

1 Appendix S2 Method for indigenous forest and mixed indigenous shrubland land cover  
2 estimates for pollen and nectar sources

3 For the two land covers “mixed indigenous shrubland” and “indigenous forest”, we used the  
4 information from the National Vegetation Survey (NVS) (Landcare Research, [http://](http://nvs.landcareresearch.co.nz/)  
5 [nvs.landcareresearch.co.nz/](http://nvs.landcareresearch.co.nz/)) because of the high variety of species and great variability of  
6 bee forage plants. The NVS database holds plot-based vegetation data from different projects  
7 that recorded species presence. Within the case study area 180 plots were available. We  
8 intersected the NVS plots with the LCDB spatial layer to assign the plots a land cover  
9 according to LCDB. These fell into indigenous forest (165 sites), and broadleaved indigenous  
10 shrublands (15 sites). We had 215 individual species in the shrub category and 504 species in  
11 indigenous forest. 41 and 54 species in mixed indigenous shrubland and indigenous forest  
12 respectively were identified as bee forage plants (table 2).

13 For each of the two land cover types, we then proceeded as follows:

- 14 1. Filtered each species list by the Sum across months of the flowering data for each  
15 species in order to eliminate all species that do not have any data on flowering times.  
16 (Sum = 0). This means a species with no flowering data but a good resource may have  
17 been eliminated. The flowering data were derived from the flowering times for  
18 selected known bee forage plants from a comprehensive list of bee forage plants in  
19 Newstrom-Lloyd (2013). The flowering times for this list are based on flowering data  
20 at the national level from the New Zealand Flora as found in the Landcare Research  
21 Plant Names Database and E-Flora.
- 22 2. A rank score was given for each species in this subset of species with flowering data.  
23 The rank ranged from 0 to 10 to indicate the value of the species as a bee forage plant  
24 (for pollen and nectar combined) according to the table below. Several species were

25 scored as 0 because they are not known to be used as bee forage or they are  
 26 insignificant herbaceous plants even if bees do visit them. The rank was determined  
 27 by expert opinion (Dr Linda Newstrom-Lloyd in consultation with beekeeper Barry  
 28 Foster) and is based on > 40 years of beekeeper experience, 6 years of botanical field  
 29 observations and literature reports (Walsh 1967, Butz Huryn 1995, 1997, Butz Huryn  
 30 and Moller 1995). The provision of pollen and/or nectar was estimated according to  
 31 the following scale:

32 **TABLE S1. Score system for pollen and/or nectar value of New Zealand flora.**

Score	Raw ranks based on literature and experience
0	no or little value as forage because small herb or no source includes it in their list
2	poor source because not a tree or shrub or not cited in Walsh (1967) but may be in Butz-Huryn (Butz Huryn 1995, 1997, Butz Huryn and Moller 1995)
4	medium source because is a tree or shrub and is in Walsh (1967) but not in Butz-Huryn (Butz Huryn 1995, 1997, Butz Huryn and Moller 1995)
6	good source because in both Walsh (1967) and Butz-Huryn (Butz Huryn 1995, 1997, Butz Huryn and Moller 1995)
8	very good source because in both Walsh (1967) and Butz-Huryn (Butz Huryn 1995, 1997, Butz Huryn and Moller 1995) and we observed it is very good
10	Excellent source because we observed it frequently and it has great pollen and/or nectar so not need to look in the literature

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34 3. Using the list with the number of occurrences from the NVS data base, the plant  
 35 species were arranged in order of those that start flowering in June, then July, etc., for  
 36 each successive month with the plants with the highest number of occurrences at the  
 37 beginning of each set for each start month. This makes a reliable/accurate  
 38 visualisation tool for perusing the sequence of plant species coming into flower each

39 month and the duration of flowering. During this sorting process both the list by the  
40 number of occurrences and the list by the species presence/absence were sorted in the  
41 same row.

42 4. A third species list was created with their values of the raw rank multiplied by the  
43 number of occurrences. The number of occurrences was taken as a proxy for  
44 frequency of the plant in the land cover category. The absolute values of the  
45 occurrences were used in this index but the percentage value of the occurrences is also  
46 available in the next column should it be a better way to calculate this index. This  
47 index implies a value of the quality and quantity of the resource. A high number  
48 means that the plant species occurred frequently in the NVS plots for that land cover  
49 and it is a very valuable nectar and/or pollen source.

50 5. Sums for each month (column) were calculated for all three lists and then were  
51 charted in the associated work sheet for each of the two land cover types as labelled.  
52 The charts were arranged on top of each other and in line so that the reader could scan  
53 the three charts to evaluate the differences in the relative heights of the bars in the  
54 charts. For the spatial scale and the level of estimation in this work it is probably not  
55 important which version of the charts is used as they are all very similar. However, it  
56 is very important to look at the contribution in June and July in winter for both  
57 indigenous forest and shrubland when comparing this with other land cover types.  
58 Also note that the species lists for indigenous forest and shrubland are very similar. In  
59 fact, shrubland is a subset of indigenous forest with only about 4 or 5 new species  
60 added. There are more species in the indigenous forest that are not found in the  
61 shrubland.

62 **NOTE:** It is very important to realise that these rankings are very rough estimations only and  
63 many of the ranks will need to be revised as research progresses. They are qualitative  
64 estimates but do reflect the value of the two land-cover types especially in autumn to winter.  
65 For all the land covers other than indigenous forest and broadleaved indigenous hardwoods,  
66 common species were identified by driving along the roads within the case study area and  
67 recording species. The “other” category includes all the land cover with no data or knowledge  
68 on nectar or pollen production relevant to honey bees.  
69 Table 2: list of species found in the National Vegetation Survey in the Ruamahanga  
70 catchment.

Species name	Land cover type <sup>1</sup>	Count	Biostatus	Common name	Life form	Flowering time
<i>Brachyglottis repanda</i>	IF	29	Native	Wharangi	Tree/Shrub	Aug-Oct
<i>Griselinia littoralis</i>	IF	324	Native	Mahimahi	Tree	Nov-Jan
<i>Melicytus ramiflorus</i>	IF	95	Native	Whiteywood	Tree	Nov-Feb
<i>Nestegis cunninghamii</i>	IF	24	Native	Black maire	Tree	Oct-Nov
<i>Pseudowintera colorata</i>	IF	261	Native	Mountain horopito	Shrub	Nov-Mar
<i>Ripogonum scandens</i>	IF	22	Native	Supplejack	Liana	Dec-Jan
<i>Schefflera digitata</i>	IF	57	Native	Seven-finger	Tree	Feb-Mar
<i>Astelia solandri</i>	IF	31	Native	Kowharawhara	Herb	Oct-Jun
<i>Beilschmiedia tawa</i>	IF	7	Native	Tawa	Tree	Sep-Dec
<i>Hedycarya arborea</i>	IF	25	Native	Pigeonwood	Tree	Sep-Dec
<i>Weinmannia racemosa</i>	IF	240	Native	Kāmahi	Tree	Dec-Jan
<i>Pseudopanax crassifolius</i>	IF	28	Native	Hoheka	Tree	Jan-Apr
<i>Elaeocarpus dentatus</i>	IF	41	Native	Hangehange	Tree	Oct-Feb
<i>Knightia excelsa</i>	IF	6	Native	Rewarewa	Tree	Oct-Dec
<i>Aristotelia serrata</i>	IF	26	Native	Wineberry	Tree	Sep-Dec
<i>Carpodetus serratus</i>	IF	141	Native	Marble leaf	Tree	Nov-Mar
<i>Metrosideros diffusa</i>	IF	71	Native	Rata vines	Liana	Oct-Jan
<i>Raukawa edgerleyi</i>	IF	10	Native	Raukawa	Tree	Sep-Dec
<i>Rubus cissoides</i>	IF	33	Native	Bush lawyer	Liana	Aug-Dec
<i>Neomyrtus pedunculata</i>	IF	31	Native	Myrtle	Tree/Shrub	Dec-Apr
<i>Pseudowintera axillaris</i>	IF	106	Native	Lowland horopito	Tree/Shrub	Sep-Dec
<i>Metrosideros robusta</i>	IF	13	Native	Northern rata	Tree	Nov-Jan
<i>Pseudopanax arboreus</i>	IF	21	Native	Five-finger	Tree	Jun-Aug

<sup>1</sup> IF = Indigenous forest, BLS = Mixed indigenous shrubland

<i>Elaeocarpus hookerianus</i>	IF	90	Native	Puka	Tree	Oct-Jan
<i>Gaultheria antipoda</i>	IF	32	Native	Bush snowberry		Nov-Feb
<i>Luzuriaga parviflora</i>	IF	96	Native	Lantern berry	Perennial	Dec-Mar
<i>Myrsine divaricata</i>	IF	199	Native	Weeping matipo	Shrub	Jun-Nov
<i>Astelia nervosa</i>	IF	105	Native	Kakaha	Herb	Oct-Dec
<i>Metrosideros perforata</i>	IF	35	Native	Small white rata	Liana	Jan-Mar
<i>Olearia rani</i>	IF	31	Native	Heketara	Tree/Shrub	Aug-Nov
<i>Fuchsia excorticata</i>	IF	52	Native	Tree fuchsia	Tree/Shrub	Jun-Jan
<i>Pseudopanax colensoi</i>	IF	18	Native	Three-finger	Tree/Shrub	(Jun)-Oct-Mar
<i>Metrosideros fulgens</i>	IF	26	Native	Scarlet rata	Liana	Feb-Jun
<i>Cordyline indivisa</i>	IF	16	Native	Mountain cabbage tree	Tree	Dec-Jan
<i>Pennantia corymbosa</i>	IF	6	Native	Kahikōmako	Tree	Nov-Feb
<i>Pittosporum eugeniooides</i>	IF	1	Native	Lemonwood	Tree	Oct-Dec
<i>Leptospermum scoparium</i>	IF	19	Native	Mānuka	Tree/Shrub	Sep-Mar
<i>Cordyline banksii</i>	IF	12	Native	Bank's cabbage tree	Tree	Nov-Jan
<i>Freycinetia banksii</i>	IF	2	Native	Kiekie	Perennial/Cl imber	Sep-Nov
<i>Phormium tenax</i>	IF	9	Native	New Zealand flax	Tufted	Nov-Dec
<i>Melicope simplex</i>	IF	4	Native	Poataniwha	Shrub	Sep-Nov
<i>Acaena novae-zelandiae</i>	IF	1	Native	Red bidibid	Herb	Oct-Dec
<i>Astelia trinervia</i>	IF	10	Native	Kauri grass	Herb	Mar-Jun
<i>Hebe salicifolia</i>	IF	10	Native	Koromuka	Shrub	Jan-Feb-(Apr)
<i>Leucopogon fasciculatus</i>	IF	35	Native	Mingimingi	Shrub	Sep-Nov
<i>Griselinia lucida</i>	IF	4	Native	Pukatea	Tree/Shrub	Oct-Dec
<i>Brachyglottis bidwillii</i>	IF	16	Native	Brachyglottis	Shrub	Dec-Mar
<i>Oxalis corniculata</i>	IF	4	Exotic	Oxalis	Perennial	Jan-Dec
<i>Euphrasia zelandica</i>	IF	8	Native	Eyebright	Annual	Oct-Apr
<i>Olearia furfuracea</i>	IF	8	Native	Tanguru	Tree/Shrub	Oct-Jan
<i>Melicytus lanceolatus</i>	IF	3	Native	Narrow-leaved mahoe	Tree/Shrub	Jun-Dec
<i>Lophomyrtus obcordata</i>	IF	4	Native	Rohutu	Shrub	Dec-Feb
<i>Kunzea ericoides</i>	IF	1	Native	Kānuka	Tree/Shrub	Sep-Feb
<i>Alseuosmia macrophylla</i>	IF	4	Native	Korotaiko	Shrub	Aug-Dec
<i>Brachyglottis repanda</i>	Shrub	4	Native	Wharangi	Tree/Shrub	Aug-Oct
<i>Pennantia corymbosa</i>	MIS	8	Native	Kahikōmako	Tree	Nov-Feb
<i>Elaeocarpus dentatus</i>	MIS	7	Native	Hangehange	Tree	Oct-Feb
<i>Griselinia littoralis</i>	MIS	3	Native	Mahimahi	Tree	Nov-Jan
<i>Myrsine divaricata</i>	MIS	2	Native	Weeping matipo	Shrub	Jun-Nov
<i>Nestegis cunninghamii</i>	MIS	5	Native	Black maire	Tree	Oct-Nov
<i>Hedycarya arborea</i>	MIS	9	Native	Pigeonwood	Tree	Sep-Dec
<i>Olearia rani</i>	MIS	1	Native	Heketara	Tree/Shrub	Aug-Nov
<i>Raukawa edgerleyi</i>	MIS	3	Native	Raukawa	Tree	Sep-Dec
<i>Rubus cissoides</i>	MIS	2	Native	Bush lawyer	Liana	Aug-Dec
<i>Aristolelia serrata</i>	MIS	4	Native	Wineberry	Tree	Sep-Dec
<i>Astelia solandri</i>	MIS	4	Native	Kowharawhara	Herb	Oct-Jun
<i>Carpodetus serratus</i>	MIS	10	Native	Marble leaf	Tree	Nov-Mar

<i>Weinmannia racemosa</i>	MIS	7	Native	Kāmahi	Tree	Dec-Jan
<i>Knightia excelsa</i>	MIS	7	Native	Rewarewa	Tree	Oct-Dec
<i>Ripogonum scandens</i>	MIS	5	Native	Supplejack	Liana	Dec-Jan
<i>Beilschmiedia tawa</i>	MIS	10	Native	Tawa	Tree	Sep-Dec
<i>Metrosideros diffusa</i>	MIS	5	Native	Rata vines	Liana	Oct-Jan
<i>Melicytus ramiflorus</i>	MIS	9	Native	Whiteywood	Tree	Nov-Feb
<i>Pseudowintera axillaris</i>	MIS	4	Native	Lowland horopito	Tree/Shrub	Sep-Dec
<i>Schefflera digitata</i>	MIS	5	Native	Seven-finger	Tree	Feb-Mar
<i>Pseudowintera colorata</i>	MIS	2	Native	Mountain horopito	Shrub	Nov-Mar
<i>Metrosideros fulgens</i>	MIS	2	Native	Scarlet rata	Liana	Feb-Jun
<i>Luzuriaga parviflora</i>	MIS	2	Native	Lantern berry	Perennial	Dec-Mar
<i>Pseudopanax crassifolius</i>	MIS	2	Native	Hoheka	Tree	Jan-Apr
<i>Pseudopanax arboreus</i>	MIS	1	Native	Five-finger	Tree	Jun-Aug
<i>Alectryon excelsus</i>	MIS	3	Native	Tokitoki, Titoki	Tree	Oct-Dec
<i>Kunzea ericoides</i>	MIS	7	Native	Kānuka	Tree/Shrub	Sep-Feb
<i>Cordyline banksii</i>	MIS	1	Native	Bank's cabbage tree	Tree	Nov-Jan
<i>Fuchsia excorticata</i>	MIS	1	Native	Tree fuchsia	Tree/Shrub	Jun-Jan
<i>Leptospermum scoparium</i>	MIS	6	Native	Manuka	Tree/Shrub	Sep-Mar
<i>Elaeocarpus hookerianus</i>	MIS	1	Native	Puka	Tree	Oct-Jan
<i>Metrosideros perforata</i>	MIS	1	Native	Small white rata	Liana	Jan-Mar
<i>Lophomyrtus obcordata</i>	MIS	1	Native	Rohutu	Shrub	Dec-Feb
<i>Melicope simplex</i>	MIS	1	Native	Poataniwha	Shrub	Sep-Nov
<i>Digitalis purpurea</i>	MIS	4	Exotic	Foxglove	Perennial	Oct-Jan
<i>Astelia nervosa</i>	MIS	1	Native	Kakaha	Herb	Oct-Dec
<i>Geranium dissectum</i>	MIS	2	Exotic	Cut-leaved cranesbill	Annual	Nov-Feb
<i>Trifolium pratense</i>	MIS	2	Exotic	Red clover	Herb	Oct-Mar
<i>Trifolium repens</i>	MIS	2	Exotic	White clover	Herb	Jul-Mar
<i>Leucopogon fasciculatus</i>	MIS	4	Native	Mingimingi	Shrub	Sep-Nov

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