The indigenous flora of the 'dry' kahikatea forest remnants of the southeastern Hamilton Basin

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SUMMARY

The indigenous vascular flora of eleven 'dry' kahikatea (*Dacrycarpus dacrydioides*) forest remnants of the southeastern Hamilton Basin is documented based on a survey conducted between 1984–1989. At that time it was considered that most of the remnants surveyed were too dry, small, and isolated to act as viable long-term examples of this forest type in the basin without extensive intervention management. This opinion is probably still valid, although since that survey some remnants have been fenced and/or replanted. A comparison of the floral composition of these 'dry' forest remnants with those of adjacent 'wet' gully forest remnants is made, concluding that the 'wet' forest remnants of the gully margins, although often spatially smaller, retain a greater indigenous biodiversity. It is argued that more effort is still needed to protect these 'wet' forest remnants if we wish to preserve viable kahikatea-dominated forest in the eastern Hamilton Basin.

INTRODUCTION

Between 1984 and June 1989 the author conducted a survey of kahikatea (*Dacrycarpus dacrydioides*) forest remnants within the Hamilton Basin, Waikato (for a definition and description of this geological structure see: Kear 1960; Kear & Schofield 1978; McCraw 1967; Soons & Selby 1992). These remnants lie south of the small settlement of Newstead and east of the Waikato River (Fig. 1). The area encompassed covers approximately one fifth of the Hamilton Basin, and is that part which forms the head of the alluvial fan left by the ancestral Waikato River when the present river course formed and aggraded *c.* 12000–10000 years ago (McCraw 1967; Crowcroft 1992; Soons & Selby 1992; de Lange 1996).

The survey area was historically free of restiad (*Sporadanthus* / *Empodisma*) high moor and low moor *Empodisma* / *Machaerina* peat bogs

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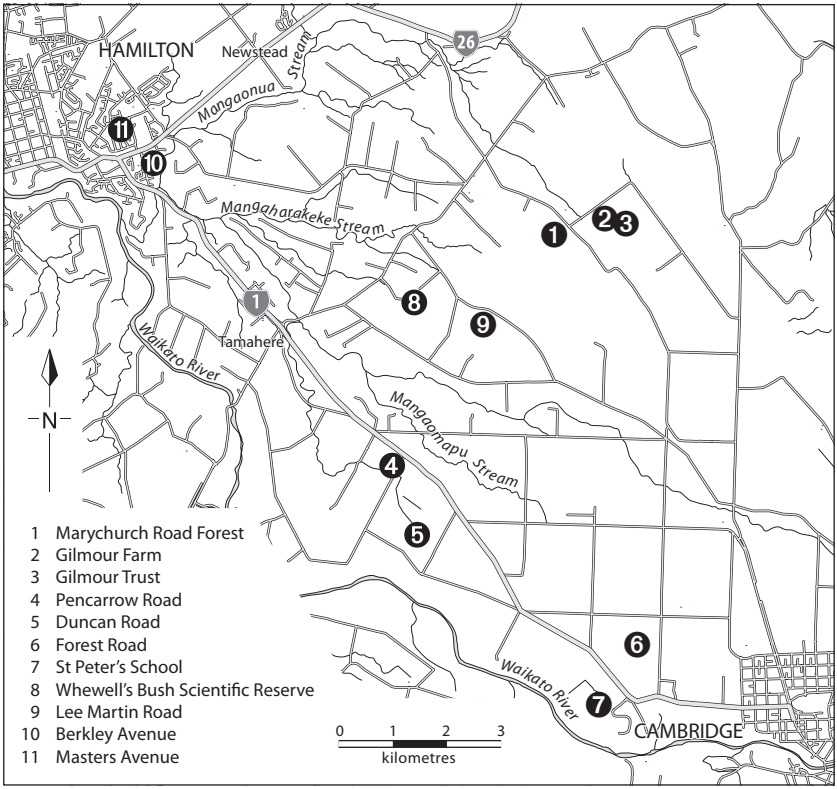

Figure 1. Location of 'dry' forest remnants discussed in article.

which once dominated much of the basin (McCraw 1967). Instead, based on the soils of the survey area, it seems likely that the area was once vegetated with mixed lowland podocarp forest (see comments by Newnham et al., 1989); with those remnants developed on the more freely draining Horotiu Sandy Loam complex dominated historically by totara (*Podocarpus totara* var. *totara*), while kahikatea or rimu (*Dacrydium cupressinum*) dominated on the more poorly draining, gleyed Te Kowhai Silt Loam. Where the intermediate Bruntwood soils complex is present it seems that the forests were host to a mix of these three conifers (Bruce 1979; de Lange 1987a, b, 1996; Champion 1988; L. Martin, pers. comm. 1987). At the time of the survey much of this area was used for dairy farming, growing market produce such as asparagus (*Asparagus officinalis*), maize (*Zea mays*) and strawberries (*Potentilla ×ananassa*) or planted in orchard trees. Over the last two decades there has been a shift from these land uses to one dominated by residential housing and 'life style blocks' (Crowcroft 1992).

This shift in land use has had an unexpected impact on some of the forest remnants, which at the time of survey were mostly unfenced and nearing collapse. Many are now fenced off, replanted and some of the key weed species seen during the survey are being controlled or have been removed.

Eleven forest remnants were located in the area during the survey, of which at that time only two were formally protected: Whewell's Bush Scientific Reserve (11.49 ha) and a small (c.1 ha) forest on the Gilmour Farm, maintained as a Queen Elizabeth Trust open space covenant (D. Gilmour, pers. comm. 1985) and called here the Gilmour Trust Forest. As far as I can tell the protected status of the other remnants has not changed since I surveyed them in the 1980s. Further, at that time none of the non-reserved remnants had any obvious formal names and I am unaware of any subsequent naming, so for the purposes of this article I have retained the names I used during my survey. Regardless, the grid references and map provided (Fig. 1) make it obvious which remnants I examined and the names I used for them at that time.

All of the forest remnants examined are considered examples of 'dry' forests since the remnants are no longer subject to a seasonal regime of flooding and have an oxidised forest litter. Thus in 'dry' remnants the forest soil's humic layer is either absent or has been so seriously oxidised as a result of peripheral drainage that the canopy tree root systems are partially to almost entirely exposed. Correspondingly, 'wet' forests are defined as those remnants subjected to a natural flooding regime, or with a seasonally (naturally) high (or perched *sensu* Crowcroft 1992) ground water table, and an unoxidised forest litter (tending toward a forest peat).

Herbarium acronyms follow Thiers (2012). Nomenclature of plants usually follows that suggested by Cheeseman (1925), Allan (1961), Moore & Edgar (1970), Brownsey & Smith-Dodsworth (1989), Glenny (1996), Mitchell et al. (1997) and de Lange et al. (2012) except for *Radula* where I follow M.A.M. Renner (pers. comm.). Vegetation associations, being derived from field inspections only, are loosely based on the system proposed by Atkinson (1985).

THE FOREST REMNANTS

Most of the forest remnants examined (Fig. 1) have kahikatea/rimu or kahikatea/matai (*Prumnopitys taxifolia*) canopies with a developing tawa (*Beilschmiedia tawa*), pukatea (*Laurelia novae-zelandiae*), or titoki (*Alectryon excelsus* subsp. *excelsus*) understorey (Champion 1988). This forest composition reflects a long history of drainage of the surrounding landscape, sufficient to allow the establishment of tawa and titoki, which are

both intolerant of sites subjected to prolonged flooding (Champion 1988; de Lange 1996). Indigenous forest of this type is now largely all that remains within the eastern sector of the Hamilton Basin. Only a few examples of 'wet' kahikatea forest are left within the area, and these are mainly found scattered along the flood margins of the gullies within the Mangaonua-Mangaharakeke catchment system (Crowcroft 1992). The following briefly describes the vegetation, condition of each of the eleven remnants examined, and for the basin area, any notable species. All grid references are given in both NZMS 260 and Topo50 map series.

Marychurch Road Forest **(NZMS 260 S14 228738 / Topo50 BD34 126122) (Fig. 2)**

Figure 2. Marychurch Road forest remnant as viewed from the eastern side looking west.

At c. 11 ha this is the second largest of the eleven remnants visited. The forest is situated within a large swale on the western side of the Marychurch and Bellevue road junction. The forest consists of one large c. 10.5 ha area with a smaller (c. 0.5 ha) remnant separated by 30–40 m of arable ground. The larger area comprises a dense canopy of 15–20 m tall, young kahikatea, with rare emergent matai, rimu, pokaka (*Elaeocarpus hookerianus*), and lancewood (*Pseudopanax crassifolius*). This part of the forest is partially fenced, and is said to be a Maori Reserve (G. Appleton, pers. comm.), although I have not been able to confirm this.

A feature of the forest is the paucity of tawa and titoki, both typical of other 'dry' kahikatea forests of the basin (Champion 1988). Pukatea,

however, is common in parts of the understorey suggesting that the forest is still in an early transitory stage from 'wet' to 'dry' (Champion 1988).

At the time of the survey, Marychurch contained a unique botanical assemblage not seen in any of the other forests examined in this paper. The swale in which the forest has developed naturally ponds fog, resulting in a cooler, moister inner forest microclimate (see discussion on microclimates by de Lange 1996). Thus an especially luxuriant fern flora has developed; this includes such species as *Leptopteris hymenophylloides* and *Pneumatopteris pennigera* which dominate parts of the groundcover. This is unusual for the Hamilton Basin, where these ferns are more usually found in the wetter gullies rather than the drier surrounds, and of course in the larger forests of the adjacent ranges. The moister inner forest environment has also allowed the persistance of a rich (when compared to the other forest remnants discussed here) cryptogamic flora, which includes such notable species for the Hamilton Basin as the moss *Dicnemon dixonianum*, liverworts *Plagiochila gigantea, P. lyallii, Radula aneurismalis*, *R. strangulata, Schistochila appendiculata,* and the macrolichens *Nephroma australe, Pseudocyphellaria chloroleuca, P. dissimilis*, *P. granulata* and *P. hookeri.* The *Nephroma* and *Pseudocyphellaria granulata* are especially interesting as these are uncommon species in the greater Waikato, where they are usually found in the upper 'cloud' forest of the higher ranges west and south of the Hamilton Basin. Aside from this diverse fern and cryptogamic flora, a number of species with local distributions (see de Lange 1987a, b, 1996) in the Hamilton Basin were also found here in 1985; e.g., *Collospermum microspermum*, *Corybas trilobus*, *Earina autumnalis*, *Hymenophyllum armstrongii*, and *H. sanguinolentum*. Unfortunately, a brief visit to the remnant in 2011 failed to locate the *Collospermum*, *Corybas* and *Earina*, and it seems that they may now have been extirpated from this site which has continued to deteriorate since 1985.

The presence of the small fern *Hymenophyllum armstrongii* is especially noteworthy. *Hymenophyllum armstrongii* has a very local distribution in the western Waikato, being largely confined to sites above 600 m a.s.l. (e.g., Mt Pirongia and Mt Karioi) or cold 'frost flat' associations like those of the Tawarau Forest (Ogle & Druce 1987). In the eastern Waikato it is more common, especially along the ridges, tops and high points of the Coromandel, Kaimai and Mamaku Ranges. At Marychurch (c. 50 m a.s.l), specimens were discovered growing on the plank roots of kahikatea trees in the most shaded part of the forest. Currently this is only the second occurrence of this species in the Hamilton Basin that I am aware of (see de Lange 1987a). The discovery of this species in the basin proper adds to the small list of distinctive cooler climate species (or putting it another way,

plants typical of higher altitudes) in the Waikato which have until recently been scarcely documented from the area (see Gudex 1963; de Lange 1986, 1987b).

In 1986 Marychurch forest contained 105 vascular species (and one hybrid fern) compared to the 86 recorded from Whewell's (see below), and of these, 72 are common to both forests. In the 1980s I felt that the differences were at least partly due to the levels of disturbance experienced by both forests. Of the two, Whewell's has been more extensively drained, and subsequently it has also been the most 'interfered' with by reserve managers (Boase 1984; Champion 1988). Also the physiography of both forests differs, with Whewell's occupying a series of small swales and hummocks, while Marychurch is confined to a single deep swale, which has acted as a trap for water draining the surrounding land. Nevertheless, Marychurch has been damaged through the clearance of the southern end of the swale for pasture, which has left the forest margin exposed to the prevailing wind. This has caused the oxidation of the forest peat, thereby exposing the kahikatea root stocks to the prevailing wind, causing them to 'rock' and in many cases topple over and die. Furthermore, in 1986 there was unrestricted stock access to the bush margins, with the result that through the combination of wind and stock movement and browse most of the peripheral forest understorey had been severely damaged (however, at that time stock were being prevented from accessing the inner forest because of the interlocking maze of exposed kahikatea tree buttresses and roots that had already been exhumed through past oxidation of the forest margin litter and soil). Although stock could not access the inner portion of the forest, their impact on the damper peaty forest soil of the forest margins had caused severe damage through 'pugging' from their hooves during wet winter conditions. This has not only damaged the soil structure but exposed the kahikatea tree roots further. Consequently, through the lack of any natural 'buffer' between pasture and forest since 1986, there has been an ongoing degradation of the forest along the south-western margin of the forest.

Gilmour Farm **(NZMS 260 S14 237743 / Topo50 BD34 135127) (Fig. 3)**
A fenced c. 1 ha remnant accessed across private property from Bellevue Road (Fig. 3). In this remnant much of the understorey is absent and hares (*Lepus europaeus*) have severely damaged the regenerating saplings. The forest canopy is dominated by kahikatea, emergent tawa and occasional rimu. Titoki and white maire (*Nestegis lanceolata*) are frequent components of the understorey, which also includes a single karaka (*Corynocarpus laevigatus*) which was possibly planted by the previous landowners (D. Gilmour, pers. comm.).

Figure 3. Gilmour Farm forest remnant viewed from Bellevue Road.

The composition of the forest canopy shows a strong demarcation between kahikatea and tawa/titoki forest associations that suggests an underlying pedological cause. Elsewhere in the Hamilton Basin it has been recognised that the poorer draining gleyed Te Kowhai silt loam and the freer draining Bruntwood and Horotiu sandy loams support different forest types. Thus Te Kowhai silt loams tend to support pure kahikatea or kahikatea/rimu forest while the freer draining Bruntwood and Horotiu sandy loams support totara-dominated or tawa/titoki forest with white maire (de Lange 1987a, b; Champion 1988). Of those remnants examined in this survey, Gilmour Farm provides the best example of such demarcation. Indeed, there are few Hamilton Basin examples that I know of where such a clear-cut distinction in overlying forest cover based on underlying soils types can be seen.

***Gilmour Trust* (NZMS 260 S14 239741 / Topo 50 BD34 137125)**

In 1986 this forest remnant was at the point of collapse. Most of the major canopy trees were either moribund or dead. The forest formerly had been dominated by kahikatea, but as evidenced by the stumps most of these had been milled leaving a subcanopy of titoki. This forest remnant is interesting in that it contains a few battered specimens of houhere (*Hoheria sexstylosa*), the only ones known to the author from the 'dry' remnants of the basin. In 2011 a roadside inspection (at some distance) showed that the remnant had apparently been fenced, but the land was under different ownership and I was declined permission to inspect the forest further.

***Pencarrow Road* (NZMS 260 S15 196684 / Topo50 BD34 094068)**
This privately owned forest remnant (0.75 ha) has been extensively milled and browsed. All that remains now is a canopy of kahikatea, pokaka, and a single totara with little understorey. The forest had once contained rimu and more totara but these had been milled several years before my visit (L. Martin, pers. comm.). At the time of the survey the forest floor was dominated by an exotic pasture containing large patches of nettle (*Urtica urens*) and tangles of pohuehue (*Muehlenbeckia australis*). Only seven indigenous species were recorded.

***Duncan Road* (NZMS 260 S15 199684 / Topo50 BD34 097068)**
A privately owned forest (c. 3 ha) which at the time of the survey contained thirty indigenous species, several of which were not recorded from the other remnants of the survey area namely: *Callitriche petriei* subsp. *petriei*, *Gratiola sexdentata*, waoriki (*Ranunculus amphitrichus*), and poniu (*Rorippa palustris*). The forest structure had been severely damaged by wind throw and milling. As a consequence there were many open patches within the canopy.

The forest canopy contains about equal numbers of kahikatea, matai, rimu, pokaka, pukatea, rewarewa (*Knightia excelsa*), titoki, and tawa. In places a shrubby understorey dominated by taurepo (*Streblus heterophyllus*) and mapou (*Myrsine australis*) is present. During 1985 some taurepo supported the lichen *Pseudocyphellaria hookeri*, suggesting that the forest remnant then at least still preserved a relatively cool, moist microclimate. I was unable to visit this remnant in 2010 but a roadside inspection using binoculars suggested that it had significantly deteriorated and many of the taurepo seen were either dead or dying.

During 1985 a number of small ephemeral ponds covered parts of the forest floor and in these were found large patches of *Callitriche petriei* and waoriki. In addition to these species, the shaded cattle-pugged ground under the kahikatea trees was covered in large patches of *Callitriche muelleri*. This species often dominates such sites during the early spring with the plants dying off in summer. Poniu was also found scattered through the remnant, although most specimens were severely browsed and only plants growing in thickets of barberry (*Berberris glaucophylla*) were seen flowering and fruiting. In 2010, based on a roadside binocular survey, there was no evidence that any of these pools had survived.

In the 1980s the Duncan Road forest was an interesting example of the former lowland forest of the Hamilton Basin, and within the survey area it was the closest example to a 'wet' forest remnant found outside the adjacent gully systems. At the time of the survey the landowner (G. Black, pers.

comm.) commented that the remnant was useful for providing shelter for farm stock, and as such it was anticipated that further deterioration and species losses from the forest were likely. Even without a full survey it is evident that 25 years later this observation has come to pass.

***Forrest Road* (NZMS 260 S15 243663 / Topo50 BD34 141047)**
This forest remnant (c. 1 ha) is situated at the end of a large berry farm off the main Cambridge-Hamilton road and Forrest Road. It was surveyed in 1985. Although it was then surrounded by intensively cultivated land the forest canopy and understorey was still intact, and an indigenous vascular flora of nineteen species was recorded. At that time the canopy was entirely kahikatea though the milled remains of several totara indicate that the past forest structure of the area contained areas of totara-dominated forest. Some pukatea and titoki are emergent on the forest edge of the canopy, and the understorey was dominated by sapling tawa and taurepo. A healthy shrub layer of mapou, *Melicytus micranthus*, and small taurepo were present. The vines kohia (*Passiflora tetrandra*) and *Parsonsia heterophylla* were common throughout the forest tiers, while a dense pohuehue vineland was present on the exposed and damaged southern fringe of the forest. In 2010 access to the forest was declined and much of the remnant was now obscured by large houses and their attendant 'life style blocks', all of which had largely replaced the strawberry fields and maize paddocks observed in 1985. Despite the lack of access a roadside binocular inspection suggested that the canopy composition had not changed.

***St Peter's School* (NZMS 260 S15 237653 / Topo50 BD34 135037) (Fig. 4)**
This small remnant (c. 1 ha) on the grounds of the privately run St Peter's School was formerly part of a much larger kahikatea-dominated forest that also included Forrest Road, Pencarrow Road, and Duncan Road remnants discussed above (L. Martin, pers. comm.). In 1985 the forest canopy of this remnant was pure kahikatea, with a poorly developed understorey of titoki, mahoe, taurepo, cabbage tree (*Cordyline australis*) and rimu. A single black maire (*Nestegis cunninghamii*), the only one discovered in the survey, was located on the forest margin.

In places the forest floor of the remnant was covered in patches of white-flowered violet (*Viola odorata*) and small shrubby specimens of holly (*Ilex aquifolium*). Although several seedlings of *Pittosporum tenuifolium* subsp. *tenuifolium* were found, these were unlikely to be indigenous as they were not of the typical Waikato form (which has small purple-blotched leaves, with tomentose, undulose margins, superficially not unlike mapou) and they are probably self-introduced from nearby planted specimens on the school grounds.

Figure 4. St Peters School forest remnant from St Peter's School Grounds. The fountain and oxidation pond were absent when this remnant was first surveyed in 1985.

In 2010 this remnant had undergone much modification, with the southern side now given over to a water feature and oxidation pond (Fig. 4), the remnant understorey had been planted with a range of inappropriate 'native' plants (including cultivars) and the forest floor was festooned with sculptures. While the canopy and understorey remained unchanged the long-term prospects for the indigenous integrity of this forest remnant are doubtful.

Whewell's Bush Scientific Reserve **(NZMS 260 S14 199729 / Topo50 BD34 097113) (Fig. 5)**

The flora of this 11.49 ha reserve has been especially well documented (see discussion on this remnant by Champion (1988)). As such there is little need to discuss the forest in detail here, and the reader is recommended to consult either Boase (1984) or Champion (1988).

Whewell's comprises two broad forest associations, a peripheral kahikatea forest and a central tawa/pukatea forest. The forest has been partially milled and extensively drained (Boase 1984) but still contains an indigenous vascular flora of 86 species. Of these, Boase (1984) failed to locate three during his survey: *Machaerina tenax, Callitriche muelleri*, and *Eleocharis acuta*. All of these have since been relocated, although the *Machaerina*

occupies a vulnerable situation and is unlikely to persist in the long-term. Examination of four smaller, unreserved forest remnants adjacent to Whewell's located healthy populations of all these species (these remnants are included within the plant listing for Whewell's Scientific Reserve in the Appendix). An interesting feature of these remnants is the abundance of pokaka, a species not yet recorded from Whewell's proper; this is unusual as pokaka is an almost ubiquitous component of Waikato kahikatea forest remnants. The only species presently confined in the survey area to Whewell's Bush Scientific Reserve is *Hymenophyllum dilatatum*.

Figure 5. Whewell's Bush Scientific Reserve.

Records of black maire for the reserve remain unsubstantiated (see Champion 1985). All material at WAIK referred to this species that I have seen is immature white maire. Champion (1985) also recorded sapling *Pseudopanax discolor* and *Raukaua simplex* from the forest; I have verified the specimens in WAIK, but these species are considered introductions, although neither is cultivated nearby. *Pseudopanax discolor* is commonly grown in parts of nearby Hamilton, and its fruits are readily dispersed by exotic and indigenous birds, while *Raukaua simplex* was known to have been inappropriately planted in Whewell's Bush in the 1980s by the then Department of Lands & Survey (C. Annan, pers. comm.).

Lee Martin Road (NZMS 260 S14 214725 / Topo50 BD34 112109) (Fig. 6)

Figure 6. Lee Martin Road forest remnant viewed from Lee Martin Road.

At c. 0.5 ha this is the smallest remnant visited during the 1985 portion of this survey. The remnant was once part of a larger forest of which Whewell's and Marychurch were also part. Lee Martin is of some interest because it contains a single tanekaha (*Phyllocladus trichomanoides*), a tree otherwise only known naturally in the eastern Hamilton Basin from a few locations at the basin's northern end (de Lange 1987b; de Lange 1989a), though it is common in the adjoining, easterly Pakaroa Range. In 1985 the canopy trees of the remnant consisted of mostly dead or dying kahikatea, a single totara (the second specimen found in the survey area), several titoki, tawa, white maire, and taurepo. Several specimens of mapere (*Gahnia xanthocarpa*) grew in the rotted stumps of kahikatea. This species is very local in the southern Hamilton Basin, with the most significant populations I have seen confined to the gully systems of that area (see de Lange 1987a). In 1985 an open induced-pasture dominated by hemlock (*Conium maculatum*) and Jerusalem cherry (*Solanum pseudocapsicum*) covered the forest floor. One interesting loss since this survey was completed has been cabbage tree (*Cordyline australis*), all adults having succumbed to the phenomena known as 'Sudden Decline' by 1992.

While the long-term prospects for this remnant in 1985 seemed rather unlikely, a brief roadside inspection in 2010 discovered the reverse. The remnant had been fenced, and a new driveway established leading to a house abutting the forest (Fig. 7). The house owners have obviously taken

Figure 7. Lee Martin Road forest remnant showing new driveway and house nestled on margin of remnant.

to managing and 'restoring' the forest. Although cabbage tree had yet to re-establish, many of the kahikatea that had been in ill-thrift were now sporting a healthy crown of foliage. The only obvious absence (as seen from the road) was the mapere. A portion of the remnant had been planted with tarata (*Pittosporum eugenioides*), a species not known from the survey area though it is common in the nearby Pakaroa Range, and hybrid golden totara (*Podocarpus acutifolius* × *P. totara* var. *totara*).

***Berkley Avenue* (NZMS 260 S14 154750 / Topo50 BD34 052134) (Fig. 8)**

A small remnant (c. 1 ha) bordering the extensive Mangaonua-Mangaharakeke catchment system (see de Lange 1987a; Crowcroft 1992) on the outskirts of the suburb of Hillcrest. The forest occupies a small tributary gully draining into the Mangaonua Stream and was in a reasonably healthy condition. The remnant consists of a young canopy

Figure 8. Berkley Ave forest remnant—all but obscured by residential houses.

of kahikatea although with some emergent rimu, cabbage tree, titoki, tawa and pukatea also present. Little understorey was present largely due to vandalism (i.e., trees being cut down by children), although occasional taurepo and mahoe were present. On the gully side of the remnant a dense stand of mapere was found, while most of the forest floor was covered in wandering jew (*Tradescantia fluminensis*) and *Selaginella kraussiana*. One of the kahikatea supports a small colony of *Bulbophyllum tuberculatum*. A brief inspection in 2011 revealed no obvious changes.

***Masters Avenue* (NZMS 260 S14 147758 / Topo50 BD34 045142) (Fig. 9)**
This remnant is the largest piece of a once extensive kahikatea forest that dominated the former Masters Farm (A. McMeiken, pers. comm.). A few trees of this larger forest still persist near Orchard Park (Student Accommodation of the nearby University of Waikato) and at the back of Silverdale School. The remnant is situated in the middle of a city park (now known as Hillcrest Park) behind the Masters Avenue shopping-centre. The forest is especially well known to the author, who as a pre-schooler in the 1960s attended the nearby kindergarten, and roamed the 'soggy bottomed' remnant on nature walks there with his parents and kindergarten teachers. During the late 1960s the forest was very wet, with large peaty pools, a dense understorey of kiekie (*Freycinetia banksii*) and other vines, and a thick groundcover of sedges and shrubs. The remnant remained in this condition until 1972 when the forest understorey and shrub layers were severely damaged when an asphalt path was placed through the forest to access a Scout's clubroom that had been built within the remnant margin, I believe, during the 1960s. Further drainage operations and forest

Figure 9. Masters Ave forest remnant as viewed from Masters Ave shops car park.

clearance continued until by 1977 council workers had effectively destroyed any vestiges of the former indigenous forest floor vegetation to 'make mowing and maintenance of the surrounding park grounds easier, and to prevent youths loitering in the area' (B. McLeary, pers. comm.). As a result, one of the few good south eastern Hamilton City examples of 'wet' kahikatea dominated forest was reduced by the 1980s to a stand of mature trees with little potential to regenerate.

In the mid 1980s the forest consisted of a dense canopy of young kahikatea and pokaka, with occasional emergent pukatea, cabbage tree, titoki, white maire, and taurepo. A single hinau (*Elaeocarpus dentatus*) (Fig. 10), only the fourth natural specimen that I know of from the basin proper was also found here (and it persists to this day). During April 1989 a storm dislodged several plants of *Bulbophyllum tuberculatum* from the forest canopy (and the species was still present there in 2010). This orchid is now known to be locally common on kahikatea in kahikatea-dominated forests of the greater Waikato. All trace of the large tangles of kiekie and supplejack (*Ripogonum scandens*) that I saw in my childhood had long gone.

Despite the open nature of the present forest some interesting indigenous understorey species still persist. During 1984–1987 occasional specimens of poroporo (*Solanum lacinatum*) appeared within the remnant but these were invariably killed before reaching reproductive maturity by mowers. In the few places out of reach of mowing, such as around tree trunks, small shrubby mapou have remained and within these small-flowered nightshade (*Solanum nodiflorum*) sometimes establishes. On the mowed turf, pennyworts (*Hydrocotyle* spp.) became locally common, while the sedges *Carex inversa* and naturalised *C. divulsa* are now well established, as a consequence of past regular mowing.

Figure 10. Solitary hinau (*Elaeocarpus dentatus*) growing on south-eastern side of Masters Ave forest.

Other than the pennyworts, by 1988 the forest floor was largely devoid of any indigenous vegetation, although the Hamilton City Council had tried planting young kahikatea saplings in an attempt to restore the forest. By 1989 the opening up of the forest understorey to the elements had killed most of these plantings and vandalism has claimed the rest. In 1994 a new planting programme initiated by the local High School (Hillcrest High) (B. Chibnall, pers. comm.) together with the council fencing off the remnant to restrict people and traffic has resulted in an improvement in this forest's condition. A visit in 1999 showed a marked improvement in the forest condition, while many of the ecologically compatible plantings were thriving. However, some of the plantings comprised species not suited to the area or indeed indigenous to the Hamilton Basin. No attempt was made during the visit to update the species list presented here.

DISCUSSION

The eleven forest remnants surveyed had a combined flora of 136 indigenous vascular taxa (see Appendix). By comparison four 'wet' kahikatea remnants (all of which are under 1 ha) surveyed from the adjacent Mangaonua, Mangaomapu and Mangaharakeke gullies contained a total of 180 taxa (initial data from de Lange 1987a; updated to include four new additions: poroporo (*Solanum laciniatum*), poniu, small-flowered nightshade and *Lobelia anceps*). Specifically, the 'wet' remnants contained more taxa (numbers given in parenthesis) within the following phylogenetic groupings, Lycophytes (1), Ferns (6), Eudicots and Core Eudicots (28), and Monocot I & II (10) (Table 1).

Table 1. Different floral composition by taxa (determined by broad taxonomic groupings) from 'dry' versus 'wet' remnants within the survey area.

Taxonomic Grouping [1]	Dry Forest Remnants [2]	Wet Forest Remnants [3]
Lycophytes	–	1
Ferns	46	52
Gymnosperms	5	4
Magnoliids	3	3
Eudicots and Core Eudicots	42	70
Monocot I & II	40	50
TOTAL	136	180

1. Values include hybrid combinations.
2. Based on a survey sample of 11 remnants (this article)
3. Based on a survey sample of 4 remnants (data from de Lange 1987a)

Possibly the most striking difference between the 'dry' and 'wet' remnants is the absence in the former of the distinctive shrubby *Coprosma* species

(e.g., *C. areolata*, *C. propinqua*, *C. rigida*, *C. tenuicaulis*), the small tree *C. grandifolia* and rohutu (*Neomyrtus pedunculata*). These are species typical of the wetter or cooler kahikatea remnants of the greater Waikato, where they usually dominate the understorey and light wells within canopy clears (e.g., Awaroa Wildlife Management Reserve, Barrett Road Bush, Koromatua Gully System, Hammond Bush, and Mangapu Forest; de Lange 1985, 1986, 1989b, 1996; de Lange & Compton 1985; Champion 1988). Of those lianes typical of 'wet' western Waikato kahikatea remnants the scramblers *Fuchsia perscandens* and *F.* ×*colensoi* were absent from the 'dry' remnants surveyed here, while kohia, pohuehue, and *Parsonsia heterophylla* (all common in 'dry' remnants) were often dominant. However, the most significant absences from the 'dry' remnants occur within the dicotyledon herbs. These plants are especially sensitive to the drying out of the forest floor, as well as the encroachment of introduced weeds like wandering jew and *Selaginella*.

As is well known, a major constraint dictating floral diversity is the area of habitat available. Thus the smaller a forest fragment, the lower its expected diversity (MacArthur & Levins 1964; Diamond 1975; Harris 1984; Soulé 1987). However, within the 'wet' remnants surveyed (de Lange 1987a), area does not appear to be as significant a constraint on diversity, possibly because these remnants are subjected to seasonal flooding, and so maintain a high water table for most of the year, and situated as they are in gully floors, they are not subjected to the same level of dessication that the 'dry' remnants suffer due to the year-round influence of the prevailing wind. However, the importance of size and diversity of habitats offered within 'dry' forest remnants investigated is much more apparent. For instance, of the 136 taxa recorded from the 'dry' remnants, the majority were confined to the two largest (>10 ha) remnants surveyed: Marychurch and Whewell's. This is the same pattern observed for similar-sized remnants elsewhere in the basin, and is considered directly attributable to desiccation, the influx of aggressive weed species such as wandering jew, and possibly forest management (Gudex 1954; Champion 1988; Whaley et al. 1997).

It is anticipated that as the 'dry' forest remnants continue to dry out, taxa indicative of formerly 'wet' conditions within them will become more scarce and eventually die out (as indeed has happened in several of the remnants over the last 25 years). However, these anticipated losses will, to some extent, be compensated for by an increase in indigenous species favouring drier ground; e.g., titoki, tawa, porokaiwhiri (*Hedycarya arborea*), and the grasses *Microlaena avenacea*, *M. stipoides*, and *Echinopogon ovatus*. However, an associated increase in the number of naturalised species (which, regrettably, were not surveyed in the 1980s) establishing within these 'dry' forests is also

likely, and some of these (e.g., wandering jew) will have a serious impact on the lower forest tiers and recruitment of canopy species (Kelly 1984a, b; Standish et al. 2001). Another change in vegetation structure within the 'dry' remnants has come about through the virtual elimination of mature cabbage trees through the depredations of the myo-plast-like organism popularly known as 'Cabbage Tree Sudden Decline' (Beever et al. 1996). In 1990 the first signs of this apparent disease were manifest at Lee Martin Road, and by 1997 no adult specimens free of the ailment were left in any of the remnants surveyed. This is particularly concerning because following this loss very few seedlings of this once common tree have been found in the survey area, and that despite the abundance of this tree in adjacent gully systems as well as in urban plantings nearby. In that context it is perhaps notable that during the same survey time period, no cabbage tree losses were experienced within any of the 'wet' remnants, and nor has this species been lost from these remnants since.

In the 1980s and early 1990s I became convinced that these 'dry' forest remnants would, even if protected, replanted and 'rehydrated' (i.e., following realignment, or even blocking of nearby drains), be unlikely to return to their former condition. Further, I did feel that there would be continued loss of those less resilient indigenous plants from the remnants as they continued to dry out. In some cases this seems to have happened, notably for those remnants whose management regimes have not changed since the 1980s (e.g., Duncan Road Forest). However, looking back over the last 25 years, I had not foreseen the shift in surrounding landuse to one dominated by 'lifestyle blocks' including the construction of rural mansions and the renewed interest in indigenous forest remnants by their (often new) proud landowners. Whilst in many cases this has resulted in the proliferation of often inappropriate and ecologically improbable plantings, the upside has been that some forest remnants considered in terminal decline in the 1980s (e.g., Lee Martin Road) have now improved condition. Others, like Masters Ave Bush have at least held their own, though in time the plantings used there will alter the canopy to a composition not compatible with the past indigenous forest composition of the Hamilton Basin. In this regard the spread of houhere (*Hoheria populnea*) and hybrid *Pseudopanax* (*P. crassifolius* × *P. lessonii*), plants that are not indigenous to the Hamilton Basin, is especially concerning.

Despite the expected losses, there are some interesting examples of unexpected rediscoveries, which offer some hope. For example Boase (1984) considered the loss of *Callitriche muelleri* from Whewell's Bush Scientific Reserve as proof of the gradual drying out of the inner forest. However, during this survey this species was rediscovered there, and it was later

deduced that in 'dry' Hamilton Basin forest remnants *C. muelleri* behaves as an annual, germinating on wet (often cattle pugged soil) in late winter, and completing its life cycle before the ground has dried out sufficiently by late spring. Other wetland species can also persist by colonising drains or rotting trunks; e.g., *Eleocharis acuta*.

Nevertheless, these examples are unusual and there are now more losses of indigenous plants than rediscoveries. While replanting does offer at least a cosmetic improvement to the visual impact of some forest remnants, the long term effect of this action is still unclear, while in the short term the spread of 'alien' indigenous plants is concerning (see above). Clearly unless plants put into these remnants are derived from those eco-sourced from the remaining indigenous forest remnants of the Hamilton Basin, any plantings whether of the appropriate species or not, are more likely to be potentially damaging to the genetic integrity of the Hamilton Basin indigenous flora than not. It is this author's view that the only viable long-term prospect for maintaining a Hamilton Basin kahikatea-dominated forest ecosystem in the south-eastern portion of the basin now is to protect those few examples left with a natural flooding regime (effectively all gully remnants), and to replant where possible, suitable wet and/or flood prone gully systems with species eco-sourced from the surrounding indigenous forest remnants described here so as to ensure the long-term survival of the local Hamilton Basin genetic stock of indigenous plants. With regard to this suggestion it is very encouraging that such measures are being taken by some private landowners in the survey area with impressive results; e.g., the Morris Property, Matangi. One can only hope that these measures draw sufficient recognition as to encourage the development of a complete revegetation project by the administering authorities.

ACKNOWLEDGEMENTS

This article, unearthed from the bowels of an ancient computer file, has finally seen the light of day through pressure on the author by friends and colleagues. The first version was originally written for the *Auckland Botanical Society Journal* in 1989 but an untimely computer crash, and lack of electronic back up contributed to a very long period of neglect. Of course this article, based as it is on a manuscript mostly abandoned for 23 years, and then revised (2012) with the virtual lack of vital updating field work is a risky undertaking. Nevertheless I decided to publish this article because even if I have inadvertently overlooked some other seminary works on the Hamilton Basin vegetation, got some facts wrong and the work, being empirical, may not be defensible (ecologically speaking), this account at least provides a useful historical context of the remnants that I knew as a child

and teenager during a time when I lived in Hamilton (1966–1990). That was a time when many people considered the Hamilton Basin to be nothing more than one boring 'Great Green Desert' illuminated mostly by vistas of green grass and cows, and thus scarcely worth bothering with botanically. It is now great to see that views have changed and that Hamiltonians now have an interest in Hamilton's forest remnants and are attempting not only their restoration but also that of other associated indigenous vegetation systems. This is a significant shift in attitudes that I feel needs to be applauded.

For this article's 'conception' I remain indebted to Peter and Bruce Morris (father and son) who accompanied me in the field during my early botanical forays (1983–1989). I also thank the past and current landowners of many of the forest remnants I visited, notably my former Hillcrest High School mates Grant Appleton and Colin Masters; farmers Greg Black, David Gilmour, Lee Martin, and retired orchardist Andrew McMeiken for comments about the forest remnants of the survey area. Alas many of these people have now passed on. Hillcrest High School Head of Science Brett Chibnall commented on that school's planned restoration of Masters Ave Bush to me in 1994, while Bill McLeary former head of the Hamilton City Parks (1982–1986) told me about the past management of that forest remnant. Chris Annan, Ranger, Department of Conservation, Waikato Area Office, commented on the attempted management of Whewell's Bush Scientific Reserve by the former Lands & Survey Department during the 1980s. In hindsight I now regret that I undertook my survey at a time when it was not fashionable to study naturalised plants and—*even worse*—consider cryptogamic plants and mycobiota. As some redress I did try to collect these in my 'quick' recent visits to some of the remnants in 2009, 2010 and 2011. For assistance with these I thank Jessica Beever, John Braggins and Matt Renner. However, as judged from the meagre pickings I made, I am sure that future bryologists and/or lichenologists would find these forest remnants worthy of critical investigation. Also I express my sincere gratitude to ('Prof') J.D. MacCraw, Rhys Gardner, Gillian Crowcroft, Jack MacKinder, David Norton and Paul Champion, all of whom provided encouragement and constructive criticism on the myriad past drafts of this article delivered to them at various times over the last 25 years or so of this articles protracted 'gestation'. I thank here also Jeremy Rolfe who kindly prepared the map used for Figure 1 and reviewed the text. Finally, to my parents Leany and Wim, and those past teachers (names all forgotten) of my former Kindergarten (Masters Ave) (1968–1970) and most especially my Standard Four teacher Carolyn Smith (1977) for fostering my love of nature in those early formative years—a sincere thank you!

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Appendix: The indigenous vascular flora of the 'dry' Kahikatea forest remnants of the southeastern Hamilton Basin

	Family	Marychurch	Gimour Farm	Gilmour Trust	Pencarrow Road	Duncan Road	Forrest Road	St Peter's School	Whewell's Bush Scientific Reserve	Lee Martin Road	Berkley Avenue	Masters Avenue	Herbarium Voucher
Ferns (46)													
Adiantum cunninghamii	Pteridaceae	+							+				
A. hispidulum	Pteridaceae										+		
Asplenium bulbiferum	Aspleniaceae	+							+				
A. flaccidum	Aspleniaceae	+		+		+	+	+	+	+	+		
A. gracillimum	Aspleniaceae	+							+				
A. oblongifolium	Aspleniaceae	+							+				
A. polyodon	Aspleniaceae	+							+				
A. bulbiferum × *A. flaccidum*	Aspleniaceae	+											
Blechnum chambersii	Blechnaceae	+							+				
B. filiforme	Blechnaceae	+	+	+					+			+	
B. fluviatile	Blechnaceae	+							+				
B. membranaceum	Blechnaceae	+											
B. minus	Blechnaceae	+		+									
B. novae-zelandiae	Blechnaceae	+							+				
Cyathea cunninghamii	Cyatheaceae								+				
C. dealbata	Cyatheaceae	+		+					+				
C. medullaris	Cyatheaceae	+							+				

	Family	Marychurch	Gimour Farm	Gilmour Trust	Pencarrow Road	Duncan Road	Forrest Road	St Peter's School	Whewell's Bush Scientific Reserve	Lee Martin Road	Berkley Avenue	Masters Avenue	Herbarium Voucher
Dicksonia fibrosa	Dicksoniaceae	+							+				
D. squarrosa	Dicksoniaceae	+							+				
Deparia petersenii subsp. *congrua* (incl. *D. tenuifolia*)	Athyriaceae	+							+			+	
Diplazium australe	Athyriaceae	+							+	+	+		
Doodia australis	Blechnaceae	+		+					+	+	+		
Histiopteris incisa	Dennstaedtiaceae	+	+						+				
Hymenophyllum armstrongii	Hymenophyllaceae	+											AK 329751
H. dilatatum	Hymenophyllaceae								+				
H. sanguinolentum	Hymenophyllaceae	+											
Hypolepis ambigua	Dennstaedtiaceae	+		+					+	+			
H. distans	Dennstaedtiaceae	+							+				
H. lactea	Dennstaedtiaceae	+											
H. rufobarbata	Dennstaedtiaceae	+											
Lastreopsis hispida	Dryopteridaceae	+											
L. glabella	Dryopteridaceae	+							+				
L. microsora subsp. *pentangularis*	Dryopteridaceae	+											
Leptopteris hymenophylloides	Osmundaceae	+							+				
Microsorum pustulatum subsp. *pustulatum*	Polypodiaceae	+				+	+		+			+	

	Family	Marychurch	Gimour Farm	Gilmour Trust	Pencarrow Road	Duncan Road	Forrest Road	St Peter's School	Whewell's Bush Scientific Reserve	Lee Martin Road	Berkley Avenue	Masters Avenue	Herbarium Voucher
M. scandens	Polpyodiaceae	+	+			+			+				
Paesia scaberula	Dennstaedtiaceae	+							+				
Pellaea rotundifolia	Pteridaceae	+		+					+				
Pneumatopteris pennigera	Thelypteridaceae	+							+				
Polystichum neozelandicum subsp. *neozelandicum*	Dryopteridaceae	+							+				
P. silvaticum	Dryopteridaceae	+											
Pteris macilenta	Pteridaceae	+							+				
P. tremula	Pteridaceae	+							+			+	
Pteridium esculentum	Dennstaedtiaceae	+	+	+					+				
Pyrrosia eleagnifolia	Polypodiaceae	+	+	+		+	+	+	+		+	+	
Rumohra adiantiformis	Dryopteridaceae	+							+				
Gymnosperms (5)													
Dacrycarpus dacrydioides	Podocarpaceae	+	+	+	+	+	+	+	+	+	+	+	AK 319329
Dacrydium cupressinum	Podocarpaceae	+		+		+		+	+		+		AK 329789
Phyllocladus trichomanoides	Phyllocladaceae									+			WAIK 7402
Podocarpus totara var. *totara*	Podocarpaceae				+					+			WAIK 7403
Prumnopitys taxifolia	Prumnopityaceae	+							+				
Magnoliids (3)													
Beilschmiedia tawa	Lauraceae	+	+	+		+	+		+		+	+	

	Family	Marychurch	Gimour Farm	Gilmour Trust	Pencarrow Road	Duncan Road	Forrest Road	St Peter's School	Whewell's Bush Scientific Reserve	Lee Martin Road	Berkley Avenue	Masters Avenue	Herbarium Voucher
Hedycarya arborea	Monimiaceae	+							+				
Laurelia novae-zelandiae	Atherospermataceae	+	+	+		+	+	+	+		+	+	
Monocots I (14)													
Astelia solandri	Asteliaceae	+				+			+				
Bulbophyllum tuberculatum	Orchidaceae										+	+	
Collospermum hastatum	Asteliaceae	+				+			+			+	
C. microspermum	Asteliaceae	+											
Cordyline australis	Asparagaceae	+	+	+		+	+	+	+	+	+	+	
Corybas trilobus	Orchidaceae	+											
Dendrobium cunninghamii	Orchidaceae					+			+				
Drymoanthus adversus	Orchidaceae	+			+	+	+	+		+		+	
Earina autumnalis	Orchidaceae	+				+							
E. mucronata	Orchidaceae	+		+		+	+		+	+			
Freycinetia banksii	Pandanaceae	+							+			+	
Gastrodia aff. *sesamoides*	Orchidaceae											+	AK 329515
Lemna aff. *disperma*	Araceae	+							+				
Ripogonum scandens	Ripogonaceae	+		+					+	+		+	
Monocots II – Commelinids (26)													
Carex dissita	Cyperaceae	+							+				

	Family	Marychurch	Gimour Farm	Gilmour Trust	Pencarrow Road	Duncan Road	Forrest Road	St Peter's School	Whewell's Bush Scientific Reserve	Lee Martin Road	Berkley Avenue	Masters Avenue	Herbarium Voucher
C. inversa	Cyperaceae	+							+		+	+	
C. lambertiana	Cyperaceae	+							+		+		
C. lessoniana	Cyperaceae	+											
C. secta	Cyperaceae	+		+									
C. solandri	Cyperaceae	+							+		+		
C. virgata	Cyperaceae	+							+			+	
Cyperus ustulatus	Cyperaceae								+				
Echinopogon ovatus	Poaceae									+		+	
Eleocharis acuta	Cyperaceae								+				
Gahnia setifolia	Cyperaceae	+											
G. xanthocarpa	Cyperaceae									+	+		
Isolepis inundatus	Cyperaceae	+											
I. reticularis	Cyperaceae	+							+			+	
Juncus australis	Juncaceae			+	+								
J. edgariae	Juncaceae	+							+				
J. planifolius	Juncaceae	+							+				
Machaerina tenax	Cyperaceae								+				
Microlaena avenacea	Poaceae	+							+				
M. stipoides	Poaceae	+	+	+		+	+	+	+	+	+	+	
Oplismenus hirtellus subsp. *imbecillis*	Poaceae	+										+	

	Family	Marychurch	Gimour Farm	Gilmour Trust	Pencarrow Road	Duncan Road	Forrest Road	St Peter's School	Whewell's Bush Scientific Reserve	Lee Martin Road	Berkley Avenue	Masters Avenue	Herbarium Voucher
Rytidosperma biannulare	Poaceae								+				
R. unarede	Poaceae	+											
Typha orientalis	Typhaceae								+				
Uncinia distans	Cyperaceae	+											
U. uncinata	Cyperaceae	+							+				
Eudicots (3)													
Clematis paniculata	Ranunculaceae	+							+				
Knightia excelsa	Proteaceae	+				+			+				
Ranunculus amphitrichus	Ranunculaceae					+							
Core Eudicots (39)													
Alectryon excelsus subsp. *excelsus*	Sapindaceae	+	+	+		+	+	+	+	+	+	+	
Aristotelia serrata	Elaeocarpaceae	+							+		+		
Callitriche muelleri	Plantaginaceae	+				+			+			+	
C. petriei subsp. *petriei*	Plantaginaceae					+							
Calystegia sepium subsp. *roseata*	Convolvulaceae	+	+	+		+	+	+	+				
Cardamine corymbosa agg.	Brassicaceae	+											
Carpodetus serratus	Rousseaceae	+						+					
Coprosma robusta	Rubiaceae										+	+	
Corynocarpus laevigatus	Corynocarpaceae			+									AK 304223
Elaeocarpus dentatus	Elaeocarpaceae											+	WAIK 4630

	Family	Marychurch	Gimour Farm	Gilmour Trust	Pencarrow Road	Duncan Road	Forrest Road	St Peter's School	Whewell's Bush Scientific Reserve	Lee Martin Road	Berkley Avenue	Masters Avenue	Herbarium Voucher
E. hookerianus	Elaeocarpaceae	+			+	+	+		+			+	AK 319318
Geniostoma ligustrifolium var. *ligustrifolium*	Loganiaceae	+							+				
Gratiola sexdentata	Plantaginaceae					+							
Griselinia lucida	Griseliniaceae	+											
Hoheria sexstylosa	Malvaceae			+									
Hydrocotyle heteromeria	Apiaceae	+							+			+	
H. microphylla	Apiaceae	+										+	WAIK 6018
Hydrocotyle moschata var. *moschata*	Apiaceae	+										+	
Hydrocotyle moschata var. *parvifolia*	Apiaceae	+										+	
Leucopogon fasciculatus	Ericaceae	+											
Lobelia anceps	Campanulaceae								+				
Melicytus micranthus	Violaceae						+						
M. ramiflorus subsp. *ramiflorus*	Violaceae	+	+	+				+	+		+		
Metrosideros diffusa	Myrtaceae	+	+	+					+				
M. perforata	Myrtaceae	+		+					+				
Muehlenbeckia australis	Polygonaceae	+	+	+	+	+	+	+	+	+	+	+	
Myrsine australis	Primulaceae	+		+		+	+	+	+	+			
Nertera villosa	Rubiaceae	+											
Nestegis cunninghamii	Oleaceae							+					AK 329758

	Family	Marychurch	Gimour Farm	Gilmour Trust	Pencarrow Road	Duncan Road	Forrest Road	St Peter's School	Whewell's Bush Scientific Reserve	Lee Martin Road	Berkley Avenue	Masters Avenue	Herbarium Voucher
N. lanceolata	Oleaceae	+	+	+					+	+		+	
Parsonsia heterophylla	Apocynaceae	+	+	+		+	+	+	+				
Passiflora tetrandra	Passifloraceae	+	+	+		+	+	+	+				AK 329790
Pseudopanax crassifolius	Araliaceae	+		+					+				
Rorippa palustris	Brassicaceae					+							WAIK 10807
Rubus australis	Rosaceae	+											
Senecio minimus	Asteraceae								+				
Solanum aviculare var. *aviculare*	Solanaceae			+									
S. laciniatum	Solanaceae											+	
S. nodiflorum	Solanaceae										+	+	
Streblus heterophyllus	Moraceae	+	+	+		+	+	+	+	+		+	