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Reconstruction of the 1750 pre-European vegetation cover of Norfolk Island: the importance of combining historical information with field investigations

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Abstract

Mapping and description of the pre-European natural vegetation cover on the Australian territory of Norfolk Island in the Pacific Ocean between New Zealand and New Caledonia based on plant communities is achieved for the first time. The island is 34.6 km^2 in area with a highest point of 316 m. At a latitude of about 29 degrees south, equivalent to Evans Head on Australia's east coast, Norfolk Island is regarded as subtropical. Eight forest and six treeless plant communities are described and mapped. The vegetation includes hardwood forests, shrubland, herbland, grassland, sedgeland and freshwater swamp. The original extent of the characteristic Norfolk Island Pine *Araucaria heterophylla* is discussed. A Checklist of plant species is provided in an accompanying paper (Mills 2025b).

Consideration of remnant vegetation, field investigation and critical evaluation of historical information was essential for understanding the original vegetation patterns and reconstructing the pre-European 1750 vegetation cover.

Keywords: Norfolk Island; natural vegetation; plant communities

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Introduction

The reconstruction of original, pre-human vegetation cover for any area is fraught with difficulties. Extant remnants may provide clues but may not be absolutely reliable, while educated guesses usually form a significant part of any reconstruction of former vegetation patterns. A good knowledge of the significant environmental attributes that influence vegetation communities and their distribution are essential inunderstanding vegetation patterns (e.g. Mills 1988).

Norfolk Island, an external territory of Australia, is located in the Pacific Ocean between New Zealand and New Caledonia, 1,412 km directly east of Australia's Evans Head and about 900 km from Lord Howe Island. The island is 34.6 km^2 in area with a highest point of 316 m. At a latitude of about 29 degrees south, equivalent to Evans Head on the east coast of Australia, Norfolk Island is regarded as subtropical. Together with the neighbouring Phillip Island and Nepean Island, the three islands collectively form the Territory of Norfolk Island. At the 2021 census, it had 2,188 inhabitants.

This study involved the identification of the natural plant communities on Norfolk Island and the mapped reconstruction of the pre-European distribution of these communities. The natural vegetation has been heavily impacted since European settlement as a convict gaol in 1788. Little of the lowland forest remains, while the higher land, now contained within Norfolk Island National Park, is heavily infested with woody weeds (Figure 1). After 237 years of settlement, the original patterns in the distribution of plant communities are not immediately obvious.

The paper describes the methods used to identify how the various plant communities were determined, and how decisions were made in delineating the boundaries on the vegetation map. As well as being of scientific and general interest, such a map assists in determining what the original vegetation was like at a particular location, thus serving as a guide for future revegetation projects.

Figure 1. View south from Mount Pitt (316 m elevation) showing the generally cleared lowlands beyond the forested slopes of the mountains.

Methods

The author has been involved in the study of the island's flora for a long time and has developed an intimate knowledge of the island's plants and plant communities. During 2018-2020 targeted field surveys were undertaken across the island by the author with Norfolk Island botanist Naomi Christian, to identify and map existing native remnants and identify the plant communities (Christian and Mills 2018, Mills 2018).

A parallel project by the author was to identify and map the probable vegetation cover of 1750. This involved a review of all available historical information, from the first visit by James Cook and accompanying botanists Johann Reinhold and Johann Georg Forster in 1774, and through the Convict Settlements to the mid-1800s. Following investigation of existing information, discussions with relevant people and much field survey, a suite of plant communities was identified. While the author prepared the map presented here, a contemporary map of vegetation cover was largely prepared and digitised by Naomi Christian. Existing vegetation mapping covering the national park and the public reserves, mostly as paper maps made available by Parks Australia, was initially checked for accuracy and relevance. Where the mapping was useful, the maps were scanned and imported into the GIS program. The map of the national park prepared by Gilmore and Helman (1989) was most useful in this regard. The plant communities on that map were transferred to our communities and the boundaries checked for consistency with our understanding of the vegetation; modifications were made where necessary. The 1750 map was expanded from the national park map by the author using the GIS platform ArcGIS by digitising free-hand the boundaries of the plant communities onto a contour map of the island overlaid by our map of extant vegetation remnants.

No attempt has been made to map the original vegetation of Phillip Island (190 ha) and Nepean Island (10 ha), located to the south of Norfolk Island (Figure 2). Any attempt to do so would be highly speculative as the vegetation of both islands was completely destroyed following the settlement of Norfolk Island. Phillip Island in particular, overrun with introduced grazing animals, rabbits and pigs, was stripped of vegetation and lost all of its topsoil into the ocean and has only recently begun to naturally revegetate (Mills 2009a).

Plant names used here are those found in the online site Australian Plant Census, maintained by the National Herbarium, Canberra, which includes the Norfolk Island flora (see note in Mills 2025b).

An outline of the history of botanical investigation on Norfolk Island along with an updated checklist of the indigenous flora for the island group is provided by Mills (2025b).

Background

Early commentators invariably mention the thick forest that covered the island and there is little doubt that forest covered the vast majority of the 34 km^2 island. After stepping ashore at Duncombe Bay, botanist George Forster (1754-1794), who accompanied James Cook (1728-1779) in the ship *Resolution* in 1774, wrote "*we penetrated into the woods with great difficulty, through a thick tissue of bindweeds and climbers. However, as soon as we had passed through this outward fence, we found the forest tolerably clear of underwood, and had not the least difficulty to walk forwards*" (Forster 1777).

Philip Gidley King (1758-1808) landed at Slaughter Bay in March 1788 to establish the First Convict Settlement. King "*ascended ye Northern hill [Mount Pitt] which is very steep, we found ye Woods so very thick & so much underwood which was rendered still worse by a large kind of supple jack [climbing plant] which formed an impenetrable net work thro' which we had to cut our way*" (Fidlon and Ryan 1980). King also noted that "*we were so thoroughly bewildered in impassable woods & steep hollows…*".

Government botanist in New South Wales Allan Cunningham (1791-1839) on a visit to the island during the Second Convict Settlement in 1830 wrote, *"An inspection of the surface of the Island was originally found clear of Timber & Underwood but the whole on penetration discover'd to be once cont[d] mass of jungle…"* (Mills 2012).

Early observers also noted the similarity of the plants on Norfolk to those they had seen in New Zealand; both James Cook and George Forster commented on this fact. Forster, foreshadowing later work on the origin of the island's flora, writing *"The productions of New Zeeland were here united to those of New Caledonia, and the New Hebrides…"* (Forster 1777).

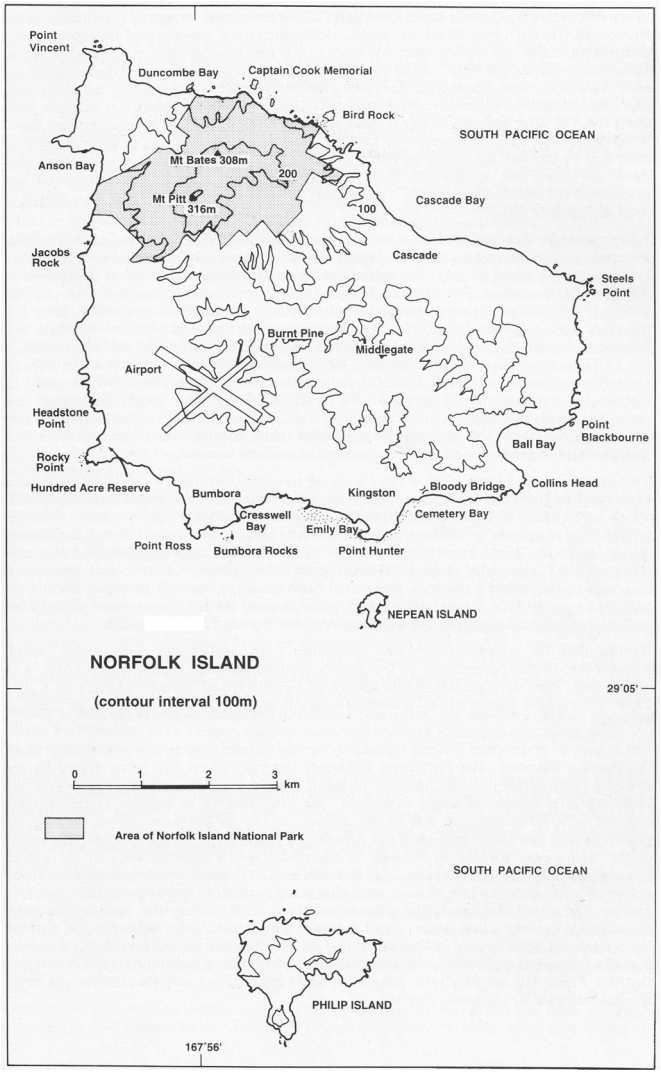


Figure 2. The Norfolk Island Group. Source: *Flora of Australia*. *Volume 49, Oceanic islands*, Australian Government Publishing, Canberra, 1994.

Much clearing of the lowland forest took place during the five and a half decades when the island was a convict settlement. English Quaker and naturalist James Backhouse (1794-1869), visiting the island in 1835 during the Second Convict Settlement, noted "*the upper portions of the vallies, and the higher parts of the hills, are covered in wood* [forest]" (Backhouse 1843). He later observed that pines grew "*in clumps, and singly, on the grassy parts of the island*", later noting that the hills and valleys were "*thickly wooded*".

While the island was largely covered in subtropical rainforest, which no doubt varied across the island as to its floristic composition, other plant communities were almost completely restricted to coastal cliffs and nearby.

The plant communities

Given the large-scale removal of the forest, the identification of the plant communities on Norfolk Island requires a fair amount of speculation, albeit based on some firm assumptions. Early historical information is available, as noted above, although the authors of such material did not set out to describe plant communities. From James Cook in 1774 onwards, most observers described the forest as dense and thick and various plants are mentioned as being abundant in one place or another.

A drawing by Austrian botanical artist and plant collector Ferdinand Bauer (1760-1826) made during his visit in 1804-05 is most instructive in appreciating the forest of that time, when little had been cleared or modified. The drawing is a view towards the northeast with the Mount Pitt - Mount Bates ridge in the background (Figure 3). The most interesting aspect of the sketch is the low density of pines across the island. What we can glean from this drawing is that:

- Pines were probably mainly a coastal tree, unable to regenerate under a dense forest cover.
- Hardwood forest covered most of the island's inland areas.
- The ridges of the mountains supported pines; the plateau areas perhaps less so.

Figure 3. Drawing by Ferdinand Bauer dated 1804. Natural History Museum, London.

Based on the communities identified here, Bauer's drawing shows Plateau Hardwood Forest across most of the foreground, Moist Upland Hardwood Forest on the slopes and Pine Hardwood Ridgetop Forest on some ridges. The immediate foreground, with palms and tree ferns, is likely to be a valley supporting Lowland Valley Hardwood Forest.

In a report on the forests of Norfolk Island, forester Charles Lane-Poole (1926) recognised that pines were probably more common now than in the original forest, stating "*The island offers a unique example of the survival of the fittest. In its original state pine was in the minority, driven to take up its stand on the poor ridges and on the mountains, driven there by its broad-leaved and more numerous and more exigent brothers, the jungle species, that*

held the bulk of the deep lands and the cool gorges. Man then destroyed the forest conditions and in so doing gave the pine a tremendous advantage over the jungle types…". It seems that the prominence of pine was considerably less across the inland parts of the island in its natural condition than it is today. This suggests that pines were more a coastal feature, where they dominate today in the Coastal Pine-White Oak Forest community described here. Today pines co-dominate the ridges of the mountains (Figure 4), but it is not clear whether this was originally the case, or the disturbance over 200 plus years has promoted the pines on these areas, as suggested by Lane-Poole (1926).

Figure 4. View looking east from Mount Pitt, showing the Moist Upland Hardwood Forest on the slopes, and Pine – Hardwood Ridgetop Forest on the ridges. The plants in the foreground are *Phormium tenax* (left, planted) and *Cordyline obtecta* (right).

The plant communities identified in this study with their main species and associated landforms are summarised in Appendix 1. In all, 14 plant communities have been identified, eight forest communities, five treeless coastal communities and one wetland community. Each plant community is briefly described below, particularly in terms of how to identify each from related communities. Mapping considerations are also noted for each community. A flow diagram showing the general relationships between the plant communities (Figure 5) and map showing original plant community distributions (Figure 6) are provided.

Mention must be made of the exotic flora of Norfolk Island, which has been introduced since 1788. These introductions now out-number the indigenous plants by at least two to one (Mills 2025b). Two key woody weeds are very prominent in the forest communities of the national park and elsewhere, *Psidium cattleyanum* var. *cattleyanum* and *Olea europaea* subsp. *cuspidata*. Both species dominate in many places around the island today. The former forms dense thickets of smallish trees, most obvious on the moister southern side of the mountains, while the latter does best on drier sites such as the northern side of the mountains. *Psidium cattleyanum* var. *cattleyanum* in particular forms extensive stands across the lower sections of the mountains, sometimes with few other trees present.

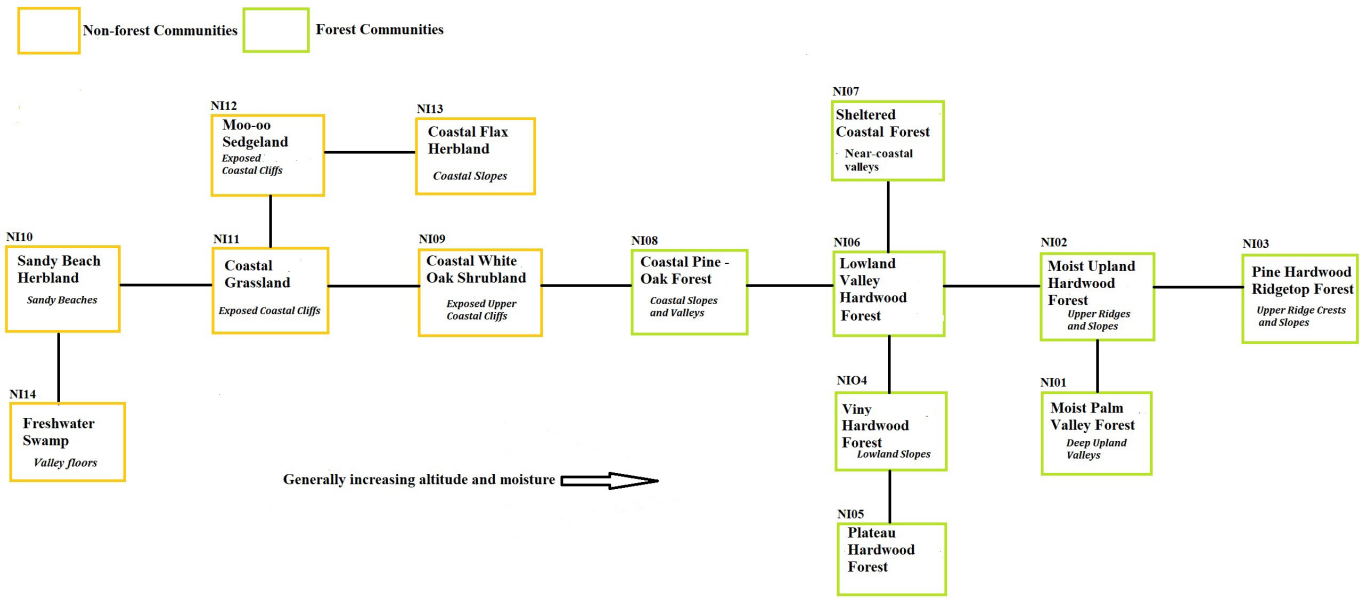
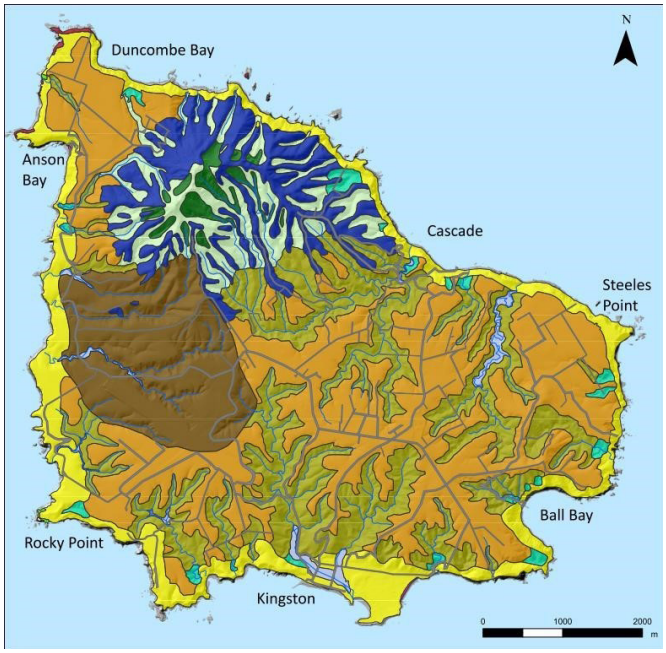


Figure 5. Diagram showing general relationships between plant communities.



Legend

NI01	Moist Palm Valley Forest
NI02	Moist Upland Hardwood Forest
NI03	Pine Hardwood Ridge Forest
NI04	Viny Hardwood Forest
NI05	Plateau Hardwood Forest
NI06	Lowland Valley Hardwood Forest
NI07	Sheltered Coastal Forest
NI08	Coastal Pine and White Oak Forest
NI09	Coastal White Oak Shrubland
NI10	Sandy Beach Herbland
NI11	Coastal Grassland
NI12	Moo-oo Sedgeland
NI13	Coastal Flax Community
NI14	Freshwater Swamp
Road	
Waterway	

Figure 6. The 1750 map of plant communities on Norfolk Island. Prepared by the author and Naomi Christian; the project was managed by the Invasive Species Council and Tierra Mar.

Plant Community descriptions and mapping considerations

NI01. Moist Palm Valley Forest

This community occurred in the deep valleys on the mountains and is almost entirely within the national park, at least today (Figure 7). Primarily on the moister, southern side of the mountains, perhaps historically extending down into deep lower valleys away from the mountains. In the national park, the mapping by Gilmore and Helman (1989) has been incorporated into the current 1750 map, albeit with some minor changes.

The community is usually a dense stand of the palm *Rhopalostylis baueri* with the island's two tree ferns, *Cyathea brownii* and *Cyathea australis* subsp. *norfolkiensis*, along with scattered hardwoods, including *Pennantia endlicheri* and *Dysoxylon bijugum*. At lower altitudes, on upper slopes and on the northern side of the mountains, hardwoods become more common in the community. Many terrestrial ferns are common in this forest, including *Asplenium dimorphum*, *Ptisana salicina*, *Diplazium* species, *Blechnum norfolkianum*, along with the climbing ferns *Arthropteris tenella* and *Zealandia pustulata*. Epiphytes are quite common, including the ferns *Pyrrosia confluens* and *Asplenium polyodon* and the orchids *Oberonia titania* and *Eria paleata*. The lithophytic filmy ferns *Callistopteris baueriana* and *Polyphlebium endlicherianum* are associated with waterfalls and heavily shaded rock outcrops.

Figure 7. Moist Palm Valley Forest in Norfolk Island National Park, dominated by *Rhopalostylis baueri*.

NI02. Moist Upland Hardwood Forest

This community occurs on the slopes of the valleys around the mountains, between the previous (NI01) and following communities (NI03). Most of the occurrence has previously been mapped within the national park (Gilmore and Helman 1989); again, that map is largely incorporated into the current 1750 map.

The forest is quite species diverse, but generally lacks some species that occur at lower altitude but includes a few species that prefer higher (moister) altitudes (Figure 8). Typical woody species include *Coprosma pilosa, Melicope littoralis*, *Pennantia endlicheri*, *Piper excelsum* subsp. *psittacorum, Pittosporum bracteolatum*, *Cordyline obtecta, Dysoxylum bijugum, Melicytus ramiflorus* subsp. *oblongifolius, Freycinetia baueriana*, *Myrsine ralstoniae* and *Meryta angustifolia*. Vines are usually abundant, including *Melodinus baueri* and *Capparis nobilis*. Common ferns include *Arachniodes aristata, Asplenium dimorphum, Blechnum parrisiae*, *Arthropteris tenella* and *Zealandia pustulata*.

Moist Upland Hardwood Forest is the moist version of Plateau Hardwood Forest (Community 5), the boundary between the two being somewhat arbitrarily made when slopes have low gradient rather than steeply sloping as in the foothills of the mountains. The community has been mapped nearly to the coast on the northern side of the mountains due to the steep topography.

Figure 8. Moist Upland Hardwood Forest. The large-leaved plant at right is the endemic *Meryta angustifolia*.

NI03. Pine - Hardwood Ridgetop Forest

The ridges on the flanks of the mountains support stands of *Araucaria heterophylla*, a species largely excluded from the Moist Upland Hardwood Forest; Figure 4 shows both communities. Pine - Hardwood Ridgetop Forest (Figure 9), contains hardwoods such as *Lagunaria patersonia, Elaeodendron curtipendulum, Ungeria floribunda, Exocarpos phyllanthoides, Dysoxylum bijugum, Myrsine ralstoniae, Nestegis apetala, Pittosporum bracteolatum, Meryta angustifolia*, *Melicytus ramiflorus* subsp. *oblongifolius*, *Cordyline obtecta* and the rare endemic *Wikstroemia australis*. Understorey species include *Alyxia gynopogon, Jasminium simplicifolia* subsp. *australiense* and the ferns *Archniodes aristata* and *Adiantum diaphanum*.

The mapping of this forest extended down to the 120 m contour line; the forest below that altitude being mapped as Plateau Hardwood Forest, that forest being the drier, lowland extension of the Moist Upland Hardwood Forest. In the national park, the map by Gilmore and Helman (1989) has been incorporated into the current 1750 map, albeit with some minor changes.

Figure 9. Pine - Hardwood Ridgetop Forest, Mount Bates ridge.

NI04. Viny Hardwood Forest

This community occurred at a low altitude on the south-western flanks of the mountains and extending towards the coast. Remnants include the Botanic Garden and patches around Mission Road. Most of this community has been cleared, but two key species appear to indicate its previous extent and are largely restricted to the mapped area. These key indicator species are large old *Celtis paniculata* trees and the robust vine *Austrocallerya australis* (Figure 10).

Other characteristic species include *Dysoxylum bijugum, Nestegis apetala, Achyranthes arborescens*, *Piper excelsum* subsp. *psittacorum*, large numbers of *Baloghia inophylla* and *Planchonella costata,* which is only found at lower altitudes and primarily in this community. Understorey species include the ferns *Arthropteris tenella* and *Adiantum diaphanum*. In addition to the above vine, *Capparis nobilis* and *Melodinus baueri* are present.

Mapping the extent of this community is based largely on the presence of *Celtis paniculata* and *Austrocallerya australis* in highly disturbed areas and on occurrences of the community around Mission Road, including an intact stand in the Botanic Garden. The distribution of the forest is to some extent speculative. Backhouse (1843) was probably referring to this community between Kingston and Anson Bay when he wrote "*the road was chiefly through thick forest, overrun with luxuriant climbers. Among them was a Wisteria, with pea-flowers, of purple and green, and leaves something like those of the Ash* [*Austrocallerya australis*]." This is fairly consistent with the interpretation of the extent of Viny Hardwood Forest presented here.

Figure 10. Viny Hardwood Forest in the Norfolk Island Botanic Garden. The large buttressed trees in the background are *Celtis paniculata*, while the robust vine is *Austrocallerya australis*.

NI05. Plateau Hardwood Forest

This community was probably the most widespread forest on the lower parts of the island (Figure 11). It is the drier version of the Moist Upland Hardwood Forest (Community NI02) of higher elevations. Key species that seem to be consistent across the areas surveyed, such as at Steeles Point and above Duncombe Bay, are *Lagunaria patersonia*, *Elaeodendron curtipendulum, Baloghia inophylla, Ceodes brunoniana, Jasminum simplicifolium* subsp. *australiense, Nestegis apetala* and *Myrsine ralstoniae*. *Araucaria heterophylla* may have been rather uncommon in this forest (see Figure 2 drawing by Ferdinand Bauer), perhaps because pines find it difficult to regenerate under a dense rainforest canopy. Old and naturally occurring *Ceodes brunoniana* occur in several places and may be indicative of this forest community. The understorey may have been quite open in places, supporting the shrub *Alyxia gynopogon* and the hardier ferns, such as *Blechnum parrisiae* and *Arachniodes aristata*.

Mapping of this forest was based on topography and altitude. Topography was used to differentiate this forest from the valleys containing Lowland Valley Hardwood Forest (Community 6), while altitude delineated this forest and the Moist Upland Hardwood Forest (Community 2). The community is mapped

below a rather arbitrary 120 metres in elevation, approximately where a change in species composition was noted. Because of the gentle topography, almost all of this forest has been removed so that its original composition is somewhat speculative.

Figure 11. Plateau Hardwood Forest, Duncombe Bay. The dominant trees in this remnant are hardy species, *Elaeodendron curtipendulum* and *Nestegis apetala*.

NI06. Lowland Valley Hardwood Forest

This community (Figure 12) is a drier version of the Moist Palm Valley Forest (Community NI01), which occurs higher up the mountain valleys and slopes. The tree species include *Lagunaria patersonia, Streblus pendulinus*, *Baloghia inophylla, Myrsine ralstoniae, Melicytus ramiflorus* subsp. *oblongifolia* and *Nestegis apetala*. The community largely lacks several species found in the moister forests on the mountains, such as *Pennantia endlicheri* and *Freycinetia baueriana*. However, this forest would have been moister than the Plateau Hardwood Forest on the surrounding plateaus, resulting in the presence of many ferns, including tree ferns, still a feature of many of these valleys today. A soil wetness map prepared by the CSIRO correlates well with the distribution of the two lowland forest communities, Communities 5 and 6.

The community was mapped in lowland valleys away from the mountains, where the valleys have a low gradient, compared to the higher, steeper and moister mountain valleys supporting Moist Palm Valley Forest (Community NI01). While the boundary is somewhat arbitrary, it is clear that moisture increases at the foot of the mountains and a change in species can be observed, particularly the increasing abundance of *Rhopalostylis baueri*.

Figure 12. Lowland Valley Hardwood Forest, Duncombe Bay. The strap-leaved plant at right is *Cordyline obtecta*.

NI07. Sheltered Coastal Forest

This forest is differentiated from Lowland Valley Hardwood Forest (Community 6) by its location in the lowest parts of the lowland valleys, very close to the coast and where there is apparently a strong coastal influence (Figure 13). Coastal species, largely absent in the Lowland Valley Hardwood Forest include the ferns *Pteris kingiana* and *Asplenium difforme,* and the trees *Excoecaria agallocha* and *Ceodes brunoniana*.

This forest was mapped on the basis of location, that is sheltered valleys just back from the coast and usually protected by a ridge from the most severe oceanic exposure. The mapped inland limit, that is the change to Lowland Valley Hardwood Forest, is rather arbitrary. Very little remains in anything like the original condition; the best example seems to be in the valley at Bumbora Reserve, where there are many old *Excoecaria agallocha* trees, a characteristic tree along the southern coast of the island. The following community occurs closer to the coast, in more exposed locations.

Figure 13. Modified Sheltered Coastal Forest, Cascade Reserve.

NI08. Coastal Pine - White Oak Forest

This community occurs along the whole length of coast around the island, and was once on Nepean Island and probably on Phillip Island. The width of the community inland from the coast is dependent upon exposure to coastal influences. To some extent, it is the extension of the Pine Hardwood Ridgetop Forest (Community NI03) found on inland ridges, both being rather drier than the adjacent valley vegetation and with a prominence of *Araucaria heterophylla* (Figure 14). The other dominant tree is *Lagunaria patersonia*. Hardwoods are generally uncommon but are often found in inland sheltered places. The understorey is usually quite open, remaining intact examples indicating a discontinuous herbaceous ground cover with scattered shrubs. Typical species include the herbs *Commelina cyanea* and *Tetragonia implexicoma*, with *Sporobolus virginicus* close to the cliffs. Near the coast in the south of the island *Excoecaria agallocha* may occur, while remnant populations of the endemics *Euphorbia norfolkiana* and *Coprosma baueri* appear to favour this forest.

This community was mapped on the basis of exposure to oceanic influences, ranging from highly exposed coastal cliffs to nearby inland valleys and plateaus. The boundary between this forest and adjoining forests, most often Plateau Hardwood Forest (Community 5), is therefore somewhat speculative as there is little evidence in most places for such a change in forest community due to past clearing.

Figure 14. Coastal Pine - White Oak Forest in Hundred Acre Reserve; the key trees are *Araucaria heterophylla* and *Lagunaria patersonia*.

Coastal Complex (Communities NI09-NI13)

The following five treeless communities occur on the immediate coast, primarily on exposed cliffs. These communities form a Coastal Complex and primarily occurred seaward of the Coastal Pine - White Oak Forest, as they do today; generally these communities are not mapped separately. In some places evidence exists that larger areas of these communities occurred and these are mapped, e.g., Moo-oo Sedgeland.

Several early commentators mention the thick coastal vegetation, apparently thickets of low vegetation before entering the rainforest behind, which was mostly said to have little 'underwood'. As previously mentioned, George Forster went ashore at Duncombe Bay in 1774 and "penetrated into the woods with great difficulty, through a thick tissue of bindweeds and climbers" before entering the forest behind with its open understorey. Walking along the cliffs south of Anson Bay, Ensign Best, a junior officer stationed at Norfolk in 1838, found his progress slow going, "*...now our difficulties commenced a thorny scrub extending in many places to the edge of the cliffs...*" (Taylor 1966).

NI09. Coastal White Oak Shrubland

Stunted shrubby plants of *Lagunaria patersonia* occur on very exposed coastal cliffs (Figures 15) and this shrubland of low, contorted trees may have previously been quite common around the edges of the island. The associated species are typical coastal species, including *Carpobrotus glaucescens, Tetragonia implexicoma* and *Achyranthes aspera*. The rare plant *Coprosma baueri* is also sometimes found in this community and in the past may have been common there.

It was probably this community that James Cook was referring to on Monday 10th October 1774 after landing at Duncombe Bay. Echoing George Forster's comment, Cook wrote "*for about two hundred yards from the shore, the ground is covered so thick with shrubs and plants, as hardly to be penetrated farther inland. The woods were perfectly clear and free from underwood...*". The Flax plant was probably also present here as Cook later promoted the island to the British Navy as a source of flax for rope making.

Figure 15. Coastal White Oak Shrubland, Hundred Acre Reserve.

NI10. Sandy Beach Herbland

The more stable, upper sections of sandy beaches at Slaughter Bay, Cemetery Bay and Anson Bay support typical sandy beach species (Figure 16). These species, all cosmopolitan coastal plants, include *Sporobolus virginicus, Vigna marina, Ipomoea pes-caprae* subsp. *brasiliensis*, *Canavalia rosea* and *Ficinia nodosa*. The rare *Euphorbia obliqua* is largely found in this community. The creeping plant *Calystegia soldanella*, now probably extinct on the island, once occurred in this beach community. The introduced beach grass *Spinifex sericeus* is common in some places today.

Figure 16. Sandy Beach Herbland, Slaughter Bay; the flowering plant is the vine *Ipomoea pes-caprae* subsp. *brasiliensis*.

NI11. Coastal Grassland

Today, the cosmopolitan grass *Sporobolus virginicus* dominates many exposed sites on coastal cliffs, much as it has likely always done (Figure 17). Other species present include *Carpobrotus glaucescens, Tetragonia tetragonoides, Achyranthes aspera, Senecio australis* and *Ficinia nodosa*.

Figure 17. Coastal Grassland in Hundred Acre Reserve, with wind-sheared White Oak Shrubland and Coastal Pine-White Oak Forest behind.

NI12. Moo-oo Sedgeland

Sedgeland dominated by *Cyperus lucidus*, locally known as Moo-oo, grows very densely and almost at the exclusion of other plants (Figure 18). This community originally covered large parts of Phillip Island (Mills 2009a). Phillip Gidley King in December 1788 wrote "*...most of the Hills are covered with a thick entangled Kind of Reed which only wants burning to clear away 100 acres of Ground which would make a fine Wheat land if not too dry*" (Fidlon and Ryan 1980). This sedge is currently colonising Phillip Island and likely in future to cover a significant proportion of that island as a stable community. *Cyperus lucidus* community must have been common along parts of the exposed edges of the sea cliffs around Norfolk Island, largely along the northern coastline; today it occurs in the north-western corner (Figure 18).

Figure 18. Moo-oo Sedgeland, dominated by dense *Cyperus lucidus,* growing on a coastal cliff, northwest corner of Norfolk Island.

NI13. Coastal Flax Community

This community is rather speculative as little evidence remains of its character and distribution (Figure 19). The key species *Phromium tenax* is somewhat of a controversy as to its indigenous status on Norfolk (MacPhail *et al.* 2001, Coyne 2009, Mills 2009b, Smissen and Scheele 2022), some promoting its early introduction to the island by Polynesians. Historic records indicate that Flax was common on the cliffs and slopes above the sea in various locations at the time of European settlement. On finding and naming Norfolk Island in October 1774, James Cook wrote "*We found this isle uninhabited and near akin to New Zealand, many trees and plants common to that country was found here, the flax plant was here full as luxuriant as in any part of New Zealand...*" (Cook 1774). Naturalist George Forster, accompanying Cook ashore, also commented, "*The New Zeeland flag (phormium tenax), shot stalks eight or nine feet high, having flowers much larger and brighter than we had seen at Queen Charlotte's Sound* [New Zealand]" (Forster 1777).

During a descent into Anson Bay in 1789, Phillip Gidley King "*found our road must be down the hill which is perpendicular & quite full of a large kind of iris* [*Phormium tenax*]" (Fidlon and Ryan 1980). On realising the true identity of the 'Iris' plant on Norfolk, King stated "*the isle abounds*" with it (Fidlon and Ryan 1980).

In 1830 Allan Cunningham wrote "*Phormium tenax F. ravines & Cliffs of the Coasts*" (Mills 2012). Five years later, James Backhouse visited the island reporting "*New Zealand Flax Phormium tenax, a large, handsome plant, with sedgy leaves, covers the steep declivities of many parts of this island, particularly at the tops of cliffs of the coast*" (Backhouse 1843). Backhouse also mentions Flax at the Cockpit waterfall, where the creek is "*margined by luxuriant plants, of the broad, sedgy-leafed New Zealand Flax...*".

Figure 19. A remnant of the Coastal Flax Community.

NI14. Freshwater Swamp

A large fresh swamp existed across the Kingston Common prior to convict times. While that swamp is now largely drained, a few swamps still occur on low gradient valley floors elsewhere on the island (Figure 20). It is speculated that other similar valleys probably originally supported swamps prior to infilling caused by erosion after clearing of the surrounding forests. Part of the lowland behind Emily Bay, now the golf course, was likely also swamp; that area was shown as 'swampy' on a 1904 map of the island (Murphy 1904).

Indigenous wetland species in these swamps include *Typha orientalis, Persicaria decipiens, Eleocharis acuta, Hibiscus diversifolia, Schoenoplectus tabernaemontani*, *Juncus continuus* and *Crinum pedunculatum*. Today, many introduced wetland species also occur. These swamps would have been surrounded by dense forest, most probably Lowland Valley Hardwood Forest (Community 6).

Fresh swamps are mapped along several valleys with the above characteristics. The occurrence of swamps on Norfolk is based on the existence of swamps today and references in the historical literature. For example, writing in relation to the Kingston area, King mentions swamp several times in his journal (Fidlon and Ryan 1980). King states that four men were "*clearing away a piece of swampy ground to sow Rice on*" and later eight men were "*clearing away in the swamp*". King later entering in his journal, "*the swamp is quite overflowed by the late rain*" and a few weeks later, "*the swamps and Vale were quite overflowed by 11 o'clock & had every appearance of a large navigable river*". The next day the swamp was still "*entirely overflowed*". Seven months later, King had "*all the People Cutting away a Water Way Making drains.*"

Allan Cunningham wrote in 1830, "*at the Eastern extremity of this plain, above a swamp which originally occupied the greater part of its area, stands the Commandants Cottage…*" (Mills 2012). With regard to the swamp species *Typha orientalis*, Cunningham writes it is "*frequent in marshy ground (in tufts) in the vicinity of the settlement, is most proby. an exotic introduced, as it has not been found elsewhere on the Island*." Pollen studies in Kingston Swamp have shown that the swamp and *Typha orientalis* have been present on the island for a long time, MacPhail *et al.* (2001) finding an age of 5450 ± 180 years BP at the maximum depth of their dating.

The Kingston swamp was drained in convict times, the extensive drain system still in evidence. Pollen evidence (MacPhail *et al.* 2001) shows that wetland plants were present thousands of years ago, indicating at least a very wet environment, probably a swamp, and the indigenousness of *Typha orientalis, Persicaria decipiens, Hibiscus diversifolius* and Cyperaceae species. Kingston swamp was formed through infilling of a low-lying area inland of the calcarenite outcrops and sand dunes following the most recent stabilisation of sea level. Swamp or peat soils, also known as acid sulphate soils on Norfolk Island, have recently been mapped by CSIRO (S. Philip, pers. comm., April 2020). These soils are thousands of years old and their occurrence on the floor of the main stream valleys on Norfolk correspond to the occurrences of the Freshwater Swamp community.

The previously mentioned Ensign Best explored much of the island in his spare time, primarily it seems to shoot birds. In his journal in 1838, he notes the presence of a swamp, somewhere south of Mount Pitt. After descending the mountain, Best followed a gully where "*…the water by degrees increased to a small stream & from that degraded into a narrow swamp too deep to cross & laying between me & the settlement…*" (Taylor 1966). The swamp was narrow enough to be able to fell a tree to cross from one side to the other. The side of the gully containing the swamp was "*…covered with a thick mat of Ferns & Bines* [vines] *on which I could make no impression with the axe*"; this appears to be the scrubby boundary of the swamp and rainforest. Given the location, the swamp encountered by Best could have been along Mission Creek, north of Douglas Drive.

Figure 20. Freshwater Swamp north of New Farm Road. The dominant plant is *Schoenoplectus tabernaemontani*.

Conclusions

It should be appreciated that vegetation communities occur as a continuum along environmental gradients, usually exhibiting change over a broad ecotone rather than exhibiting abrupt boundaries. Therefore, vegetation maps must be approached in the knowledge that they show patterns in plant community occurrence, rather than delineating exact boundaries to the communities. Additionally mapping historical vegetation cover is not straight-forward, especially where most of the original (pre-human influenced) vegetation has been removed or heavily modified. After 237 years of European presence, the vegetation across most of Norfolk Island bears little resemblance to what it was like prior to their arrival.

While I am confident that the map and descriptions demonstrate the original pattern of distribution of plant communities, in many instances exact boundaries are speculative, as there is little existing floristic or other evidence upon which to base such boundaries. However, after much field investigation by the author over many years, including recent targeted field studies, my confidence in the map is generally high. The map, in electronic form, can of course be modified over time as more information and the results of further investigation become available.

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Appendix 1 - Native Plant Communities of Norfolk Island

Island endemic species are in bold. Significant species are those considered of conservation importance on Norfolk Island.

Map Code	Name	Key species	Other species	Significant species	Landform
NI01	**Moist Palm Valley Forest**	*Cyathea australis* ***Cyathea brownii*** *Rhopalostlyis baueri*	***Freycinetia baueriana*** ***Pennantia endlicheri*** *Ptisana salicina*	***Blechnum norfolkianum*** ***Elatostema montanum*** ***Phreatia limenophylax*** *Polyphlebium endlicherianum* *Ptisana salicina*	Mountain valleys, floor and lower slopes, reaching highest ridge on southern side of mountains. Replaced by NI06 at base of mountains.
NI02	**Moist Upland Hardwood Forest**	*Dysoxylon bijugum* ***Freycinetia baueriana*** ***Myrsine ralstoniae*** *Nestegis apetala* ***Pittosporum bracteolatum***	***Araucaria heterophylla*** *Cordyline obtecta* ***Melicope littoralis*** ***Meryta angustifolia*** ***Pennantia endlicheri*** ***Ungeria floribunda***	***Coprosma pilosa*** ***Melicytus latifolia*** ***Parapolystichum calanthum*** ***Ungeria floribunda*** ***Wikstroemia australis***	Slopes and valley sides on the flanks of the mountains. Replaced by NI05 at lower altitudes.
NI03	**Pine -Hardwood Ridgetop Forest**	***Araucaria heterophylla*** *Dysoxylon bijugum* ***Myrsine ralstoniae*** *Nestegis apetala* ***Pittosporum bracteolatum***	***Araucaria heterophylla*** *Cordyline obtecta* ***Meryta angustifolia*** ***Pennantia endlicheri*** ***Ungeria floribunda***	***Coprosma pilosa*** ***Ungeria floribunda*** ***Wikstroemia australis***	Primarily ridges on the flanks of the mountains, down to 120 m altitude, where it blends with NI05.
NI04	**Viny Hardwood Forest**	*Austrocallerya australis* *Baloghia inophylla* *Celtis paniculata* *Planchonella costata*	*Arachniodes aristata* ***Araucaria heterophylla*** ***Melicytyus ramiflorus*** ***Myrsine ralstonia****e* *Nestegis apetala* ***Pittosporum bracteolatum***	***Achyranthes arborescens*** ***Meryta latifolia***	Mid-altitude valleys and slopes; primarily Mission Road area and upslope into the National Park.
NI05	**Plateau Hardwood Forest**	*Baloghia inophylla* *Elaeodendron curtipendula* *Lagunaria patersonia* *Nestegis apetala*	***Alyxia gynopogon*** *Dysoxylon bijugum* ***Myrsine ralstoniae***	*Ceodes brunoniana* ***Melicytus latifolius***	Plateau areas and lowland ridges up to 120 m altitude, where it blends with NI03.
NI06	**Lowland Valley Hardwood Forest**	*Baloghia inophylla* *Lagunaria patersonia* ***Myrsine ralstoniae*** *Nestegis apetala*	***Cyathea brownii*** ***Streblus pendulinus***	***Streblus pendulinus***	Lowland valleys with gentle gradients; replaced by NI01 at base of mountains.
NI07	**Sheltered Coastal Forest**	*Baloghia inophylla* *Excoecaria agallocha* *Lagunaria patersonia* ***Myrsine ralstoniae*** *Nestegis apetala*	***Araucaria heterophylla*** *Asplenium difforme* ***Capparis nobilis*** *Elaeodendron curtipendula*	*Ceodes brunoniana* *Hypolepis tenuifolia* ***Pteris kingiana*** ***Streblus pendulinus***	Sheltered valleys and slopes just back from coast.
NI08	**Coastal Pine - White Oak Forest**	***Araucaria heterophylla*** *Lagunaria patersonia*	*Asplenium difforme* ***Myrsine ralstoniae*** *Tetragonia implexicoma*	***Coprosma baueri*** ***Euphorbia norfolkiana*** *Excoecaria agallocha* *Senecio australis*	Exposed coastal cliffs and slopes.
NI09	**Coastal White Oak Shrubland**	*Lagunaria patersonia*	*Ficinia nodosa* *Sporobolus virginicus* *Tetragonia implexicoma*	***Coprosma baueri*** *Senecio australis*	Exposed headlands.
NI10	**Sandy Beach Herbland**	*Ficinia nodosa* *Ipomoea pes-caprae* *Spinifex hirsuta** *Sporobolus virginicus* *Wollastonia uniflora*	*Carpobrotus glaucescens* *Tetragonia tetragonoides*	***Euphorbia obliqua*** *Ipomoea pes-caprae* *Vigna marina*	Sandy beaches (Emily Bay, Cemetery Beach, Anson Bay).
NI11	**Coastal Grassland**	*Achyranthes aspera* *Carpobrotus glaucescens* *Sporobolus virginicus*	*Lobelia anceps* *Samolus repens* *Senecio australis*	*Senecio australis*	Extensive on the cliff tops and coastal slopes down to high tide limit in places.
NI12	**Moo-oo Sedgeland**	*Achyranthes aspera* *Carpobrotus glaucescens* *Cyperus lucidus*	*Commelina cyanea* *Phormium tenax*		Northern islets, mainly on Phillip Island, present northwest coast of Norfolk Island.
NI13	**Coastal Flax Herbland**	***Araucaria heterophylla*** *Phormium tenax*		*Senecio australis*	Coastal cliffs and slopes.
NI14	**Freshwater Swamp**	*Persicaria decipiens* *Schoenoplectus tabernaemontani* *Typha orientalis*	*Eleocharis acuta* *Hibiscus diversifolius* *Histiopteris incisa* *Juncus continuus*	*Hibiscus diversifolius*	Along low gradient valley floors on peaty soils; previously extensive at Kingston.