UNDER-COLLECTED AREAS IN THE BAY OF PLENTY

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Species richness is a relative term that refers to the number of species present in a taxonomic group or a given area. It is well documented that species richness varies across the earth and several hypotheses try to explain the observed patterns. Some taxa are more species rich than others, e.g. *Coprosma* versus *Disphyma*. Some parts of the world are more species rich than others. One of first hypotheses to explain the latter is based upon the idea that there is a latitudinal gradient in species richness: species richness is higher in tropical regions than in temperate or polar regions. In the context of island biogeographic theory more relevant to New Zealand, a recent hypothesis predicts that species diversity can drive speciation, i.e. the probability of extinction and speciation for each species on an island increases as the number of species increase (Emerson & Kolm, 2005)—there has been resistance to this idea (Pereira et al., 2007). Local species richness can be influenced by many biotic and abiotic factors and areas with diverse ecological conditions are often associated with higher species richness.

At the heart of determining which areas are species rich is raw data regarding what grows where. In the realm of plants, herbaria play a fundamental role in providing such data because not only are records vouchered (a crucial necessity to verify identifications, etc.), but they are now-a-days also handily geo-referenced. However, collecting intensity places a limitation on the use of natural history records for biodiversity studies. While herbarium specimens provide an abundant source of collections, the number of localities over a large area is often small, and so areas of high endemism often coincide with areas of high collecting intensity (Murray-Smith et al., 2008).

Beadel et al. (2009) have recently published a checklist of indigenous and naturalised plants in the Bay of Plenty as defined by 16 ecological districts (ED). The list was

compiled by an amalgamation of vouchered specimens as well as published and unpublished reports of plant observations. Species are reported for each ED. The Rotorua Lakes ED was identified as the most species rich probably due to a combination of "botanical investigative" intensity and ecological diversity. An analysis of this work revealed a large number of records not vouchered in the National Forestry Herbarium (NZFRI) or any other herbarium leading me to the conclusion that parts of the Bay of Plenty were under-collected, but how to provide some substance to this assertion?

I extracted NZFRI data relevant to the Bay of Plenty area (excluding records marked as being cultivated). One of the difficulties in reporting species per ED, as Beadel et al. (2009) have done, is that areas of different sizes are being compared with each other. For a species richness analysis a region of interest is divided into equal sized cells. I opted to use both $^1/_4$ degree and $^1/_{10}$ degree cells which in this part of the globe correspond to cell areas about 28 km x 22 km and 11 km x 9 km in size, respectively. I also specified five size classes for plotting the number of species per cell to a map.

I calculated the number of species per cell and mapped the results to Google Earth (Figure 1). The cells obviously do not follow the borders of the EDs, so that some EDs will contain more than one full cell and parts of other cells. A single cell at the $^1/_4$ degree resolution within the Rotorua Lakes ED comes out as the winner with 926 taxa vouchered from there. This cell is flanked by those having 290 and 293 taxa partly within the same ED (Figure 1A). It is evident that species richness is a relative term when comparing Figures 1A and B. At the $^1/_{10}$ degree resolution, one cell within the Rotorua Lakes ED remains the most species rich, this time with 644 vouchered taxa. This cell is centred squarely on Rotorua town (Figure 1 B). Of greater interest to me are the large numbers of cells with a relatively low number of species. At the $^1/_4$ degree resolution about 40% of the cells have 50 species per cell or less. The biggest losers

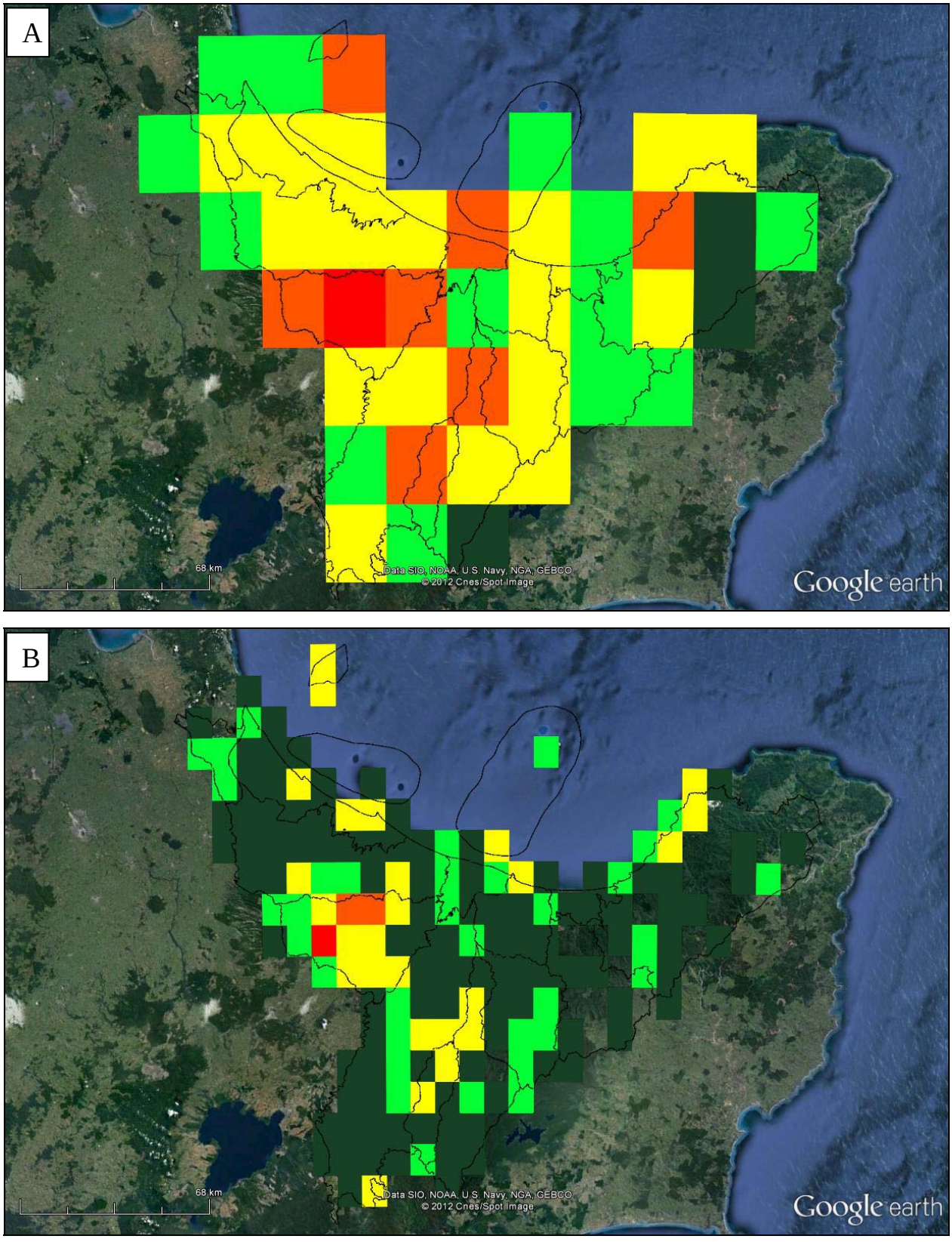

Figure 1. Number of non-cultivated species per $^{1}/_{4}$ degree (A) and $^{1}/_{10}$ degree (B) cells housed in NZFRI for the Bay of Plenty. Dark green: < 20 species, light green: 21–50 species, yellow: 51–150 species, orange: 151–300 species, red: > 300 species.

(dark green cells) occur in two EDs, namely central and south-eastern Motu and southern Ikawhenua (Figure 1A). At the $^{1}/_{10}$ degree resolution, about 20 cells have no associated vouchers at present and large tracts of the Bay of Plenty have less than 20 species in our collection (Figure 1B).

While it is true that some areas within the Bay of Plenty have been heavily degraded by anthropogenic activities, when compared with the Beadel et al. (2009) figures for each ED, the green cells on the offered maps most likely reflect low collection intensity rather than low species richness. Clearly, much collecting work still needs to be done and perhaps these maps can guide the planning of future day trips for the Rotorua Botanical Society.

I have entered all non-vouchered records from Beadel et al. (2009) into the NZFRI database to serve as a wish list for the herbarium. Christmas holidays are upon us and if you are undecided of where to slip away to for a couple of days, I have heard that Opotiki ED is very pleasant at this time of year. We have currently 30 species in the NZFRI collection for this ED—Beadel et al. (2009) report more than 500. I provide our wish list for this ED as a Christmas or New Year's challenge (Table 1). I will welcome all decent specimens (fertile, georeferenced and with collection numbers) that fill in the gaps. Feel free to come and see me or email me[1] for your custom wish list if you are already set to go somewhere else within the Bay of Plenty these holidays.

REFERENCES

Beadel, S., Ecroyd, C., de Lange, P., Cashmore, P., Shaw, W. & Crump, S. 2009. Checklist of indigenous and naturalised vascular plants inthe Bay of Plenty. Rotorua Botanical Society, Rotorua.

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Murray-Smith, C., Brummitt, N.A., Oliveira-Filho, A.R.Y.T., Bachman, S., Moat, J., Lughadha, E.M. & Lucas, E.V.E.J. 2008. Plant diversity hotspots in the Atlantic coastal forests of Brazil. *Conservation Biology* 23: 151-163.

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Table 1. NZFRI voucher wish list for the Opotiki Ecological District.

Fern Allies

Lycopodiaceae
- *Huperzia varia*
- *Lycopodium deuterodensum*
- *Lycopodium volubile*

Psilotaceae
- *Tmesipteris lanceolata*

Selaginellaceae
- *Selaginella kraussiana*

Ferns

Aspleniaceae
- *Asplenium bulbiferum*
- *Asplenium flaccidum*
- *Asplenium oblongifolium*
- *Asplenium polyodon*

Blechnaceae
- *Blechnum chambersii*
- *Blechnum colensoi*
- *Blechnum discolor*
- *Blechnum filiforme*
- *Blechnum fluviatile*
- *Blechnum membranaceum*
- *Blechnum minus*
- *Blechnum minus* × *novae-zelandiae*
- *Blechnum novae-zelandiae*
- *Doodia australis*

Cyatheaceae
- *Cyathea cunninghamii*
- *Cyathea dealbata*
- *Cyathea medullaris*

Davalliaceae
- *Arthropteris tenella*

Dennstaedtiaceae
- *Histiopteris incisa*
- *Hypolepis ambigua*
- *Hypolepis distans*
- *Hypolepis lactea*
- *Leptolepia novae-zelandiae*
- *Lindsaea trichomanoides*
- *Paesia scaberula*
- *Pteridium esculentum*

Dicksoniaceae
- *Dicksonia fibrosa*
- *Dicksonia squarrosa*

Dryopteridaceae
- *Diplazium australe*
- *Lastreopsis glabella*
- *Lastreopsis hispida*
- *Lastreopsis microsora* subsp. *pentangularis*
- *Polystichum neozelandicum* subsp. *neozelandicum*
- *Rumohra adiantiformis*

Gleicheniaceae
- *Gleichenia microphylla*

Hymenophyllaceae
- *Hymenophyllum demissum*
- *Hymenophyllum flabellatum*
- *Hymenophyllum frankliniae*
- *Hymenophyllum multifidum*
- *Hymenophyllum sanguinolentum*
- *Trichomanes elongatum*
- *Trichomanes venosum*

Osmundaceae
- *Leptopteris hymenophylloides*

Polypodiaceae
- *Grammitis billardierei*
- *Loxogramme dictyopteris*

Microsorum pustulatum
Pyrrosia eleagnifolia
Adiantum cunninghamii
Adiantum diaphanum
Adiantum hispidulum
Pellaea rotundifolia
Pteris macilenta
Thelypteridaceae
Pneumatopteris pennigera

Gymnosperms
Pinaceae
Pinus pinaster
Pinus radiata
Podocarpaceae
Dacrycarpus dacrydioides
Dacrydium cupressinum
Phyllocladus trichomanoides
Podocarpus hallii
Podocarpus totara var. *totara*
Prumnopitys ferruginea
Prumnopitys taxifolia

Monocotyledons
Agapanthaceae
Agapanthus praecox
Alismataceae
Alisma plantago-aquatica
Alliaceae
Allium triquetrum
Amaryllidaceae
Amaryllis belladonna
Narcissus tazetta
Araceae
Alocasia brisbanensis
Arum italicum
Lemna minor
Arecaceae
Rhopalostylis sapida
Asparagaceae
Arthropodium cirratum
Asparagus asparagoides
Cordyline australis
Cordyline banksii
Asteliaceae
Astelia solandri
Collospermum hastatum
Collospermum microspermum
Cannaceae
Canna indica
Commelinaceae
Tradescantia fluminensis
Cyperaceae
Baumea articulata
Baumea juncea
Baumea rubiginosa
Bolboschoenus fluviatilis
Carex breviculmis
Carex dipsacea
Carex divulsa
Carex flagellifera
Carex forsteri
Carex geminata
Carex inversa
Carex lambertiana
Carex maorica
Carex pumila
Carex secta
Carex spinirostris
Carex testacea
Carex virgata
Cyperus brevifolius
Cyperus rotundus
Cyperus ustulatus
Desmoschoenus spiralis
Eleocharis acuta
Eleocharis sphacelata
Ficinia nodosa
Gahnia pauciflora
Gahnia setifolia
Isolepis distigmatosa
Isolepis habra
Isolepis pottsii
Isolepis reticularis
Lepidosperma australe
Morelotia affinis
Schoenoplectus tabernaemontani
Schoenus apogon

Schoenus maschalinus
Schoenus tendo
Uncinia banksii
Uncinia ferruginea
Uncinia uncinata
Hemerocallidaceae
Dianella nigra
Phormium cookianum subsp. *hookeri*
Phormium tenax
Iridaceae
Crocosmia ×*crocosmiiflora*
Iris foetidissima
Libertia grandiflora
Juncaceae
Juncus acuminatus
Juncus articulatus
Juncus bufonius var. *bufonius*
Juncus edgariae
Juncus effusus var. *effusus*
Juncus kraussii var. *australiensis*
Juncus microcephalus
Juncus planifolius
Juncus prismatocarpus
Juncus sarophorus
Juncus tenuis var. *tenuis*
Luzula picta var. *picta*
Juncaginaceae
Triglochin striata
Orchidaceae
Diplodium trullifolium
Drymoanthus adversus
Earina autumnalis
Earina mucronata
Gastrodia cunninghamii
Ichthyostomum pygmaeum
Nematoceras acuminatum
Nematoceras trilobum
Pterostylis banksii
Pterostylis montana
Thelymitra longifolia
Pandanaceae
Freycinetia banksii
Poaceae
Agrostis capillaris
Agrostis stolonifera
Ammophila arenaria
Anthoxanthum odoratum
Arundo donax
Austrostipa stipoides
Axonopus fissifolius
Briza maxima
Briza minor
Bromus diandrus
Bromus willdenowii
Cortaderia fulvida
Cortaderia selloana
Cynodon dactylon
Cynosurus cristatus
Dactylis glomerata
Deyeuxia avenoides
Deyeuxia quadriseta
Dichelachne crinita
Digitaria ischaemum
Digitaria sanguinalis
Echinochloa crus-galli
Echinopogon ovatus
Holcus lanatus
Isachne globosa
Lachnagrostis billardierei
Lagurus ovatus
Lolium perenne
Microlaena avenacea
Panicum dichotomiflorum
Paspalum dilatatum
Paspalum vaginatum
Pennisetum clandestinum
Phalaris minor
Phyllostachys nigra var. *nigra*
Poa anceps
Poa annua
Poa trivialis
Rytidosperma gracile
Rytidosperma penicillatum
Rytidosperma racemosum
Rytidosperma unarede
Schedonorus arundinaceus
Setaria gracilis
Setaria verticillata

Sporobolus africanus
Stenotaphrum secundatum
Vulpia bromoides
Restionaceae
Apodasmia similis
Ripogonaceae
Ripogonum scandens
Typhaceae
Typha orientalis
Zingiberaceae
Hedychium flavescens
Hedychium gardnerianum

Dicotyledons
Acanthaceae
Acanthus mollis
Avicennia marina subsp. *australasica*
Aizoaceae
Carpobrotus edulis
Disphyma australe subsp. *australe*
Tetragonia tetragonioides
Amaranthaceae
Amaranthus lividus
Amaranthus powellii
Atriplex patula
Chenopodium album
Chenopodium erosum
Sarcocornia quinqueflora
Apiaceae
Apium prostratum subsp. *prostratum* var. *filiforme*
Centella uniflora
Conium maculatum
Daucus carota
Foeniculum vulgare
Hydrocotyle elongata
Hydrocotyle heteromeria
Hydrocotyle microphylla
Hydrocotyle novae-zeelandiae var. *novae-zeelandiae*
Pastinaca sativa
Sison amomum
Torilis arvensis
Apocynaceae
Parsonsia capsularis
Parsonsia heterophylla
Vinca major
Araliaceae
Hedera helix
Pseudopanax arboreus
Pseudopanax crassifolius
Pseudopanax crassifolius × *P. lessonii*
Pseudopanax lessonii
Schefflera digitata
Asteraceae
Achillea millefolium
Anaphalioides trinervis
Anthemis cotula
Aster subulatus
Bellis perennis
Bidens frondosa
Brachyglottis kirkii var. *kirkii*
Brachyglottis repanda
Carduus nutans
Carduus pycnocephalus
Cichorium intybus
Cirsium arvense
Cirsium palustre
Cirsium vulgare
Conyza sumatrensis
Crepis capillaris
Erigeron karvinskianus
Euchiton audax
Euchiton collinus
Euchiton involucratus
Gamochaeta coarctata
Helminthotheca echioides
Hypochaeris glabra
Hypochaeris radicata
Jacobaea vulgaris
Lactuca serriola
Lagenifera pumila
Lapsana communis
Leontodon taraxacoides
Leucanthemum vulgare
Matricaria discoidea
Mycelis muralis

Olearia rani var. colorata
Pseudognaphalium luteoalbum
Senecio bipinnatisectus
Senecio biserratus
Senecio glomeratus
Senecio lautus var. *lautus*
Senecio minimus
Senecio vulgaris
Sigesbeckia orientalis
Silybum marianum
Soliva sessilis
Sonchus asper
Sonchus oleraceus
Taraxacum officinale
Tragopogon porrifolius
Xanthium spinosum

Bignoniaceae
Podranea ricasoliana

Boraginaceae
Echium plantagineum
Myosotis sylvatica
Symphytum asperum

Brassicaceae
Barbarea intermedia
Brassica oleracea
Brassica rapa subsp. *sylvestris*
Cakile edentula
Cakile maritima
Capsella bursa-pastoris
Cardamine sp.
Lepidium didymum
Lepidium squamatum
Sisymbrium orientale

Campanulaceae
Lobelia anceps
Wahlenbergia violacea

Caprifoliaceae
Lonicera japonica

Caryophyllaceae
Cerastium fontanum subsp. *vulgare*
Dianthus armeria
Polycarpon tetraphyllum
Sagina procumbens
Silene gallica
Spergula arvensis
Stellaria alsine
Stellaria media
Stellaria parviflora

Convolvulaceae
Calystegia sepium subsp. *roseata*
Calystegia sepium subsp. *roseata* × *soldanella*
Calystegia soldanella
Calystegia tuguriorum
Dichondra micrantha
Dichondra repens
Ipomoea cairica

Coriariaceae
Coriaria arborea var. *arborea*

Corynocarpaceae
Corynocarpus laevigatus

Cunoniaceae
Weinmannia racemosa

Droseraceae
Drosera auriculata
Drosera binata

Elaeocarpaceae
Aristotelia serrata
Elaeocarpus dentatus

Ericaceae
Archeria racemosa
Dracophyllum strictum
Gaultheria antipoda
Gaultheria oppositifolia
Leptecophylla juniperina var. *juniperina*
Leucopogon fraseri

Euphorbiaceae
Euphorbia helioscopia
Euphorbia lathyris
Euphorbia peplus
Homalanthus populifolius
Ricinus communis

Fabaceae
Acacia dealbata
Acacia decurrens
Acacia sophorae
Acacia verticillata
Carmichaelia australis

Cytisus scoparius
Lathyrus latifolius
Lotus angustissimus
Lotus pedunculatus
Lotus suaveolens
Lupinus arboreus
Trifolium dubium
Trifolium pratense
Trifolium repens
Ulex europaeus
Vicia sativa

Fagaceae
Quercus robur

Gentianaceae
Centaurium erythraea

Geraniaceae
Erodium moschatum
Geranium dissectum
Geranium homeanum
Geranium molle
Geranium pusillum
Pelargonium inodorum

Goodeniaceae
Selliera radicans

Griseliniaceae
Griselinia lucida

Haloragaceae
Gonocarpus micranthus
Haloragis erecta subsp. *erecta*

Hydrangeaceae
Hydrangea macrophylla

Hypericaceae
Hypericum involutum
Hypericum pusillum
Hypericum tetrapterum

Juglandaceae
Juglans ailantifolia

Lamiaceae
Marrubium vulgare
Mentha pulegium
Mentha suaveolens
Mentha × *piperita* var. ?
Prunella vulgaris
Stachys sylvatica
Teucrium scorodonia

Linaceae
Linum bienne
Linum catharticum

Loganiaceae
Geniostoma ligustrifolium var. *ligustrifolium*

Lythraceae
Lythrum hyssopifolia

Malvaceae
Entelea arborescens
Hoheria sexstylosa
Malva sylvestris
Modiola caroliniana
Plagianthus divaricatus

Meliaceae
Dysoxylum spectabile

Monimiaceae
Hedycarya arborea

Monimiaceae
Laurelia novae-zelandiae

Moraceae
Streblus heterophyllus

Myrtaceae
Leptospermum scoparium
Metrosideros carminea
Metrosideros colensoi
Metrosideros diffusa
Metrosideros excelsa
Metrosideros fulgens
Metrosideros perforata
Metrosideros robusta

Nothofagaceae
Nothofagus solandri var. *solandri*

Oleaceae
Ligustrum lucidum
Ligustrum sinense
Nestegis lanceolata

Onagraceae
Epilobium brunnescens subsp. *brunnescens*
Epilobium ciliatum
Epilobium nerteroides
Epilobium nummulariifolium
Epilobium pedunculare
Epilobium pubens

Epilobium rotundifolium
Fuchsia excorticata
Ludwigia palustris
Oenothera glazioviana
Oenothera stricta
Orobanchaceae
Orobanche minor
Parentucellia viscosa
Oxalidaceae
Oxalis exilis
Oxalis rubens
Papaveraceae
Fumaria muralis
Papaver rhoeas
Papaver somniferum
Paracryphiaceae
Quintinia serrata
Passifloraceae
Passiflora edulis
Passiflora tetrandra
Pennantiaceae
Pennantia corymbosa
Phrymaceae
Mimulus moschatus
Phytolaccaceae
Phytolacca octandra
Piperaceae
Macropiper excelsum subsp. *excelsum*
Peperomia urvilleana
Pittosporaceae
Pittosporum crassifolium
Pittosporum tenuifolium
Plantaginaceae
Callitriche muelleri
Callitriche stagnalis
Digitalis purpurea
Hebe stricta var. *stricta*
Hebe tairawhiti
Plantago australis
Plantago coronopus
Plantago lanceolata
Plantago major
Plantago raoulii
Veronica anagallis-aquatica
Veronica arvensis
Veronica serpyllifolia
Polemoniaceae
Navarretia squarrosa
Polygonaceae
Muehlenbeckia australis
Muehlenbeckia complexa
Persicaria capitata
Persicaria hydropiper
Persicaria maculosa
Persicaria orientalis
Polygonum aviculare
Rumex acetosella
Rumex obtusifolius
Rumex pulcher
Portulacaceae
Portulaca oleracea
Primulaceae
Anagallis arvensis
Lysimachia nummularia
Myrsine australis
Myrsine salicina
Samolus repens var. *repens*
Proteaceae
Hakea gibbosa
Knightia excelsa
Ranunculaceae
Clematis foetida
Clematis paniculata
Clematis vitalba
Ranunculus flammula
Ranunculus parviflorus
Ranunculus repens
Rhamnaceae
Pomaderris amoena
Rosaceae
Acaena anserinifolia
Crataegus monogyna
Eriobotrya japonica
Prunus persica
Prunus ×domestica cult. *domestica*
Rubus australis
Rubus cissoides
Rubus fruticosus

Rubus phoenicolasius
Rubus schmidelioides var. *schmidelioides*
Rousseaceae
Carpodetus serratus
Rubiaceae
Coprosma areolata
Coprosma grandifolia
Coprosma lucida
Coprosma propinqua var. *propinqua*
Coprosma robusta
Coprosma tenuicaulis
Galium aparine
Galium palustre
Nertera depressa
Rutaceae
Melicope simplex
Salicaceae
Salix cinerea
Salix fragilis
Santalaceae
Mida salicifolia
Sapindaceae
Alectryon excelsus subsp. *excelsus*
Dodonaea viscosa
Scrophulariaceae
Buddleja davidii
Myoporum laetum
Solanaceae
Datura ferox
Datura stramonium
Solanum laciniatum
Solanum linnaeanum
Solanum mauritianum
Solanum nigrum
Solanum physalifolium
Solanum pseudocapsicum
Urticaceae
Urtica urens
Verbenaceae
Verbena bonariensis
Verbena rigida
Vitex lucens
Violaceae
Melicytus ramiflorus subsp. *ramiflorus*
Viola riviniana
Vitaceae
Vitis vinifera