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Cover image: *Selaginella kraussiana*. Upturned strobili on lateral branches.

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Contents

Introduction

The large and widespread family Selaginellaceae includes one genus, *Selaginella*, and 750 species. It is mainly tropical but extends to temperate regions of both hemispheres. However, *Selaginella* is not indigenous to New Zealand and is represented only by three naturalised or casual species. *Selaginella kraussiana* was first recorded from the wild in the Bay of Islands in 1919 and has since spread throughout most of the country along river banks and in damp shady places, where it replaces bryophytes and small vascular plants. *Selaginella martensii* and *S. moellendorffii* are both occasional escapees from cultivation in northern New Zealand, from Whangārei to Hamilton. All species of *Selaginella* can be recognised by their small, delicate, ligulate leaves with single unbranched veins. *Selaginella kraussiana* and *S. martensii* have prostrate, creeping and irregularly branching stems, whereas *S. moellendorffii* has an erect stem with a frond-like branching system.

Selaginellaceae Willk., *Anleit. Stud. Bot. 2,* 163 (1854)

Type taxon: *Selaginella* P.Beauv.

Terrestrial (NZ) or rarely epiphytic (not NZ). Plants of varied habit, with an erect or prostrate main stem, giving rise to subsidiary branching systems; lacking a clearly defined rhizome, but erect species sometimes spreading by creeping basal branches; lacking scales. Roots (rhizophores) arising from axils of branches, dichotomously branched, of varying thickness, occurring throughout the length of prostrate stems, or arranged basally to support erect species. Main stems either far-creeping and sometimes scrambling or climbing, much-branched and of indefinite growth; or short-creeping, becoming erect with an unbranched stem giving rise to a frond-like branch-system of finite growth. Leaves spirally arranged, ligulate, undivided, with a single unbranched vein; leaf margins entire to minutely toothed or ciliate; leaves either all similar or of two kinds, those on the basal creeping stems often far apart, those on the ultimate branches closely inserted in four ranks. Strobili terminal on primary or ultimate branches, sometimes inconspicuous. Sporophylls similar to leaves but usually smaller, arranged in four ranks, monomorphic (NZ) or rarely dimorphic (not NZ). Sporangia solitary on adaxial surface of sporophyll, inserted just above the ligule, of two types variously arranged in the strobili. Heterosporous; megasporangia usually containing four megaspores; microsporangia containing more than 100 microspores. Megaspores trilete, pale brown or white, ridged around the equator and trilete scar, variously patterned on the surface, 200–600 µm in diameter; microspores trilete, yellow or orange-brown or red, variously patterned on the surface, 20–60 µm in diameter.

Taxonomy: A family of one genus, *Selaginella*, and c. 750 species (Weststrand & Korall 2016b).

Selaginellaceae have long been recognised as one of three isolated families within the Lycopodiopsida, distinguished by their terrestrial habit, delicate ligulate leaves, and heterosporous sporangia borne in strobili. The range of variation within the family has been summarised by Jermy (1990).

Distribution: A large family found mainly in the tropics but with a few species in the temperate zones of both hemispheres. Indigenous species are present in Australia (Jermy & Holmes 1998), New Caledonia, Fiji and many other islands of the South Pacific, but none in New Zealand. One species fully naturalised, and two casual, in New Zealand.

Biostatus: Exotic; fully naturalised.

Table 1: Number of species in New Zealand within *Selaginellaceae* Willk.

Category	**Number**
Exotic: Fully Naturalised	1
Exotic: Casual	2
Total	**3**

Recognition: Selaginellaceae comprise terrestrial lycophytes bearing delicate, ligulate, and either monomorphic or dimorphic leaves with single unbranched veins. The stems are either prostrate, creeping and irregularly branching, or erect and forming a frond-like branching system. Sporangia are solitary on the adaxial surface of the sporophylls, which are aggregated into strobili. Plants are heterosporous with mega- and microsporangia variously arranged in the strobili, releasing mega- and microspores.

Selaginella P.Beauv., *Mag. Encycl.* 9(5): 478 (1804)

Type taxon: *Selaginella selaginoides* (L.) P.Beauv. ex Schrank & Mart.

Etymology: From the Latin diminutive (-*ellus*) of *Selago*, a name used by Pliny for some coniferous trees and taken up by Linnaeus for *Lycopodium*.

Vernacular name: spikemoss

Taxonomy: A genus of c. 750 species (Weststrand & Korall 2016b, 2016a).

The range of variation within the genus was summarised by Jermy (1990), who recognised five subgenera. However, Zhou et al. (2015) and Zhou & Zhang (2015) suggested that six subgenera could be recognised based on molecular, macro-morphological, and spore characters. A more recent study involving about one-third of all species has concluded that some of Jermy's groupings were not monophyletic and that seven subgenera should be recognised based on DNA sequence data and morphology (Weststrand & Korall 2016b, 2016a). In this scheme *Selaginella kraussiana* belongs to

subg. *Gymnogynum* (P.Beauv.) Weststrand & Korall, and *S. martensii* and *S. moellendorffii* to subg. *Stachygynandrum* (P.Beauv. ex Mirb.) Baker.

The genus was first recorded in New Zealand by Cheeseman (1919), who reported *S. kraussiana* (as *S. denticulata*) from the Bay of Islands. This and two other introduced species were subsequently recognised by Brownsey (in Webb et al. 1988).

1 Stems creeping, irregularly branched, prostrate or with the ends of the branches upturned; strobili round in cross-section..... 2

Stems erect, forming a frond-like branch system with regular branching; strobili sharply four-angled in cross-section..... ..... *moellendorffii*

2 Stems forming a prostrate mat, upturned only at the apices of the branches; branches widely spaced, overlapping only at the stem apices; roots arising throughout the length of the stems; leaves minutely toothed on the margins..... ..... *kraussiana*

Stems prostrate to suberect, upturned for about half their length; branches crowded and overlapping; roots arising only in the proximal half of the stem; leaves bearing fine cilia on the margins..... *martensii*

Distribution: A large genus found mainly in the tropics but with a few species in the temperate zones of both hemispheres; 18 indigenous species in southern South America (Zuloaga et al. 2008), 10 in southern Africa (Crouch et al. 2011), 10 in Australia (Jermy & Holmes 1998), and perhaps 30 species in the South Pacific region. Three introduced species in New Zealand.

Biostatus: Exotic; fully naturalised.

Table 2: Number of species in New Zealand within *Selaginella* P.Beauv.

Category	**Number**
Exotic: Fully Naturalised	1
Exotic: Casual	2
Total	**3**

Recognition: In New Zealand, species of *Selaginella* can be distinguished by their small, delicate, ligulate leaves with single unbranched veins. The stems are either prostrate, creeping and irregularly branching, or erect and forming a frond-like branching system. Sporangia are solitary on the adaxial surface of sporophylls, which are aggregated into strobili. Mega- and microspores have very different surface patterns (Large & Braggins 1991).

Cytology: Base chromosome numbers of x = 7, 8, 9, 10 and 12 have been reported in *Selaginella* (Jermy 1990).

Selaginella kraussiana (Kunze) A.Braun, *Index Seminum [Berlin] 1859,* App. 22 (1860)

≡ *Lycopodium kraussianum* Kunze, *Linnaea* 18: 114 (1844)

Lectotype (selected by Bizzari 1975): Port. Natal., no collector or date, Herb. Hooker., K000351292 (!online; see Roux 2009)

Etymology: Named in honour of Christian Ferdinand Friedrich von Krauss (1812–1890), German botanist and zoologist whose collections from southern Africa 1838–1840 included the type specimen of this species.

Vernacular name: African clubmoss

Terrestrial plants. Stems far-creeping, up to 420 mm long, irregularly and widely branched, branches not overlapping except at the stem apices, forming a loose, prostrate mat with apices of ultimate branches upturned; stems yellow-brown proximally, green distally; longest branches 25–130 mm long. Roots arising from axils of branches, occurring throughout the length of the stems. Leaves widely spaced on creeping stems, but imbricate on ultimate branches, pale green proximally, dark green at branch apices, minutely toothed on margins, bases cordate, of two sizes; those in the two lateral rows larger, 2.5–4 mm long, 1.0–2.3 mm wide, spreading, ovate or rarely elliptic, apices acute; those in the two upper rows smaller, 1.5–2.5 mm long, 0.5–1.3 mm wide, closely appressed to stem, ovate, acute to acuminate. Strobili lateral on ultimate branches, sessile, 4–15 mm long, 1.4–2.5 mm diameter, round in cross-section, inconspicuous. Sporophylls similar to leaves of upper rows but smaller and

more acuminate, 1.0–1.6 mm long, monomorphic, arranged in four ranks. Megaspores cream to white, with surface ridges forming 5–6-sided polygons. Microspores cream to buff, with long spines projecting from the surface.

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

South Island: Western Nelson, Westland, Canterbury, Otago.

Kermadec Islands, Chatham Islands, Stewart Island.

Altitudinal range: 0–640 m.

Selaginella kraussiana occurs in lowland and montane areas of the North Island from Karikari Peninsula to Wellington but is apparently scarce in the central North Island. It extends from near sea level, reaching over 450 m at Matawai and in north Taranaki. In the South Island it occurs in coastal and lowland regions from north-west Nelson south to Fox Glacier, and on the east coast from Christchurch to Dunedin, reaching 640 m near Sewell Peak, Greymouth. It also occurs on Stewart Island, the Chatham Islands, and on the Kermadec Islands, from where it has been eradicated. It has been seen in Fiordland (Alex Fergus, pers. comm., June 2016), but not yet collected from there, and hence not included on the distribution map.

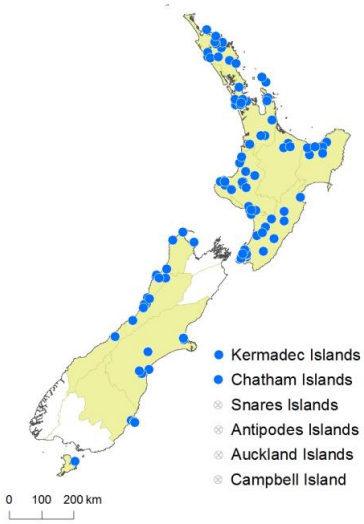

Fig. 1: *Selaginella kraussiana* distribution map based on databased records at AK, CHR & WELT.

Occurs naturally in tropical and southern Africa, but is now naturalised in central and western Europe (Crouch et al. 2011), south-eastern USA (Valdespino 1993), South America (Zuloaga et al. 2008), Australia (Jermy & Holmes 1998), Hawai'i (Palmer 2003), and probably elsewhere.

Biostatus: Exotic; fully naturalised.

Habitat: *Selaginella kraussiana* grows on damp banks, tracksides, stream banks, river terraces, forest margins, and in generally shady and damp places under kauri, podocarp, broadleaved, kānuka forest and introduced trees, and in scrub or amongst introduced grasses. It also occurs in parks, gardens, shade houses, cemeteries, picnic areas and lawns. It spreads readily from vegetative fragments.

First record: Cheeseman (1919, p. 92, as *Selaginella denticulata*). Voucher AK 110931, Pākaraka, Bay of Islands. Cheeseman noted that it had been known for many years as a garden escape at Pākaraka, and had lately appeared in great abundance on the banks of several swampy creeks in the neighbourhood. He also remarked that it was known in several localities near Wellington, and anticipated that it would spread further.

Recognition: *Selaginella kraussiana* is now a widespread weed in New Zealand and easily the most common of the three introduced species. Its prostrate and irregularly branching habit with roots produced throughout the length of the stem readily distinguish it from *S. moellendorffii*, which produces erect, aerial, frond-like branching systems with roots at the base. *Selaginella kraussiana* is similar to *S. martensii* but the latter has a suberect habit with ultimate branches upturned in the distal half, and roots produced only in the proximal half. Branches are more widely spaced in *S. kraussiana* and rarely overlapping, whereas in *S. martensii* they regularly overlap. The leaf margins are minutely toothed in *S. kraussiana* but finely ciliate in *S. martensii*. The microspores of *S. kraussiana* have distinctive surface spines and the megaspores have irregular hexagonal ridges (Large & Braggins 1991, figs 49–57).

Notes: The species was misidentified by Cheeseman (1919, 1925) as *Selaginella denticulata* Link.

Fig. 2: *Selaginella kraussiana*. Plants forming a loose, prostrate mat.

Fig. 3: *Selaginella kraussiana*. Creeping stem showing leaves that are widely spaced on the stem but imbricate at the ends of the branches.

Fig. 4: *Selaginella kraussiana*. Apex of creeping stem, showing two rows of small leaves on the adaxial surface and two rows of larger lateral leaves.

Fig. 5: *Selaginella kraussiana*. Upturned strobili on lateral branches.

Fig. 6: *Selaginella kraussiana*. Lateral branch bearing strobili that are round in cross-section and have sporophylls in four rows.

Fig. 7: *Selaginella kraussiana*. Lateral branch showing leaves of two sizes, and upturned strobili with sporophylls in four rows.

Selaginella martensii Spring, *Mém. Acad. Roy. Sci. Belgique* 24: 129 (1849)

Lectotype (selected by Mickel & Beitel 1988): Mexico, Oaxaca, *Galeotti 6618* (LG, BR, P). Mickel & Smith (2004) noted that there is no specimen at LG, and that one of the three specimens at BR should be selected as a "second-stage" lectotype.

Etymology: Named in honour of Martin Martens (1797–1863), a Belgian botanist at Leuven and Brussels who wrote a memoir on the ferns of Mexico.

Terrestrial plants. Stems far-creeping, up to 400 mm long, irregularly and abundantly branched with branches overlapping, prostrate to suberect, curling upwards in the distal half; stems yellow-brown proximally, green distally; longest branches 20–175 mm long. Roots arising from axils of branches, occurring in proximal half of the stems. Leaves spaced on creeping stems, but imbricate on ultimate branches, pale green proximally, dark green at branch apices, bases cordate, of two sizes; those in the two lateral rows larger, 3–4.5 mm long, 1.2–2.0 mm wide, spreading, ovate, apices acute to obtuse, bearing fine cilia on margins up to 0.3 mm long; those in the two upper rows smaller, 1.5–2.4 mm long, 0.8–1.3 mm wide, closely appressed to stem, ovate or elliptic, with a hair-point 0.6–1.0 mm long, bearing fine cilia on the margins. Strobili lateral on ultimate branches, sessile, 5–16 mm long, 1.8–3.0 mm diameter, round in cross-section, inconspicuous. Sporophylls similar to leaves of upper rows but slightly smaller with acuminate apices, 1.5–1.7 mm long, monomorphic, arranged in four ranks. Megaspores cream to white, with surface ridges forming 5–6-sided polygons. Microspores cream to buff, granulate to rugulate.

Distribution: North Island: Northland, Auckland.

Altitudinal range: 10–40 m.

Collected from Whangārei, Waiheke Island and Hamilton as an escape from cultivation.

Occurs naturally in the highlands of Mexico and Central America (Mickel & Smith 2004).

Biostatus: Exotic; casual.

Habitat: Frequently cultivated in glasshouses and conservatories (Gardner 1995), and found on stream banks and in gullies and water-courses in broadleaved forest as an escape from cultivation.

First record: Brownsey in Webb et al. (1988, p. 5, as an unknown species of *Selaginella*), later identified as *S. martensii* by Gardner (1995). Voucher AK 27111–271115, Whangārei Falls.

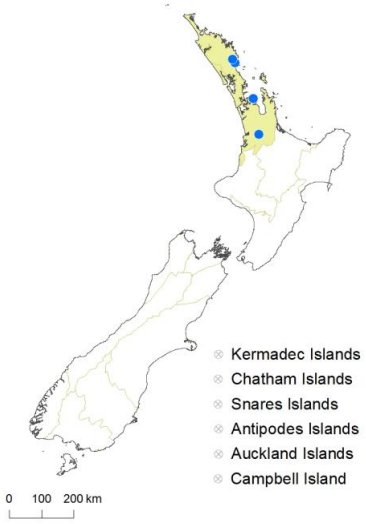

Fig. 8: *Selaginella martensii* distribution map based on databased records at AK, CHR & WELT.

Recognition: *Selaginella martensii* is similar to *S. kraussiana*, but distinguished by its suberect habit with the ultimate branches upturned in the distal half, and the roots produced only in the proximal half. Branching is more abundant in *S. martensii*, with branches regularly overlapping, whereas in *S. kraussiana* the branching is much more widely spaced. The leaf margins are finely ciliate in *S. martensii* but minutely toothed in *S. kraussiana*. Strobili are rarely seen outside cultivation. The microspores of *S. martensii* are granulate to rugulate and markedly different to the echinate microspores of *S. kraussiana* (Large & Braggins 1991, figs 49–57).

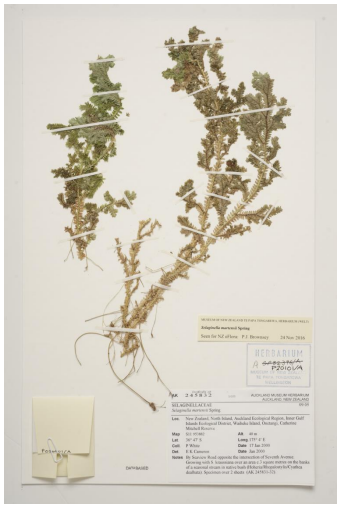

Fig. 9: *Selaginella martensii*. Herbarium specimen from Waiheke Island, Auckland, WELT P020101/A, showing branching stem bearing roots in proximal half.

Fig. 10: *Selaginella martensii*. Herbarium specimen from Waiheke Island, Auckland, WELT P020101/B, showing branching stem leaves spaced on the stem but densely imbricate on lateral branches.

Selaginella moellendorffii Hieron. in Engler & Prantl, *Nat. Pflanzenfam. 1(4),* 680 (1901)

Holotype: Kinkiang ad Yangste, China, *O. von Möllendorff 26*, B 20 0129961-C (!online)

Etymology: Named in honour of Otto von Möllendorff (1848–1903), a German natural historian and diplomat who collected plants in China while serving as German Consul in Hong Kong.

Terrestrial plants. Basal stems very short-creeping, bearing erect, unbranched aerial stems that give rise to a frond-like branch-system of finite growth; “fronds” 75–300 mm long; unbranched stems 10–155 mm long; branching portion of “fronds” 65–210 mm long, 20–120 mm wide; longest lateral branches 15–110 mm long. Roots arising only at the base of the main aerial stems. Leaves widely spaced on the unbranched portion of aerial stems; those on the branching portion 1.5–3.0 mm long, 0.9–1.8 mm wide, ovate, acuminate, minutely toothed on margins, cordate at base. Leaves on ultimate aerial branches densely imbricate, minutely toothed on margins, rounded at base, of two sizes, both decreasing in size towards stem apices; those in the two lateral rows larger, 1.2–2.2 mm long, 0.6–1.4 mm wide, spreading, broadly ovate, apices acute; those in the two upper rows smaller, 1–1.7 mm long, 0.5–0.8 mm wide, closely appressed to stem, ovate, acuminate to attenuate. Strobili terminal on ultimate branches, sessile, 5–9 mm long, 1.7–2.0 mm diameter, sharply 4-angled in cross-section. Sporophylls similar to leaves of upper rows but slightly smaller, 1.6–1.8 mm long, arranged in 4 ranks, monomorphic. Megaspores not seen. Microspores orange, baculate/clavate.

Distribution: North Island: Auckland, Volcanic Plateau.

Altitudinal range: 20–65 m.

Collected from a few sites in Auckland, Hamilton, and Tauranga.

Occurs naturally in China, Japan, Taiwan, Vietnam, and Philippines (Xianchun et al. 2013).

Biostatus: Exotic; casual.

Habitat: *Selaginella moellendorffii* is a terrestrial species that grows on sunny banks and on river banks and in damp, shaded sites, probably as an escape from cultivation.

First record: Brownsey (1981, p.11). Voucher WELT P010222, 1978.

Recognition: In New Zealand, *Selaginella moellendorffii* is easily recognised by its erect, aerial, frond-like branching systems with roots confined to the base. It is quite distinct from the prostrate or suberect, irregularly branching stems of *S. kraussiana* and *S. martensii*. The microspores of *S. moellendorfii* are also very distinctive, with baculate/clavate projections (Large & Braggins 1991, figs 49–57).

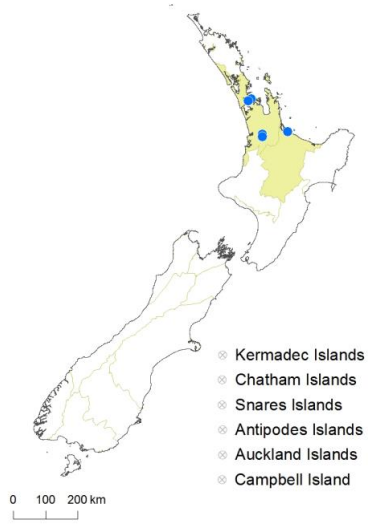

Fig. 11: *Selaginella moellendorffii* distribution map based on databased records at AK, CHR & WELT.

Fig. 12: *Selaginella moellendorffii*. Habit showing the frond-like form of mature plants.

Fig. 13: *Selaginella moellendorffii*. Close up of apical portion of “frond” showing strobili terminal on ultimate branches.

Fig. 14: *Selaginella moellendorffii*. Close up from WELT P016395. Adaxial surface of branch showing two rows of smaller leaves, two rows of larger lateral leaves, and a terminal strobilus.

Fig. 15: *Selaginella moellendorffii*. Close up from WELT P010635. Adaxial surface of branch showing four-angled strobili terminal on the ultimate branches.

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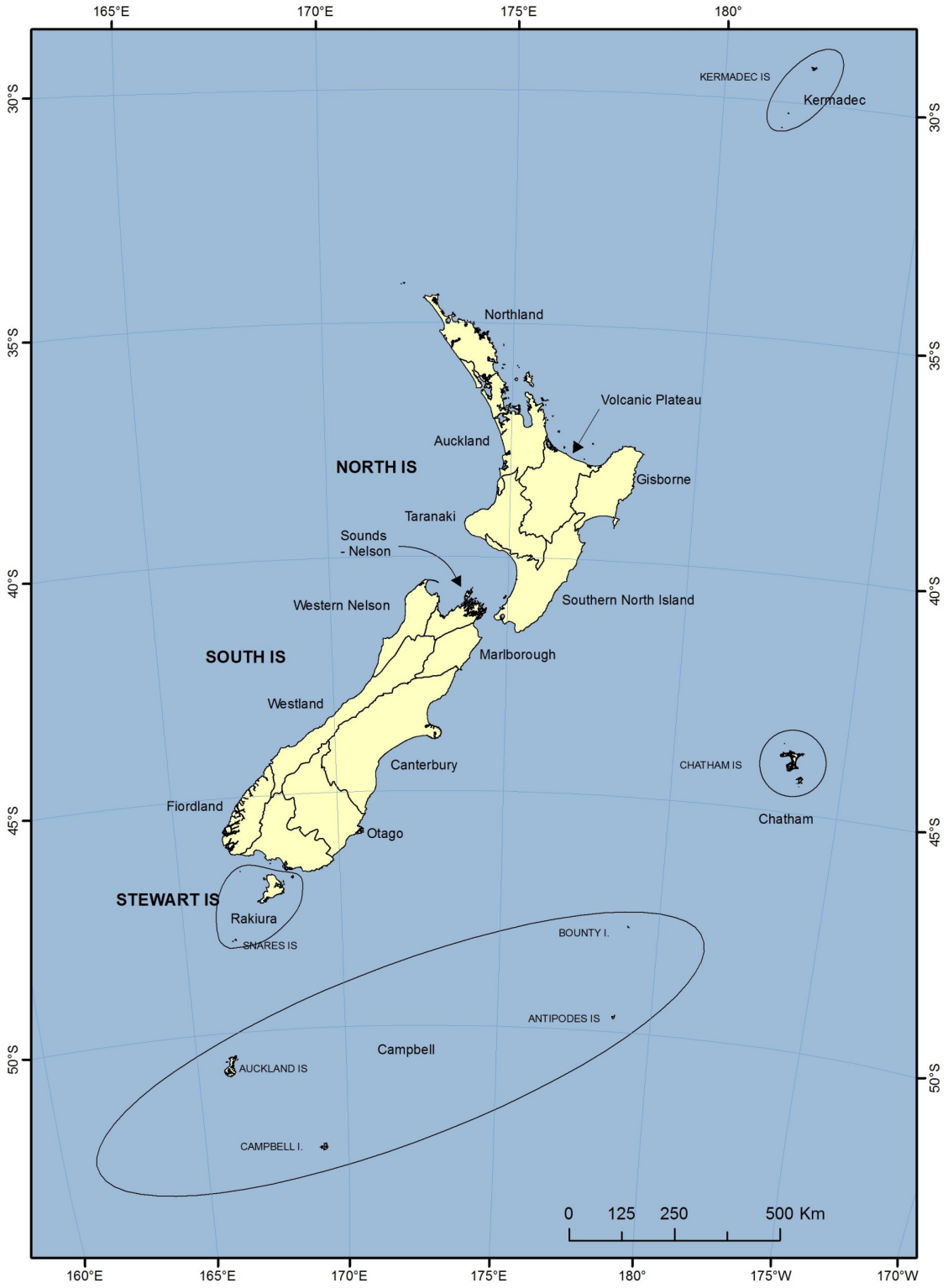
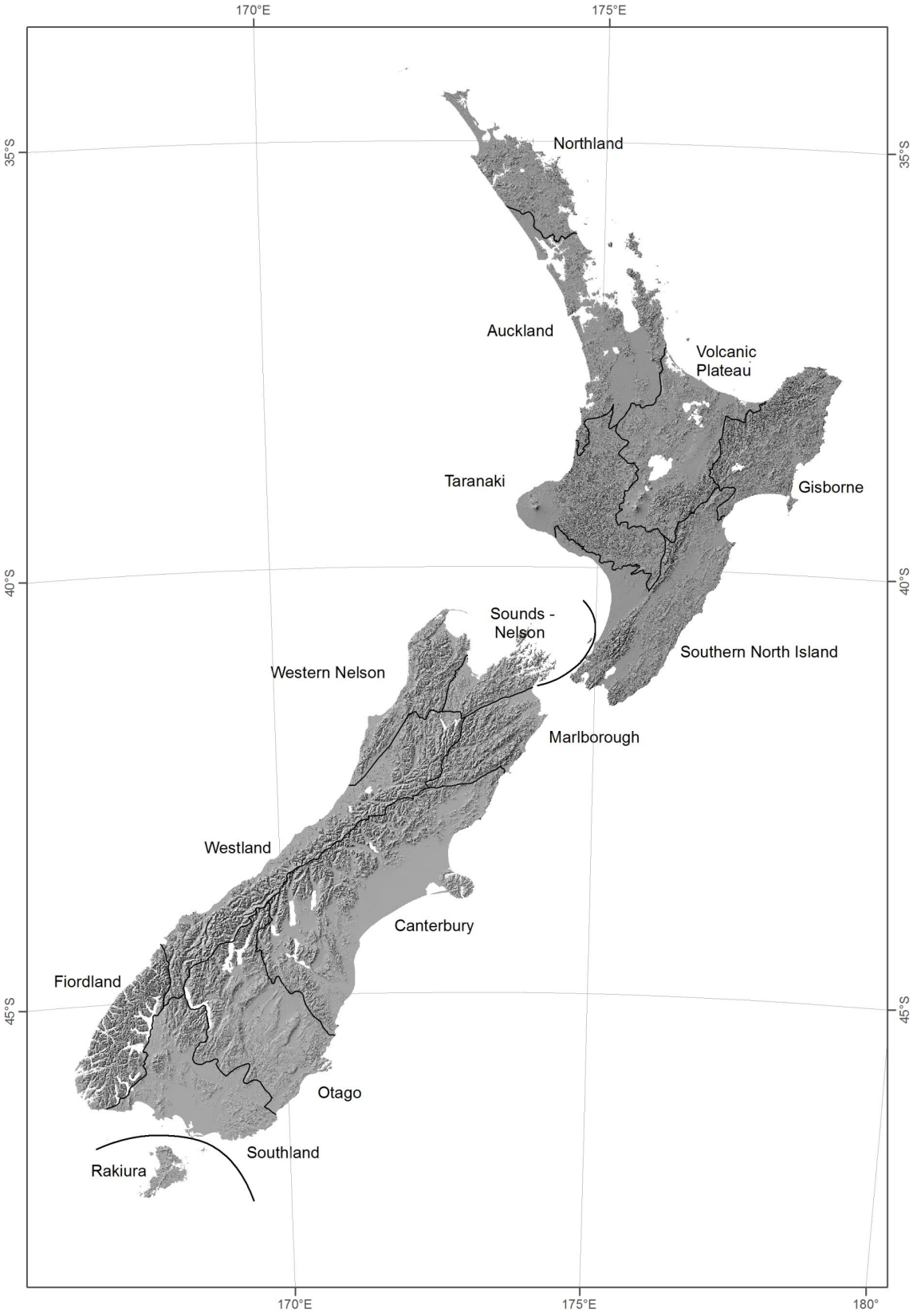


Map 1: Map of New Zealand and offshore islands showing Ecological Provinces



Map 2: Map of New Zealand showing Ecological Provinces

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The electronic Flora of New Zealand (**eFloraNZ**) project provides dynamic, continually updated, online taxonomic information about the New Zealand flora. Collaborators in the project are Manaaki Whenua – Landcare Research, the Museum of New Zealand Te Papa Tongarewa, and the National Institute of Water and Atmospheric Research (NIWA).

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