Forest Ecosystems of the Wellington Region

December 2018

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Contents

Wellington Forest Ecosystems Introduction

Understanding the regional ecosystem diversity, its distribution and status has important implications for land use decisions, the prioritisation of funding for the maintenance of biological diversity, ecological restoration efforts and for state of the environment reporting.

In simple terms, an ecosystem is defined as a biological community of interacting organisms and their physical or abiotic environment. Ecosystems have four essential elements: i) a biotic complex or assemblage of species; ii) an associated abiotic environment or complex; iii) the interactions within and between those complexes; and iv) a physical space in which these operate (Keith et al. 2013). Ecosystems are defined by a degree of uniqueness in composition and processes (involving the biota and the environment) and a spatial boundary. In this regard they are similar to "ecological communities", "habitats", "biotopes" and "vegetation types" though with the added dimension of the characterisation of the abiotic component.

The Greater Wellington region has a diverse range of ecosystem types which is largely a consequence of the diverse geography. This creates differences in temperature, a variable west — east moisture gradient and a variety of land forms and soil types which favour different plant communities. While this guide is focussed on describing the forest ecosystem types, 44 ecosystem types in total have been identified in the region: 21 forest, 7 wetland, 1 cliff, 6 coastal, 4 alpine and 1 braided river ecosystem types (see Appendix 1). Due to human vegetation clearance, many of these ecosystems are now greatly reduced in extent and condition. Ecosystem types described in this technical guide are based on "*A classification of New Zealand's terrestrial ecosystems*" developed by the Department of Conservation (Singers and Rogers 2014).

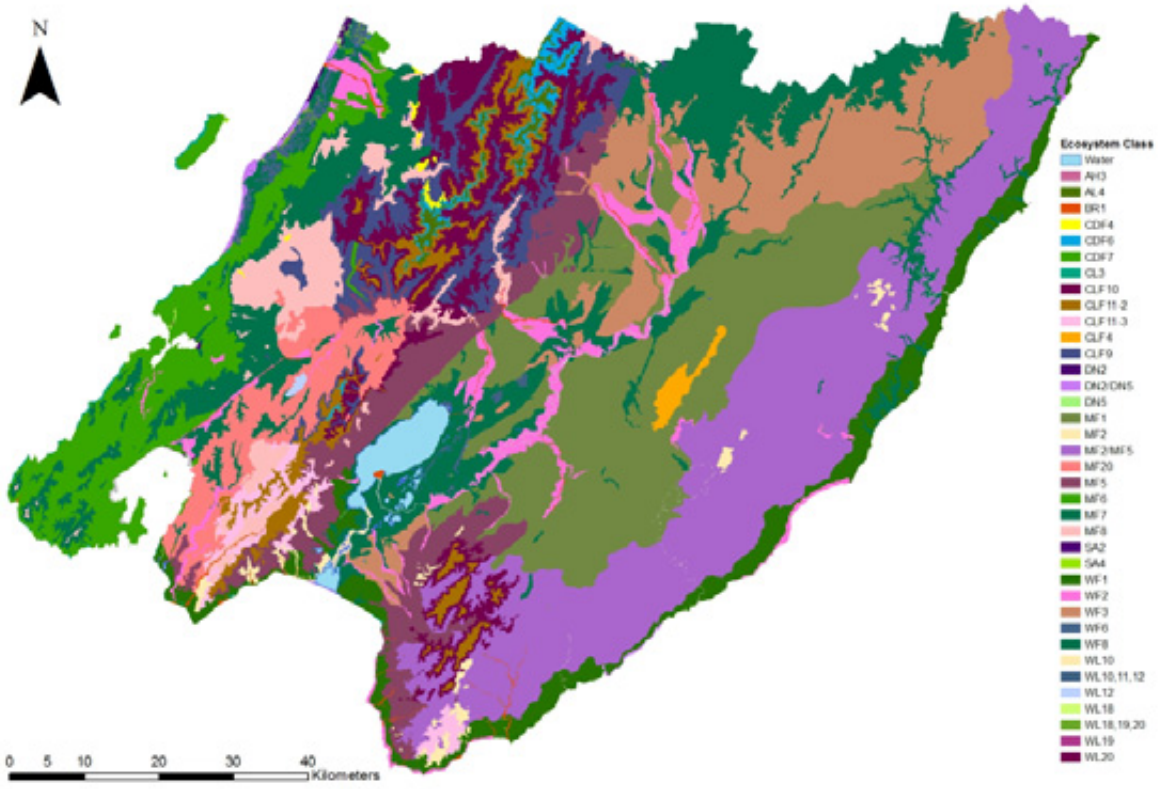
Most of the Greater Wellington region area is optimal for the growth of forest ecosystems. Prior to human occupation forest occupied most land from the sea shore to the treeline, except for areas which were too wet, steep, physically disturbed or excessively cold. In warm and mild climatic areas angiosperm broadleaved trees dominate the forests of which tawa, titoki, kamahi, and near the coastline in more sheltered locations kohekohe, are numerically significant. Podocarp forest ecosystems of kahikatea, matai, and totara are more restricted, occurring on river terraces and stable dunes – though very little of these forests remain. On steeper land and in cooler climates beech trees dominate - silver beech and red beech are most abundant though black beech and hard beech also occupy large areas. Silver beech typically grows to the tree line though in some areas where it is absent, Hall's totara, broadleaf or leatherwood are usually abundant.

Moisture availability is also a major determinant that influences forest ecosystem composition. The Rimutaka and Tararua Ranges affect rainfall patterns and intercept prevailing westerly and southerly weather systems. Consequently, rainfall is greater in the west and considerably less in the east. In the Wairarapa, the Aorangi Range also intercepts southerly weather patterns and the combined influence of the ranges result in parts of the eastern Wairarapa often experiencing the most severe drought conditions in the region. Drought excludes some species which require more humid conditions and conversely favours species tolerant of drought conditions. In much of the eastern Wairarapa, drought restricts the distribution and abundance of tawa which is typically dominant in areas of similar temperature but higher rainfall. Instead drought tolerant trees such as titoki, black

beech, totara, matai, hinau and species of maire are more abundant in the remaining isolated remnants present, forming an unusual ecosystem composition.

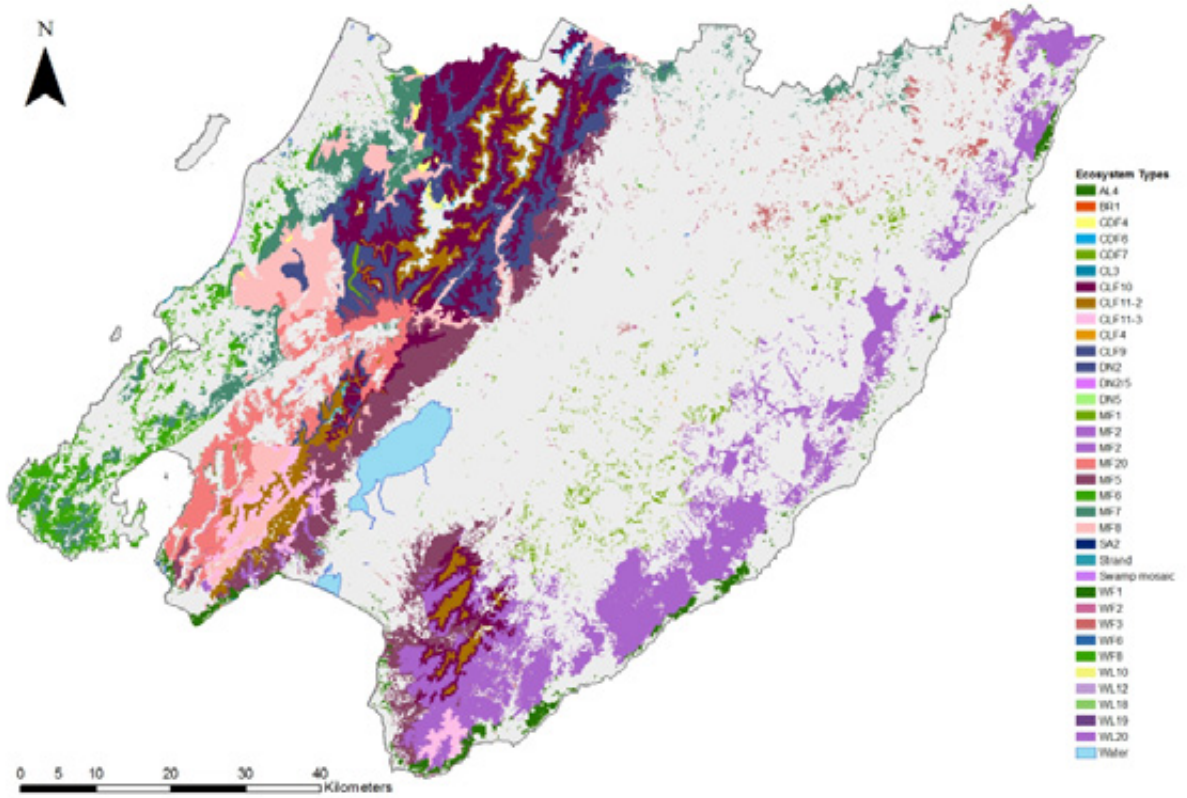
Non-forest ecosystems are more restricted in area and are associated with coastal areas including dunes, beaches and cliffs and in wetlands, along river margins and above the tree line. This technical guide is focussed on the forest ecosystems of the Wellington Region, but a further guide to the non-forest ecosystems of the region is planned. Those ecosystem types are detailed in Appendix 1.

The map shown below shows the natural (historic) extent of Greater Wellington's terrestrial ecosystems. "Natural extent" is intended to mean a combination of our understanding of the historic pre-human diversity, distribution and extent of ecosystems in Wellington and what we would expect this to be given past and current environmental drivers.

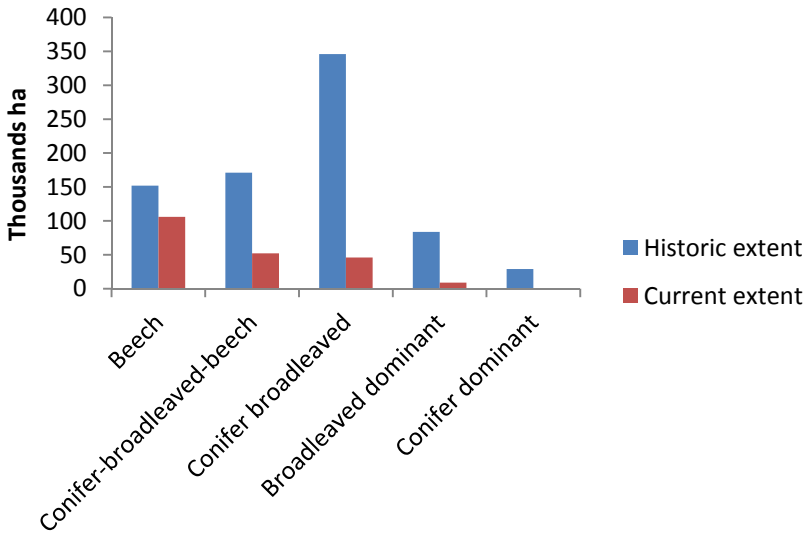


Forest ecosystems are thought to have once covered around 782,000 ha of the Wellington Region, but roughly 214,000 ha now remain (27%), with the greatest loss having occurred in lowland forests. This is significant because all of these forests would have provided habitat for native fauna- birds, lizards, bat and invertebrates. Today the breeding habitat of many of the remaining native bird species is restricted to the larger old-growth forest areas of the Tararua, Rimutaka and Aorangi Ranges, but intensive pest control areas, such as Pukaha, Wainuiomata Mainland Island, Zealandia, and the pest-free islands (Kapiti, Mana and Matiu-Somes) are playing an important role in aiding the recovery of the populations of many of these species. The remaining lowland remnants still provide food for many native species.

The map below shows the remaining extent of Greater Wellington's terrestrial ecosystems.



It is important to minimise any further loss of the threatened forest ecosystem types, but it should also be recognised that pests and weeds have an ongoing impact on non-threatened forest types. These latter forest types now provide the remaining breeding habitat for many native fauna, including many threatened species. If the forest ecosystems covered in this technical guide are grouped together into major forest types (which strongly align with altitudinal gradients), it can be seen as illustrated in the figure below, that the greatest loss has occurred in lowland forests (conifer broadleaved, broadleaved and conifer dominant).



This guide and associated GIS layers can provide planners, landowners and conservation agencies with information about the spatial extent of the historic ecosystems in the region. A map of the original extent of each forest type is shown in the following pages, along with a detailed description of each forest type. Information about distribution, abiotic processes that drive the ecosystem type, characteristic native biota, key processes and interactions, and threatening processes is also provided. A regional threat status is attributed to each ecosystem type. This threat status has been assigned to each forest described by using criteria detailed in a system developed by the International Union for Conservation of Nature (Keith et al. 2013). The system can be used at local, regional and national levels where threatened ecosystem types are assigned a status based on quantitative thresholds; Critically endangered, Endangered or Vulnerable. While a number of factors are used to assess threat status, the criterion associated with historic forest loss has been the key aspect considered. In the case of the Wellington forest ecosystem types, the threat assessment has been made using a quantification of forest remaining versus original extent through the use of Land Cover Database and the Singers potential ecosystem extent GIS layers. The threat determination is then made based on the following which is in accordance with international threat listing processes (Rodriguez et al. 2010):

- Critically endangered Less than 10% remaining
- Endangered Less than 30% remaining
- Vulnerable Less than 50% remaining

A summary of the forest types, their threat status and key threats is shown below:

Forest Type	**Forest Name**	**Regional Threat Status**	**Threats**
WF1	Titoki, ngaio	Critically endangered	Fragmentation, grazing
WF2	Totara, matai, ribbonwood	Critically endangered	Fragmentation, grazing
WF3	Tawa, titoki, podocarp	Critically endangered	Fragmentation, grazing
WF6	Totara, matai, broadleaf	Critically endangered	Pest animals, grazing, weeds
WF8	Kahikatea, pukatea	Critically endangered	Drainage, weeds
MF1	Totara, titoki	Critically endangered	Fragmentation, grazing
MF2/5	Rimu,matai, hinau,black beech	Endangered	Deer, goats, stock, predators
MF5	Black beech	Vulnerable	Deer, goats, stock, predators
MF6	Kohekohe, tawa	Endangered	Pest animals
MF7	Tawa, kamahi, podocarp	Endangered	Pest animals
MF8	Kamahi, broadleaf, podocarp	Not threatened	Pest animals
MF20	Hard beech	Not threatened	Pest animals
CLF4	Kahikatea, totara, matai	Critically endangered	Fragmentation, grazing
CLF9	Red beech, podocarp	Not threatened	Pest animals
CLF10	Red beech, silver beech	Not threatened	Pest animals
CLF11	Silver beech (two variants)	Not threatened	Pest animals
CDF4	Hall's totara, kamahi	Not threatened	Pest animals
CDF6	*Olearia* scrub	Not threatened	Pest animals
CDF7	Mountain beech	Not threatened	Pest animals

New approaches to landscape planning, restoration planting and pest control initiatives provide an opportunity for the improvement of habitat for native species and to re-establish the forest diversity that was once a major part of the biodiversity of the region. It is hoped that this guide can be used to inform these approaches.

WF1: Titoki, ngaio forest — Regionally critically endangered — 3% remaining

Ecosystem Description

Regional Distribution: Very few examples remain of this coastal broadleaved forest ecosystem type. The remnants are small, with patches found near Cape Palliser, the Whangaimoana Coast and on the lowlands southwest of Lake Wairarapa. Most of the remnants of this forest type are now dominated by a mosaic of early successional scrub, especially in the eastern Wairarapa.

National Distribution: This ecosystem is found along a narrow strip of the eastern central New Zealand coastline from Mahia Peninsula (Wairoa District) in the North Island to Bank's Peninsula (Canterbury) in the South Island.

Abiotic Processes: This coastal ecosystem occurs in areas exposed to frequent salt laden winds and on topography below approximately 300 m a.s.l. (Wardle 1971). As it occurs close to the coastline, the climate is mild, though periods of drought occur. These droughts are often less severe than inland eastern areas, as these areas receive more rain and cloud cover from southerly and eastern weather patterns. Frosts are infrequent due to the coastal exposure, frequent coastal winds and often steep seaward facing landforms this ecosystem occupies.

Characteristic native biota: Very few examples of the original eastern central coastal forest remain, and most examples are seral and dominated by a mosaic of broadleaved forest or early successional coastal scrub. As such this ecosystem description is somewhat speculative, having been pieced together from the few better condition remaining examples (e.g. Kaikoura Coastline).

Remaining areas are dominated by a broadleaved forest mosaic of titoki, ngaio, mahoe, five-finger, red mapou, kaikomako, kowhai, akeake, kohuhu and akiraho. Historically, titoki, ngaio and locally rewarewa were likely the canopy dominants with nikau abundant in the sub-canopy, especially on steep landforms. Small stands of totara and matai also remain on the Kaikoura coastline indicating that drought tolerant podocarps were likely to have been more common particularly on coastal and alluvial terraces. Kahikatea and tawa were also likely to have been present, though more restricted to deeper and moister soils, especially in or adjacent to coastal swales on coastal terraces.

Titoki, ngaio remnant near Mataikona

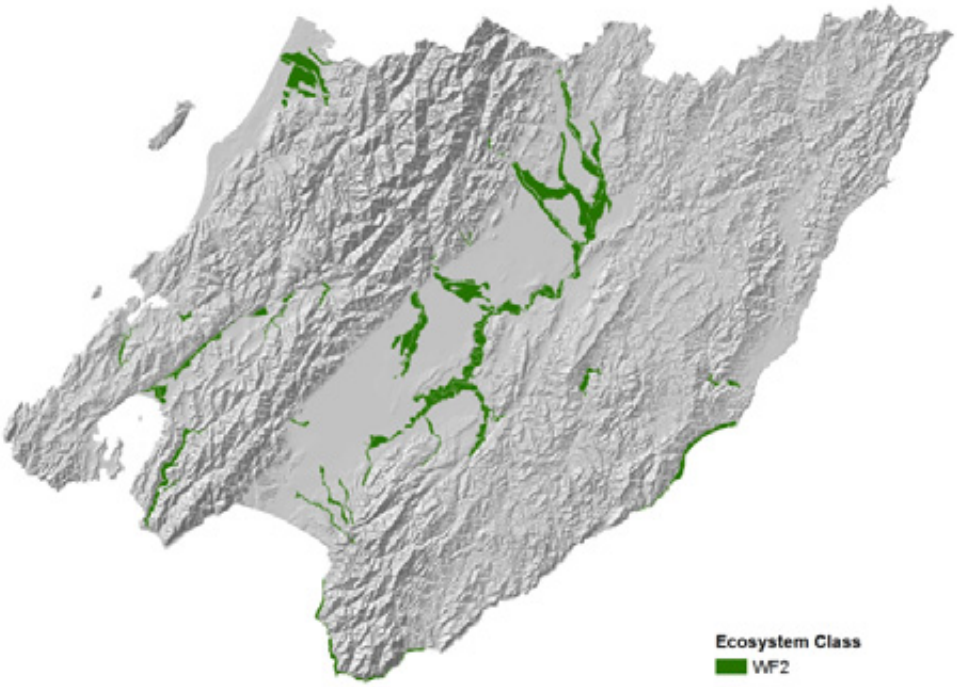
Key Processes and Interactions: The major factors that influence the composition and structure of this ecosystem type are related to the coastal windswept landforms it occupies. Coastal winds ameliorate the climate, reducing frost frequency and severity making this ecosystem more suitable for frost sensitive species tolerant of coastal salt spray.

Threatening Processes: The eastern coastal margin of central North Island was occupied by and deforested by Maori in the early colonisation period, with forest clearing at Palliser Bay dated at AD1256 +/- 72 (Leach & Leach 1979). Consequently, at the time of European colonisation very few remnants representative of the original forest remained and areas where it had previously occurred were quickly used for grazing stock. Today few fragments of forest remain, especially on flat land suitable for agriculture, though large areas on steep coastal hill slopes are reverting, such as along the Kaikoura, south Wellington and Wairarapa coastlines. Many forest remnants are however dominated by karaka which is likely of anthropogenic origin (Stowe 2003). Being so fragmented, grazing by stock is a major threat and weeds are a significant threat to young regenerating vegetation, especially climbing species such as banana passionfruit (*Passiflora* spp.).

WF2: Totara, matai, ribbonwood forest — Regionally critically endangered — 3% remaining

Ecosystem Description

Regional Distribution: This forest once formed a rich podocarp, riparian forest on free-draining and stony alluvial soils associated with the lowland river systems. In the Wellington Region this ecosystem was most abundant on the Wairarapa Plains adjacent to the main rivers draining from the Tararua Ranges and in the west, the largest area occurred on Te Horo Plain, south of the Otaki River. Today only minute relict examples remain though locally areas of regenerating totara occur, particularly on pastoral land, such as at Te Horo and northern Wairarapa Plains. Remaining significant sites of this forest type are located to the west of the Aorangi Range, Matarawa Conservation Area and Greytown Park Bush on the Wairarapa Plains and the Te Horo forest remnants on the Kapiti Coast.



National Distribution: This ecosystem predominantly occurs east of the main divide on recent, free draining stony soils from the Hawke's Bay in the North Island to North Otago in the South Island. In Canterbury it once occupied lowland parts of the Canterbury Plains (Meurk 2008). West of the main divide it occurs in the Horowhenua, Manawatu, Rangitikei and Nelson Districts, on similar free draining soils.

Abiotic Processes: This ecosystem is exclusively found on recent (Holocene) alluvial terraces with free draining stony and alluvial soils with a low organic content in warm to mild and semi-arid to sub-humid regions. It is primarily found in eastern regions where drought is a common occurrence as it is a significant factor that affects ecosystem composition.

Characteristic native biota: Vegetation is typically dominated by totara with occasional to frequent matai. Younger successional examples of this ecosystem include kanuka, cabbage tree and kowhai, which totara and matai regenerate through and eventually succeed (Meurk 2008).

Older examples also locally have a sub-canopy of titoki, kaikomako, mahoe and a wide range of divaricating shrubs with kowhai occurring particularly along riparian margins. White maire is locally present in the North Island while riparian black beech and red beech occur in transition zones close to foot hills where beech forest dominates.

Totara, matai remnant near Te Horo

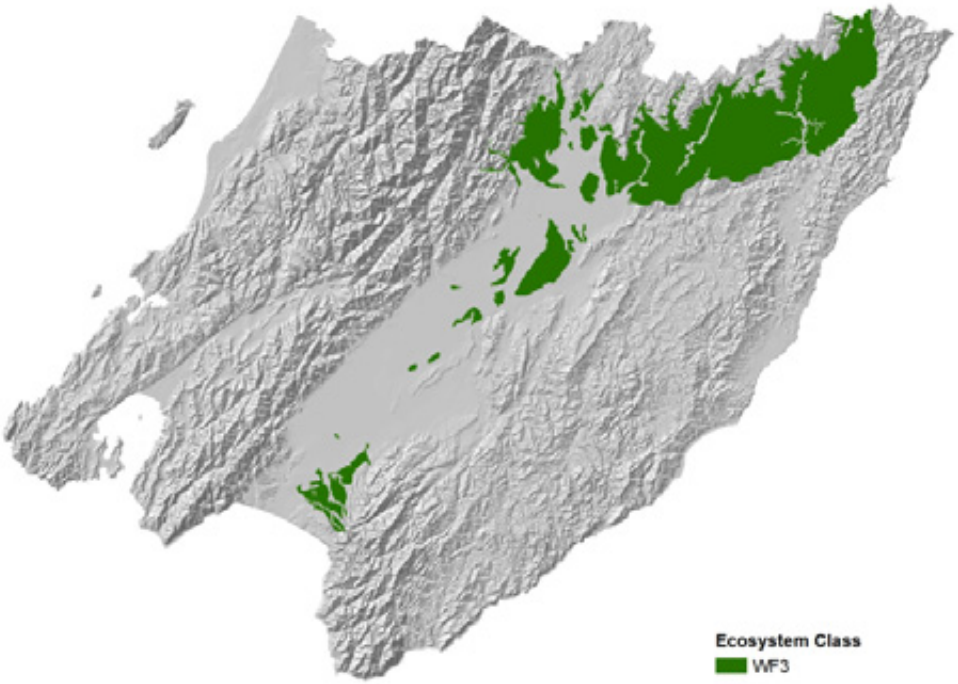
Key Processes and Interactions: Recent free draining alluvial landforms form during large floods and following large earthquakes when rivers move course and expose new ground. These two processes facilitate vegetation succession on these new river terrace landforms. Totara, matai, ribbonwood forest occupies a secondary succession stage in this process, displacing the initial scrub or early successional forest typically dominated by kanuka, cabbage tree and kowhai. Initially densely stocked, young totara and matai forest progressively thins over time, though being long-lived these trees dominate the emergent forest tier for 500–600 years. Periodic flood deposition and decomposition of leaf litter results in greater soil development and colonisation by a wider range of broadleaved tree species.

Threatening Processes: As this ecosystem type is fire prone, and primarily occurs in semi-arid and sub-humid drought-prone areas, much was lost shortly after Maori colonisation, with the greatest loss in the driest districts (Rogers et al. 2005; Perry et al. 2014). At the time of European occupation some of the largest remaining examples occurred in sub-humid regions such as in the Horowhenua and Manawatu (Duguid 1990; Esler 1978), though a substantial amount still occurred in the Wairarapa (Beadle et al. 2000).

WF3: Tawa, titoki, podocarp forest — Regionally critically endangered — 3% remaining

Ecosystem Description

Regional distribution: This forest type occurs in the hill country north of Masterton and on suitable older alluvial terraces with deeper and moister soils on the Wairarapa Plains. Small remnants of this podocarp, broadleaved forest are located on farms in the north of the region, e.g. Tinui River Bush. One of the best remaining examples of this forest type in the region can be seen at Sulphur Wells, east of Masterton.



National Distribution: This ecosystem type predominantly occurs east of the main divide from Ruatoria (Leathwick et al. 1995) to southern Wairarapa (Beadle et al. 2004). It is also present in areas within the Manawatu, Horowhenua (Ravine 1995) and Rangitikei Districts (Lake & Whaley 1995).

Abiotic Processes: Predominantly occurring in warm to mild semi-arid areas or warm to mild sub-humid climates on moderate to steep hill country of eastern and central New Zealand, this ecosystem also locally occurs on older alluvial terraces with well-developed top soils. Soils are typically derived from sedimentary rocks including mudstone, siltstone and sandstone of moderate fertility that are naturally unstable (Molloy 1998).

Characteristic native biota: This podocarp, broadleaved forest ecosystem is characterised by a dominant canopy of tawa and locally titoki, rewarewa and hinau, which are more abundant on northern aspects, ridges and free draining river terraces that experience periods of greater soil moisture deficit. Emergent podocarp trees are present though typically at a low abundance and are dominated by matai and totara. Kahikatea and pukatea is generally restricted to moist gullies,

though kahikatea and pukatea are locally common on imperfectly drained alluvial terraces. Rimu is largely restricted to inland areas of higher rainfall (Maxwell et al. 1993) and nikau to coastal areas in the north-east of its range. Black beech is occasionally present typically occurring on dry ridges, while northern rata is restricted to humid microclimates and absent from the driest areas.

Tawa, titoki, podocarp forest at Sulphur Wells

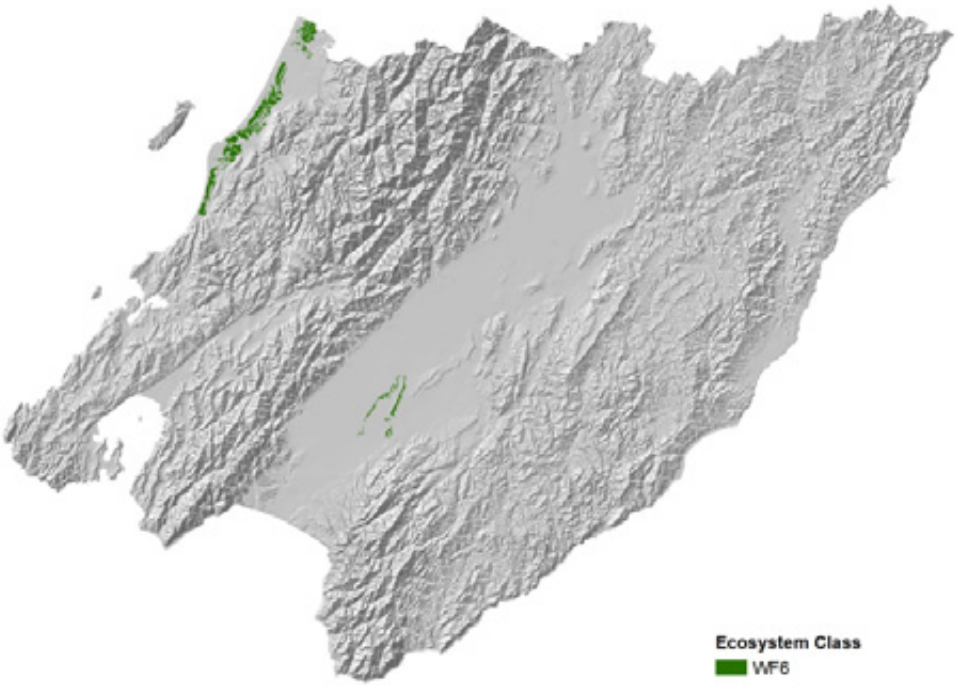
Key Processes and Interactions: Occurring in eastern areas of the North Island, typically with summer droughts, more drought tolerant broadleaved trees dominate, such as tawa, titoki and hinau. Pre-Maori matai was the most common podocarp tree in the Hawkes Bay (McGlone 2002; Wilmshurst et al. 1997). Native birds, especially kereru and tui are important for the pollination and seed dispersal of a wide range of canopy and sub-canopy species in this ecosystem. Predominantly found on unstable mudstone and siltstone soils on moderate to steep hill slopes, landslides are frequent, especially as a result of large storms (Crozier et al. 1982). Therefore, many areas have a range of communities, from early successional manuka or kanuka to mature forest.

Threatening Processes: This ecosystem type was modified as a result of Maori fires, though at the time of European occupation a large amount remained on steep hill country from the East Cape to Wairarapa (Wilmshurst et al. 1997; Rogers et al. 2005; Perry et al. 2014). European land clearance fires for agricultural development were most likely responsible for the greatest loss of this ecosystem type. Little of this ecosystem remains unmodified and few formally protected reserves exist, though large areas of steep and erodible land have regenerated into manuka and kanuka (Smale et al. 1997; Leathwick et al. 1995). As a result, remnant areas are typically small, and most are still grazed and are modified by animal pests.

WF6: Totara, matai, broadleaved forest [Dune Forest] — Regionally critically endangered — 2% remaining

Ecosystem Description

Regional Distribution: Very little remains of this forest type, which was found on stabilised sand dunes with excessively drained soils. The composition of the forests would have been a mosaic of communities that reflected the environmental gradients present. This forest type is nationally rare.



National Distribution: This ecosystem is found on stable dunes of the Motuiti and Foxton Phases in the Foxton Ecological District from Waverley to Paekakariki (Clement et al. 2010). Similar forest may have occurred in Nelson such as on Rabbit Island and locally in smaller dune areas in the lower North Island. Now very rare and fragmented only small areas remain, typically dominated by kanuka.

Abiotic Processes: The dune forest ecosystem occurs on stabilised dunes with excessively drained soils. Soils are derived from coastal sands of a variety of parent materials, though because quartz is the greatest soil component, soil fertility is low. Soils range from very recent soils such as Motuiti soils, to older more developed soils, such as the Foxton soils with a higher clay content, greater water holding capacity and fertility (Molloy 1998). Drought is a primary factor affecting the composition of this ecosystem type.

Characteristic native biota: Very few examples of the original dune forest remain, and most examples are seral and are dominated by kanuka scrub or forest. As such this ecosystem description is somewhat speculative, being pieced together from the few better condition remaining examples (e.g. Pakipaki, Levin and Himatangi Bush Scientific Reserve) supported by the opinions of others (e.g.

Ogle 1997; Ravine 1991). Closest to the coastline and further inland on recently stabilised (though formerly transgressive and parabolic) dunes, coastal shrubland of tauhini, coastal tree daisy, sand coprosma, coastal pohuehue, matagouri, tutu and kanuka would have been colonised by a wider range of forest species. Kanuka was likely the dominant colonising forest species however akeake, ngaio, kohuhu, akiraho, lancewood, kaikomako, mahoe and kowhai would have also been present. Over most of the dune landform, totara and matai likely succeeded these species though drought tolerant taller trees such as kanuka, ngaio, kowhai likely remained on dune ridges. In association with totara and matai, a wide variety of broadleaved trees would have occurred including titoki and rewarewa. Large dune lands with more diverse landforms likely had a greater range of dune forest communities when compared to simple coastal dune ridges (e.g. Eastern Wairarapa).

Totara, matai, broadleaved forest at Nga Manu Sanctuary

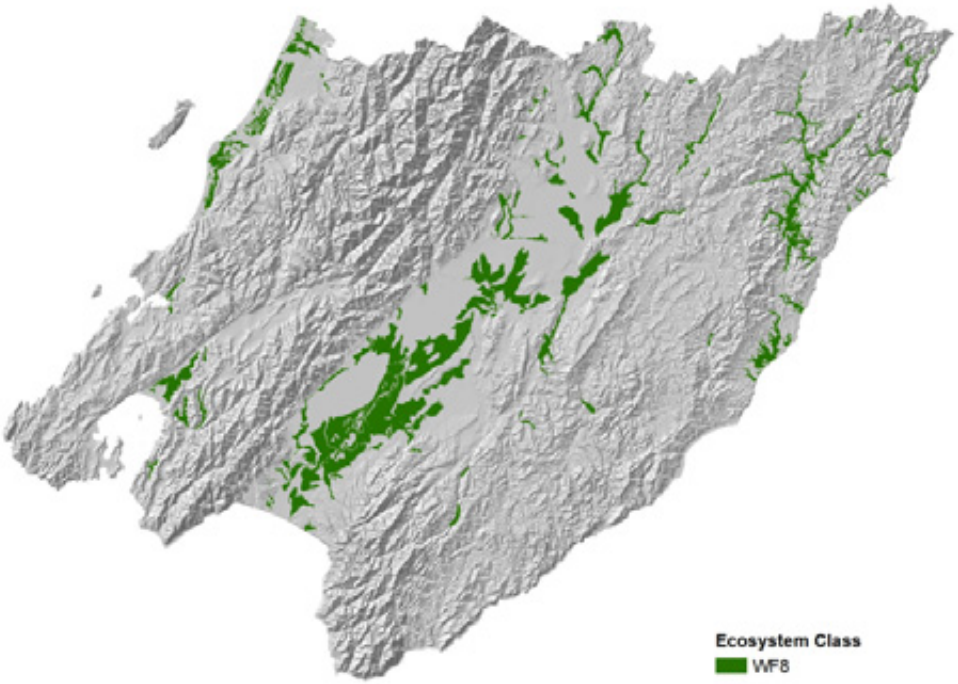
Key Processes and Interactions: This ecosystem occupies the warm climatic zone on stabilised coastal dunes of the mid to recent Holocene (6500 – 500 years BP). Exposure to salt laden winds along with excessively drained soils results in significant periods of moisture deficit for this ecosystem type; so consequently, this ecosystem was highly vulnerable to fire. With soil development a wider range of broadleaved trees invaded and remnants on the oldest dunes in the region include kohekohe and tawa, which are examples of the MF6 ecosystem type.

Threatening Processes: Primarily due to Maori fires and the resultant induced soil erosion leading to mobile dunes, this ecosystem is now very rare and threatened, with less than 1% remaining across its entire range. Extant examples are predominantly small fragments largely dominated by kanuka and other serial vegetation (Ravine 1991). Key threats include animal pests (possums and locally feral Sambar deer), weeds, stock grazing, coastal land development, sand encroachment from mobile dunes, dune transformation for agriculture and edge effects from adjoining land uses (e.g. agriculture and forestry).

WF8: Kahikatea, pukatea forest — Regionally critically endangered — 1% remaining

Ecosystem Description

Regional Distribution: This rich swamp forest would once have dominated areas with high water tables, such as that found on the eastern side of Lake Wairarapa. Most of this forest type has been lost, but small remnants can be found on the Kapiti Coast and in the Wairarapa at Lowes Bush and Fensham Reserve.



National Distribution: Kahikatea, pukatea forest is found predominantly west of the main divide on poor draining alluvial, organic and gley soils in warm to mild and humid to sub-humid areas of the North Island, from Northland to Wellington (e.g. western Egmont National Park). Localised areas also occur in Nelson and Blenheim - the southern limit of pukatea and swamp maire. East of the main divide in semi-arid regions, such as on the Wairarapa Plains, it is restricted to soils derived from silts and clays, such as the alluvial terraces draining the eastern hill country e.g. Tauweru River and lake margins e.g. Lake Wairarapa.

Abiotic Processes: This ecosystem is essentially swamp forest or seasonally waterlogged floodplain forest. It occurs on poor and imperfectly draining organic, gley and recent fluvial soils with (seasonally) high water tables. Climatically it was more common in the warm /humid zone, though extended into mild / humid areas e.g. Egmont National Park (Clarkson 1986). In semi-arid zones it is restricted to more permanent wet areas such as the margins of swamps and lakes (McGlone 2002). In humid to semi-humid areas (e.g. western Waikato, Taranaki to Horowhenua), it was more historically widespread and common, especially on alluvial river terraces with recent fluvial soils derived from mudstone/ siltstone/ sandstone (e.g. Hutiwai River, Taranaki).

Characteristic native biota: The forest contains podocarp and broadleaved species with emergent trees or a canopy of kahikatea and pukatea. Locally rimu, and swamp maire may be a forest component, particularly in areas with a high water-table (Johnson & Brooke 1989). Tawa, mahoe and locally titoki, kowhai, ribbonwood and pokaka occur on the areas of drier, slightly raised ground with imperfectly drained soils adjacent to streams and rivers (Smale 1984). Kiekie and supplejack are often abundant creating a dense structure and sub-canopy. This ecosystem locally can be habitat for mudfish (*Neochanna* spp.) (McDowall 2000). Modified fragments typically have had kahikatea harvested from them and are often now dominated by a forest of pukatea, swamp maire, kiekie and supple-jack.

Kahikatea, swamp forest in Nga Manu Sanctuary

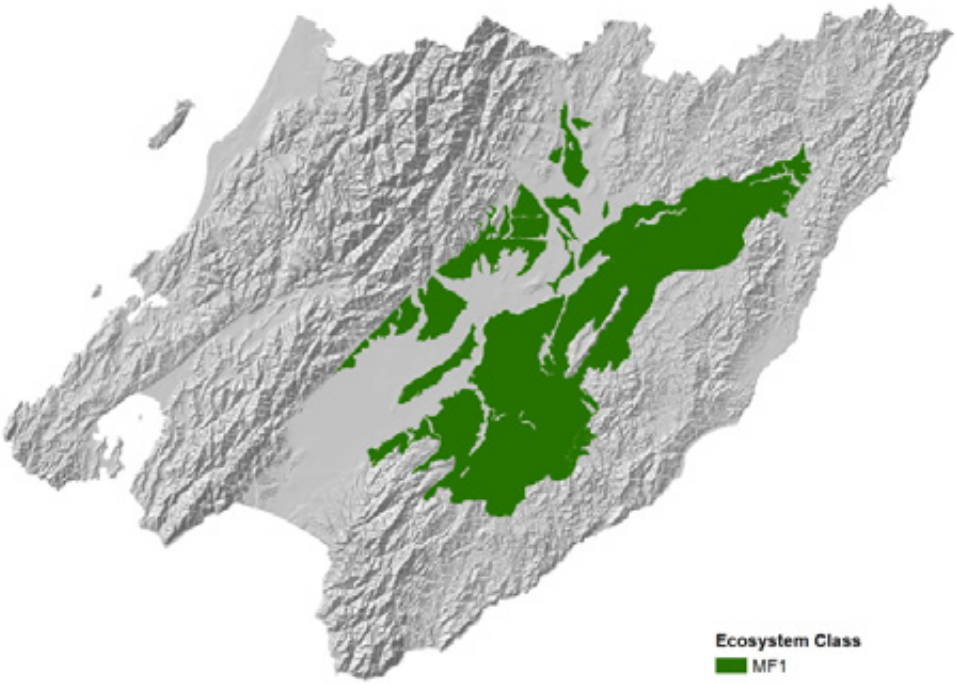
Key Processes and Interactions: This ecosystem is primarily dependent on a high water-table and limited (if any) periods of moisture deficit. It occurs on landforms or in humid climates where these conditions prevail, such on the margins of wetlands and lakes, older dune plains and alluvial flood plains especially with imperfectly and poorly drained soils. Kahikatea and swamp maire have bird dispersed fruits and these forests would have periodically been seasonally significant resources for many species (e.g. tui & kereru).

Threatening Processes: This forest type has been greatly reduced in extent with land development for agriculture and most examples are now highly fragmented or small in size. Most of the other extant examples have additionally suffered from lowered water tables as a result of land drainage, allowing invasion or replacement by species more suited to drier habitats.

MF1: Totara, titoki forest — Regionally critically endangered — 2% remaining

Ecosystem Description

Regional Distribution: Once the second largest forest ecosystem type in the region, only small remnants now remain. The most notable examples are at Rewanui, east of Masterton and Strang's Bush to the east of Carterton. In the eastern Wairarapa most remnant indigenous vegetation is dominated by kanuka scrub and forest though small highly fragmented remnants of titoki and totara occur in some areas, such as near Gladstone.



National Distribution: This ecosystem type occurs in the North Island from the Hawkes Bay to the Wairarapa and in the South Island in Nelson. Historically, it potentially also occurred from Marlborough to the Banks Peninsula. It typically occurs on shallow to moderate hill country. Small areas remain on the driest coastal downlands from Wanganui to Rangitikei (Esler 1978). In Pre-Maori times this ecosystem may have been present in north eastern South Island e.g. Marlborough to Kaikoura.

Abiotic Processes: Totara, titoki forest is predominantly found in the warm to mild and semi-arid eastern North Island where drought is common. In the eastern Wairarapa it primarily occurs in hill slopes and older alluvial terraces with pallic and brown soils.

Characteristic native biota: As this ecosystem occurs in some of the most drought prone hill country of eastern North Island very little remains, and the ecological description is somewhat speculative and compiled from small remnant areas (Beadle et al. 2004). In the canopy, titoki is abundant with occasional rewarewa, hinau and species of maire. Locally ribbonwood, narrow leaved hourere, kowhai, lemonwood and ngaio are also present. Totara and matai are the dominant emergent

podocarps while kahikatea occurs in moist gullies and on imperfectly drained alluvial terraces with recent silty soils. Pukatea, tawa and rimu are locally present in the northern part of its range, though always restricted to moist gullies or seepage areas. In the eastern Wairarapa relicts of this ecosystem are habitat for a range of threatened shrubs including *Coprosma wallii* and *Teucridum parviflorum*.

Totara, titoki forest at Rewanui Bush

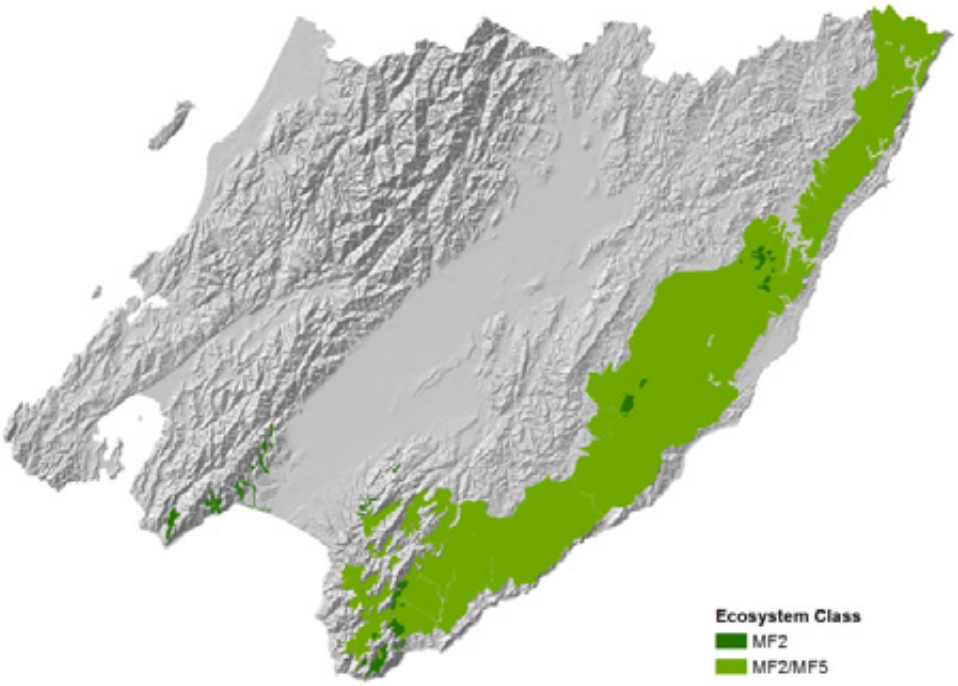
Key Processes and Interactions: This ecosystem type occurs in warm to mild temperature areas suitable for titoki but generally too drought prone for tawa and rimu to be dominant, both of which are largely restricted to moist gully sites. Consequently, drought tolerant trees dominate.

Threatening Processes: This is one of the most degraded forest ecosystems in New Zealand with an extremely low proportion remaining (<1%) with very few areas formally protected. Most remnants are still being grazed and there is a lack of forest regeneration. As the ecosystem is highly fragmented weeds are a major threat to long term viability, especially old man's beard which is capable of ecosystem transformation by smothering canopy and emergent trees.

MF2: Rimu, matai, hinau forest (forms a mosaic with MF5 in Eastern Wairarapa) — Regionally endangered — 16% remaining

Ecosystem Description

Regional Distribution: Over much of the range of this ecosystem, such as in the Bracken Range, Eastern Wairarapa this forest type probably occurred as a mosaic with black beech forest (MF5). Black beech occupied the dry ridges and steep hillslopes while podocarp, broadleaved forest occupied the gullies and shallow hillslopes with more fertile, moister soils. Remnants with this pattern are still present, such as at Rewa Bush Conservation Area. Rocky Hills Sanctuary is a classic but rare example of rimu, matai, hinau forest.

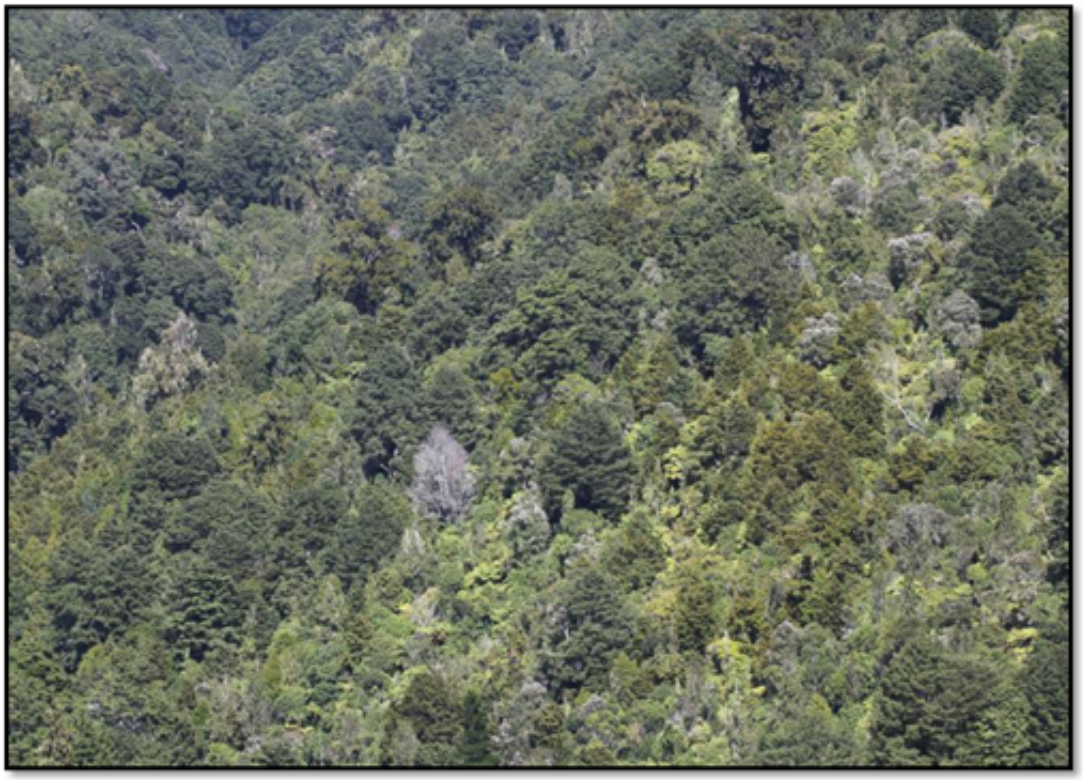


National Distribution: In the North Island this ecosystem type occurs in the eastern Wairarapa (e.g., Rocky Hills Forest Sanctuary & Aorangi Range) and the southern Rimutaka Range, while in the South Island it occurs in the Seaward Kaikoura Range (Franklin 1967; Wardle 1967 & 1971; McKelvey 1984) and historically potentially to the Waiau River, North Canterbury.

Abiotic Processes: This forest type is found in mild and sub-humid areas on typically steep argillite and greywacke foothills and lower mountain ranges up to 520 m a.s.l. Soils are variable and range from raw to recent on land-slips, to more developed brown soils on older surfaces, with low to moderately low fertility.

Characteristic native biota: Much of this podocarp, broadleaved forest ecosystem type has been affected by human induced fires, as well as landslides and associated vegetation collapse from large earthquakes, such as the 1855 A.D. Wairarapa earthquake. Most remaining areas are modified and dominated by a canopy of low statured broadleaved trees. Remaining intact areas have scattered emergent rimu, matai and totara amongst a diverse broadleaved canopy which hinau is the most

abundant tree. Recent slip areas and canopy gaps are dominated by a broadleaved low forest mosaic of mahoe, porokaiwhiri and kaikomako, five-finger, tarata, broadleaf and red mapou. Titoki is also present (though mainly at lower altitude warmer sites) and kahikatea, miro and kotukutuku are present in moist gully areas. In the North Island rewarewa, black maire, and white maire are also locally present, though absent from the Seaward Kaikoura Range.



Rimu, matai, hinau forest at Rocky Hills Sanctuary

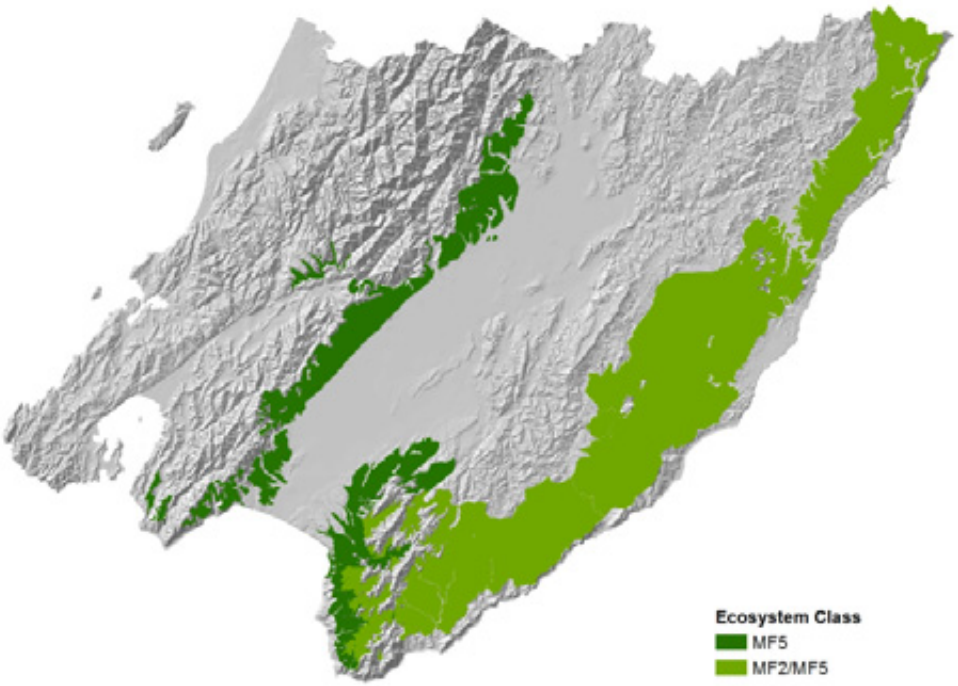
Key Processes and Interactions: This ecosystem occurs in eastern central New Zealand typically in steep greywacke foothill and lower range areas. Periodic drought, frost and natural disturbance events are likely major factors that influence its composition and structure. Environmentally the area is generally unsuitable for tawa to be abundant, probably because of a combination of drought and infertile soils. Conversely, drought is not sufficiently severe to greatly restrict the abundance of rimu, though it is largely absent on north facing slopes (Wardle 1967). Frost also likely limits the distribution of titoki to warmer, lower altitude sites. As a consequence, a wide range of other more drought prone broadleaved trees dominate the canopy, especially hinau, and in the North Island rewarewa. Seral broadleaved vegetation is likely a significant component in this ecosystem.

Threatening Processes: Wild fires have affected much of its range over the last 800 years with abundant charcoal in the soil profile, Wardle (1971). Areas have also been cleared for agriculture, though because of the environment it occupies many areas have been abandoned and large areas are reverting or have been planted in exotic forestry. In remaining areas goats, red deer and possums have reduced the abundance of palatable species, leading to a shift towards unpalatable species. As ungulates are present throughout most of this ecosystem at low to moderate abundance, continued decline of these important palatable species is likely to occur, potentially leading to further dominance by unpalatable species and potentially novel canopy forest composition (Wardle 1967 & 1971; Jane & Pracy 1974; Thomas et al. 1993; Husheer et al. 2005).

MF5: Black beech forest (forms a mosaic with MF2 in the eastern Wairarapa) — Regionally vulnerable — 47% remaining

Ecosystem Description

Regional Distribution: Black beech forest forms a mosaic with rimu, matai, hinau forest in eastern Wairarapa, but stands of this ecosystem type can be found on the foothills on the Rimutaka and Tararua Ranges. An accessible example of this forest type can be found at Western Lake Reserve (the only site where an original forest sequence from upland to lakeshore can be found in the Wairarapa).



National Distribution: This ecosystem type occurs primarily east of the main divide from the East Coast in the North Island to Mt Sommers, Canterbury foothills in the South Island (Nicholls 1976; McKelvey 1984). In the Wellington Region it is primarily found in the eastern Rimutaka, Haurangi and Tararua Ranges. Small areas also remain in eastern Wairarapa where it formerly was likely to have been a dominant forest type on the Bracken Range (Franklin 1967; Beadle et al. 2004).

Abiotic Processes: Predominantly occurring in warm to mild and semi-arid to sub-humid areas, this forest type grows on infertile soils that are prone to a high soil moisture deficit, typically steep hillslopes on greywacke, argillite and sandstone.

Characteristic native biota: Black beech forms near monotypic forests on steep, infertile and seasonally dry hill slopes, gullies and ridges, especially in eastern New Zealand. These forests contain very few other canopy species. On alluvial, moister and deeper soils occasional podocarp trees occur including matai, rimu and totara. These more mixed forests may also have hinau, black maire and rewarewa are occasional and pokaka and occasionally kahikatea on imperfectly drained soils. Typically, these forests have a sparse sub-canopy layer, though small broadleaved small trees

including putaputaweta, red mapou, fivefinger and locally broadleaf are found in gullies. On dry ridges and hillslopes low-statured xerophilous shrubs occur, including *Coprosma lucida*, *C. rhamnoides* and tall and soft mingimingi.

Black beech forest at Rocky Hills Sanctuary

Key Processes and Interactions: Black beech is a relatively short-lived tree which typically goes through stages of die back and recruitment forming single age cohorts. It grows in eastern drought prone areas and dry ridges prone to drought (Wardle 1984). Die back has been implicated as being initially caused by drought (Hocking 1946) which is then hastened by insect and fungal attack (Stewart 1989).

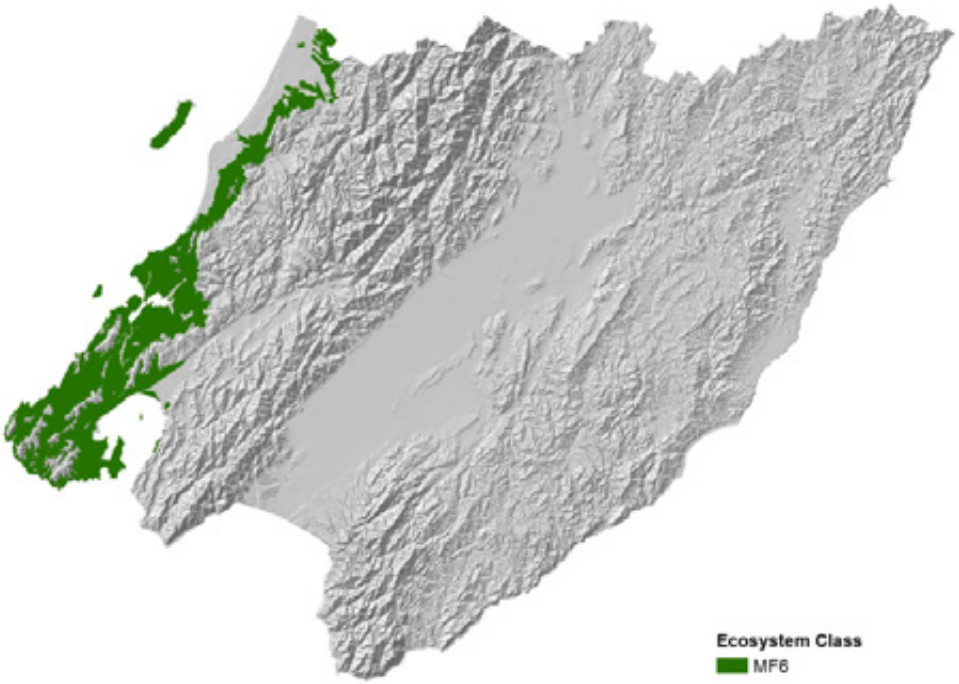
Threatening Processes: Predominantly occurring in eastern dryland areas, there has been a large loss of this ecosystem type across the range as a result of Maori fires (Rogers et al. 1997; Perry et al. 2014). In the Wellington Region large areas remain in the Rimutaka, Aorangi Ranges, though forest loss has been extensive on the eastern Tararua foothills and Bracken Range (Beadle et. al 2004).

Where ungulates are present understorey composition has generally been modified with the loss of many palatable species and a replacement by non-palatable species (Wardle 1967; Wardle 1984). Black beech (like its close relative mountain beech) is palatable to both goats and deer and regeneration is locally retarded especially where ungulate populations have modified the understorey vegetation and little palatable vegetation is left. Locally this has eliminated the seedling bank and is resulting in canopy collapse as stands die (Hosking 1993).

MF6: Kohekohe, tawa forest — Regionally endangered — 16% remaining

Ecosystem Description

Regional Distribution: This ecosystem type is most abundant on the Kapiti Coast in the Wellington Region. Remnant examples of this forest are found on Kapiti Island, at Paraparaumu Scenic Reserve and in Otari Reserve in Wellington.



National Distribution: Found in central New Zealand from Taranaki to the Marlborough Sounds, this ecosystem type is absent from between the Manawatu and Patea rivers (Nicholls 1976; Bayfield & Benson 1986; Ravine 1995). In the Wellington Region it is most abundant on the Kapiti Coast and Kapiti Island. Remnant areas also remain in the Marlborough Sounds while it is very restricted in Southern Taranaki. Historically it may have been present on the eastern margin of the Rimutaka Range inland towards Lake Wairarapa as a minute remnant containing kohekohe occurs west of Lake Onoke.

Abiotic Processes: Kohekohe has a restricted distribution in central New Zealand largely because of its sensitivity to frost, however it is the physiognomic dominant species in this ecosystem. Therefore, this ecosystem occurs in areas with a low frequency of frost such as steep terrain, typically coastal north facing hillslopes or areas with persistent winds. This forest type occurs on a wide range of low to moderately fertile soils types, including, brown and recent soils. On the Wellington Peninsula it occurs from sea level to approximately 240 m a.s.l. (Druce & Atkinson 1958), though increases to 420 m on north facing hill slopes in the Horowhenua District, and inland to maximum distance of 8 km (Wassilief et al. 1986).

Characteristic native biota: Kohekohe typically dominates steeper hill slopes, while tawa is more abundant in gullies, toe slopes and shallow hill slopes often in association with titoki. Terrestrial northern rata is common on ridges on Kapiti Island though is scarce on the mainland. Emergent trees are typically sparse though rimu is occasional and in the North Island northern rata is present, while kahikatea and pukatea also occur in gullies and on imperfectly drained soils. Nikau and supplejack are particularly abundant, while mahoe, porokaiwhiri, and kawakawa are common in the sub-canopy.

Kohekohe, tawa forest at Battle Hill Farm Forest Park

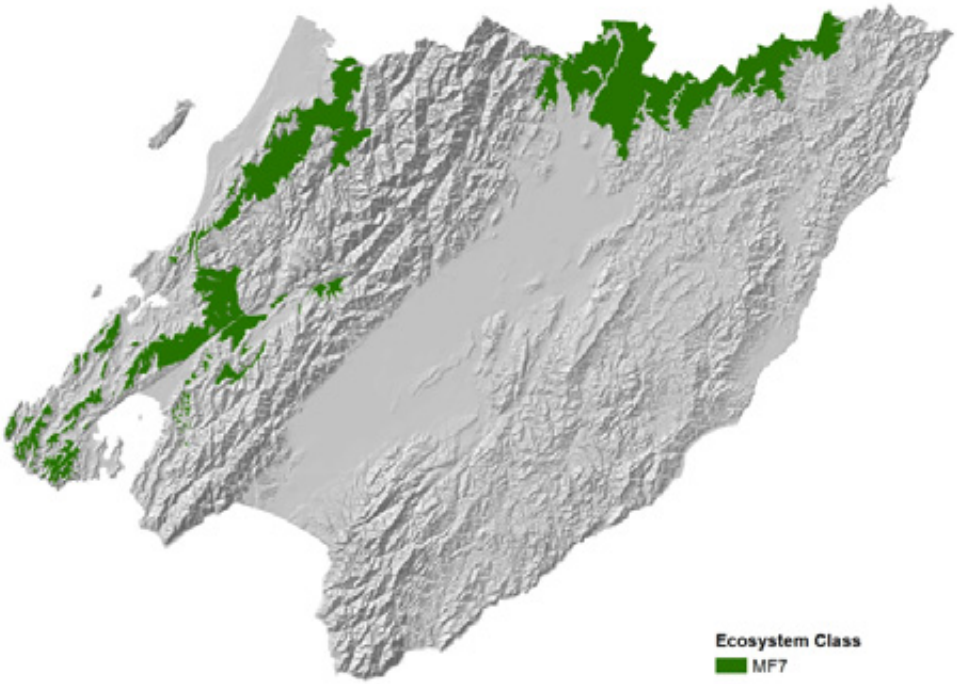
Key Processes and Interactions: The dense dark canopy of this ecosystem results in a heavily shaded understorey. Dominant species (e.g. tawa, kohekohe) have shade tolerant seedlings and readily regenerate in tree fall canopy gaps (Smale & Kimberly 1983). Conversely, podocarp trees such as rimu and kahikatea often require major disturbance events that create larger gaps —a probable reason for a lack of podocarp trees in this ecosystem type. Native birds, especially kereru and tui are important for the pollination and seed dispersal of a wide range of canopy and sub-canopy species.

Threatening Processes: Formerly this ecosystem was common on hill slopes in the Marlborough Sounds, Wellington to Horowhenua and Taranaki, but has been greatly reduced in extent by Maori and European burning and land development for agriculture. Animal pests are significant threats, with possums, goats and rats especially causing the decline of palatable flora (e.g. kohekohe & northern rata) and vulnerable fauna (e.g. kokako) (Payton 2000). Possums and goats in combination have the potential to cause canopy collapse and regeneration failure of a wide range of species within this ecosystem. Closed canopy intact examples are highly resistant to weed invasion though shade tolerant ground covers (e.g. wandering willie, African clubmoss) and trees and shrubs (e.g. privet & exotic palms) readily invade (Wiser & Allen 2006).

MF 7: Tawa, kamahi, podocarp forest — Regionally endangered —22% remaining

Ecosystem Description

Regional Distribution: In the Wellington Region this ecosystem type primarily occurs in the western Hutt – Akatarawa Range and northern Wairarapa hill country. Remnant examples of tawa, kamahi, podocarp forest can be found in Trentham Scenic Reserve and at Dry Creek in Belmont Regional Park.



National Distribution: Tawa, kamahi, podocarp forest occurs from the northern Waikato and the Raukumara Range to the Marlborough Sounds, primarily west of the main divide (Nicholls 1976).

Abiotic Processes: Predominantly found in mild and sub-humid to humid hill country and mountain ranges in central New Zealand, this forest type is found both on relatively flat plateau (Smale et al. 1997) and steep hill country (Nicholls 1976). This ecosystem occurs on a wide range of parent materials such as greywacke and rhyolite, though soil fertility is typically low to moderately low.

Characteristic native biota: As this ecosystem type is widely distributed across the North Island and into the Marlborough Sounds several local variants occur, including in Waikato/Bay of Plenty, King Country and Taranaki, western Raukumara and southern Urewera Ranges, inland Wanganui and the western margin of the Tararua Range.

Typically occurring in hill country areas forest composition is varied in relation to landform. The canopy is dominated by tawa and kamahi with rimu generally the most abundant emergent

podocarp tree, though locally northern rata is also common. Miro, kahikatea, matai, totara and Hall's totara may be also present.

Tawa, kamahi, podocarp remnant in Nikau Valley

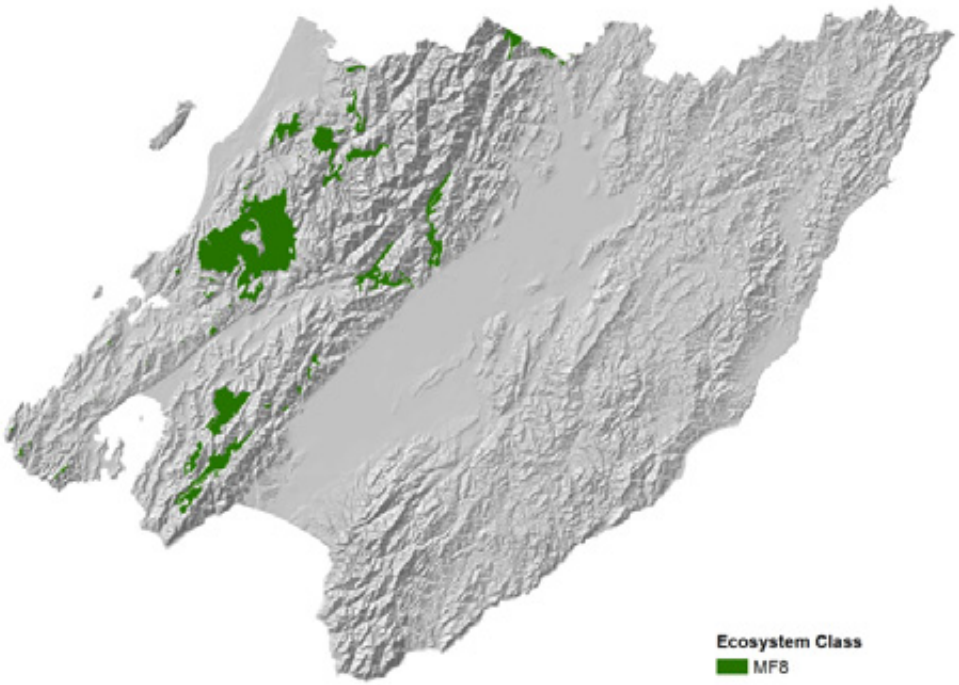
Key Processes and Interactions: The major factors that influence the composition and structure of this ecosystem type are related to altitude, the landforms it occupies, soil drainage and the historic disturbance processes. In the western Wellington Region, it is present either inland of or at higher altitude of MF6: Kohekohe, tawa forest as the characteristic species are more frost tolerant than kohekohe. On the Wellington peninsula this is altitude limit is approximately 240 m a.s.l. (Druce & Atkinson, 1958), though increases to 420 m in the north-west along the Kapiti - Horowhenua coastline, and inland from the coast to a maximum distance of 8 km (as mapped by Wassilief et al. 1986). Tawa and kamahi are the most abundant canopy trees while tree ferns are common in the sub-canopy. Tawa typically dominates shallow hill slopes rises and alluvial sites while kamahi is most common either as an understorey tree especially in moist gullies and also on steep ridges where it often co-occurs with rewarewa, hinau and miro. Rimu and locally pukatea and kahikatea occupy moist gully sites. Native birds, especially kereru and tui are important for the pollination and seed dispersal of a wide range of canopy and sub-canopy species within this forest type.

Threatening Processes: Despite a large area of this forest type remaining nationally, a substantial proportion has been fragmented or entirely lost for pastoral agriculture and forestry. Animal pests are significant threats resulting in a decline of palatable canopy and sub-canopy species and functionally important forest birds (Clout 2006). Die-back of northern rata and kamahi has been attributed to possum browse and, in many locations, northern rata is now an uncommon emergent tree (Rogers & Leathwick 1997). Goats are locally a threat and in combination with other pests have the potential to cause canopy collapse, regeneration failure and species loss within this ecosystem (Payton 2000).

MF 8: Kamahi, broadleaved, podocarp forest — Not threatened — 86% remaining

Ecosystem Description

Regional Distribution: In the Wellington Region, kamahi, broadleaved, podocarp forest primarily occurs in the western Hutt Valley, and the Rimutaka, Akatarawa, and northern Tararua Ranges. A good example of this forest type can be found in the Wainuiomata Water Collection Area.



National Distribution: This ecosystem type is found from the volcanic uplands of the Waikato and Bay of Plenty regions and southern Urewera Ranges to the Rimutaka Ranges (Nicholls 1976). It is also the dominant forest in the beech gap regions of Mt Taranaki (Clarkson 1986) and the northern Tararua Range (Franklin 1967) to the Southern Ruahine Range (Rogers & Leathwick 1997).

Abiotic Processes: Occurring in predominantly mild and sub-humid to humid areas, this ecosystem type also extends into cool climate areas at higher altitude. Typically, it is found in areas where beech and tawa are absent or above (in altitude) MF7: Tawa, kamahi, podocarp broadleaved forest. In the Wellington Region it occurs from approximately 150 m to 610 m a.s.l. (Druce & Atkinson 1958; Franklin 1967) usually on steep hill slopes.

Characteristic native biota: As this ecosystem type is widely distributed across the North Island and occupies a wide altitudinal range, several local variants occur, with two altitudinal variants recognised in the Tararua, Akatarawa and Rimutaka Ranges (Franklin 1967).

Kamahi is the dominant canopy tree and rimu is typically the most common emergent podocarp tree at lower altitude. Below 440 m a.s.l. northern rata is also locally abundant and hinau and rewarewa

are also present. Matai, totara, kahikatea, maire and pokaka are also locally present, especially on alluvial sites and on the volcanic plateau. With increasing altitude rimu is replaced by miro as the dominant podocarp tree, often in association with Hall's totara and broadleaf.

Kamahi, broadleaved, podocarp forest in Wainuiomata Water Collection Area

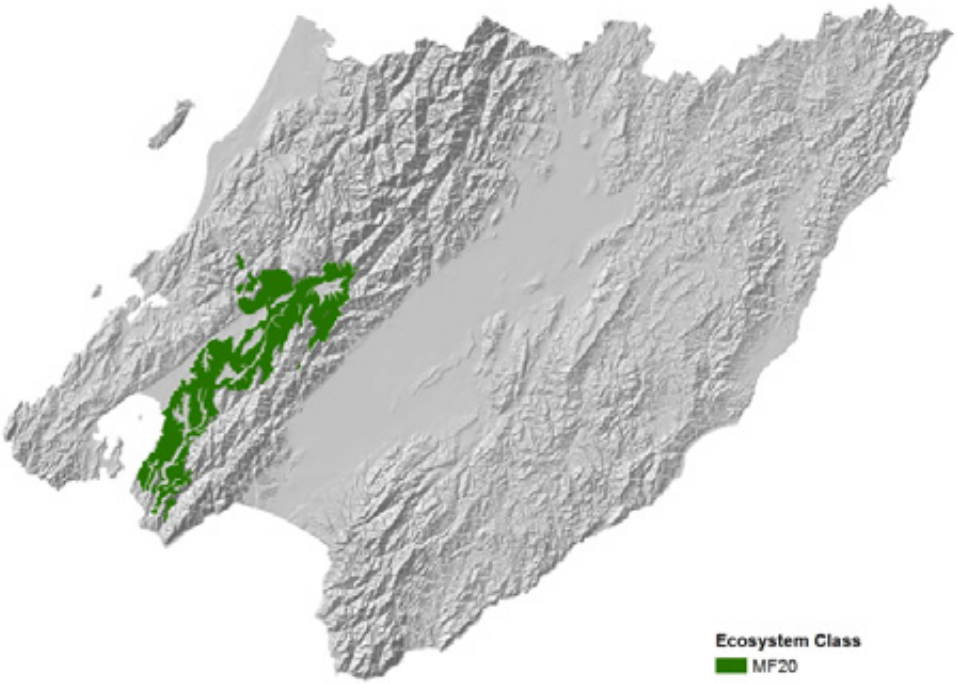
Key Processes and Interactions: The major factors that influence the composition and structure of this ecosystem type are related to altitude, the landforms it occupies, and soil drainage. The forest pattern is a mosaic related to topography with kamahi typically more dominant on ridges and podocarps abundant in gullies. Native birds, especially kereru and tui are important for the pollination and seed dispersal of a wide range of canopy and sub-canopy species.

Threatening Processes: While large areas of this forest type remain nationally, much of which is in the conservation estate, selective logging and the impacts of animal pests have modified most areas. Animal pests, particularly possums, have been implicated as causal agents in the decline of kamahi and northern rata (Allen et al. 2002). In some areas such as the the northern Tararua Range (Esler 1978) and the southern Ruahine Range (Cunningham 1979; Rogers & Leathwick 1997), these pests are implicated as causing widespread canopy collapse. Goats and deer are also likely to be limiting recovery. Weeds are generally uncommon and closed canopy intact examples are highly resistant to weed invasion, though shade tolerant shrubs (e.g. privet) can invade (Wiser & Allen 2006).

MF20: Hard beech forest — Not threatened — 51% remaining

Ecosystem Description

Regional Distribution: This ecosystem type occurs primarily in the eastern Hutt hills and the Akatarawa Ranges in the Wellington Region. The most notable example of this ecosystem type is the beech forest in East Harbour Regional Park. While there is more than 50% of this forest type remaining, much of it has regenerated since early settler times, so this ecosystem should still be considered as vulnerable.



National Distribution: Hard beech forest occurs in three discrete areas in the North Island; north Taranaki (Bayfield et al. 1991) Bay of Plenty (Wardle 1984) and Wellington (Franklin 1967; Druce & Atkinson 1958). In the South Island it occurs from the Marlborough Sounds and Northwest Nelson south to the Paparoa Range on the West Coast.

Abiotic Processes: This forest predominantly occurs in mild and humid and sub-humid areas, though enters cool climate areas in the ranges at higher altitude.

Characteristic native biota: As this ecosystem is found from the Bay of Plenty to the West Coast and in mild to cool climatic zones, the forest composition is variable and ranges from beech–podocarp–broadleaved forest in lower altitude sites to more pure beech forest at higher altitude and on steep and infertile sites. This ecosystem type occurs where hard beech forest is the dominant beech species present, though often black beech is present and locally red and silver beech occur. Kamahi is usually the most abundant canopy and sub-canopy tree in association with hard beech, but it is absent in the extreme eastern and more drought prone areas, such as in the Hawkes Bay Ranges. Typically, rimu, miro and Hall's totara are emergent and locally such as in NW Nelson can be common. In the North Island other broadleaved trees locally occur including northern rata, hinau

and rewarewa and in the South Island, southern rata and tawheowheo (Nicholls 1976; Wardel 1984). In the Wellington Region hard beech is typically associated with kamahi and black beech typically on dry ridges (Franklin 1967).

Hard beech forest at East Harbour Regional Park

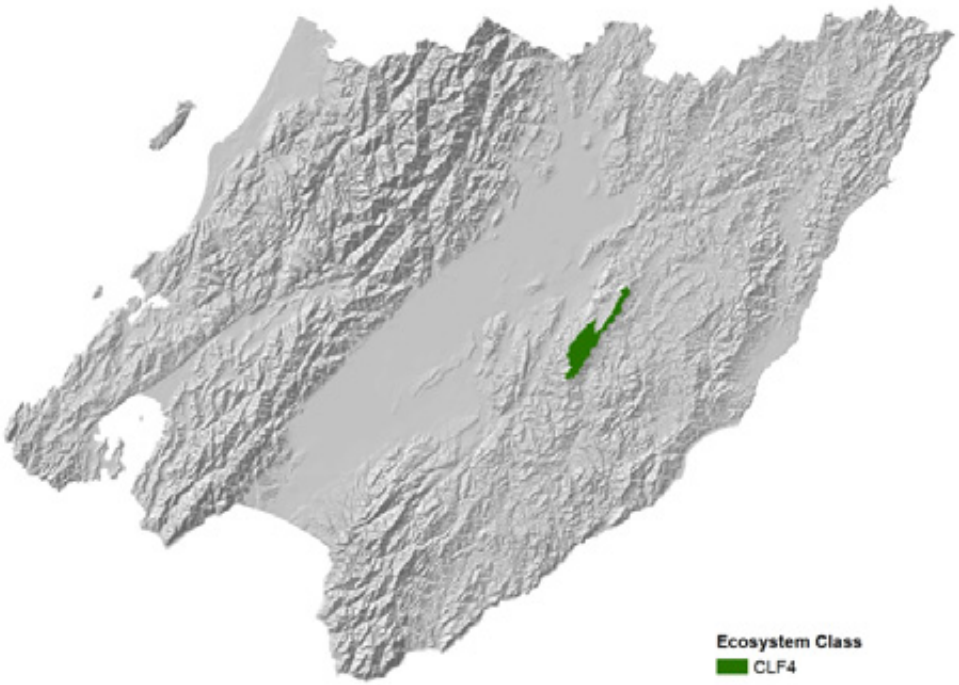
Key Processes and Interactions: In comparison to other New Zealand beech species, hard beech forest occurs at lower altitude typically on steep hill-country below 600 m a.s.l. (Wardle 1984) and on soils of low fertility (Walls & Laffan 1986). Hard beech is a long-lived canopy tree and regenerates following periodic disturbance events (Stewart et al. 1983).

Threatening Processes: As it occurs at relatively low altitudes, hard beech forest was burnt and cleared for pastoral development especially in the Wellington, Marlborough Sounds and Nelson regions. Much of this land was however unsuitable for pastoral agriculture and was abandoned or developed into exotic forest plantations because of the low inherent soil fertility and the spread of gorse. Large areas of abandoned former hard beech forest are now actively regenerating (Walls & Laffan 1986). Significant areas of hard beech forest remain especially in Northwest Nelson. Hard beech periodically mast seeds and produces the largest and most nutritious seeds of New Zealand's beech trees. Consequently, mice and occasionally rat populations erupt resulting in stoat population explosions (Murphy 1992; Fitzgerald et al. 1996; White & King 2006). These cycles in pest abundance have caused the local extinction of a wide range of fauna such as kakariki and kaka and suppress the abundance of many common bird species (Wilson et al. 1998; Dilks et al. 2003; O'Donnell & Hoare 2012). While hard beech is non-palatable to ungulates, a range of palatable associate canopy and sub-canopy trees occur in this ecosystem. Where ungulates are present understorey composition has generally been modified with the loss of many palatable species and a replacement by non-palatable species (Wardle 1984).

CLF4: Kahikatea, totara, matai forest — Regionally critically threatened — 0.4% remaining

Ecosystem Description

Regional Distribution: This ecosystem type is now nationally very uncommon. In the Wellington Region it occurs on the Kourarau Stream plateau east of Gladstone (Eastern Wairarapa) above the 440 m a.s.l. (Beadle et al. 2004).



National Distribution: In the North Island this ecosystem is largely restricted to inland areas south of the volcanic plateau including Taihape–Mataroa and Wairarapa. In the South Island it occurs from western Southland to Otago (Moeraki) in areas with <1000 mm (e.g. Hokonui Hills) and likely historically elsewhere. This ecosystem type is now very uncommon and highly fragmented examples remain.

Abiotic Processes: Kahikatea, totara, matai forest occurs on shallow to steep hillslopes and on free draining older alluvial terraces of moderate fertility, where tawa, titoki, hinau and kamahi are neither present nor abundant for environmental or biogeographical reasons. The environmental conditions are however highly suitable for kahikatea, totara and matai. In the North Island this is likely due to a combination of periodic drought and frost intensity. These environmental factors occur in relatively small areas on inland plateaux and free draining alluvial terraces that experience cold air ponding.

Characteristic native biota: Kahikatea, matai and totara are the dominant canopy trees in this ecosystem and are typically abundant on free draining alluvial terraces or shallow hillslopes forming a tall canopy but are present typically as scattered emergent trees on steeper hill slopes. Broadly, two variants occur though structure is similar with an open canopy of podocarps over a

discontinuous broadleaved canopy. In the North Island this locally includes species of maire and kowhai, ribbonwood and locally narrow leaved hourere, lemonwood and kaikomako. In the South Island Hall's totara is typically also present with narrow leaved hourere, ribbonwood, kowhai, mahoe, broadleaf and tarata. Rimu is only present in the most humid part of this ecosystems range or edaphically moist sites. In coastal Otago ngaio and *Olearia* spp. are also present in the subcanopy. Divaricating shrubs and small trees are typically abundant in the sub-canopy many of which are now threatened including; *Coprosma wallii*, *Coprosma obconica*, *Melicytus flexuosus*, *Pittosporum obcordatum*, *Olearia gardeneri* and *O. hectorii*.

Kahikatea, totara, matai forest remnant near Kourarau Dam

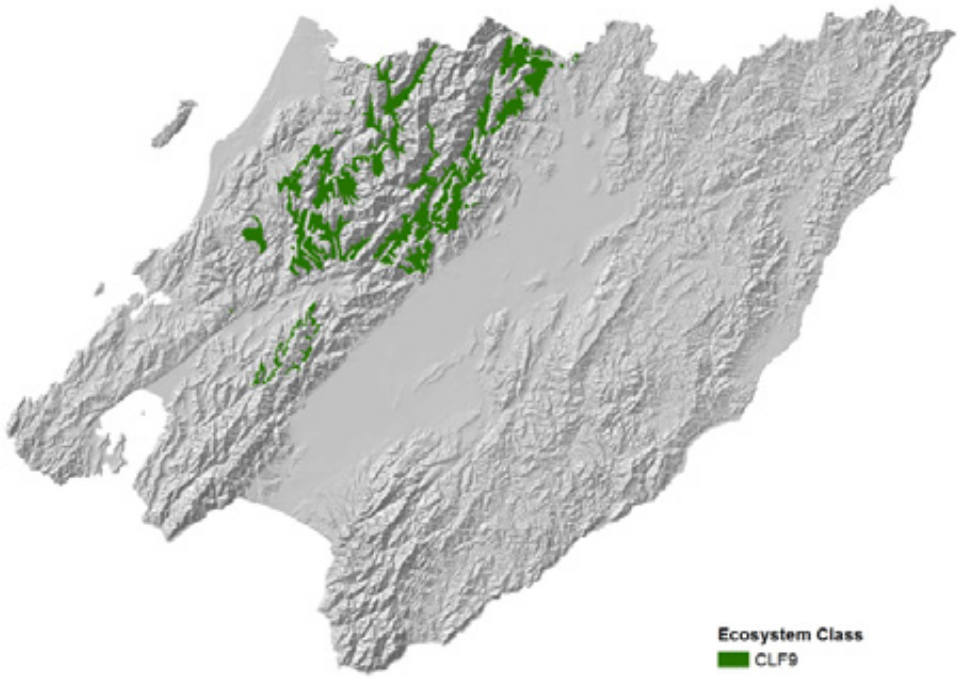
Key Processes and Interactions: The composition and structure of this ecosystem is nationally unusual and floristically rich (Ogle et al. 2000). The absence of broadleaved canopy trees with dense canopies below a tall canopy or emergent layer of podocarp trees results in high light levels reaching the lower tiers. This is likely a significant reason for the diversity and abundance of shrubs and small trees with a divaricating vegetative form. While suitable environmental conditions prevail in northern Southland and Otago, in the North Island these conditions are much rarer due to a combination of greater diversity of broadleaved trees and more restricted environmental suitability.

Threatening Processes: Major loss of this ecosystem occurred with Maori deforestation especially in Otago and Southland (Rogers et al. 1997; Perry et al. 2014). In the North Island only small remnants remain. In the Wellington Region it mainly occurs on the Kourarau Stream plateau, though small remnants are present in the southern Tararua District near Alfredton. All remnants are small, fragmented and many have been selectively logged. Weeds are a significant threat and this ecosystem is highly vulnerable to invasion by a wide range of invasive weeds. Of greatest threat are species such as old man's beard which is capable of smothering forest canopies and reducing species diversity (Ogle et al. 2000).

CLF9: Red beech, podocarp forest — Regionally not threatened — 95% remaining

Ecosystem Description

Regional Distribution: This forest type can be found at lower altitudes in the Tararua Range, Akatarawa Forest and Pakuratahi Forest. At many sites the forest grades into red beech, silver beech as altitude increases.



National Distribution: This forest is extensive in both the North and South Islands, primarily in western districts on hill slopes and alluvial stony soils in mountain ranges, from the Urewera Range to Westland and also in Southland (Wardle 1984).

Abiotic Processes: Primarily this ecosystem occurs in cool and humid foothill and mountain range areas, though it is also present in sub-humid regions in the North Island and in the eastern limit of its range. Soils are typically raw and recent mountain soils of low to moderate fertility.

Characteristic native biota: Red beech, podocarp forest occupies wide altitude and moisture ranges and therefore there are several regional variants ranging from beech, broadleaved and podocarp forest to more pure beech forest. Red beech is the canopy dominant tree, becoming increasingly dominant as conditions become unsuitable for broadleaved and podocarp species with altitude or a decline in rainfall towards the eastern limit of its range. In these transitional areas mountain beech or black beech usually become more common also.

Red beech is found locally with occasional silver beech, kamahi and occasional podocarp trees (rimu, matai, miro and Hall's totara and kahikatea on alluvial sites), locally hinau and maire species in the northern part of its range and southern rata in the South Island.

Red beech, podocarp forest in the eastern Hutt catchment

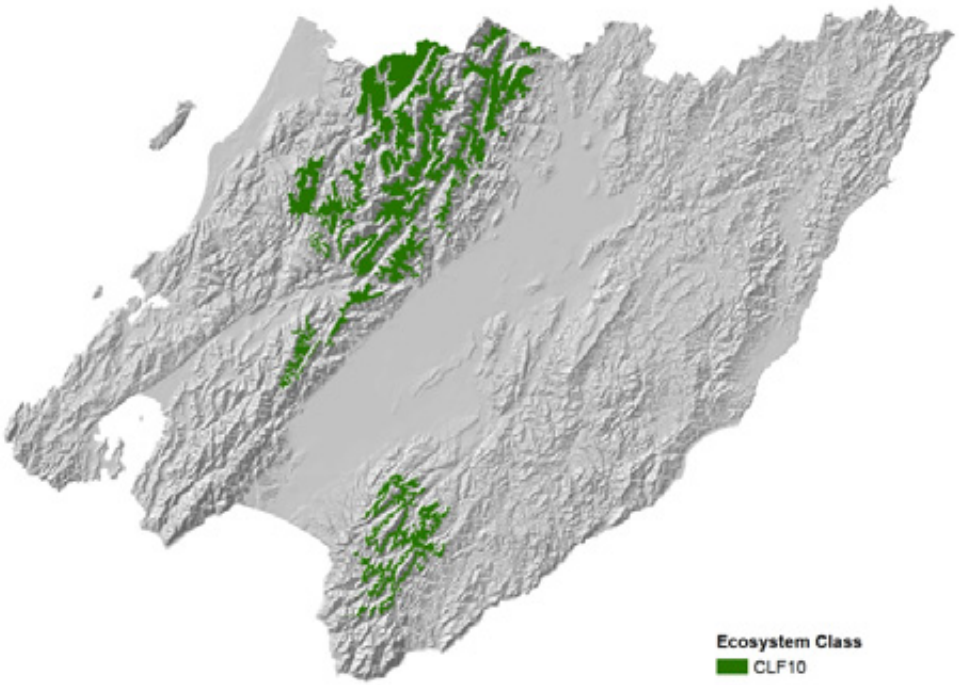
Key Processes and Interactions: This ecosystem is most common where silver beech is rare or uncommon in mid-slope foothills and mountain ranges. Red beech is a long-lived tall canopy tree and regenerates following periodic disturbance events associated with wind-throw and damage during storms, drought and insect pests (Wardle 1984; Hosking & Kershaw 1985; Ogden 1988). It usually regenerates on rotting trees, root plates or fresh alluvium in microsites with higher light. With increasing altitude this ecosystem usually transitions into CLF10: Red beech, silver beech forest, while at lower altitude podocarp and broadleaved trees usually become increasingly abundant. Red beech is strongly ecto-mycorrhizal and its dispersal into non-beech forest types is thought to be limited due to this dependency. It does however readily regenerate into manuka and kanuka, a probable consequence of shared ecto-mycorrhizal symbionts (Baylis 1980).

Threatening Processes: Occurring in the cool and humid areas of New Zealand a limited area of this forest was lost to Maori and European fires and consequently large areas remain. Selective logging for red beech and the occasional podocarps occurred in accessible locations, but as much of this forest occurs on steep and inaccessible mountain ranges on public conservation land, most areas have had minimal human interference. Deer and possums are almost ubiquitous in this ecosystem and typically have caused the decline of palatable canopy trees such as Hall's totara, kamahi and understorey species such as large leaved *Pseudopanax* and *Coprosma*. The decline in abundance has been greatest for the most palatable species such as beech mistletoes and kotukutuku (Sweetapple et al. 2004) and these would have been major dietary components of many forest birds (Murphy & Kelly 2003). Red beech periodically mast seeds and produces large nutritious seeds which consequently result in mice and rat population eruptions, facilitating stoat population increase (White & King 2006). These cycles in pest abundance have caused local extinction of a wide range of fauna (Dilks et al. 2003; O'Donnell & Hoare 2012).

CLF10: Red beech, silver beech forest — Regionally not threatened — 93% remaining

Ecosystem Description

Regional Distribution: This upland ecosystem type is found in the Tararua, Rimutaka and Aorangi Forest Parks, as well as in the Hutt Water Collection Area. It is the largest remaining ecosystem in the region, covering over 42,000 ha.



National Distribution: This is a widespread ecosystem and often dominant throughout the mountain ranges of the main divide from the East Cape to north western South Island, though it does occur sporadically south to Lake Te Anau (Wardle 1984).

Abiotic Processes: Found predominantly in mild to cool temperatures and high rainfall humid areas on steep mountain hillslopes, this forest grows on typically free-draining soils of low to moderate fertility. In the Tararua Range it usually occupies an altitudinal zone from approximately 600–900 m a.s.l. (Franklin 1967) though increases to 1200 m further north (Wardle 1984).

Characteristic native biota: Red beech, silver beech forest occupies a wide geographic, altitude and moisture gradient and consequently there are several regional variants ranging from beech, broadleaved and scattered podocarp forest to more pure beech forest. Red beech and silver beech are dominant, though silver beech usually has a higher stem density of smaller trees in comparison to red beech. Structure also varies with altitude with silver beech more abundant at higher altitude and valley floors that experience cold air ponding and red beech more common at lower elevations. Occasional associate trees include Hall's totara, kamahi, broadleaf and tawari in northern areas (Wardle 1984). Common sub-canopy broadleaved trees and shrubs include putaputaweta, three-finger, mountain fivefinger, lancewood and wineberry.

Red beech, silver beech forest on the ridge above Hutt Forks

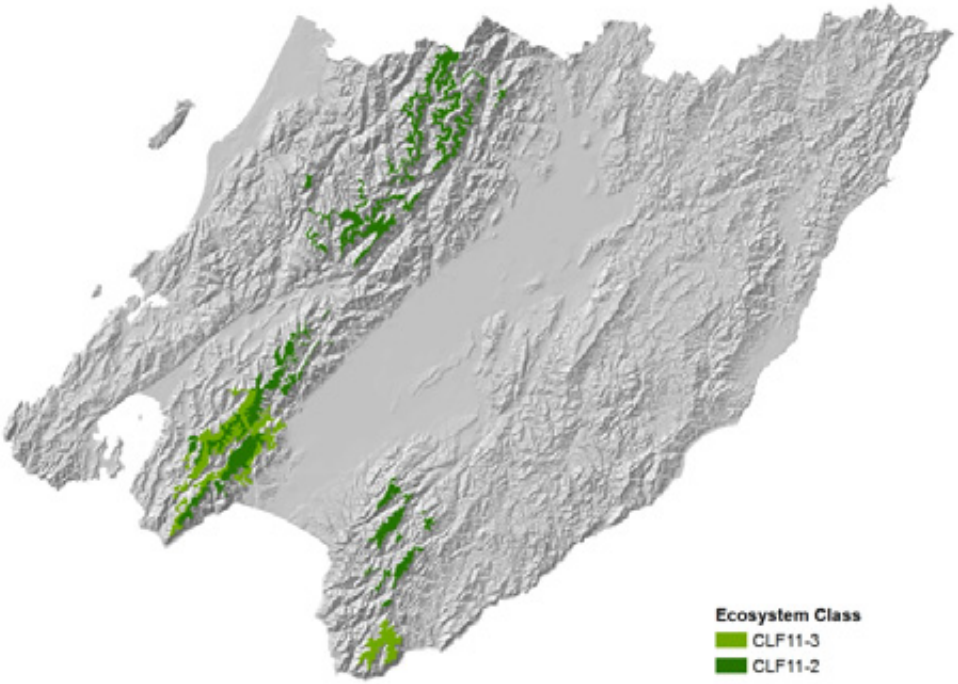
Key Processes and Interactions: This ecosystem is one of the most common forest types of the mountain ranges along the main divide. Beeches are long-lived tall canopy trees and regenerate following periodic disturbance events associated with wind-throw and damage during storms, drought and insect pests (Wardle 1984; Hosking & Kershaw 1985; Ogden 1988). With increasing altitude this ecosystem usually transitions into CLF11: Silver beech forest. Both red beech and silver beech are strongly ecto-mycorrhizal and dispersal into non-beech forest types is thought to be limited due to this dependency. They do however readily regenerate into manuka and kanuka, a probable consequence of shared ecto-mycorrhizal symbionts (Baylis 1980).

Threatening Processes: As this forest type is found in the cool, humid, mountainous areas of New Zealand, forest loss from Maori and European fires and development has been relatively minor and large areas remain. Locally, selective logging and land clearance occurred especially where this ecosystem occurred on alluvial terrace landforms. Deer and possums are almost ubiquitous in this ecosystem though red beech and silver beech. Silver beech is eaten by deer (Wardle 1984) though regeneration failure has only been reported in in tree fall gaps the Kaimanawa Range where sika deer are dominant browsers (Husheer et al. 2003). Forest modification by deer and possums has been greatest in the short-lived understorey species in this ecosystem. Significant declines of highly palatable species such as species of *Pseudopanax*, kotukutuku, broadleaf and large leaved coprosma shrubs have occurred (Wardle 1984, Husheer et al. 2003; Sweetapple et al. 2004). Both red beech and silver beech periodically mast seeds which consequently results in rodent and then stoat population explosions (White & King 2006), which have caused local extinction of a wide range of fauna.

CLF11: Silver beech forest — Regionally not threatened — 91% remaining

Ecosystem Description

Regional Distribution: This upland forest type has been classified into two variants in the Wellington Region— CLF11-2 which is found above 900 m a.s.l. and forms the treeline, as exemplified in the Tararua Ranges and CLF11-3 which occurs where red beech is absent and silver beech is found at lower altitudes (down to 630 m a.s.l.). The latter is found in the southern Rimutaka and Aorangi Ranges and the Wainuiomata Water Collection Area.



National Distribution: This ecosystem type is found from the Kaimai and Raukumara Ranges in the North Island to Fiordland in the South Island typically in humid to sub-humid climates.

Abiotic Processes: Silver beech is most competitive in cool to cold humid climates on low fertility often podzol soils that are and periodically saturated (Molloy 1998). Where mountain beech is absent it typically forms the tree line.

Characteristic native biota: Occurring from the Bay of Plenty to Fiordland, forest composition is variable and ranges from silver beech mixed with broadleaved and occasional podocarp trees at lower altitude sites to more pure silver beech forest at higher altitude sites.

At lower altitude sites kamahi is typically abundant often forming a dominant sub-canopy tier while in the South Island is often in association with southern rata. In the southern Rimutaka and Haurangi Ranges, low altitude silver beech forest contains occasional emergent trees of rimu, miro and northern rata (Franklin 1967). At higher altitude silver beech forms a more monotypic forest with broadleaf, mountain celery pine, three-finger, and species of *Olearia*, kotukutuku and small leaved shrubs in the sub-canopy.

Occurring at higher altitude and typically in high rainfall areas, silver beech forest is often covered in a range of epiphytic ferns such as species of filmy fern and bryophytes.

Silver beech forest on Mt Elder in the Hutt Water Collection Area

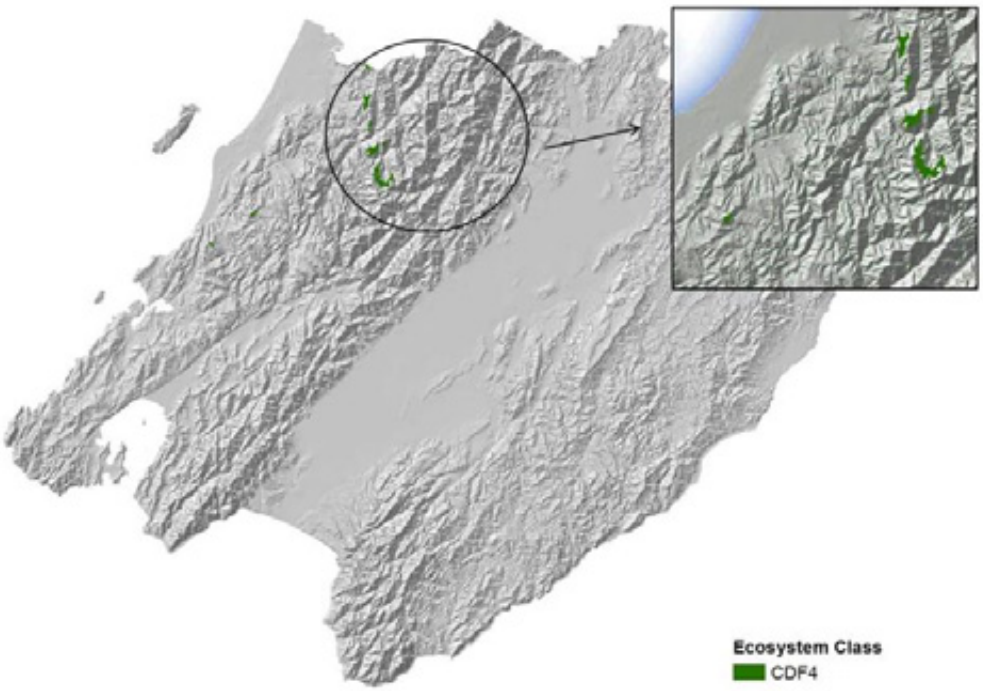
Key Processes and Interactions: This ecosystem is most common in humid and cool mountain ranges along the main divide where it forms a near monoculture. It is also abundant in areas where mountain beech and red beech are absent such as the Tararua Range and parts of Fiordland and south Westland. Silver beech seedlings are shade tolerant and regenerate beneath an intact canopy though they also readily regenerate following tree falls and periodic disturbance events associated with wind-throw and damage during storms, drought and insect pests (Wardle 1984). Large scale disturbance events result in even aged cohorts which synchronously die when mature. This ecosystem often forms the tree line at the high altitudes. Silver beech is strongly ecto-mycorrhizal and its dispersal into non-beech forest types is thought to be limited due to this dependency. It does however readily regenerate into manuka and kanuka, a probable consequence of shared ecto-mycorrhizal symbionts (Baylis 1980).

Threatening Processes: As this ecosystem type occurs in the cool, humid, mountainous areas of New Zealand limited forest loss has occurred and large areas remain. Silver beech produces a valuable hardwood timber and in some accessible areas is harvested. Deer and possums are almost ubiquitous in this ecosystem and locally silver beech is eaten by deer (Wardle 1984), though regeneration failure has only been reported in in tree fall gaps the Kaimanawa Range where sika deer are dominant browser (Husheer et al. 2003). Silver beech periodically mast seeds though its seeds are much smaller of lower nutritious value than red and hard beech (Wardle 1984; Beggs 1999). Consequently, mice and stoat population explosions may be less severe in silver beech forest than forests containing large populations of red beech or hard beech.

CDF4: Hall's totara, pahautea, kamahi forest — Regionally not threatened — 91% remaining

Ecosystem Description

Regional Distribution: In the Wellington Region, this forest type primarily occurs in the northern Tararua and Akatarawa Ranges (Druce & Atkinson 1958; Franklin 1967). While Hall's totara, pahautea, kamahi forest is not threatened, it is rare within the region, as it occurs under specific environmental conditions.



National Distribution: This ecosystem type occurs in beech gap montane areas of the North Island's mountains from the Raukumara to the Akatarawa Ranges (Nicholls 1976). Several variants occur largely due to variation in altitudinal range and the presence of montane conifer species.

Abiotic Processes: Found in montane areas from 700–1200 m a.s.l. in the North Island mountain ranges, this ecosystem experiences cool to cold temperatures and a humid, high rainfall climate with frequent cloud cover, low solar radiation, periodic snow fall and often gale-force winds. Soils are typically leached and of low fertility with poor draining soils especially on flat plateaux and stable shallow sloping sites.

Characteristic native biota: Kamahi is typically the most abundant canopy tree below 1100 m a.s.l. in association with one or more montane conifers of which Hall's totara is almost similarly ubiquitous. At lower attitude miro is often present while at higher altitude mountain celery pine, pahautea and pink pine are also reasonably wide-spread. At higher altitude this ecosystem subtly

merges into sub-alpine scrub (CDF6: *Olearia*, *Pseudopanax*, *Dracophyllum* scrub) as these two ecosystem types share many species. In the Wellington Region, Hall's totara and miro are the common podocarps with occasional mountain celery pine and a dominant kamahi canopy, (Druce & Atkinson 1957; Franklin 1967).

Hall's totara, pauhautea, kamahi forest on Mt Wainui in Akatarawa Forest

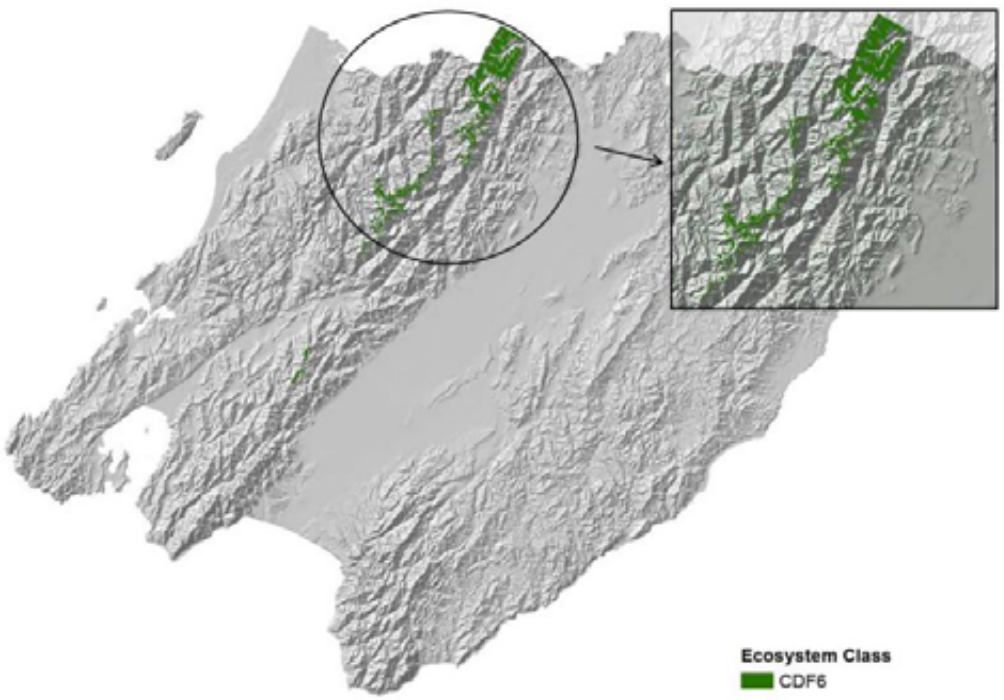
Key Processes and Interactions: Although this ecosystem occurs in areas where montane beech forest is generally environmentally suitable, it is absent most likely due to displacement through historical landscape factors and differences in competing species colonisation rates (Leathwick 1998). The dominant species of this ecosystem, such as kamahi and Hall's totara are capable of rapid dispersal into suitable areas when conditions are favourable. In comparison beech spreads more slowly, generally radial and rarely spreads over large distances (Baylis 1980), though has been shown to competitively suppresses the abundance of conifer and broadleaved species especially in montane areas (Leathwick & Austin 2001). Where these two ecosystems occur adjoining one another, beech invasion is thought to be limited primarily by the absence of suitable mycorrhizal fungi (Baylis 1980). Landscape history is thought to be the main cause for the distribution of this ecosystem type, including volcanism and local extinction of beech during the last glacial period. Volcanism creates new habitat, destroys competitive beech forest and facilitates the colonisation and rejuvenation of this ecosystem (Druce 1966; Clarkson 1990, Wilmshurst & McGlone 1996). Frequent large-scale storms causing widespread forest collapse is also thought to favour conifer and broadleaved trees to the detriment of beech (Rogers 1989; Rogers & McGlone 1994).

Threatening Processes: Occurring in a high altitude and typically in a humid climate much of this ecosystem remained extant at the time of European colonisation. Animal pests, especially possums and ungulates are the most significant threat to this ecosystem and have caused the local decline of some palatable species, such as kamahi and Hall's totara (Rogers & Leathwick 1997).

CDF6: *Olearia*, *Pseudopanax*, *Dracophyllum scrub* [sub-alpine scrub] — Regionally not threatened — >95% remaining

Ecosystem Description

Regional Distribution: In the Wellington Region, this upland ecosystem type is found in the Tararua Forest Park and the Hutt Water Collection Area. While not a forest type *per se*, this ecosystem is included in this guide as it forms a distinct ecotone with the upland forests in the region.



National Distribution: This ecosystem occurs in all mountain regions of New Zealand, though it is most abundant in beech gap montane–sub-alpine regions including; Central North Island, Mt Egmont–Taranaki, southern Ruahine–northern Tararua and in the central Westland, including in the upper Canterbury mountains east of the divide. It is also extensive on Stewart Island and the Subantarctic Islands. Where beech forest is present it is considerably less abundant and is restricted to areas with lowered tree lines, such as U–shaped basins prone to cold air ponding or south facing gullies (Wardle 1962).

Abiotic Processes: Occurring at or near the tree line, typically in high rainfall mountain regions this ecosystem experiences cold and frosty temperatures, frequent cloud cover, low solar radiation, intense, often gale-force, winds and a cold climate.

Characteristic native biota: This ecosystem is dominated by a combination of cold tolerant subalpine scrub species often in association with stunted canopy and sub-canopy forest tree species of upper mountain slopes. As it occurs from Mt Moehau in the northern Coromandel to the Subantarctic Islands there is a wide range in composition. Composition also varies with altitude — there is a general decline in canopy height and montane forest species with altitude, while scrub-line species increase.

Typically, it includes one or more species of *Olearia* (especially leatherwood) and locally species of *Brachyglottis, Pseudopanax, Dracophyllum, Hebe, Coprosma*, *Hoheria*, locally whararikiand manuka, montane podocarp trees such as alpine celery pine, pink pine, bog pine and Hall's totara and hybrids with Hall's totara and snow totara. At lower altitude stunted trees of kamahi, broadleaf, southern rata and pahautea locally occur. Prickly shield fern and species of astelia typically dominate the forest floor. Locally single species dominate some locations forming near monocultures such as leatherwood (*O. colensoi*) scrub in the southern Ruahine and northern Tararua Ranges.

Olearia, Pseudopanax, Dracophyllum scrub in the Hutt Water Collection Area

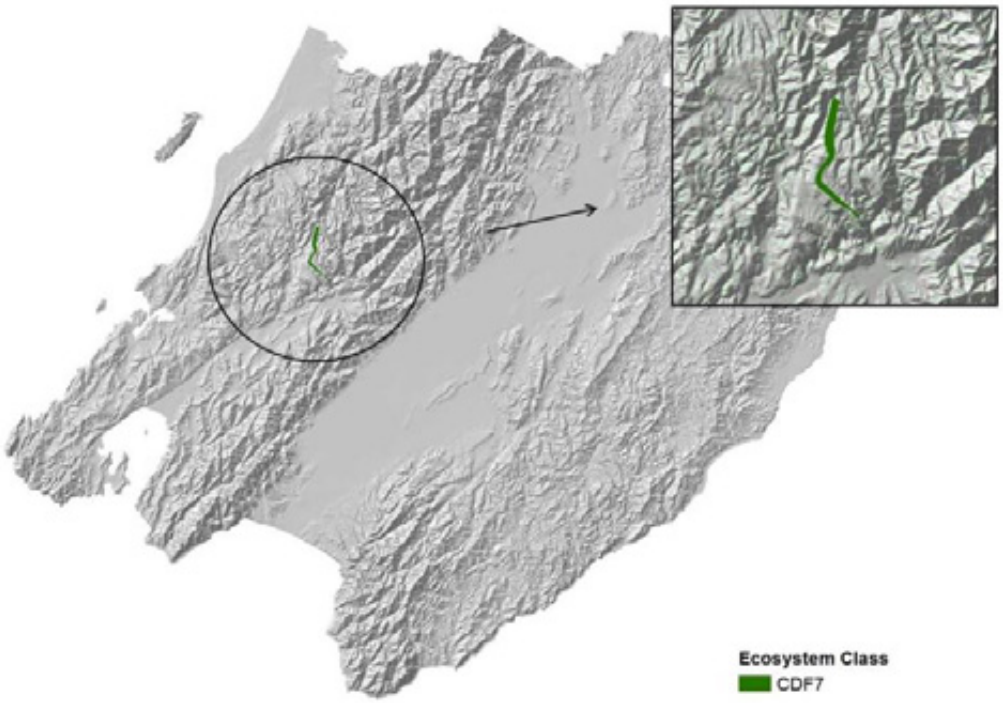
Key Processes and Interactions: This ecosystem occurs in tree line areas where beech forest is absent or where beech is present, in areas which are generally too hostile for beech. The major factors that influence the composition and structure of this ecosystem type are related to altitude, the landforms it occupies and soil drainage.

Threatening Processes: Very little of this ecosystem has been modified for other land uses primarily because it occurs at or near the tree line in humid mountainous regions, most of which are on public conservation land. Despite this it was burnt, predominantly in eastern areas, by both early Maori and later Europeans opening land up for grazing, though much of this has now regenerated. Some decline in condition has occurred with animal pests especially deer, and locally feral goats and Himalayan thar, causing the decline of some palatable species, such as kotukutuku and species of *Pseudopanax* and *Hoheria* (Wardle 1991). Long-term these pests pose the greatest threat and will likely result in the continuing decline of palatable species.

CDF7: Mountain beech, silver beech, montane podocarp forest — Regionally not threatened — >95% remaining

Ecosystem Description

Regional Distribution: Only 377 ha of this forest type is present in the Wellington Region. It occurs only on Maymorn Ridge which is in the Hutt Water Collection Area and Tararua Forest Park (Druce & Atkinson 1958), so while it is not a threatened ecosystem it is very rare within the region.

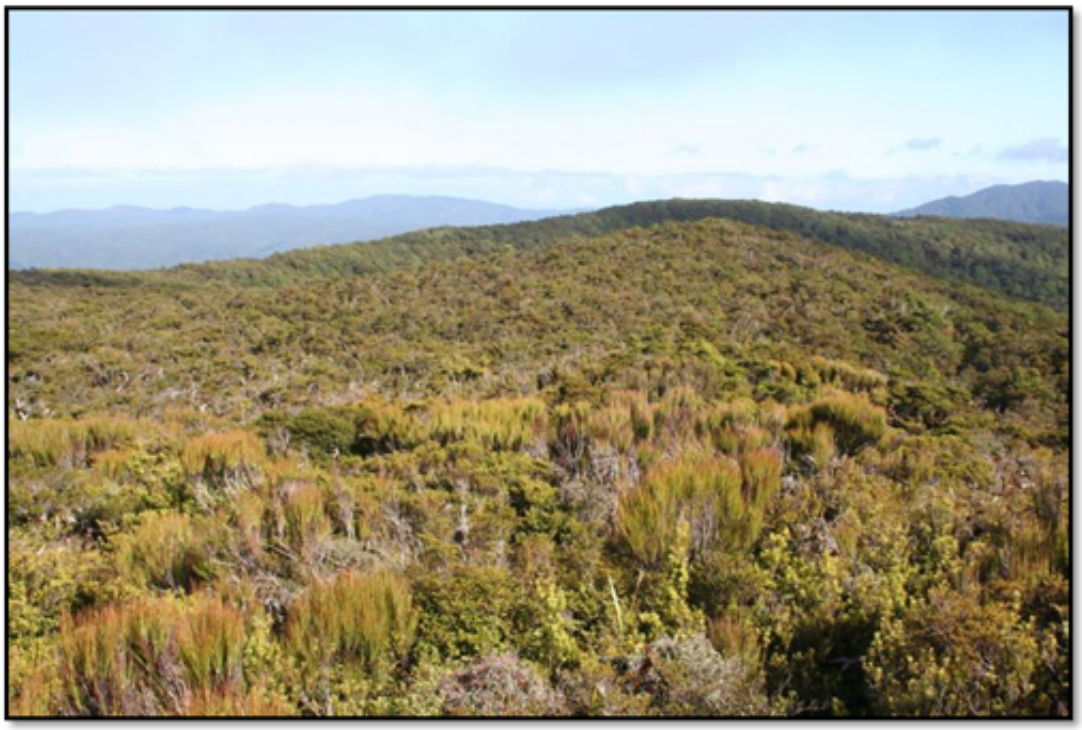


National Distribution: In the North Island this ecosystem type mostly occurs in the Raukumara, Ahimanawa, Ruahine Ranges and on southern and western Mt Ruapehu. In the South Island it is predominantly found in Northwest Nelson, Fiordland (including Waitutu) and in the Catlins.

Abiotic Processes: Mountain beech, silver beech, montane podocarp forest occurs in cool to cold and humid mountainous areas. Soils are infertile and poor draining and are either organic soils or podozols, especially on plateau and stable hillslopes (Molloy 1998 plate 8.6:130; Mark et al. 1998). It also widely occurs on the margin of fen and bog wetlands.

Characteristic native biota: Mountain and or silver beech are always present either singly or together where their ranges overlap. In association with beech one or more montane conifer species and locally southern rata occur. In the North Island, montane trees found locally include Hall's totara, pahautea, pink pine, bog pine and silver pine. In association with these are a range of scrub and shrub species including manuka and a variety of species of *Dracophyllum*, *Coprosma*, *Olearia* and *Pseudopanax* are typically common.

Locally this ecosystem descends to lower altitude, such as in the Catlin's and south western Ruapehu typically on podzol soils. In these areas rimu and kahikatea can be locally abundant. In the Wellington Region this forest type occurs at one relatively low altitude site on the Maymorn ridge (southern Tararua Range) where silver beech occurs in association with Hall's totara, rimu and miro.



Mountain beech, silver beech, podocarp forest in the Hutt Water Collection Area

Key Processes and Interactions: Occupying infertile cool to cold and humid locations, the composition of this ecosystem is variable largely because of its extensive geographic range across New Zealand. It typically occurs as geographically separated zones on the summits of mountain ranges. Soil development, fertility and drainage are also significant factors affecting composition and tree height ranges from low forest up to 12 m height to short stature and open Krummholz scrub (Wardle 1984).

Threatening Processes: Due to the location, soil infertility and climate a large amount of this ecosystem remains in a relatively unmodified state. Animal pests pose the greatest long-term threat, however because of a combination of the environment it occurs in and that it typically contains a high proportion of unpalatable species, pest abundance is generally low. Selective browsing by possums and deer is causing decline in some highly palatable species such as beech mistletoes and species of *Pseudopanax* (Wardle 1984).

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Appendix 1: Terrestrial ecosystems of the Greater Wellington region

Forest ecosystems

MF1, Totara, titoki forest
MF2, Rimu, matai, hinau forest
MF2, Rimu, matai, hinau forest and MF5, Black beech forest mosaic
MF20, Hard beech forest
MF5, Black beech forest
MF6, Kohekohe, tawa forest
MF7, Tawa, kamahi, podocarp forest
MF8, Kamahi, broadleaved, podocarp forest
WF1, Titoki, ngaio forest
WF2, Totara, matai, ribbonwood forest
WF3, Tawa, tiitoki, podocarp forest
WF3, Tawa, tiitoki, podocarp forest
WF6, Totara, matai, broadleaved forest [Dune Forest]
WF8, Kahikatea, pukatea forest
CDF4, Hall's totara, pahautea, kamahi forest
CDF7, Mountain beech, silver beech, montane podocarp forest
CLF10, Red beech, silver beech forest
CLF11-2, Silver beech
CLF4, Kahikatea, totara, matai forest
CLF9, Red beech, podocarp forest
CDF6, Olearia, Pseudopanax, Dracophyllum scrub [Subalpine scrub]

Wetland ecosystems

Swamp mosaic
WL10, Oioi restiad rushland/reedland
WL12, Manuka, tangle fern scrub/fernland
WL18, Flaxland
WL19, Raupo reedland
WL20, Coprosma, twiggy tree daisy scrub
Fen mosaic

Coastal ecosystems

DN2, Spinifex, pingao grassland/sedgeland
DN2/5 Coastal Sand Dunes Mosaic
DN5, Oioi, knobby clubrush sedgeland
Rocky beach
SA2, Searush, oioi, glasswort, sea primrose rushland/herbfield [Saltmarsh]
SA4, Shore bindweed, knobby clubrush gravelfield/stonefield

Alpine ecosystems

AL4, Mid-ribbed and broad-leaved snow tussock tussockland/shrubland
AH3, Gravelfield/stonefield, mixed species cushionfield

Cliff ecosystems

CL3, Coprosma, Muehlenbeckia shrubland/herbfield/rockland

River ecosystems

BR1: Hard tussock, scabweed gravelfield/stonefield

Appendix 2: Example forest remnant species lists for regionally threatened forests

Species lists for each of the threatened forest types detailed in this guide can be found at www.nzpcn.govt.nz. Click on Plant Distribution Maps, then 'Site search" and enter the district and site name as shown below.

Forest Type	Forest Name	District	Site name
WF1	Titoki, ngaio	Masterton	Mt Percy
WF2	Totara, matai, ribbonwood	South Wairarapa	Soldiers Memorial Park
WF3	Tawa, titoki, podocarp	Masterton	Tuki Waha QEII
WF6	Totara, matai, broadleaf	Kapiti Coast	Forest Lakes Chraistian Camp
WF8	Kahikatea, pukatea	Kapiti Coast	Nga Manu F&B area
MF1	Totara, titoki	Carterton	Eringa Road Bush
MF2	Rimu, matai, hinau	Masterton	Rewa & Meredith
MF2/5	Rimu matai, hinau/black beech	Carterton	Rocky Hills Taipos
MF5	Black beech	South Wairarapa	Western Wairarapa Lakeshore Res
MF6	Kohekohe, tawa	Kapiti Coast	Paraparaumu SR
MF7	Tawa, kamahi, podocarp	Upper Hutt City	Trentham SR
MF20	Hard beech	Upper Hutt City	Wi Tako & Fendalton Res
CLF4	Kahikatea, totara, matai	Carterton	Admiral Road remnant

Note that other examples may be found at other locations by using placing the cursor on the map and right-clicking as described.

Appendix 3: Glossary of plant names

Common name	Scientific name
Akeake	Dodonaea viscosa
Akiraho	Olearia paniculata
Black beech	Fuscospora solandri
Black maire	Nestegis cunninghamii
Bog pine	Halocarpus bidwillii
Broadleaf	Griselinia littoralis
Cabbage tree	Cordyline australis
Coastal pohuehue	Muehlenbeckia australis
Coastal tree daisy	Olearia solandri
Five-finger	Pseudopanax arboreus
Hall's totara	Podocarpus laetus
Hard beech	Nothofagus truncata
Hinau	Elaecocarpus dentatus
Kahikatea	Dacrycarpus dacrydioides
Kaikomako	Pennantia corymbosa
Kamahi	Weinmannia racemosa
Kanuka	Kunzea ericoides
Kawakawa	Piper excelsum subsp. excelsum
Kiekie	Freycinetia banksii
Kohekohe	Dysoxylum spectabile
Kohuhu	Pittosporum tenuifolium
Kotukutuku	Fuchsia excorticata
Kowhai	Sophora microphylla
Lancewood	Pseudopanax crassifolius
Large-leaved coprosma	Coprosma grandifolia
Leatherwood	Olearia colensoi var. Colensoi
Lemonwood	Pittosporum eugenioides
Mahoe	Melicytus ramiflorus
Maire	Mida salicifolia
Manuka	Leptospermum scoparium var. scoparium
Matagouri	Discaria toumatou
Matai	Prumnopitys taxifolia
Mingimingi	Coprosma propinqua var. propinqua
Miro	Prumnopitys ferruginea
Mountain beech	Fuscospora cliffortioides
Mountain celery pine	Phyllocladus alpinus
Ngaio	Myoporum laetum
Nikau	Rhopalostylis sapida
Northern rata	Metrosideros robusta

Pahautea	Libocedrus bidwillii
Pink pine	Halocarpus biformis
Pokaka	Elaeocarpus hookerianus
Porokaiwhiri	Hedycarya arborea
Prickly shield fern	Polystichum vestitum
Pukatea	Laurelia novae-zelandiae
Putaputaweta	Carpodetus serratus
Red beech	Fuscospora fusca
Red mapou	Myrsine australis
Rewarewa	Knightia excelsa
Ribbonwood	Plagianthus regius subsp. regius
Rimu	Dacrydium cupressinum
Sand coprosma	Coprosma acerosa
Silver beech	Lophozonia menziesii
Silver pine	Manoao colensoi
Southern rata	Metrosideros umbellata
Supplejack	Ripogonum scandens
Swamp maire	Syzygium maire
Tanekaha	Phyllocladus trichomanoides
Tauhini	Ozothamnus leptophyllus
Tawa	Beilschmiedia tawa
Tawheowheo	Quintinia serrata
Three-finger	Pseudopanax colensoi var. colensoi
Titoki	Alectryon excelsus
Totara	Podocarpus totara
Tutu	Coriaria arborea var. arborea
Whaririki	Phormium cookianum subsp. cookianum
White maire	Nestegis lanceolata
Wineberry	Aristotelia serrata

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