

# FLORA OF NEW ZEALAND

## FERNS AND LYCOPHYTES

### ISOETACEAE



---

**P.J. BROWNSEY & L.R. PERRIE**

Fascicle 25 – OCTOBER 2018

© Landcare Research New Zealand Limited 2018.

Unless indicated otherwise for specific items, this copyright work is licensed under the Creative Commons Attribution 4.0 International licence



Attribution if redistributing to the public without adaptation: "Source: Manaaki Whenua – Landcare Research"

Attribution if making an adaptation or derivative work: "Sourced from Manaaki Whenua – Landcare Research"

See Image Information for copyright and licence details for images.

#### CATALOGUING IN PUBLICATION

Brownsey, P. J. (Patrick John), 1948–

Flora of New Zealand : ferns and lycophytes. Fascicle 25, Isoetaceae / P.J. Brownsey and L.R. Perrie. -- Lincoln, N.Z.: Manaaki Whenua Press, 2018.

1 online resource

ISBN 978-0-9 47525-47-7 (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 582.392.2(931)

DC 587.90993

DOI: 10.7931/B1DD0W

This work should be cited as:

Brownsey, P.J. & Perrie, L.R. 2018: Isoetaceae. *In*: Breitwieser, I.; Wilton, A.D. *Flora of New Zealand – Ferns and Lycophytes*. Fascicle 25. Manaaki Whenua Press, Lincoln.  
<http://dx.doi.org/10.7931/B1DD0W>

Cover image: *Isoetes alpina*. Mature plants growing in cultivation.

# Contents

Introduction.....	1
Taxa	
<i>Isoetaceae</i> Dumort. ....	2
<i>Isoetes</i> L. ....	2
<i>Isoetes alpina</i> Kirk ....	5
<i>Isoetes kirkii</i> A.Braun ....	7
References .....	10
Acknowledgements .....	11
Maps .....	12
Index .....	14
Image Information .....	15



---

## Introduction

The medium-sized, cosmopolitan family Isoetaceae includes the single genus *Isoetes*, which has traditionally been represented in New Zealand by two species, *I. alpina* and *I. kirkii*. Despite considerable morphological and molecular investigation over the last 40 years, there is no clear evidence as to whether this is correct, or whether there is just one variable species, or up to three or four separate entities present in New Zealand. The long-standing concept of two species is maintained here until further work can clarify the taxonomy of this difficult group.

Both species are endemic, diploid and sexually reproducing, with *I. alpina* believed to be confined to the South Island and *I. kirkii* to the North Island. However, the possibility of tetraploid, apomictic populations in both islands, and a possibly genetically distinct population in Lake Ōmāpare, Northland (but now extinct in the wild), may complicate this simple geographic separation. *I. alpina* is a generally more robust plant than *I. kirkii*, best distinguished by its grey to white, smooth megaspores; it is widespread in montane and sub-alpine lakes and tarns throughout the South Island. *I. kirkii* is a more delicate plant, distinguished by its white, tuberculate megaspores; it is confined to a relatively small number of lakes and rivers in lowland areas of the North Island. It is now extinct in the Waikato Lakes and Wairua River, and is declining in its other localities.

Species of *Isoetes* are distinguished by their submerged or semi-aquatic habitat, tufts of linear, undivided leaves with conspicuous air chambers, and heterosporous spores produced in the swollen leaf bases.

---

---

## ***Isoetaceae* Dumort., *Anal. Fam. Pl.* 67 (1829)**

**Vernacular name:** quillworts

Aquatic (NZ) or occasionally terrestrial (not NZ). Plants growing from a lobed (in transverse section) and erect (NZ) or elongate (not NZ) corm-like stem that gives rise to a tuft of roots and a cluster of erect leaves, completely or partially submerged or occasionally terrestrial; leaves evergreen when submerged, or losing their leaves in dry periods when terrestrial. Scales absent. Leaves spirally arranged, ligulate, undivided, with a single unbranched vein surrounded by four longitudinal air canals divided by transverse septae; all leaves similar, linear, either terete and winged at base, with a subulate or acuminate apex (NZ), or flattened with a spatulate or rounded, apiculate apex (not NZ); leaf margins entire, bases swollen and colourless. Sporophylls similar to leaves, bearing sporangia that are embedded on the adaxial face of the swollen leaf base. Sporangia ovoid or globose, indehiscent, partially or completely covered by a thin membrane (velum). Heterosporous; mega- and microspores usually produced in separate sporangia (NZ) or rarely in the same one (not NZ). Megaspores trilete, with pronounced laesurae and equatorial ridge, variously patterned from almost smooth to verrucate or tuberculate, 250–800 µm in diameter. Microspores monolet, variously patterned but usually echinate, 20–40 µm in diameter.

**Taxonomy:** A family with one genus and from 192 (Troia et al. 2016) to 250 species (PPG 1 2016).

Isoetaceae have long been recognised as one of three isolated families within the Lycopodiopsida, distinguished by their submerged or semi-aquatic habitat, tufts of linear undivided ligulate leaves, and heterosporous spores that are produced inside the swollen bases of the leaves. The range of variation within the family has been summarised by Jermy (1990).

**Distribution:** A medium-sized cosmopolitan family, widespread from the cold-temperate zones in both hemispheres to the tropics, and growing from sea level to over 4000 m (Jermy 1990; Chinnock 1998), but absent from most of the Pacific islands. Two endemic species in New Zealand.

**Biostatus:** Indigenous; wild.

**Table 1:** Number of species in New Zealand within *Isoetaceae* Dumort.

Category	Number
Indigenous (Endemic)	2
<b>Total</b>	<b>2</b>

**Recognition:** Isoetaceae comprise aquatic or semi-aquatic lycophytes that bear ligulate, undivided leaves with single, unbranched veins. Plants grow from a corm-like stem producing tufts of leaves that are usually evergreen, or in some species may be lost in dry periods. The leaves have conspicuous air chambers. Spores are produced in solitary sporangia in the swollen leaf bases and released as the leaves decay. Plants are heterosporous, with mega- and micro-sporangia usually produced in separate sporangia.

## ***Isoetes* L., *Sp. Pl.* 1100 (1753)**

**Type taxon:** *Isoetes lacustris* L.

**Etymology:** From the Greek *isos* (alike) and *etos* (a year), a reference to the fact that some species remain unchanged throughout the year.

**Vernacular name:** quillwort

**Taxonomy:** A genus of from 192 (Troia et al. 2016) to about 250 species (PPG 1 2016).

Morphologically *Isoetes* is a very distinct genus and not closely related to any other lycophyte group. However, species in the genus are difficult to identify, partly because of their morphological simplicity resulting from a predominantly aquatic habitat, but also because of extensive polyploidy and reticulate evolution. Furthermore, genetic variation is limited among species of *Isoetes*, despite their worldwide distribution and ancient origin (Larsén & Rydin 2016).

Based on analysis of sequence data from three nuclear and plastid gene regions in 74 species, Larsén & Rydin (2016) found five major clades within the genus but struggled to correlate these with biogeographic patterns. The earliest diverging lineage (Clade A) contained species from South Africa, India, Australia and South America, and appeared to be related to ancient vicariance events, but later diverging clades appeared to be more readily explained by dispersal processes. However, the patterns were complex and require further study. Samples ascribed to the two species that have been recognised in New Zealand, *I. alpina* and *I. kirkii*, both occurred in Clade D, one of the later diverging

---

---

lineages. Two different collections of each taxon were sampled, and all four showed differences; the different collections were located in separate lineages, closely related to the Australian species *I. australis*, *I. caroli*, *I. humilior*, and *I. muelleri*. This suggests that New Zealand *Isoetes* is genetically variable, but the available evidence does not indicate any easy way to distinguish the two currently recognised species.

The taxonomy of New Zealand *Isoetes* has remained unchanged since the 19th century. *Isoetes kirkii* was described by Braun (1869), *I. alpina* by Kirk (1875) and *I. multiangularis* by Colenso (1890). No other names or combinations have been validly published since then. Cheeseman (1906) quickly reduced Colenso's *I. multiangularis* to synonymy with *I. alpina*, albeit with a question mark, and the concept of two species in New Zealand was subsequently accepted by Cheeseman (1925), Allan (1961) and Brownsey & Smith-Dodsworth (2000). The two species were distinguished primarily by the megaspores, said to be smooth in *I. alpina* but tubercled in *I. kirkii*, and both species were reported from both the North and South Islands.

Since 1979 there have been several investigations of *Isoetes* in New Zealand, but these have either never been published, or the results have mostly appeared in conference papers, or in technical or client reports, with limited accessibility. Craig Marsden (1979) undertook a PhD thesis that investigated the morphology and taxonomy of the genus in Asia and Australasia. With respect to the New Zealand species, he proposed recognising three very similar varieties: *I. kirkii* var. *kirkii*, *I. kirkii* var. *alpina*, and *I. kirkii* var. *flabellata*. He noted that var. *alpina* often differed from the others in having thicker leaves, smooth megaspores, and microspores with blunt spines, but that many intermediates existed. He observed that var. *flabellata* was most similar to var. *kirkii* and differed only in having imbricate leaves arranged in a distinct flabellate pattern, fewer corm lobes (2–3 cf. 3–4 in var. *kirkii*), and in minor details of the megaspore and microspore ornamentation. Var. *flabellata* was known only from L. Ōmāpere in Northland, but he cited specimens of the other two taxa from both main islands. However, his varietal names were never published and have no standing.

In 1998 D. Brunton and D.M. Britton investigated New Zealand *Isoetes*, studying herbarium material, spore morphology and cytology. Their results were inconclusive and never published, but were summarised as a personal communication in a Department of Conservation Technical Report (see Hofstra et al. 2006). Brunton & Britton suggested that New Zealand *Isoetes* was best viewed as a single species with three similar subspecies, roughly corresponding to Marsden's varieties. Subsp. *kirkii* was considered to be sexual, diploid, and largely confined to lowland areas of the North Island. Subsp. *alpina* was also sexual and diploid, but confined to the South Island. However, they noted that some entities on both islands were difficult to assign. They also reported (without supporting evidence) that some populations in the central North Island were tetraploid and apparently apomictic, with spores similar to, but larger than, those of subsp. *alpina* from the South Island.

Hofstra et al. (2006) carried out a preliminary genetic assessment of *Isoetes* in New Zealand for the Department of Conservation. They sampled *I. kirkii* from three North Island sites (including L. Ōmāpere) and *I. alpina* from three South Island lakes. Using ITS sequences they found little difference between any of the samples, and with rbcL sequences they reported only one base pair difference between *I. alpina* and *I. kirkii* samples. RAPDs yielded better evidence of genetically distinct entities, with the three *I. alpina* populations clustering together, distinct from both L. Taupō and L. Ōmāpere populations of *I. kirkii*. However, they concluded that further investigation was needed before any final conclusions were reached.

Hofstra & de Winton (2013, not publicly available; see Hofstra & de Winton 2016) used molecular markers to show that there were distinct differences between populations of *I. kirkii* from L. Ōmāpere and those in the central North Island, and between *I. kirkii* and *I. alpina*. However, they noted that these genetic differences did not provide any clarity on the taxonomy of *Isoetes* in the absence of clear morphological differences.

Hofstra & de Winton (2016) conducted a much larger study using RAPD profiles of 254 plants from 20 lakes to determine the level of genetic variation in New Zealand *Isoetes*. They showed that over 80% of the variation was partitioned between, rather than within, populations. Four clusters were recovered from UPGMA analysis; two clusters included only plants from 13 South Island lakes, one included only plants from L. Ōmāpere, and the fourth included plants from four North Island and two lowland South Island lakes. Morphological support for this latter relationship is not known, and populations of other lowland West Coast lakes clustered with other South Island populations. Populations in the northern South Island were not sampled. Hofstra & de Winton (2016) noted that there were low levels of genetic variation in L. Rotoiti, near Rotorua, and L. Taupō (compared to L. Te Anau and L. Wānaka), suggesting that this may be an indication of apomictic reproduction, as previously inferred by Brunton and Britton (see Hofstra et al. 2006) at these localities. Hofstra & de Winton (2016) concluded that the

---



recognition of genetically distinct populations has significant implications for the conservation of New Zealand *Isoetes*, but offered no new taxonomic opinion.

The conclusion from investigations spanning 40 years is that although there is evidence of genetic variation between populations of *Isoetes* across New Zealand, the variation has not yet been correlated with morphological differences. In particular, it is not clear whether there is a clear boundary between *I. kirkii* and *I. alpina* or where it may lie. The most genetically distinct population appears to be that from L. Ōmāpere (now believed to be extinct in the wild, and known only from material in cultivation), but morphologically this seems less easy to distinguish from *I. kirkii* than is *I. alpina*. There are also suggestions (Hofstra et al. 2006) that some populations from L. Taupō and L. Rotoiti are tetraploid, lack microspores and are apparently apomictic, although the evidence for that has not been published. Colenso's *I. multiangularis* came from L. Taupō, so if the tetraploid apomicts were shown to be a different species, a name might be available.

The genetic evidence is, at best, inconclusive; there could be one variable species or perhaps three or four different entities. However, because these entities have not yet been correlated with morphological differences, it is unclear whether they warrant taxonomic recognition, and it would be premature to give them any formal rank. Their relationship to taxa in Australia is also unresolved. We therefore retain the *status quo* here and accept the two species, *I. alpina* and *I. kirkii*, that have been recognised in New Zealand since the late 19th century. If subsequent work shows that more than one entity can be recognised in New Zealand, three published names are available at specific rank, or alternatively the way is clear to publish new taxa at subspecific rank without any confusion from pre-existing concepts.

- 1 Plants robust; leaves 25–450 mm long, 0.5–2.5 mm in diameter; sporangia 2–9 mm long, 2–5 mm wide; megaspores smooth, grey to white..... *alpina*  
Plants delicate; leaves 30–170, rarely to 350 mm long, 0.5–1.5 mm in diameter; sporangia 1.5–6 mm long, 1–3.5 mm wide; megaspores tuberculate, white..... *kirkii*

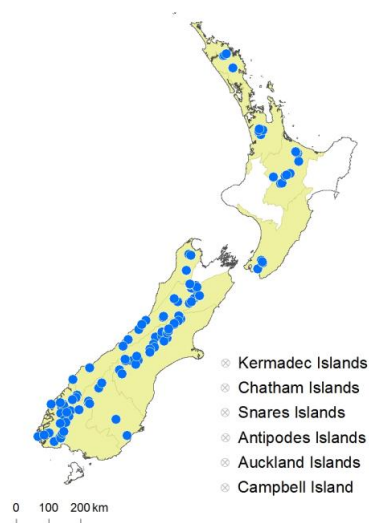
**Distribution:** *Isoetes* is a genus of up to 250 species (PPG 1 2016), mostly occurring in damper habitats such as marshy soil and swamps, springs, seepage channels, seasonal pools, flowing water, alpine tarns and permanent lakes, from sea level to over 4000 m (Jermy 1990; Chinnock 1998); 16 species in southern South America (Zuloaga et al. 2008), 13 in southern Africa (Crouch et al. 2011), five in China (Zhang & Taylor 2013), 15 in Australia (Chinnock 1998), and one in Hawai'i (Palmer 2003), but absent from the other Pacific islands. Two endemic species in New Zealand.

**Biostatus:** Indigenous (Non-endemic).

**Table 2:** Number of species in New Zealand within *Isoetes* L.

Category	Number
Indigenous (Endemic)	2
<b>Total</b>	<b>2</b>

**Cytology:** The base chromosome number in *Isoetes* is  $x = 10$  or 11, with many polyploids recorded (Jermy 1990).



**Fig. 1:** *Isoetes* distribution map based on databased records at AK, CHR and WELT.



---

***Isoetes alpina* Kirk, *Trans. & Proc. New Zealand Inst.* 7: 377, t. 25 (1875)**

Lectotype (selected by Brownsey et al. 2018): Lake Guyon, *W.T.L. Travers s.n.*, WELT P003771!

**Etymology:** From the Latin *alpinus* (alpine), a reference to the habitat of this species that includes alpine tarns.

**Vernacular name:** alpine quillwort

Aquatic, growing submerged, evergreen. Stem short, erect, 1–10 mm tall, 2–10 mm wide. Leaves in tufts of up to 35, 25–450 mm long, 0.5–2.5 mm diameter, erect, linear, terete, with conspicuous air chamber; apices long acuminate; margins entire, bases swollen, 3.5–10.5 mm wide, broadly winged. Sporangia ovoid, 2–9 mm long, 2–5 mm wide. Megaspores grey to white, surfaces smooth. Microspores echinate.

**Distribution:** South Island: Western Nelson, Marlborough, Westland, Canterbury, Otago, Southland, Fiordland.

Altitudinal range: 20–1700 m.

*Isoetes alpina* is circumscribed here as confined to the South Island, occurring in lakes and tarns from north-west Nelson to Fiordland. It is mostly found in a zone from 450–1700 m, but in Westland, Fiordland and Southland descends almost to sea level. Plants with smooth macrospores also occur at L. Taupō and L. Rotoiti (e.g. AK 259222) in the North Island, but these may be apomictic, tetraploid plants (Hofstra et al. 2006), possibly belonging to a different taxon.

**Biostatus:** Indigenous (Endemic).

**Habitat:** *Isoetes alpina* usually occurs in montane lakes and tarns, growing submerged on mud, sand or rock substrates. Occasionally it is found in mud on lake margins, and rarely in streams. It has been recorded growing in water up to 5.5 m deep in L. Pōteriteri (CHR 502298) and up to 8.5 m deep in L. Wakatipu (CHR 478370). The NIWA Aquatic Plant Database has maximum depth records of 10 m in L. Tennyson, 12 m in L. Wānaka and 12.5 m in L. Coleridge (Paul Champion, pers. comm., July 2018).

**Recognition:** *Isoetes alpina* is difficult to distinguish from *I. kirkii*, most characters overlapping in their range of variation. However, *I. alpina* is generally a more robust plant, producing tufts of up to 35 leaves, which can grow much longer and wider than in *I. kirkii*. The sporangia are also generally longer and wider than in *I. kirkii*. *Isoetes alpina* is best distinguished by the megaspores, which are grey to white in colour with a smooth surface, in contrast to those of *I. kirkii*, which are white and distinctly tuberculate on their surfaces (Large & Braggins 1991).

**Cytology:** 2n = 22 (Marsden 1979)

**Notes:** *Isoetes alpina* was first collected by F.W. Hutton and W.T.L. Travers from Lake Guyon in 1872, and then by Sven Berggren from Lake Pearson in 1874. It was subsequently described by Kirk (1875) from material sent to him by Travers. The principal point of difference noted by Kirk was the smooth surface of the macrospores, in contrast to the tuberculate macrospores of *I. kirkii*.



**Fig. 2:** *Isoetes alpina*. Mature plants growing in cultivation.



**Fig. 3:** *Isoetes alpina*. Leaves with air chambers, and swollen bases containing microspores, growing from a short corm.



**Fig. 4:** *Isoetes alpina*. Herbarium specimen from Lake Pearson, WELT P003767.



**Fig. 5:** *Isoetes alpina*. Herbarium specimen from Lake Guyon, WELT P003764.



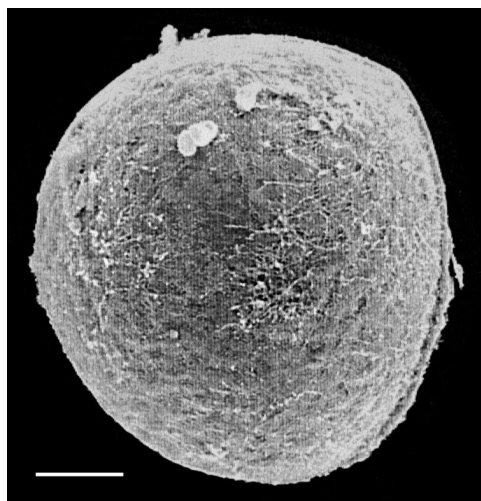
**Fig. 6:** *Isoetes alpina*. Herbarium specimen from alpine tarn, St Arnaud Range, WELT P015449.



**Fig. 7:** *Isoetes alpina*. Close up from WELT P003767, showing swollen leaf bases containing mega- and microspores.



**Fig. 8:** *Isoetes alpina*. SEM proximal view of macrospore showing trilete markings and smooth surface. From photos by D.M. Britton attached to WELT P003757. Scale bar = 100  $\mu$ m.



**Fig. 9:** *Isoetes alpina*. SEM distal view of macrospore showing smooth surface. From photos by D.M. Britton attached to WELT P003757. Scale bar = 100  $\mu$ m.

***Isoetes kirkii* A.Braun, Monatsber. Königl. Preuss. Akad. Wiss. Berlin 649 (1869)**

Holotype: New Zealand, Waikato, 1869, *T. Kirk s.n.*, com. Dr. F. v. Mueller, B 20 0107710b!

= *Isoetes multiangularis* Colenso, *Trans. & Proc. New Zealand Inst.* 22: 449 (1890)

Type: Lake Taupō, 1889, C.J. Norton (not located in AK, CHR, K, WELT).

**Etymology:** Named in honour of Thomas Kirk (1828–1898), Chief Conservator of State Forests in New Zealand (1863–1898), author of *The Forest Flora of New Zealand* (1889) and *The Students' Flora of New Zealand and the Outlying Islands* (1899), and who first collected *Isoetes* in New Zealand.

**Vernacular name:** quillwort

Aquatic, growing submerged, evergreen. Stem short, erect, 1–5 mm tall, or rarely up to 12 mm tall, 2.5–10 mm wide. Leaves in tufts of up to 25, 30–170 mm long, or rarely up to 350 mm long, 0.5–1.5 mm diameter, erect, linear, terete, with conspicuous air chamber; apices long acuminate; margins entire, bases swollen, 3–5 mm wide, broadly winged. Sporangia ovoid, 1.5–6 mm long, 1–3.5 mm wide. Megaspores white, surfaces tuberculate. Microspores echinate.

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

Altitudinal range: 0–350 m.

*Isoetes kirkii* is circumscribed here as confined to the North Island and known from Lake Ōmāpere, the Wairua River, the Waikato and Rotorua lakes, L. Taupō, L. Pōnui and L. Wairarapa. It has also been recorded from L. Waikaremoana (Hofstra & de Winton 2016), but no specimen has been seen by us, and it is therefore not included on the map. *I. kirkii* grows from near sea level up to 350 m in L. Taupō. Brunton & Britton also identified plants with tubercled macrospores from L. Onslow (CHR 394977) and L. Te Anau (CHR 480201) in the South Island, but these may be apomictic populations lacking microspores.

**Biostatus:** Indigenous (Endemic).

A possibly distinct taxon from Lake Ōmāpere in Northland was first recognised by Marsden (1979) as “var. *flabellata*”. The name has no standing because it was never published, but *Isoetes* aff. *kirkii* (CHR 247118A) from Lake Ōmāpere is treated as a Nationally Critical taxonomically indeterminate taxon (de Lange et al. 2018). It is extinct in the wild but survives in cultivation from material rescued from its last known habitat (de Lange 2011, New Zealand Plant Conservation Network website, [http://www.nzpcn.org.nz/flora\\_details.aspx?ID=860](http://www.nzpcn.org.nz/flora_details.aspx?ID=860)).

*Isoetes kirkii* is also now extinct in the Waikato Lakes and Wairua River, and is threatened in many of its remaining North Island localities, but is still common in L. Taupō, L. Ōkareka and L. Rotoiti (Paul Champion, pers. comm., July 2018). It is treated as At Risk / Declining by de Lange et al. (2018).

**Habitat:** *Isoetes kirkii* grows submerged in shallow lakes, or rarely in slow-moving river water. It has been recorded in water up to 4.1 m deep in L. Taupō (Paul Champion, pers. comm., July 2018).

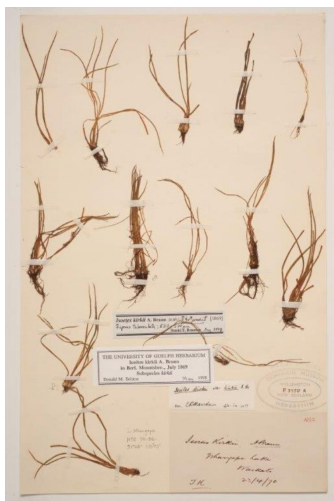
**Recognition:** *Isoetes kirkii* is generally a smaller, more delicate plant producing tufts of up to 15 leaves, which are shorter and narrower than in *I. alpina*. The sporangia are also shorter and narrower. *I. kirkii* is best distinguished by the megaspores, which are white and distinctly tuberculate on their surfaces, in contrast to those of *I. alpina*, which are grey to white in colour with a smooth surface (Large & Braggins 1991).

**Cytology:**  $2n = 22$  (Marsden 1979). There are also unpublished reports of apomictic, tetraploid populations in L. Taupō and L. Rotoiti (see Hofstra et al. 2006).

**Notes:** *Isoetes* was first collected in New Zealand in February 1869, when it was discovered by F.W. Hutton and Thomas Kirk in the Waikato Lakes region (Kirk 1875). Material was sent to J.D. Hooker at K (001094253), and to von Mueller in Melbourne. It was forwarded to A.C.H. Braun in Berlin, who described it as a new species (Braun 1869), named after Thomas Kirk. The only extant specimen at B collected prior to Braun's publication is one collected by Kirk in the Waikato area and forwarded by von Mueller in 1869. It is presumed to be the holotype. The only other specimen known to have been collected in 1869 prior to Braun's publication of *I. kirkii* is the specimen at K sent to Hooker, but this would not have been seen by Braun. Kirk returned to the Waikato in April 1870 and collected more material, but crucially this was after Braun's description of the new species.

*Isoetes multiangularis* was described by Colenso (1890) from material collected at Lake Taupō in 1889 by C.J. Norton. There is no original material in the Colenso herbaria at WELT, K or AK. There is a specimen in WELT (P003753), said to be from the Kirk herbarium, collected by Norton from Lake Taupō in 1889. This may be from the same gathering as the material sent to Colenso, but the specimen is not labelled *I. multiangularis*, and there is no evidence that Colenso saw it, so it cannot be regarded as original material. The identity of *I. multiangularis* is therefore uncertain. The name is included here, with considerable doubt, in the synonymy of *I. kirkii* solely on the basis of its geographic locality, but it could also be one of the apomictic populations thought to occur in the central North Island.

The genetic results that link the South Island populations at Lake Paringa and Lake Ellery with North Island populations of *I. kirkii* (Hofstra & de Winton 2016) require further investigation. Populations from lakes in the northern South Island have not been sampled, and these areas may be critical for assessing any possible overlap between northern *I. kirkii* and southern *I. alpina*.

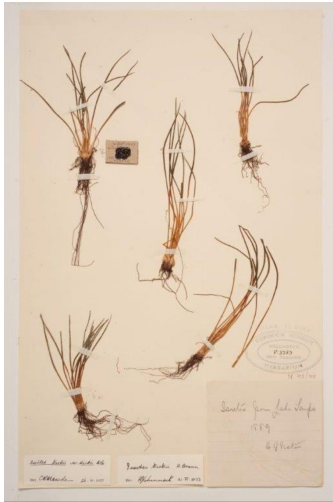


**Fig. 10:** *Isoetes kirkii*. Herbarium specimen from Lake Whangapē, WELT P003750/A.



**Fig. 11:** *Isoetes kirkii*. Herbarium specimen from Lake Whangapē, WELT P003750/B.





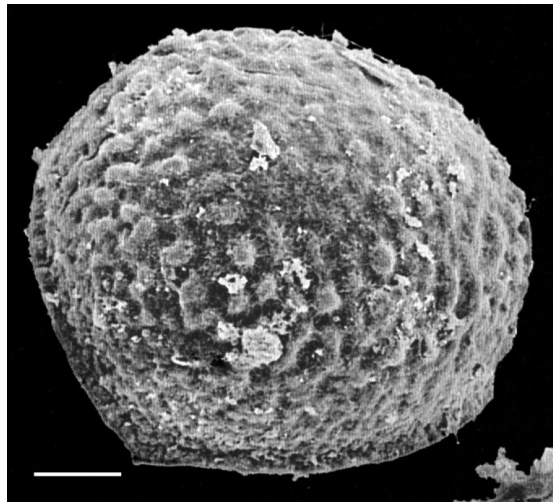
**Fig. 12:** *Isoetes kirkii*. Herbarium specimen from Lake Taupō, WELT P003753.



**Fig. 13:** *Isoetes kirkii*. Close up from WELT P003753, showing swollen leaf bases containing megaspores.



**Fig. 14:** *Isoetes kirkii*. SEM proximal view of macrospore showing trilete markings and tubercled surface. From photos by D.M. Britton attached to WELT P005837/A. Scale bar = 100 µm.



**Fig. 15:** *Isoetes kirkii*. SEM distal view of macrospore showing tubercled surface. From photos by D.M. Britton attached to WELT P005837/A. Scale bar = 100 µm.

---

## References

- Allan, H.H. 1961: *Flora of New Zealand. Vol. I. Indigenous Tracheophyta: Psilopsida, Lycopsidea, Filicopsida, Gymnospermae, Dicotyledones*. Government Printer, Wellington.
- Braun, A.C.H. 1869: Über eine neue in Neuseeland entdeckte Art der Gattung *Isoetes*. *Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin*: 648–650.
- Brownsey, P.J.; Perrie, L.R.; Field, A.R. 2018: Taxonomic notes on the New Zealand flora: lectotypes in Isoetaceae and Lycopodiaceae. *New Zealand Journal of Botany* 56(3)
- Brownsey, P.J.; Smith-Dodsworth, J.C. 2000: *New Zealand ferns and allied plants*. Edition 2. David Bateman, Auckland.
- Cheeseman, T.F. 1906: *Manual of the New Zealand Flora*. Government Printer, Wellington.
- Cheeseman, T.F. 1925: *Manual of the New Zealand Flora*. Edition 2. Government Printer, Wellington.
- Chinnock, R.J. 1998: Isoetaceae. In: *Flora of Australia*. Vol. 48. 55–65.
- Colenso, W. 1890: A description of two newly discovered indigenous cryptogamic plants. *Transactions and Proceedings of the New Zealand Institute* 22: 449–452.
- Crouch, N.R.; Klopper, R.R.; Burrows, J.E.; Burrows, S.M. 2011: *Ferns of southern Africa. A comprehensive guide*. Struik Nature, Cape Town.
- de Lange, P.J.; Rolfe, J.R.; Barkla J.W.; Courtney, S.P.; Champion, P.D.; Perrie, L.R.; Beadel, S.N.; Ford, K.A.; Breitwieser, I.; Schönberger, I.; Hindmarsh-Walls, R.; Heenan, P.B.; Ladley, K. 2018: Conservation status of New Zealand indigenous vascular plants, 2017. *New Zealand Threat Classification Series* No. 22.
- Dumortier, B.C.J. 1829: *Analyse des familles de plantes: avec l'indication des principaux genres qui s'y rattachent*. J. Casterman, Tournay.
- Hofstra, D.; de Winton, M.D. 2013: *Isoetes*, genetic comparison of Lake Ōmāpere *Isoetes* with other populations of New Zealand *Isoetes*. NIWA Client report HAM2013-2062 (not publicly accessible).
- Hofstra, D.; de Winton, M.D. 2016: Geographic scales of genetic variation amongst *Isoetes* in New Zealand. *Aquatic Botany* 131: 28–37.
- Hofstra, D.E.; Gemmill, C.E.C.; de Winton, M.D. 2006: Preliminary genetic assessment of New Zealand *Isoetes* and *Nitella*, using DNA sequencing and RAPDs. *Science for Conservation* 266: 1–30.
- Jermy, A.C. 1990: Isoetaceae. In: Kramer, K.U.; Green, P.S. (ed.) *The families and genera of vascular plants. 1 Pteridophytes and gymnosperms*. Springer-Verlag, Berlin.
- Kirk, T. 1875: Description of a new species of *Isoëtes*. *Transactions and Proceedings of the New Zealand Institute* 7: 377.
- Large, M.F.; Braggins, J.E. 1991: *Spore atlas of New Zealand ferns and fern allies*. SIR Publishing, Wellington.
- Larsén, E.; Rydin, C. 2016: Disentangling the phylogeny of *Isoetes* (Isoetales), using nuclear and plastid data. *International Journal of Plant Sciences* 177: 157–174.
- Linnaeus, C. 1753: *Species Plantarum*. Impensis Laurentii Salvii, Stockholm.
- Marsden, C.R. 1979: Morphology and taxonomy of *Isoetes* in Australasia, India, north-east and south-east Asia, China and Japan. Unpublished PhD thesis, University of Adelaide, Australia.
- Palmer, D.D. 2003: *Hawai'i's ferns and fern allies*. University of Hawai'i Press, Honolulu.
- PPG 1 2016: A community-derived classification for extant lycophytes. *Journal of Systematics and Evolution* 54(6): 563–603.
- Troia, A.; Pereira, J.B.; Kim, C.; Taylor, W.C. 2016: The genus *Isoetes* (Isoetaceae); a provisional checklist of the accepted and unresolved taxa. *Phytotaxa* 277: 101–145.
- Zhang, L.; Taylor, W.C. 2013: Isoetaceae. In: Wu, Z.; Raven, P.H.; Hong, D. (ed.) *Flora of China. Lycopodiaceae through Polypodiaceae*. Vol. 2–3. Science Press, Beijing.
- Zuloaga, F.O.; Morrone, O.; Belgrano, M.J. 2008: *Catálogo de las plantas vasculares del Cono Sur. Vol. 1. Pteridophyta, Gymnospermae y Monocotyledoneae*. Missouri Botanical Garden, St Louis.

---

## 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 Peter de Lange for discussion about the genus in New Zealand, to Bridget Hatton for imaging herbarium material in WELT, and to Paul Champion for reviewing the manuscript.

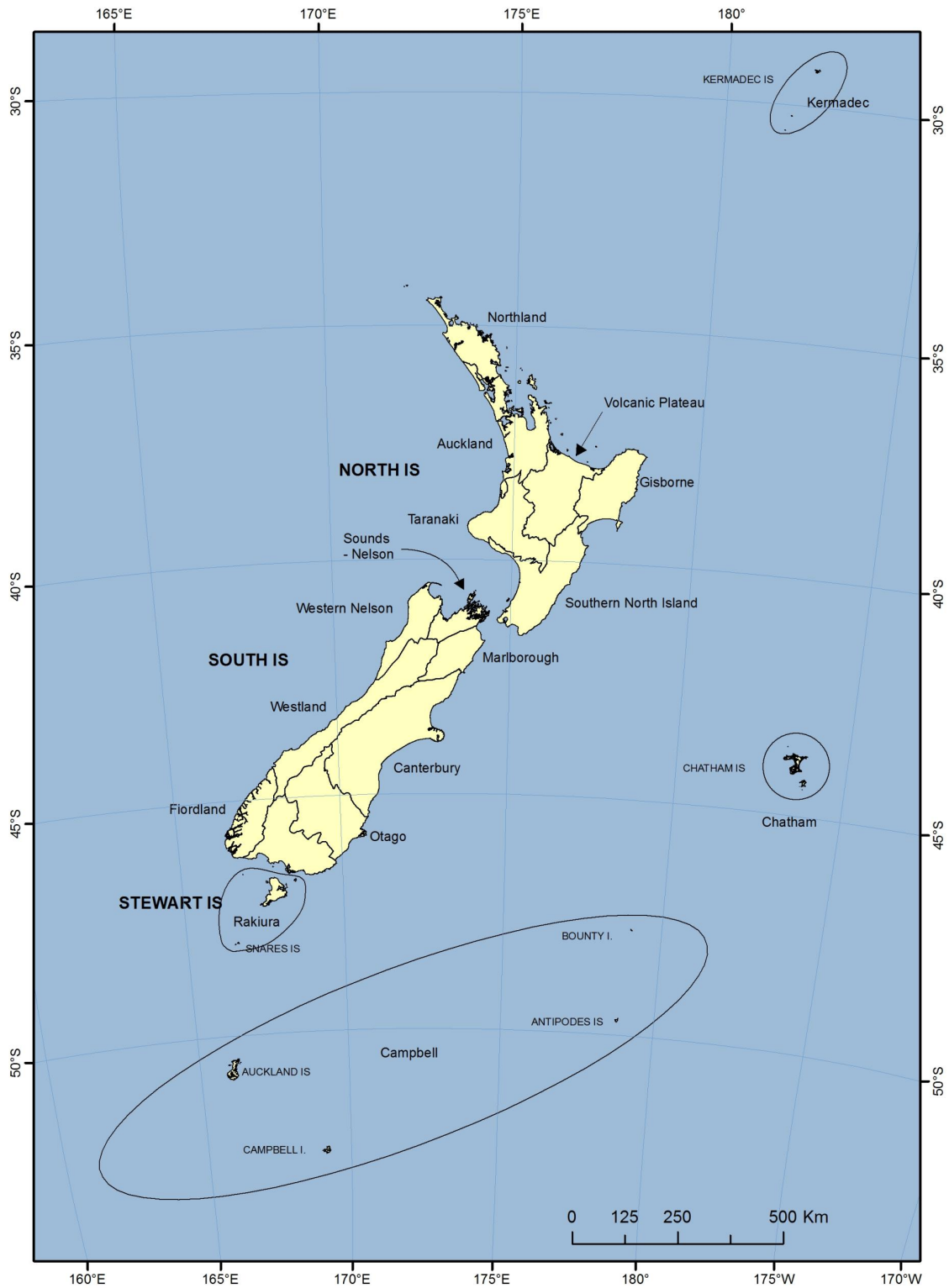
**P.J. Brownsey and L.R. Perrie**

Museum of New Zealand Te Papa Tongarewa, PO Box 467, Wellington 6140, New Zealand

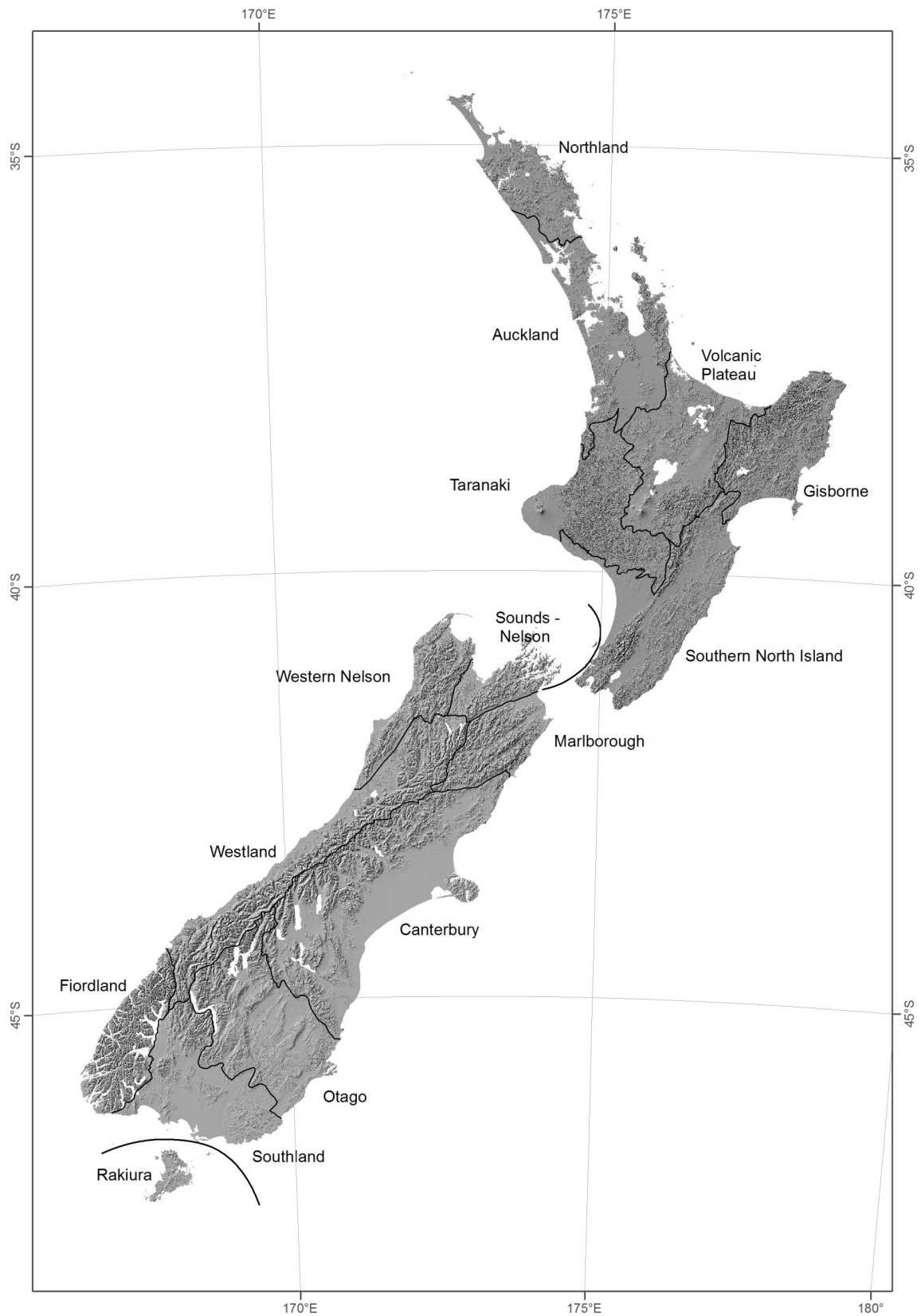
PatB@tepapa.govt.nz

LeonP@tepapa.govt.nz





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



**Map 2:** Map of New Zealand showing Ecological Provinces

---

## Index

Page numbers are in **bold** for the main entry,  
and *italic* for synonyms.

*Isoetaceae* Dumort. 1, **2**

*Isoetes* L. 1, **2**, 8

*Isoetes alpina* Kirk 1–4, **5**, 8

*Isoetes kirkii* A.Braun 1–5, **7**

*Isoetes multiangularis* Colenso 7

---

## Image Information

<b>Image</b>	<b>Creator</b>	<b>Copyright</b>	<b>Licence</b>
Front cover	P.J. Brownsey	© Patrick Brownsey	CC-BY-NC 3.0 NZ
Fig. 1	K. Boardman	© Landcare Research 2018	CC-BY 3.0 NZ
Fig. 2	P.J. Brownsey	© Patrick Brownsey	CC-BY-NC 3.0 NZ
Fig. 3	P.J. Brownsey	© Patrick Brownsey	CC-BY-NC 3.0 NZ
Fig. 4	B. Hatton	© Te Papa	CC-BY-NC 3.0 NZ
Fig. 5	B. Hatton	© Te Papa	CC-BY-NC 3.0 NZ
Fig. 6	B. Hatton	© Te Papa	CC-BY-NC 3.0 NZ
Fig. 7	B. Hatton	© Te Papa	CC-BY-NC 3.0 NZ
Fig. 8	J.C. Stahl	© Te Papa	CC-BY-NC 3.0 NZ
Fig. 9	J.C. Stahl	© Te Papa	CC-BY-NC 3.0 NZ
Fig. 10	B. Hatton	© Te Papa	CC-BY-NC 3.0 NZ
Fig. 11	B. Hatton	© Te Papa	CC-BY-NC 3.0 NZ
Fig. 12	B. Hatton	© Te Papa	CC-BY-NC 3.0 NZ
Fig. 13	B. Hatton	© Te Papa	CC-BY-NC 3.0 NZ
Fig. 14	J.C. Stahl	© Te Papa	CC-BY-NC 3.0 NZ
Fig. 15	J.C. Stahl	© Te Papa	CC-BY-NC 3.0 NZ
Map 1	A.D. Wilton	© Landcare Research 2014	CC-BY 3.0 NZ
Map 2	A.D. Wilton	© Landcare Research 2014	CC-BY 3.0 NZ



---

## Flora of New Zealand: PDF publications

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).

The eFloraNZ presents new systematic research and brings together information from the Manaaki Whenua – Landcare Research network of databases and online resources. New taxonomic treatments are published as fascicles in PDF format and provide the basis for other eFloraNZ products, including the web profiles.

eFloraNZ will have separate sets of PDF publications for algae, lichens, liverworts and hornworts, mosses, ferns and lycophytes, and seed plants.

For each eFloraNZ set the PDF files are made available as dated and numbered fascicles. With the advent of new discoveries and research the fascicles may be revised, with the new fascicle being treated as a separate version under the same number. However, superseded accounts will remain available on the eFlora website.

### **Fern and Lycophyte Set (ISBN 978-0-478-34761-6)**

The Fern and Lycophyte Set includes ferns and lycophytes indigenous to New Zealand, together with exotic species that have established in the wild. Species that are found only in cultivation are excluded.

**Editor-in-Chief:** Ilse Breitwieser

**Series Editors:** Ilse Breitwieser, Aaron Wilton

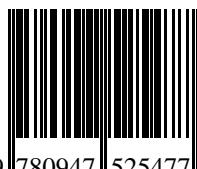
**Steering committee:** Ilse Breitwieser, Pat Brownsey, Wendy Nelson, Rob Smissen, Aaron Wilton

**Technical production:** Aaron Wilton with Kate Boardman, Bavo de Pauw, Sue Gibb, Ines Schönberger, Katarina Tawiri, Margaret Watts

**Copy Editor:** Ray Prebble



ISBN 978-0-9 47525-47-7



9 780947 525477