

FLORA OF NEW ZEALAND

FERNS AND LYCOPHYTES

NEPHROLEPIDACEAE



P.J. BROWNSEY & L.R. PERRIE

Fascicle 26 – APRIL 2019

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CATALOGUING IN PUBLICATION

Brownsey, P. J. (Patrick John), 1948–

Flora of New Zealand : ferns and lycophytes. Fascicle 26, Nephrolepidaceae / P.J. Brownsey and L.R. Perrie. -- Lincoln, N.Z.: Manaaki Whenua Press, 2019.

1 online resource

ISBN 978-0-9 47525-59-0 (pdf)

ISBN 978-0-478-34761-6 (set)

1.Ferns -- New Zealand - Identification. I. Perrie, L. R. (Leon Richard). II. Title. III. Manaaki Whenua – Landcare Research New Zealand Ltd.

UDC 582.394.742(931)

DC 587.30993

DOI: 10.7931/B17N0N

This work should be cited as:

Brownsey, P.J. & Perrie, L.R. 2019: Nephrolepidaceae. *In*: Breitwieser, I.; Wilton, A.D. *Flora of New Zealand - Ferns and Lycophytes*. Fascicle 26. Manaaki Whenua Press, Lincoln.
<http://dx.doi.org/10.7931/B17N0N>

Date submitted: 17 Dec 2018; Date accepted: 1 Mar 2019

Cover image: Nephrolepis flexuosa. Mature plants with narrow laminae.

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Introduction

Nephrolepidaceae is a small family, widespread in the tropics but with a few species extending to the southern temperate region. It includes the single genus *Nephrolepis*, represented in New Zealand by two indigenous and two naturalised species. Of the indigenous species, *N. brownii* is confined in New Zealand to the Kermadec Islands while *N. flexuosa* is found only on Raoul Island and in thermal areas of the North Island. *N. cordifolia* is widely naturalised in lowland areas from Northland to the Bay of Plenty and Gisborne, and from Whanganui to Wellington and north-west Nelson. *N. exaltata* has only recently been recorded in New Zealand and is naturalised in a few places in the Waitākere Ranges, Auckland. *Nephrolepis* species are extensively cultivated, and both naturalised species probably initially established as escapes from cultivation.

Species of *Nephrolepis* in New Zealand are mostly terrestrial ferns with erect rhizomes, but they are capable of spreading by long-creeping stolons or underground tubers. All species have erect fronds, pinnate laminae, and submarginal or medial sori protected by reniform or lunulate indusia.

***Nephrolepidaceae* Pic.Serm., *Webbia* 29: 8 (1975)**

Terrestrial, rupestral or epiphytic ferns. Rhizomes erect or short-creeping, scaly, often producing long-creeping runners that form adventitious buds and sometimes bear tubers. Fronds monomorphic, not articulated to the rhizome. Laminae 1-pinnate, herbaceous, scaly and sometimes hairy. Veins free, ending in hydathodes near the lamina margin. Sori round (NZ) to elongate (not NZ), borne on abaxial surface, marginal to medial; paraphyses absent; indusia attached on one side, reniform to lunulate (NZ) or rarely linear (not NZ); sporangial maturation mixed. Sporangia with vertical annulus, usually 64 spores per sporangium. Homosporous; spores monolete, lacking chlorophyll; perispores tuberculate, verrucate or rugose.

Taxonomy: A family of one genus and c. 19 species (Hovenkamp & Miyamoto 2005; PPG 1 2016).

Nephrolepis and 11 other genera were originally included within Davalliaceae by Copeland (1947), a classification which was followed in New Zealand by Allan (1961), Brownsey et al. (1985) and Brownsey & Smith-Dodsworth (1989). Pichi Sermolli (1975) created the new family Nephrolepidaceae for just three of these genera, *Nephrolepis*, *Arthropteris* and *Psammiosorus*, but the latter two genera are now included in Tectariaceae, leaving Nephrolepidaceae as a monotypic family (Hennequin et al. 2010, PPG 1 2016). *Nephrolepis* was included in Lomariopsidaceae by Smith et al. (2006) but is now generally treated in Nephrolepidaceae, a family that has been adopted in New Zealand since Brownsey & Smith-Dodsworth (2000).

Distribution: A small family that is pantropical in distribution, but most species are confined either to the Neotropics or to the Paleotropics, with a few extending into the southern temperate zone. The greatest diversity is in the Malesian region (Hovenkamp & Miyamoto 2012).

Biostatus: Indigenous (Non-endemic).

Table 1: Number of species in New Zealand within *Nephrolepidaceae* Pic.Serm.

Category	Number
Indigenous (Non-endemic)	2
Exotic: Fully Naturalised	2
Total	4

Recognition: The family Nephrolepidaceae comprises terrestrial or epiphytic species with erect or short-creeping rhizomes that often produce runners bearing adventitious buds and sometimes tubers. Fronds are monomorphic, 1-pinnate, scaly and sometimes hairy, and bear round to elongate sori that are marginal to medial and protected by reniform, lunulate or linear indusia.

Notes: The name Nephrolepidaceae Pic.Serm. was published in Vol. 29, No. 1 of *Webbia*. The part is dated 1974 but reprints have been hand-stamped "Pubblicato in data 10. Feb. 1975".

***Nephrolepis* Schott, *Gen. Fil. t. 3* (1834)**

Type taxon: *Nephrolepis exaltata* (L.) Schott

Etymology: From the Greek *nepbro-* (kidney-shaped) and *lepis* (scale), a reference to the kidney-shaped indusia in this genus.

Vernacular names: Boston ferns; ladder ferns; sword ferns

Terrestrial, rupestral or epiphytic ferns. Rhizomes erect or short-creeping, scaly, often producing long-creeping runners that form adventitious buds and sometimes bear tubers. Rhizome scales ovate or narrowly ovate, basifixed or peltate, concolorous or with pale margins and dark centres, bearing marginal hairs or teeth. Fronds monomorphic, not articulated to the rhizome. Laminae 1-pinnate, herbaceous, scaly and sometimes hairy. Pinnae articulated to rachis, entire or lobed, sometimes auricled on acroscopic side. Veins free, ending in hydathodes near the lamina margin. Sori round (NZ) to elongate (not NZ), borne on abaxial surface, submarginal to medial (NZ) or rarely marginal (not NZ); paraphyses absent; indusia attached on one side, reniform to lunulate (NZ) or rarely linear (not NZ). Spores monolete, lacking chlorophyll; perispores tuberculate, verrucate or rugose.

Taxonomy: A genus of c. 19 species (Hovenkamp & Miyamoto 2005).

Nephrolepis has been reviewed in its entirety by Hovenkamp & Miyamoto (2005). The Malesian taxa have been revised by Hovenkamp & Miyamoto (2012) and the Neotropical species treated by Mickel & Smith (2004). Analysis of plastid DNA data from three regions by Hennequin et al. (2010) identified three main clades in the genus, with two lineages diverging early and becoming isolated in the

Neotropics and in Asia–Australia. More recently there has been expansion into Africa from the Asia–Australia region.

Within New Zealand, Allan (1961) recognised two indigenous taxa, which he referred to *N. cordifolia* and *N. exaltata* (now *N. brownii*). Within the *N. cordifolia* complex, Brownsey (in Webb et al. 1988) documented both a native and a naturalised species, based on observations made in several earlier publications (see Notes under *N. flexuosa* for a full discussion). Although Hovenkamp & Miyamoto (2005) did not recognise this distinction, referring both taxa to *N. cordifolia* var. *cordifolia*, de Lange et al. (2005) reinstated the name *N. flexuosa* for the native species that, in New Zealand, is confined to thermal regions of the North Island and Raoul Island (Kermadec Islands group), and cytologically distinct from *N. cordifolia* (de Lange et al. 2004). Large (2016) and Large & Farrington (2016) have since shown that *N. exaltata* is also naturalised in parts of northern New Zealand.

Some species of *Nephrolepis*, notably *N. exaltata* and *N. cordifolia*, are widely cultivated around the world and are now naturalised in New Zealand and many other places. Their ability to grow vegetatively by means of runners and tubers ensures that they can establish easily from garden escapes and spread aggressively in warmer regions. Morton (1958) catalogued the species and forms of *Nephrolepis* then known to be in cultivation, including 14 cultivars and varieties of *N. exaltata*, and more recent information has been provided by Hoshizaki & Moran (2001).

- | | | |
|---|--|--------------------------------------|
| 1 | Some primary pinnae pinnatisect in distal half..... | <i>cordifolia</i> ‘ <i>Plumosa</i> ’ |
| | Primary pinnae undivided..... | 2 |
| 2 | Indusia lunulate, usually lacking a distinct sinus..... | 3 |
| | Indusia reniform, with a distinct sinus..... | 4 |
| 3 | Tubers absent; longest pinnae 9–25 mm long; mean spore size 36–39
µm long, 23–25 µm wide..... | <i>flexuosa</i> |
| | Tubers present; longest pinnae 15–53 mm long; mean spore size 28–33
µm long, 18–22 µm wide..... | <i>cordifolia</i> |
| 4 | Scales on rhizome and stipe base spreading, dull; sterile pinnae not
strongly auricled acroscopically; pinna margins minutely serrate..... | <i>exaltata</i> |
| | Scales on rhizome and stipe base appressed, shining; sterile pinnae
strongly auricled acroscopically; pinna margins irregularly serrate or lobed..... | <i>brownii</i> |

Distribution: *Nephrolepis* is pantropical in distribution, but most species are confined either to the Neotropics or to the Paleotropics, with a few extending into the southern temperate zone. The greatest diversity is in the Malesian region, where 15 species are recognised (Hovenkamp & Miyamoto 2012): seven indigenous and one naturalised species in the Neotropics (Mickel & Smith 2004), six indigenous and one naturalised in Africa (Roux 2009), six in Australia (Bell 1998), five or six in the south-west Pacific (Nakamura 2008), and two indigenous and three naturalised in Hawai’i (Palmer 2003). Four species in New Zealand: two indigenous and two naturalised.

Biostatus: Indigenous (Non-endemic).

Table 2: Number of species in New Zealand within *Nephrolepis* Schott

Category	Number
Indigenous (Non-endemic)	2
Exotic: Fully Naturalised	2
Total	4

Recognition: In New Zealand, species of *Nephrolepis* can be recognised by their erect rhizomes that often produce runners bearing adventitious buds and sometimes tubers, 1-pinnate laminae that are scaly and sometimes hairy, submarginal or medial sori protected by reniform or lunulate indusia, and tuberculate, verrucate or rugose spores (Large & Braggins 1991).

Cytology: The base chromosome number in *Nephrolepis* is $x = 41$ (Kramer 1990).

***Nephrolepis brownii* (Desv.) Hovenkamp & Miyam., *Blumea* 50: 293 (2005)**

≡ *Nephrodium brownii* Desv., *Mém. Soc. Linn. Paris* 6: 252 (1827)

Neotype (selected by Brownsey et al. 2019): Port II, East Coast, Australia, *R. Brown Iiter* Austral. No. 20, BM 001048232 (!online)

Etymology: Named in honour of Robert Brown (1773–1858), British botanist who travelled with Matthew Flinders to Australia (1802–1805) and was later the first Keeper of Botany at the British Museum.

Terrestrial ferns. Rhizomes erect, abundantly scaly, producing long-creeping runners with adventitious buds, lacking tubers. Rhizome scales appressed, narrowly ovate, 2.5–3 mm long, 0.6–0.7 mm wide, peltate, with narrow pale margins and dark centres, shining, ciliate on margins. Fronds usually 300–1830 mm long, or rarely stunted fronds c. 100 mm long found around fumaroles. Stipes 70–610 mm long, or rarely 20 mm long on stunted fronds, pale brown, brittle; bearing scales proximally similar to those of rhizomes, becoming similar to those of the rachises distally. Rachises pale brown, densely scaly; rachis scales spreading, narrowly ovate, hyaline or light brown, long-ciliate on margins. Laminae 1-pinnate, elliptic to narrowly elliptic, tapering to apex; fertile laminae 240–1220 mm long, or rarely only 100 mm long in stunted fronds, 30–285 mm wide (sterile laminae often wider), yellow-green on both surfaces, herbaceous; hair-like scales on costae and both lamina surfaces, multicellular hairs up to 0.2 mm long on costae only. Primary pinnae in 18–75 pairs, not overlapping; the longest near the middle, 34–155 mm long, or rarely only 20 mm long in stunted fronds, 7–17 mm wide, narrowly ovate with a small basal acroscopic lobe, slightly falcate; basal pinnae much reduced; pinna apices acute to acuminate, margins irregularly serrate or lobed, bases short-stalked. Sori round, terminating veins just inside the pinna margins; indusia reniform with narrow sinus, attached at sinus, 1–1.5 mm long. Mean spore size 34.5–37.5 μm long, 22.5–24.5 μm wide; perispores pale brown, verrucate.

Distribution: Kermadec Islands

Altitudinal range: 5–170 m.

In the New Zealand region *Nephrolepis brownii* occurs only on the Kermadec Islands, where it has been recorded from Raoul, Dayrell, Macauley and Curtis Islands (Sykes 1977; de Lange 2015). On Raoul Island it is locally common in coastal and lower slopes, perhaps up to 300 m. It has been recorded in permanent plots on Raoul Island from 10 to 70 m (C.J. West, pers. comm.), from one collection at 150 m near Sentinel Point, and from observations in Sunshine Valley and the ridge to Prospect (P.J. de Lange, pers. comm.). On Curtis Island it reaches 120 m, and on Macauley Island up to 170 m.

Also India, Sri Lanka, southern China, Taiwan, south-east Asia, Papua New Guinea, Australia (Western Australia, Northern Territory, Queensland), Solomon Islands, New Caledonia, Fiji, Tonga, Cook Islands, Rapa, Society Islands and Pitcairn Island. It is naturalised in tropical America and Hawai'i (Hovenkamp & Miyamoto 2005).

Biostatus: Indigenous (Non-endemic).

Nephrolepis brownii was given a conservation status of At Risk / Naturally Uncommon by de Lange et al. (2018).

Habitat: *Nephrolepis brownii* occurs in open ground, mostly in coastal and low-altitude forest, in shrubland, in clearings and around old cultivation sites, on banks and road margins, among boulders, and around thermal vents, forming “large, dense, almost pure stands” (Sykes 1977). On rich soil in the Denham Bay area it is said to reach 2 m in height (Sykes 1977), but in fernland near the coast it is more stunted.

Recognition: *Nephrolepis brownii* is distinguished from *N. cordifolia* and *N. flexuosa* by its longer pinnae (34–155 mm long, cf. 9–53 mm long), which are abundantly covered in scales on both surfaces and bear multicellular hairs on the costae. The sori are longer than in the other species (1–1.5 cf. 0.5–1 mm), and the indusia are reniform with narrow sinuses. It is distinguished from *N. exaltata* by its shining appressed rhizome scales; by its sterile pinnae, which are auricled acroscopically; and by the pinna margins, which are irregularly serrate or lobed rather than minutely serrate. The species occurs in New Zealand only on the Kermadec Islands and does not naturally reach the North Island, though it is occasionally cultivated there. On the Kermadec Islands occasional stunted plants are found around fumaroles, and these have fronds with much smaller dimensions.

Cytology: $2n = 82$ (de Lange et al. 2004 – as *N. hirsutula*)

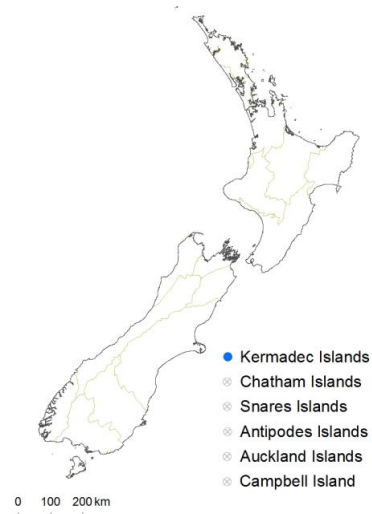


Fig. 1: *Nephrolepis brownii* distribution map based on databased records at AK, CHR, UNITEC & WELT.

Notes: This species was widely misidentified as *Nephrolepis exaltata* (L.) Schott by earlier New Zealand authors, including Allan (1961), and as *N. hirsutula* (G.Forst.) C.Presl by authors since Sykes (1977). It is very similar to *N. hirsutula* and the two species occur together in much of south-east Asia and the tropical Pacific (Hovenkamp & Miyamoto 2005).



Fig. 2: *Nephrolepis brownii*. Mature plants with broad laminae.



Fig. 3: *Nephrolepis brownii*. Mature plants showing long primary pinnae with acute apices.



Fig. 4: *Nephrolepis brownii*. Herbarium specimen from Raoul Island, WELT P001115/C, showing a broad frond, and pinnae with acuminate apices.



Fig. 5: *Nephrolepis brownii*. Close up of WELT P022746, showing the serrate pinna margins, round sori just inside the margins, and reniform indusia.

***Nephrolepis cordifolia* (L.) C.Presl, Tent. Pterid. 79 (1836)**

≡ *Polypodium cordifolium* L., *Sp. Pl.* 1089 (1753) nom. cons.

≡ *Aspidium cordifolium* (L.) Sw., *J. Bot. (Schrader)* 1800(2): 32 (1801)

Type: Hispaniola, Dominican Republic, prov. de Azua, San José de Ocoa, slope of Loma del Rancho, Ekman H11627, 23 Feb. 1929, K 000590569 (!online), typ. cons. (see Verdcourt 1996)

= *Polypodium auriculatum* L., *Sp. Pl.* 1088 (1753) nom. rej.

≡ *Nephrolepis auriculata* (L.) Trimen, *J. Linn. Soc., Bot.* 24: 152 (1887)

Lectotype (selected by Trimen 1887, see Verdcourt 1996): Ceylon, Herb. Hermann 1: 39, No. 383, BM 000621367 (!online)

= *Aspidium tuberosum* Bory ex Willd., *Sp. Pl.* 5 (1), 234 (1810)
≡ *Nephrodium tuberosum* (Bory ex Willd.) Desv., *Mém. Soc. Linn. Paris* 6: 252 (1827)
≡ *Nephrolepis tuberosa* (Bory ex Willd.) C.Presl, *Tent. Pterid.* 79 (1836)
Holotype: Réunion, *Bory 111*, Herb. Willdenow, B-W 19759-01 0 (online)

Etymology: From the Latin *cordi-* (heart-shaped) and *folium* (leaf), a reference to the auricled bases of the pinnae.

Vernacular names: erect sword fern; fishbone fern; herringbone fern; ladder fern; tuber ladder fern; tuber sword fern

Terrestrial ferns. Rhizomes erect, densely scaly, producing long-creeping runners with adventitious buds and tubers. Rhizome scales spreading, narrowly ovate, tapering from a broad base to a filiform apex, 5.5–7.0 mm long, 0.9–1.7 mm wide, peltate, light brown, dull, margins irregularly lacerate at base with ciliate projections. Fronds 260–1130 mm long. Stipes 20–570 mm long, pale brown, brittle, densely scaly. Rachises pale brown, densely scaly; rachis scales spreading, narrowly ovate to linear, light brown, margins irregularly lacerate at base with ciliate projections. Laminae 1-pinnate, narrowly elliptic to linear, tapering to apex; fertile laminae 240–1020 mm long, 30–100 mm wide, yellow-green on both surfaces, herbaceous; lamina surfaces lacking scales or with very scattered hair-like scales, sometimes bearing multicellular hairs. Primary pinnae in 45–110 pairs, not or slightly overlapping; the longest near the middle, 15–53 mm long, 5–9 mm wide, narrowly ovate or oblong with a pointed basal acroscopic lobe, slightly falcate; basal pinnae much reduced; pinna apices obtuse or rounded, margins serrate to deeply lobed, bases short-stalked and unequally auricled. Sori round, close to margin; indusia lunulate, attached at broad base, 0.7–0.8 mm long. Mean spore size 28–33 µm long, 18–22 µm wide; perispores pale brown, tuberculate.

Distribution: North Island: Northland, Auckland, Volcanic Plateau, Gisborne, Southern North Island.

South Island: Western Nelson.

Altitudinal range: 0–240 m.

Nephrolepis cordifolia is widely naturalised in the northern North Island from Northland to the Bay of Plenty and Gisborne, and again in the southern North Island from Whanganui to Wellington. It is confined to coastal and lowland districts, reaching 240 m on Whale Island in the Bay of Plenty. There are records from Golden Bay and Tasman Bay in the South Island.

Occurs naturally in the Neotropics from Cuba to Venezuela, and in the Paleotropics from Madagascar to India, Sri Lanka, China, south-east Asia, Australia (Queensland, New South Wales), Vanuatu, New Caledonia, Samoa and Hawai'i (Hovenkamp & Miyamoto 2005; de Lange et al. 2005). Naturalised in Central America and Mexico (Mickel & Smith 2004), parts of Africa (Roux 2009), south-east Australia (Bell 1998), Norfolk Island (de Lange et al. 2005) and the Cook Islands (Sykes 2016).

Biostatus: Exotic; fully naturalised.

Habitat: *Nephrolepis cordifolia* is now a serious environmental weed that occurs not only around current or former sites of human habitation, and on the sides of roads or railways, but also in urban forest remnants and coastal forest. It is common on scoria banks and rough lava, but also on rock walls, the sides of buildings, among boulders and under open pōhutukawa, mānuka, kānuka, *Eucalyptus* and pine, sometimes on thermally heated soil. Some occurrences possibly result from deliberate plantings undertaken in the mistaken belief that the species is indigenous.

First record: Heath & Chinnock (1974). Earliest voucher: AK 289696, 1887, in cultivation; AK 251931, 1928.

Recognition: *Nephrolepis cordifolia* is a naturalised species that is very similar to the indigenous *N. flexuosa*. It is distinguished by the presence of tubers on its long-creeping runners, by its more abundantly scaly rhizomes and stipe bases, and by its generally longer and wider laminae (240–1020 mm long, 30–100 mm wide, cf. 170–620 mm long, 18–50 mm wide). The rhizome scales are also longer and wider (5.5–7 mm long, 0.9–1.7 mm wide, cf. 3–5 mm long, 0.2–0.5 mm wide), with lacerate rather than entire bases. *Nephrolepis cordifolia* is a diploid species ($2n = 82$) and has smaller spores than the tetraploid *N. flexuosa* (28–33 µm long, 18–22 µm wide, cf. 36–38.5 µm long, 23–25

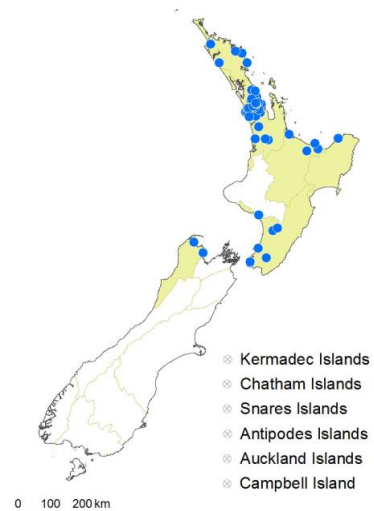


Fig. 6: *Nephrolepis cordifolia* distribution map based on databased records at AK, CHR, WELT & UNITEC.

µm wide). It is distinguished from both *N. brownii* and *N. exaltata* by its lunulate, rather than reniform, indusia.

Plants with pinnatisect apices to some of the primary pinnae are occasionally found and are referable to 'Plumosa' (Hoshizaki & Moran 2001). Plants of this cultivar from Orewa and the Waitākere Ranges, Auckland, were illustrated by Large & Farrington 2016, fig. 1b), and have also been collected from urban sites in Hamilton, Tauranga and Wellington. Large & Farrington noted the apparent absence of tubers in this cultivar, but tubers can be seen in at least some collections (see Fig. 12). Large & Farrington also noted that plants were often sterile with a high degree of spore irregularity and abortion, but whether this was due to unsuitable climatic conditions or an indication of hybrid origin was unclear.

Cytology: $2n = 82$ (de Lange et al. 2004).

Notes: Plants of *Nephrolepis* have been widely cultivated in northern New Zealand since the late 19th century, although they were not recorded in the wild until much later, and it is entirely possible that both species and hybrids have occasionally escaped. Further work is needed to determine the status of plants with aborted spores.



Fig. 7: *Nephrolepis cordifolia*. Mature plant growing on scoria.



Fig. 8: *Nephrolepis cordifolia*. Adaxial surface of mature frond showing pinnae with obtuse apices and serrate margins.



Fig. 9: *Nephrolepis cordifolia*. Mature plants.



Fig. 10: *Nephrolepis cordifolia*. Abaxial surface of fertile frond showing lunulate indusia close to the pinna margins.



Fig. 11: *Nephrolepis cordifolia*. Herbarium specimen of a cultivated plant, WELT P016272, showing tubers on the roots.



Fig. 12: *Nephrolepis cordifolia* 'Plumosa'. Herbarium specimen from Tauranga, WELT P020960, showing a tuber, and primary pinnae with pinnatisect apices.

***Nephrolepis exaltata* (L.) Schott, Gen. Fil. pl. 3 (1834)**

≡ *Polypodium exaltatum* L., Sp. Pl. 1326 (1753)

≡ *Aspidium exaltatum* (L.) Sw., J. Bot. (Schrader) 1800(2): 32 (1801)

≡ *Nephrodium exaltatum* (L.) R.Br., Prodr. Fl. Nov. Holland. 148 (1810)

≡ *Hypopeltis exaltata* (L.) Bory in Bélanger, Voy. Indes Or., Botanique 2, 66 (1833)

Lectotype (selected by Alston 1933): tab. 31 in Sloane, Voy. Jamaica 1: 77 (1707)

Etymology: From the Latin *exaltatus* (lofty, tall), a reference to the tall, upright fronds of this species.

Vernacular names: Boston fern; Boston lace

Distribution: North Island: Auckland.

Altitudinal range: 40–60 m.

Nephrolepis exaltata is naturalised as a casual species in a few places near Oratia in the Waitākere Ranges, Auckland.

Occurs naturally in Florida, Caribbean islands, Mexico, Panama, French Guyana and Hawai'i (Hovenkamp & Miyamoto 2005). It is thought to be naturalised on the Canary Islands, St Helena (Hovenkamp & Miyamoto 2005), parts of southern Africa (Roux 2009) and Rarotonga (P.J. de Lange, pers. comm.).

Biostatus: Exotic; fully naturalised.

Habitat: *Nephrolepis exaltata* grows on roadside banks and stream banks, probably as an escape from cultivation. Spread is assumed to be vegetative.

First record: Large (2016), Large & Farrington (2016). Voucher: UNITEC 9557, 2016.

Recognition: *Nephrolepis exaltata* can be recognised by its dull, spreading scales on the rhizome and stipe bases, lack of tubers, sterile primary pinnae which are not strongly auricled acroscopically, minutely serrate pinna margins, acute pinna apices, and reniform indusia. The pinnae are generally longer and wider than those of *N. cordifolia* and *N. flexuosa*, the pinna apices are acute rather than obtuse to rounded, the margins are minutely serrate rather than lobed, and the indusia are reniform rather than lunulate. It differs from *N. brownii* in its scales, which are dull and spreading rather than shiny and appressed; by its pinna margins, which are minutely serrate rather than irregularly serrate to lobed; and by its sterile pinnae, which are not strongly auricled.

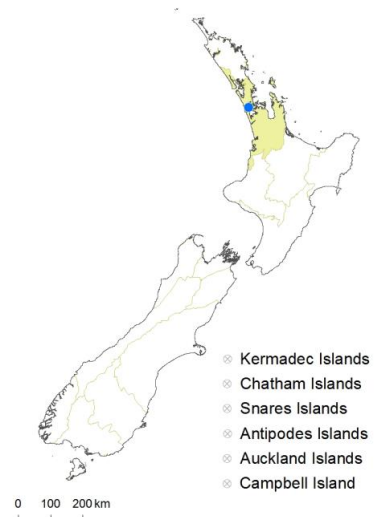


Fig. 13: *Nephrolepis exaltata* distribution map based on databased records at AK, CHR, WELT & UNITEC.

Notes: Large & Farrington (2016) noted that *Nephrolepis exaltata* was widely available as a house plant in New Zealand, sold under the names Boston fern and Boston lace.

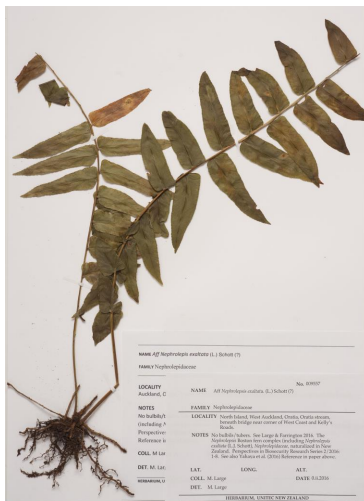


Fig. 14: *Nephrolepis exaltata*. Herbarium specimen from Oratia, UNITEC 009557, showing partial sterile fronds.

***Nephrolepis flexuosa* Colenso, *Trans. & Proc. New Zealand Inst.* 20: 231 (1888)**

Neotype (selected by de Lange et al. 2005): [New Zealand], com. W. Colenso 5/1890, K 001092494!

Etymology: From the Latin *flexuosus* (flexuous, gently zig-zag). In the original description the rhizome, rachis scales and pinna midribs are all noted as being “flexuous”, but Colenso did not indicate whether just one or all of these were responsible for the specific epithet.

Terrestrial ferns. Rhizomes erect, abundantly scaly, producing long-creeping runners with adventitious buds, lacking tubers. Rhizome scales spreading, narrowly ovate or linear, tapering from a narrow or occasionally broadened base to a filiform apex, 3–5 mm long, 0.2–0.5 mm wide, peltate, light brown, dull, margins entire. Fronds 200–750 mm long. Stipes 25–160 mm long, pale brown, brittle, bearing scattered scales. Rachises pale brown; rachis scales scattered, spreading, narrowly ovate to linear, light brown, margins lacerate at base. Laminae 1-pinnate, narrowly elliptic to linear, tapering to apex; fertile laminae 170–620 mm long, 18–50 mm wide, or rarely to 55 mm wide, yellow-green on both surfaces, herbaceous; scales absent or with very scattered hair-like scales, multicellular hairs sometimes present. Primary pinnae in 35–85 pairs, not or slightly overlapping; the longest near the middle, 9–25 mm long, or rarely to 30 mm long, 4–8 mm wide, narrowly ovate or oblong with a small obtuse basal acroscopic lobe, slightly falcate; basal pinnae much reduced; pinna apices obtuse or rounded, margins serrate or lobed, bases short-stalked and unequally auricled. Sori round, closer to margin than costa; indusia lunulate or occasionally reniform with broad sinus, attached at base, 0.5–1 mm long. Mean spore size 36–38.5 µm long, 23–25 µm wide; perispores pale brown, tuberculate.

Distribution: North Island: Volcanic Plateau.
Kermadec Islands

Altitudinal range: 20–760 m.

In the Kermadec Islands, *Nephrolepis flexuosa* occurs only on Raoul Island. It is also found in thermal areas of the North Island, from Rotorua to Lake Taupō. On Raoul Island it has been recorded in permanent plots from near sea level to 400 m (C.J. West, pers. comm.), but it also occurs up to 516 m on Moumoukai Summit. In thermal areas of the North Island it reaches 760 m near Wairakei.

Also reported from Lord Howe Island, Norfolk Island, Fiji (de Lange et al. 2005) and the Cook Islands (Sykes 2016) (see below).

Biostatus: Indigenous (Non-endemic).

Nephrolepis flexuosa was given a conservation status of At Risk / Naturally Uncommon by de Lange et al. (2018).

Habitat: On Raoul Island, *Nephrolepis flexuosa* is abundant throughout the main forest associations of the island, as well as in shrubland and around fumaroles, on banks, at the base of old slips, along roads and tracksides, on boulders and cliff faces, and commonly as an epiphyte (Sykes 1977; P.J. de Lange pers. comm.). In the North Island it is found on thermally heated ground, beside hot streams and springs, and on steaming cliffs. It is also occasionally found as an epiphyte on *Pinus radiata*.

Recognition: *Nephrolepis flexuosa* is an indigenous species, which is very similar to the naturalised *N. cordifolia*. It is distinguished by the absence of tubers on its long-creeping runners, by its less obviously scaly rhizomes and stipe bases, and by its generally shorter and narrower laminae (170–620 mm long, 18–50 mm wide, cf. 240–1020 mm long, 30–100 mm wide). The rhizome scales are also shorter and much narrower (3–5 mm long, 0.2–0.5 mm wide, cf. 5.5–7 mm long, 0.9–1.7 mm wide), with entire rather than lacerate bases. *Nephrolepis flexuosa* is a tetraploid species ($2n = 164$) and has larger spores than the diploid *N. cordifolia* (36–38.5 μm long, 23–25 μm wide, cf. 28–33 μm long, 18–22 μm wide). It is distinguished from both *N. brownii* and *N. exaltata* by its usually lunulate, rather than reniform, indusia.

Cytology: $n = 82$, $2n = 164$ (de Lange et al. 2004; de Lange et al. 2005).

Notes: This species was first recorded in New Zealand by Hooker (1864) as *Nephrolepis tuberosa* (Bory) C.Presl based on specimens collected by Hochstetter and Sinclair from “hot springs near Waikati”. Colenso (1888) later described his *N. flexuosa* from hot streams at Tapuaeharuru and hot springs at Wairakei, convinced that it was different to *N. tuberosa* as described and illustrated from overseas localities by earlier authors. However, Cheeseman (1906) referred all New Zealand material, including Colenso’s species, to *N. cordifolia* (L.) C.Presl. He cited collections from thermal sites in the North Island, adding Raoul Island only in the second edition of his *Manual* (Cheeseman 1925). Allan (1961) used the same name but provided no further information. Crookes (1963) stated that *N. cordifolia* was “found only in the thermal district”. However, she also noted that “it is easily cultivated and indeed flourishes as a garden escape ... it is likely that these vigorous ferns derive, in many cases, from imported, cultivated specimens, but I do not have precise information on the subject”. This was the first suggestion that there might be two forms of the species in New Zealand, which was followed by Chinnock (in Heath & Chinnock 1974), who recorded the presence of an adventive species “common around Auckland and other centres” that was larger than the thermal species and bore small, potato-like tubers. The two forms were referred to different species by Brownsey et al. (1985) and illustrated by Brownsey & Smith-Dodsworth (1989), but the thermal species remained without a formal name until de Lange et al. (2005) reinstated Colenso’s *N. flexuosa* as an indigenous species distinct from the introduced *N. cordifolia*. Hovenkamp & Miyamoto (2005) published their review of *Nephrolepis* world-wide at about the same time. They recognised three varieties of *N. cordifolia* and specifically stated that the native species of Brownsey & Smith-Dodsworth (1989) was the same as their *N. cordifolia* var. *cordifolia*. However, in our opinion, the morphological and cytological characters detailed above are sufficient to recognise *N. flexuosa* as a species distinct from *N. cordifolia*.

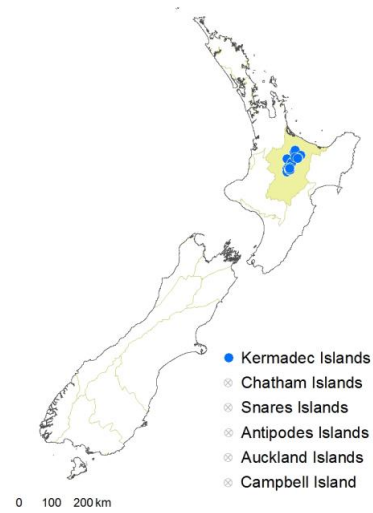


Fig. 15: *Nephrolepis flexuosa* distribution map based on databased records at AK, CHR, WELT & UNITEC.

How far *N. flexuosa* extends beyond New Zealand is unclear. It has been reported from Lord Howe Island, Norfolk Island and Fiji by de Lange et al. (2005), and from the Cook Islands by Sykes (2016). Hovenkamp & Miyamoto (2005) described a very similar entity as *N. cordifolia* var. *pseudolauterbachii* from Vanuatu, Fiji and Samoa, differing from the type in having smaller fronds and sinuose fertile pinnae, both characters that are associated with *N. flexuosa*. However, sequence data from Fijian material (L.R. Perrie unpub.) suggest that at least some plants are more similar to *N. lauterbachii*, otherwise only known from Papua New Guinea, the Moluccas and Solomon Islands (Hovenkamp & Miyamoto 2005). The identity of the species occurring in Fiji and other south-west Pacific islands therefore requires further investigation.

The possibility that the variety described from Queensland by Domin (1913) as *N. radicans* var. *cavernicola* belongs to *N. flexuosa* also needs further investigation. Andrews (1990) and Bell (1998) both characterised it as a non-tuberous form related to *N. cordifolia*.



Fig. 16: *Nephrolepis flexuosa*. Mature plants growing on thermally heated soil.

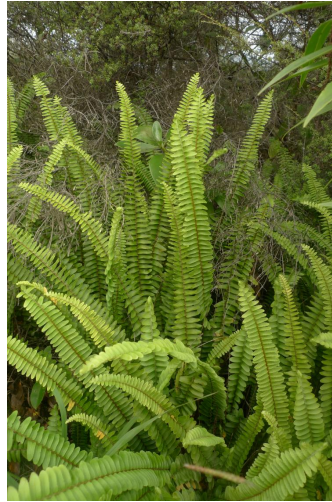


Fig. 17: *Nephrolepis flexuosa*. Mature plants with narrow laminae.



Fig. 18: *Nephrolepis flexuosa*. Stipes bearing pale, spreading scales.



Fig. 19: *Nephrolepis flexuosa*. Adaxial surface of mature frond showing pinnae with obtuse apices, shallowly lobed margins, and veins ending in hydathodes.



Fig. 20: *Nephrolepis flexuosa*. Abaxial surface of fertile frond showing slightly expanded basal acroscopic lobe on each pinna.



Fig. 21: *Nephrolepis flexuosa*. Abaxial surface of fertile frond showing lunulate indusia close to the pinna margins.

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Acknowledgements

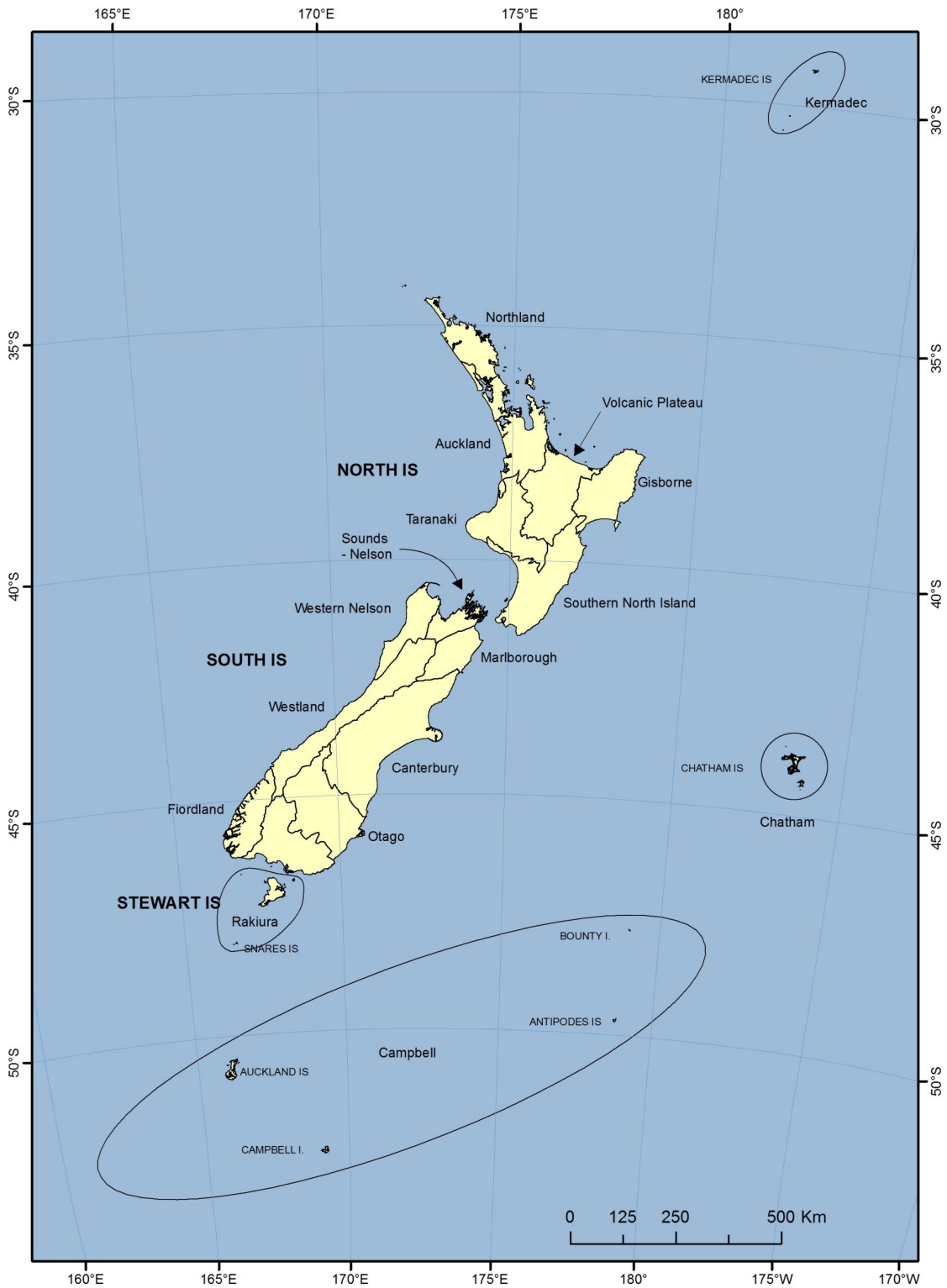
We thank the staff at AK, CHR and WELT for loans of specimens, and for databasing and providing spreadsheets of collection data. We are grateful to staff at CHR for the preparation of maps and for assistance in editing and formatting the text, to Mark Large for material of *N. exaltata*, to Peter de Lange for images and observations of species on the Kermadec Islands and of *N. cordifolia* 'Plumosa', to Carol West for information on the distribution of *Nephrolepis* species on the Kermadec Islands, to Bridget Hatton for images of herbarium material at WELT, and to Peter de Lange for reviewing the manuscript.

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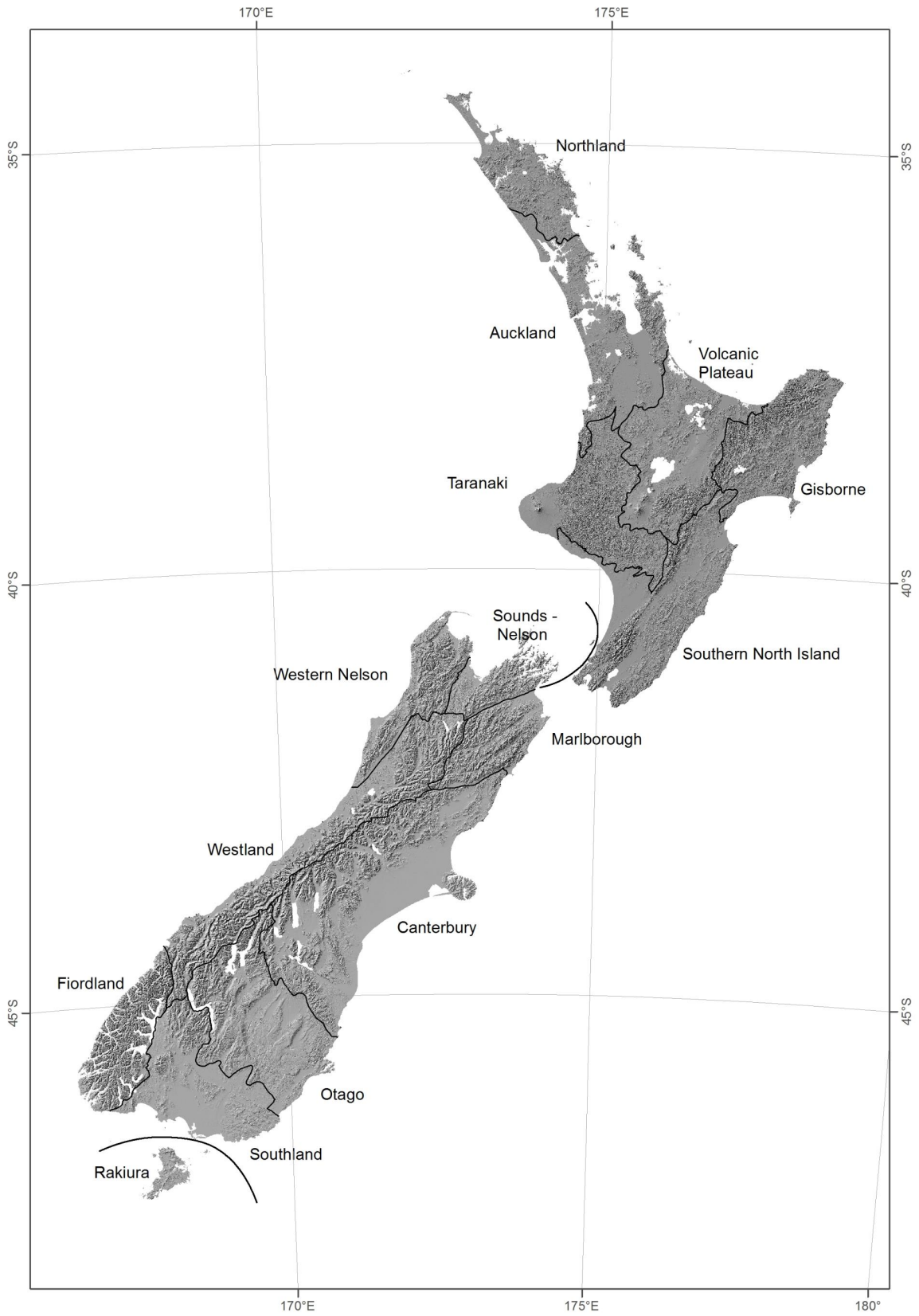
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Map 1: Map of New Zealand and offshore islands showing Ecological Provinces



Map 2: Map of New Zealand showing Ecological Provinces

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