 50-m intervals.

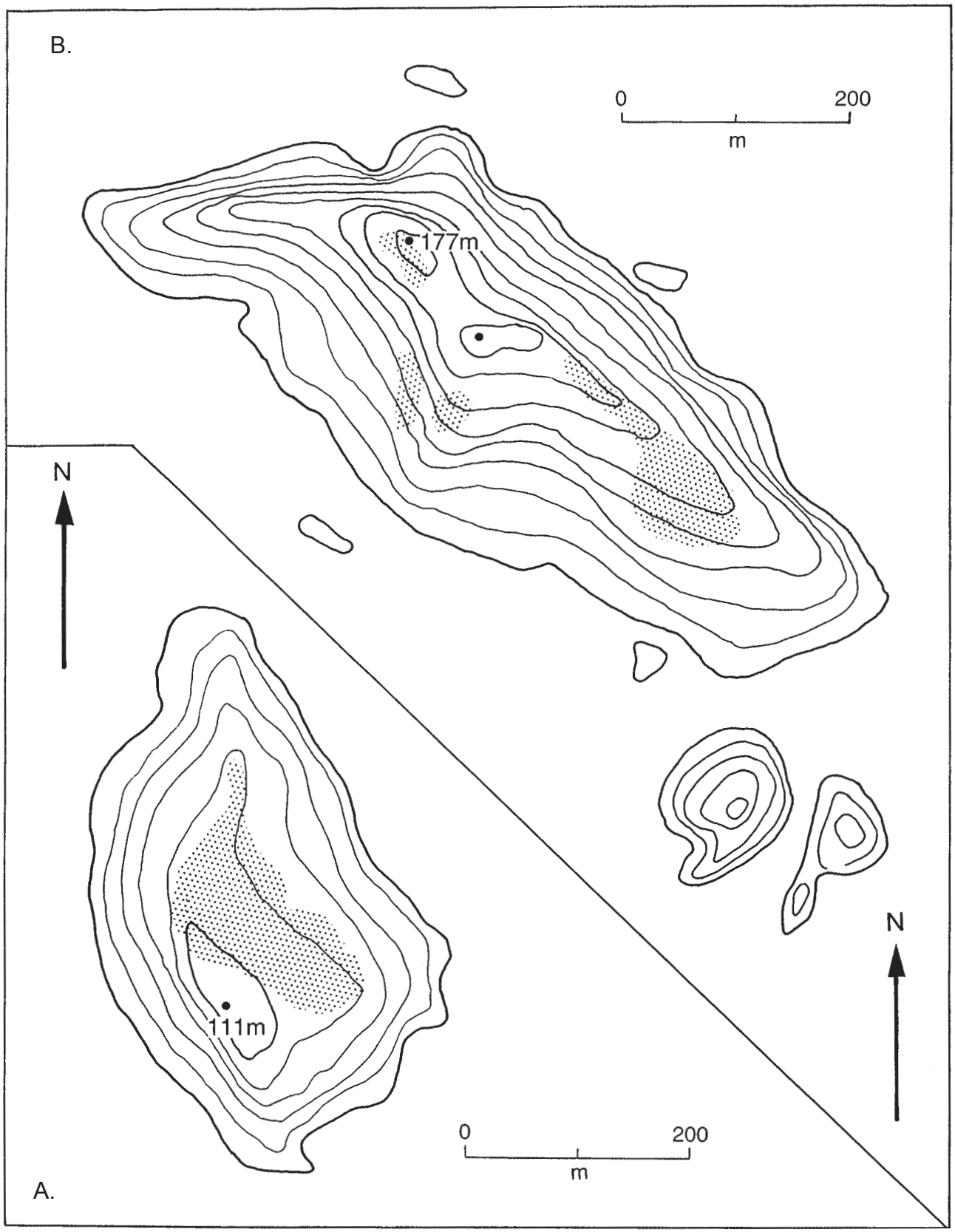

Figure 4. Distribution of *Placostylus bollonsi* on North East and West Islands. A. North East Island, 1995–96. B. West Island, 1996–97. Contours at 20-m intervals.

2.1 SOUTH EAST BAY LANDING SLOPE, GREAT ISLAND

The type locality of *P. bollonsi* was reportedly near the head of South East Bay on Great Island (Suter 1908; Powell 1935, 1948). A small population of snails was discovered here by J. Bollons in 1907, confined to a 'very small grove of karaka trees ... near a large overhanging rock on the S.E. landing slope, below the provision depot' (Powell 1935, p. 247). This population apparently became extinct within a few years of its discovery, probably as a combined result of over-collecting and habitat modification (Powell 1935). Powell (1948, p. 283) noted that, by 1946, vegetation on this slope had been greatly altered by goats, such that there was 'no trace of the original karaka grove, only *Carex* and rather sparse kanuka' (Powell 1948, p. 283).

2.2 NORTH-EASTERN GREAT ISLAND

In 1945, a population containing shells that were morphologically similar to those at the type locality (i.e. the "bollonsi" morphotype) was discovered further up-slope on the northern side of South East Bay. It occupied a boulder-strewn site at c. 100 m elevation, 'on the lower side of a long, rocky cliff face in moderately dense scrub. The colony consisted apparently of only eleven snails (all adults) and was restricted to the leaf spread area afforded by a group of seven trees of wharangi (*Melicope ternata*) and one of mahoe (*Melicytus ramiflorus*). The area occupied by the colony was not more than 5 to 10 feet wide and 30 feet long, on a slope of about 45°' (Powell 1948, p. 283).

This "bollonsi" population increased dramatically after goats were eradicated from Great Island in 1946 (Climo 1973; Brook & Laurenson 1992; Fig. 5). In 1991 it occupied a total area of c. 1.7 ha, and was estimated to comprise at least 210 individuals (Brook & Laurenson 1992). By 2001, the population extended c. 80 m further eastwards and covered a total area of c. 3 ha (Figs 2, 5). No attempt was made to assess the population size in 2001, but the number of snails present had undoubtedly increased substantially since 1991 and, by extrapolation, probably exceeded 370 individuals.

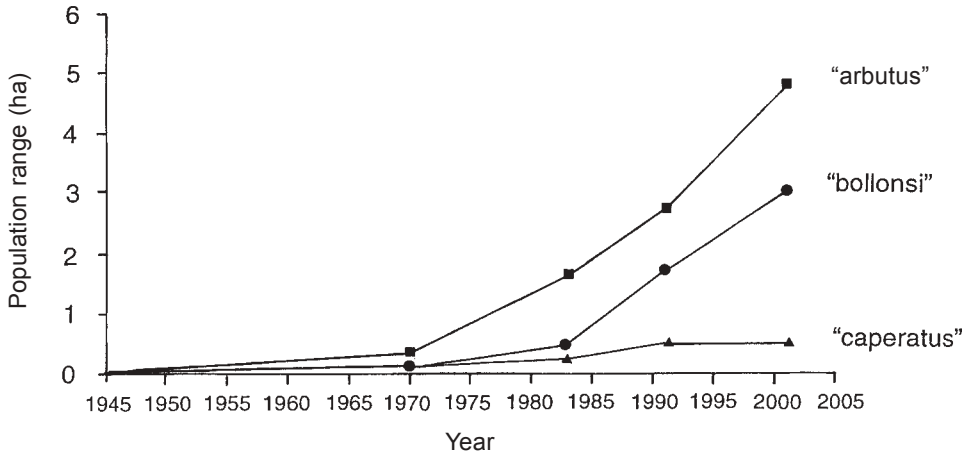

Figure 5. Estimated changes in areas occupied by *P. bollonsi* populations on Great Island from 1945–46 to 2001, adapted from Brook & Laurenson (1992).

In 1946 the *P. bollonsi* "bollonsi" population was evidently acutely threatened by goat-induced habitat deterioration, but since then it has undergone dramatic natural population recovery. It is not known to be under any threat at present, and conservation assistance is not required. If recent trends continue, snails will continue to spread eastward through patches of broadleaved-kanuka (*Kunzea ericoides*) forest and shrubland in gullies along the northern side of South East Bay. However, unfavourable habitats will probably limit further expansion to the north or southwest, at least in the short term.

2.3 NORTH WEST BAY LANDING SLOPE, GREAT ISLAND

In 1946, the "caperatus" population was discovered above North West Bay 'at about 500 feet elevation on the N. W. slope above the landing and about 500 yards west of the saddle'; it was restricted to a patch of 'stunted ngaio (*Myoporum laetum*) scrub', and contained more than 40 individual snails (Powell 1948, p. 283). Vegetation changes following the eradication of goats enabled this snail population to expand up-slope to the southwest (Climo 1973; Brook & Laurenson 1992; Fig. 2). By 1991 it extended over c. 0.5 ha of kanuka-broadleaved forest and shrubland, and was estimated to contain at least 130 snails (Brook & Laurenson 1992; Fig. 5). In 2001 it had essentially the same geographic distribution as in 1991 (Figs 2, 5), and the number of snails present was probably also approximately the same. It appears that further spread of this population is presently constrained by unfavourable habitat in the surrounding area. The population is sandwiched between sparsely vegetated cliffs to the north, and kanuka forest containing only sparse, small pockets of broadleaved litter to the south. Snails will presumably eventually be able to spread southwards into existing broadleaved-kanuka forest in Castaway Valley, as pukanui (*Meryta sinclairii*) and other broadleaved trees become more widely established within the intervening belt of kanuka forest.

The "caperatus" population has a more restricted distribution and probably contains fewer individuals than any other contemporary population of *P. bollonsi*. However, it is not known to be under any threat, and conservation assistance is not required at present.

2.4 NORTH-WESTERN GREAT ISLAND

In 1945, the "arbutus" population was discovered west of the trig, restricted to a remnant grove of broadleaved forest containing *Brachyglottis arborescens*, coastal maire (*Nestegis apetala*), mahoe, puriri (*Vitex lucens*), tawapou (*Pouteria costata*), and wharangi. Twenty-five snails, mostly adults, were found 'near the foot of a boulder scree … in deep accumulations of leaves amongst boulders', but contemporary estimates suggested more than double that number of snails could have been present at the site (Powell 1948, p. 284).

This population has increased dramatically since goats were eradicated, and particularly rapidly since 1970 (Climo 1973; Brook & Laurenson 1992; Fig. 5). In

1991, it occupied a total area of c. 2.7 ha and contained at least 360 individuals (Brook & Laurenson 1992). By 2001, snails had spread further northeast and west, and the population covered a total area of c. 4.7 ha (Figs 3, 5). No attempt was made to reassess population size in 2001, but as with the "bollonsi" colony, the number of snails present had undoubtedly increased substantially since 1991 and probably exceeded 600 individuals.

Historical records suggest that *P. bollonsi* "arbutus" was acutely threatened by goat-induced habitat deterioration in the first part of the 20th century, but has undergone dramatic natural population recovery since 1946, following the eradication of goats from the island. This population is not known to be under any threat at present, and conservation assistance is not required. If recent trends continue, the population will probably continue to expand westward and eastward into adjoining areas and pockets of broadleaved and kanuka-broadleaved forest and shrubland.

2.5 HAPUKA POINT

In 1946, old empty shells of *P. bollonsi* were discovered by E.G. Turbott at a site several hundred metres east of Hapuka Point, near the north-western tip of Great Island. These shells were 'on steep boulder scree in sparse forest consisting mainly of large pohutukawa and kanuka … The undergrowth had been eaten out by goats and the ground trampled and rendered too dry for living snails' (Powell 1948, p. 284). Other contemporary vegetation descriptions indicate that, in addition to pohutukawa (*Metrosideros excelsa*) and kanuka, this site also contained a solitary tree of Three Kings titoki (*Alectryon excelsus* subsp. *grandis*) and two trees of *Myrsine oliveri* (Baylis 1948; Oliver 1948).

Powell (1948) concluded that the Hapuka Point population of *P. bollonsi* was extinct by 1946. Climo (1973) re-examined the site in 1970, but found no snails or empty shells. In 2001, I found old empty shells of *P. bollonsi* in boulder talus within two separate pohutukawa groves southeast of Hapuka Point (Fig. 3). However, despite extensive searching I did not find any live snails or fresh empty shells at either site, confirming that this population(s) is extinct. Ironically, present-day habitats at these two sites seem ideally suited to *P. bollonsi*, because they contain abundant broadleaved food plants (e.g. *Coprosma macrocarpa*, *Myrsine oliveri*, parapara (*Pisonia brunoniana*), pukanui and wharangi) and pockets of ponded litter amongst boulders. These patches of broadleaved forest will presumably eventually be recolonised by snails from the "arbutus" population as it expands northwestwards.

2.6 NORTH EAST ISLAND

In 1947, *P. bollonsi* "North East" was evidently plentiful and fairly evenly distributed over much of the top of North East Island (Buddle 1948, p. 200; Powell 1948, p. 283). In 1995–96, this population extended over a total area of c. 1.7 ha in broadleaved forest on the gently to moderately sloping upper part of the island (Fig. 4A). Snails were absent from areas of kanuka forest on the upper

western side of the island, and from taupata (*Coprosma repens*) shrubland and vine-shrubland on the more steeply sloping north-western, eastern and southern faces (see Brook 1999 for vegetation map). Pukanui and pohutukawa were the commonest trees in the area inhabited by the snail population, but *Cordyline kaspar*, kanuka, karaka (*Corynocarpus laevigatus*), mahoe, *Pittosporum fairchildii* and wharangi were also present locally. This forest had an open shrub understorey of mainly kawakawa (*Macropiper excelsum* subsp. *peltatum*), *Melicytus novaezelandiae*, *Pittosporum fairchildii* and *Streblus smithii*, along with a patchy ground layer of sedges (*Carex elingamita*) and ferns (*Asplenium oblongifolium*).

Size frequency data for live *P. bollonsi* "North East" determined from searches of eight 10-m^2 quadrats randomly sited within broadleaved forest in December 1995, indicated that the population was strongly dominated by adults (Fig. 6A). Densities of live snails recorded in these quadrats are listed in Table 1. Qualitative field observations made in 1995 and 1996 indicated that snails were most abundant in pockets of litter ponded by rockpiles, sedges, ground ferns and prostrate shrubs of *Streblus smithii*, where they locally attained densities of up to 2–3 individuals/m^2. By contrast, snails were generally much more

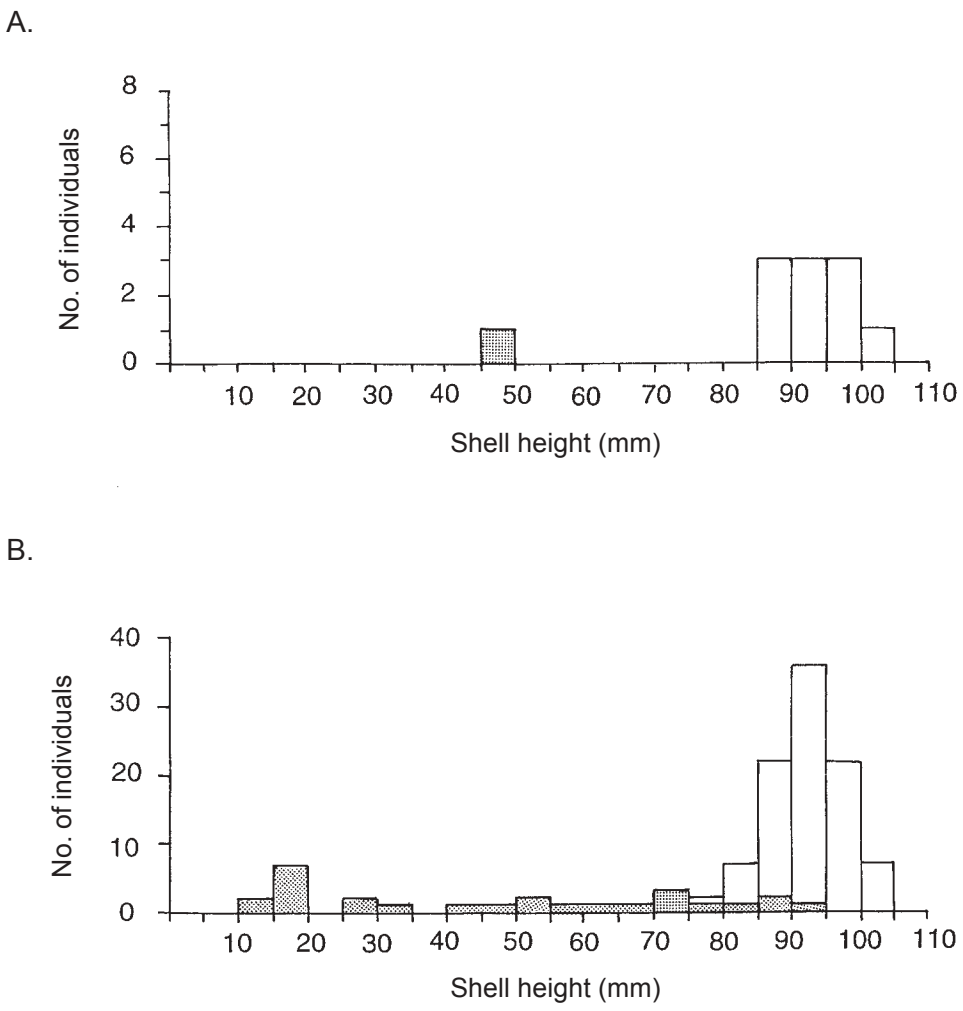

Figure 6. Size frequency distribution (shell height) in *Placostylus bollonsi* "North East" in 1995, based on searches of eight 10-m^2 quadrats. Shaded and unshaded bars denote numbers of individuals with unthickened and thickened outer lips respectively. A. Live snails. B. Empty shells.

sparsely distributed in areas of open broadleaved litter and on steep earth slopes. Assuming that snails were present throughout the distribution area at an average overall density of 0.05 individuals/m^2 in 1995 (i.e. based on a conservative extrapolation from quadrat data), then the total population would have comprised c. 850 snails at that time.

TABLE 1. MEAN (± STANDARD ERROR) AND RANGE OF DENSITIES OF *P. bollonsi* SNAILS IN BROADLEAVED FOREST ON NORTH EAST ISLAND, DECEMBER 1995, AS DETERMINED FROM SEARCHES OF EIGHT 10-m^2 QUADRATS.

	MEAN ± SE	RANGE
Adults & juveniles/m^2	0.138 ± 0.053	0–0.3
Juveniles/m^2	0.013 ± 0.013	0–0.1
Adults/m^2	0.125 ± 0.049	0–0.3

The size frequency distribution of empty shells of *P. bollonsi* "North East", as determined from the eight 10-m^2 quadrats surveyed in 1995, showed a strong peak in the adult size classes, and a minor peak in the 15–20 mm juvenile size class (Fig. 6b). Adult shells predominated overall, comprising 77% of the population. The majority of shells found were undamaged, but a few juveniles had the outer lip broken back, presumably as a result of predation by birds or lizards.

The overall density and microhabitat preferences of *P. bollonsi* on North East Island parallel the situation recorded for populations of the species on Great Island in 1991 (Brook & Laurenson 1992). However, the North East Island population was more strongly dominated by adult snails (90.9%), and death assemblages contained proportionately fewer juvenile shells, especially in the 10–20 mm size range, indicating that recruitment and mortality of juveniles were probably lower than in contemporary Great Island populations.

In 1995–96, *P. bollonsi* "North East" was common and the population appeared to be thriving. However, there is a possibility that natural vegetation changes taking place on North East Island could adversely affect this snail population in future. In the mid 20th century, large mature pukanui trees formed a closed forest canopy over much of the top of the island (Buddle 1948; Baylis 1958), but many of these trees have since collapsed, opening up the canopy. Sapling regeneration in some of these tree-fall clearings has been dominated by *Pittosporum fairchildii*, with only sparse regeneration of pukanui. Field observations in 1995–96, indicated that *P. bollonsi* snails were generally sparse or absent within tree-fall clearings and patches of regenerating shrubland-low forest dominated by *Pittosporum fairchildii*. Thus, there is a risk that widespread collapse of remaining pukanui forest, and its replacement by other tree species less favourable to *P. bollonsi*, could lead to a decline in the snail population on North East Island. No conservation assistance is required at present, but it would be prudent to carry out a more detailed assessment of historical and contemporary patterns of vegetation change on the island to determine potential future impacts on *P. bollonsi* and other invertebrate species.

2.7 WEST ISLAND

In 1996-97, *P. bollonsi* "West" had a patchy distribution on the upper western slopes of West Island. Four separate areas of distribution were mapped (Fig 4B), with the largest extending over c. 0.8 ha at the south-eastern end of the island.

The other three areas were all much smaller, at c. 0.1 ha each[1]. The vegetation in the south-eastern and western areas was predominantly mixed broadleaved forest, which comprised 3–6-m-high trees of *Brachyglottis arborescens*, coastal maire, *Elingamita johnsoni*, houpara (*Pseudopanax lessonii*), karaka, parapara, *Pittosporum fairchildii*, pukanui, *Streblus smithii*, tawapou and wharangi, locally with emergent pohutukawa to c. 10 m high. Other woody species represented in understorey shrub layers included *Coprosma macrocarpa*, *Macropiper melchior*, *Melicytus novaezelandiae*, ngaio and taupata, with patchy sedges (*Carex elingamita*), renga lily (*Arthropodium cirratum*) and ferns (*Asplenium oblongifolium*) in the ground-layer. By contrast, snails in the northernmost area occupied a mosaic of flax (*Phormium tenax*) and mixed broadleaved shrubland (see Brook 1999 for vegetation map of island). Woody shrubs present here included coastal maire, *Coprosma macrocarpa*, karaka, *Melicytus novaezelandiae*, ngaio, *Pittosporum fairchildii*, pohutukawa, pukanui, *Streblus smithii*, taupata and tawapou, while ground-layer plants included *Asplenium oblongifolium*, *Carex elingamita*, *Cyperus ustulatus*, renga lily and *Tetragonia implexicoma*.

Within the respective areas, *P. bollonsi* snails were generally restricted to sheltered, moist microhabitats under sedges and in pockets of litter ponded by logs, boulders and ground-layer plants. No quantitative surveys were undertaken, but casual observations indicated that snails were mostly very sparsely distributed with adults predominating at all sites. The area at the south-eastern end of the island probably contained c. 100–200 snails, whereas the three smaller western and northern areas probably each contained fewer than 50 snails.

The low abundance of *P. bollonsi* on West Island was probably linked to a scarcity of favourable microhabitats. Although broadleaved forest and shrubland was relatively widespread on the island, it mostly occupied steep, unstable gravelly soil slopes that were evidently prone to sheet-wash erosion during high rainfall events. Sedges and pockets of stable litter favourable for snails were generally patchily distributed and scarce on these slopes. Low soil moisture retention possibly also limited snails on West Island, given the steep topography and the situation of colonies on west-facing slopes exposed to prevailing westerly quarter winds.

Historical evidence points to major changes in vegetation cover on West Island between the late 19th and mid 20th centuries, and thus the distribution and abundance of *P. bollonsi* probably also changed over that period. According to Cheeseman (1891, p. 409–410), West Island supported only scanty vegetation in 1889, with patches of iceplant (*Disphyma australe*) and taupata shrubland on coastal cliffs, and flax, toetoe (*Cortaderia splendens*) and 'a few shrubby plants' on the upper slopes. By contrast, descriptions in Baylis (1958) indicate that pohutukawa and mixed broadleaved forest-shrubland were widely established on the upper western slopes by 1951. It follows that *P. bollonsi* on West Island was probably restricted to a series of small disjunct populations within shrubland refugia in the late 19th century. Conversely, regeneration of broadleaved shrubland-forest during the early 20th century presumably enabled these relict snail populations to increase in distribution and abundance, just as happened on Great Island after goats were eradicated.

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[1] Areas of shrubland on the lower to mid eastern slopes of West Island, which I was unable to visit during this study, possibly also contain *P. bollonsi*.

The earliest record of *P. bollonsi* on West Island, based on field observations by M.E. Johnson in 1950–51, noted the species was 'abundant over most wooded parts of the island' (Powell 1951, p. 132). This contrasts with the situation in 1995–96, when *P. Bollonsi* had a patchy, sparse distribution in forest-shrubland on the upper western slopes. Taken at face value, these differences suggest the possibility that *P. bollonsi* declined in abundance on West Island during the second half of the 20th century. However, I found no taphonomic evidence indicating that the range of the species has diminished over the last several decades. Rather, old empty shells of *P. bollonsi* were present only in areas occupied by extant snail populations, and in colluvial deposits down-slope from them.

Although *P. bollonsi* "West" was relatively uncommon in 1996–97, it was widely distributed across the island and there was no evidence to indicate any colonies or forest-shrubland habitats were threatened. No conservation assistance is required at present.

3. Management requirements

None of the extant populations of *P. bollonsi* appear to be threatened at present, and none require conservation assistance. If existing patterns of forest regeneration on Great Island continue, the "arbutus", "bollonsi" and "caperatus" populations will probably all increase further in size and range, as broadleaved trees become more widely established and abundant across the island. Historically, expansion of these populations has proceeded both by incremental spread of snails within contiguous broadleaved forest and shrubland habitats, and by dispersal of snails into isolated patches of favourable broadleaved vegetation in neighbouring areas (Brook & Laurenson 1992). By contrast, the distributions of *P. bollonsi* "North East" and *P. bollonsi* "West" are constrained by the relatively small areas of favourable habitat on the respective islands.

Although all extant populations of *P. bollonsi* are secure at present, there is a risk that human activities and invasive alien species could adversely affect not only these snail populations, but also the fundamental ecosystem structures and processes on the Three Kings Islands. Events or impacts that could pose serious threats include fires (started either by human agency or lightning), and introductions or natural arrivals of exotic predators (mammalian, avian or invertebrate), browsing mammals, invasive exotic weeds and pathogenic micro-organisms. Strict controls on human access to the Three Kings Islands are necessary to minimise the risk of these threats, and regular (annual) monitoring is required to provide early warning of the arrival of any harmful alien species on the islands.

3.1 SPECIFIC MANAGEMENT RECOMMENDATIONS

1. All populations of *P. bollonsi* should be monitored at 5–10-yearly intervals, with the aims of keeping track of changes in their distribution, abundance and mortality, and to determine whether conservation assistance is required.
2. There is a possibility that natural vegetation changes associated with the collapse of pukanui forest on North East Island could cause a decline in the population of *P. bollonsi* there. These changes could possibly also pose a serious threat to the endemic landsnail *Delouagapia tasmani*, which was restricted to a total area of only 800 m^2 in pukanui forest in 1995–96 (Brook 1999). An ecological study is needed to further investigate patterns of forest collapse and regeneration on North East Island, and to assess the potential future impacts on *P. bollonsi*, *D. tasmani* and other invertebrate species present.
3. Consideration should be given to establishing one or more translocated populations of *P. bollonsi* on South West Island in the Three Kings group. This species does not presently live on South West Island, and no shells have ever been recorded from there. However, biogeographic and paleogeographic evidence suggest *P. bollonsi* was probably present on the island earlier in the Holocene, and became extinct as a result of vegetation clearance by prehistoric Maori (Brook & Laurenson 1992; Brook 1999, 2002b). South West Island, the second largest of the Three Kings Islands (38 ha), presently supports extensive areas of broadleaved forest and flax shrubland that are closely comparable to habitats favoured by *P. bollonsi* on other islands in the group (see vegetation map and descriptions by Brook 2002b). Establishing *P. bollonsi* on this island would have two main benefits. First, it would reduce the risk of extinction of the populations concerned. Second, and potentially of greater importance, it could benefit the critically endangered endemic carnivorous landsnail *Rhytidarex buddlei* that is present on the island by providing an additional food source (as discussed by Brook (2002b)).

Although it would be quite feasible to establish two or more separate translocated populations of *P. bollonsi* on different parts of South West Island, I recommend that initially a single population be established in the vicinity of the extant *Rhytidarex buddlei* colony on the western side of the island. If that proved successful, or if populations of *P. bollonsi* elsewhere became threatened, then further translocations could be made to other suitable sites on South West Island. Snails for the initial translocation would need to be obtained from one of the larger and more secure existing populations, namely the "arbutus", "bollonsi" or "North East" populations. Translocations from the "West" and "caperatus" populations would be inappropriate at present, given the low numbers of snails and potential risk to those populations. Of the three potential source populations, the "arbutus" population is probably the most suitable in terms of proximity to South West Island and ease of access. I suggest that 20 mature snails could be removed from the core region of the "arbutus" colony west of the trig without adversely affecting the natural recovery and expansion of this population. This number should be sufficient to establish a breeding population on South West Island. Particular care would need to be taken to ensure that no other invertebrates, pathogenic organisms, seeds, or soil were attached to any *P. bollonsi* snails transferred to South West Island from Great Island.

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