

Some observations on the flora of New Caledonia*

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Introduction

The IDS Araucariaceae symposium, held in Auckland, New Zealand, 14-17 March 2002, and the pre-symposium tour of Northland is described above by Timothy Waters. Here we give an account of the post-symposium tour to New Caledonia, which ran from 19-30 March 2002.

The objective of the visit to New Caledonia was to see as many as possible of the five local species of *Agathis* and thirteen of *Araucaria*, both in natural stands and in cultivation, and to gain an appreciation of the other unique conifers and plants of the country.

Features of the New Caledonian flora and vegetation

New Caledonia is an overseas territory of France. The land area is 1,910,500 ha, of which 390,000 ha (20%) is closed forest (381,000 ha natural forest, 9,000 ha *Pinus* plantations), 575,000 ha (30%) is maquis and open forest, 550,000 ha (29%) is savanna, and other vegetation is 395,000 ha (21%) (Schmid 2000). There are around 3,400 species of higher plants of which 80% are endemic (Dawson 1981; Lowry 1986; Schmid 2000; Jaffré *et al.* 2001). Some 14% of the 840 genera and 5 of the 184 families are endemic.

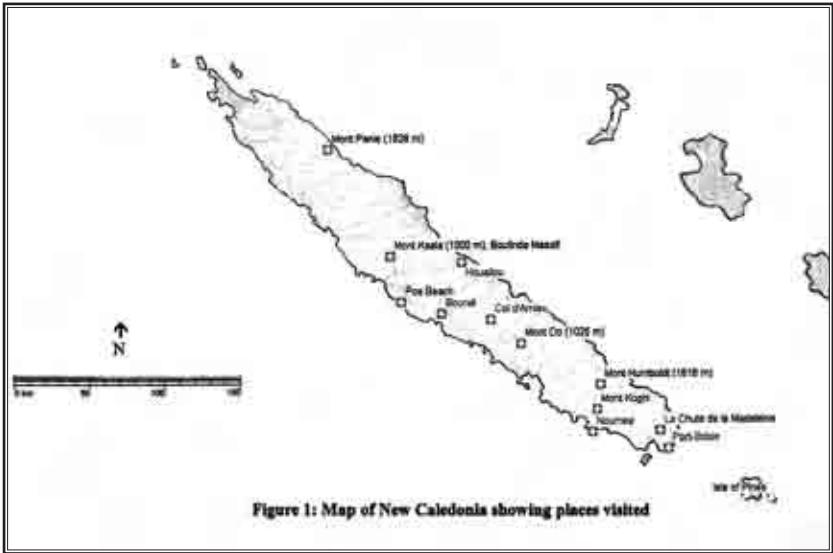
Floristic relationships have been much studied (Thorne 1965; Morat, Veillon & MacKee 1984), and it is apparent that many groups (such as the gymnosperms, Winteraceae and Cunoniaceae) are remnants of the Cretaceous-Tertiary flora of the ancient, now dispersed, continent of Gondwana. In addition, there has been adaptive radiation in many groups since the Eocene after the emplacement of ultramafic rocks, for instance in *Agathis* and *Araucaria* (Setoguchi *et al.* 1998), and in the Araliaceae which has a near-cosmopolitan distribution, but its generic and species diversity is nowhere greater than in New Caledonia. There are a remarkable 43 species of conifer – more than in any other even larger areas outside North America and Asia (de Laubenfels 1972, 1996; Jaffré 1995).

The main island, Grande Terre, is a continental fragment, which was once part of Gondwana. About 120 million years ago, Gondwana began to break up, with connections between Africa and South America becoming severed about 100 million years ago. About 80 million years ago, New Zealand and New Caledonia broke away from the eastern edge of the Australian plate, and finally, about 50 million years ago, Australia separated from Antarctica and began moving northwards. New Caledonia thus became separate from Australasia (Australia, New Zealand and New Guinea) in the early Cretaceous, 65-80 million years ago. It experienced neither the severe aridity of Australia nor the glaciations of New Zealand, allowing many ancient plants to persist. Its rich and unique flora is also explained by the extraordinary evolution of shrub species on serpentine substrates, originating 30 million years ago in the Oligocene.

There are two main types of serpentine soils in New Caledonia – the brown eutrophic hypermagnesian soils, which are rich in magnesium, silica and iron, very low in phosphorus, and are rather neutral (pH 6.6), and the ferrallitic or lateritic soils which are rich in iron oxide, chromium, and nickel, very low in magnesium, and are quite acidic (pH 5.0) (Brooks 1987; Mueller-Dombois & Fosberg 1998).

Nickel in New Caledonia occurs as secondary minerals derived from weathering of nickel-bearing ultramafic rocks under a tropical climate, the two types of nickel ore being silicate laterite and oxide laterite. Silicate nickel laterite comprises an upper, earthy, iron-rich zone, and a lower rocky zone known as saprolite in which the nickel occurs in complex Mg-rich silicates, derived from serpentinised peridotite. The main nickel mineral in the silicate laterite is garnierite or hydrated nickel silicate $[(Ni, Mg)SiO_3 \cdot n H_2O]$ which is concentrated (2-3%) in the rocky soil overlying the basement serpentine rocks. Oxide nickel laterite, rich in iron, does not have much magnesium, and occurs in the Southern Massif on the Goro Plateau (see p.25).

New Caledonia has 47 species which accumulate nickel (Brooks 1987). Those that are extreme accumulators with over 10,000 $\mu g/g$ (1%) in dried leaves are: *Homalium guillanii* & *H. francii* (Flacourtiaceae), *Hybanthus austrocaledonicus* (Violaceae), *Phyllanthus serpentinus* (Euphorbiaceae), *Geissois pruinosa* & *G. intermedia* (Cunoniaceae), *Psychotria douarrei* (Rubiaceae), & *Sebertia acuminata*



Map of New Caledonia, showing places visited.

(Sapotaceae). The latter species, known as *sève bleue*, contains a blue sap composed of nearly pure nickel citrate, with 11.2% nickel in the fresh undried state – by far the highest nickel concentration ever recorded in any plant.

The main vegetation types are moist evergreen rain forest, induced *Melaleuca* and *Casuarina* woodland or savanna, serpentine scrub or maquis minier (Brooks 1987; Mueller-Dombois & Fosberg 1998; Schmid 2000), and mangroves. The original dry sclerophyllous forest which once covered large parts of the western, rain-shadowed side of Grande Terre, and which included several deciduous tree species, has largely been cleared for cattle ranching (O'Neill 2000). This is where the rare *Captaincookia margaetae* (Rubiaceae) can be found – a beautiful shrub with crimson flowers in streamers up the stems (O'Neill 2000).

In contrast to the Grande Terre, the Loyalty Islands and the Isle of Pines are mainly ancient raised coral islands– though the latter has an ultramafic rock centre – and the flora of this calcareous substrate is quite different, with only c. 30% endemism and c. 500 species (Morat, Jaffré & Veillon 2001).

March 19

We flew from Auckland to **Nouméa**. On arrival the temperature was 28°C, and the weather fine. This city of c. 80,000 people has a mean annual temper-

ature of 23°C, and a rainfall of 1410 mm, the wettest time being January-April and the driest, October to December. We were met by Joseph Manauté of the Parcs et Reserves Terrestres, Province Sud, and Jane Jore of Arc en Ciel, the tour company attending to our arrangements, and travelled by bus to **Bourail**, staying at the Poe Beach Resort. The coastal plain from the airport northwards has much *Casuarina collina* and niaouli (*Melaleuca quinquenervia*), with abundant ipil (*Leucaena leucocephala*) and gaïac (*Acacia spirorbis*) on the roadsides. Niaouli forms a kind of savanna or parkland of scattered trees over the grassy hillsides – a vegetation induced by fire. Near Paita and Tontouta, *Acacia nilotica*, originally introduced for cattle fodder, has become naturalised. The giant sensitive plant (*Mimosa diplotricha* syn. *M. invisia*), and sensitive plant (*M. pudica*), together with blue rat's-tail (*Stachytarpheta urticifolia*), Natal redtop grass (*Melinis repens*), and also Rhodes grass (*Chloris gayana*), both introduced from southern Africa, occur abundantly on roadsides.

We visited Pierre Mathieu's sawmill at **Ouaou**, Col d'Amieu, La Foa, Commune of Sarraméa, Province Sud, in the hills. The mill cuts *Pinus caribaea* from local plantations (30%), kauri blanc (*Agathis moorei*) (10%), and various hardwoods, the most valuable being houp (*Montrouziera cauliflora*) and tamanu (*Calophyllum calademicum*). Logs of *Araucaria columnaris* from felled woodlots were also being milled, the timber being used for general carpentry. We inspected a splendid experimental plantation (0.9 ha) of *Agathis moorei*, 45 years old, with a growth rate of 50 cm per year in height and 0.83 cm per year in diameter. The form of the trees was exemplary.

The rainforest, growing at 400 m, with 2500 mm rainfall, is around 20 m tall. There were many trees of the Cunoniaceae, *Archidendropsis granulosa* – a tall leguminous timber tree, and several ferns (some familiar to New Zealanders), such as *Sticherus flabellatus*, *Dicranopteris linearis*, *Gleichenia brackenridgei* & *G. dicarpa*, *Blechnum corbassonii* (rather like *B. novae-zelandiae*), *Bolbitis palustris*, *Leptopteris wilkesiana* (with a slender 1-2 m trunk) and tree ferns - *Cyathea intermedia* and *C. novaecaledoniae* – which drop their fronds cleanly. The giant elephant fern (*Angiopteris erecta*) was common and caught the attention of everyone, and the large *Marattia attenuata* was also present. *Myodocarpus fraxinifolius* (Araliaceae) was a prominent small tree with a slender stem, and leaves clustered at the top.

At Poe Beach there was a typical Pacific strand vegetation with *Acacia simplex*, *Casuarina equisetifolia*, *Cerbera manghas*, *Thespesia populnea*, burao (*Hibiscus tiliaceus*), and *Scaevola sericea*. Common ornamentals here included *Hibiscus tiliaceus*, Jamaican cherry (*Muntingia calabura*), butterfly bush (*Bauhinia purpurea*), yellow oleander (*Thevetia peruviana* syn. *Cascabela thevetiana*), *Acropogon* (*Sterculia*) *bullatus*, and curtain fig (*Ficus microcarpa* var. *hillii*).

The most prominent roadside grasses in the hills were the introduced giant reed or grand roseau (*Arundo donax*), *Miscanthus floridulus*, and Guinea grass (*Panicum maxima*); *Bambusa vulgaris* forms large clumps with handsome arched culms in some valleys. A common wayside tree is candle nut (*Aleurites moluc-*



Above: Pin colonnaire (*Araucaria columnaris*) at Parc du Lagon de Bourail, Baie de Tortues (p.18).
These trees are planted. The hillside scrub is dominated by the introduced *Leucaena leucocephala*.
Below: La Chute de la Madeleine botanical reserve - growing here are *Retrophyllum minus*,
Dacrydium guillauminii, *D. araucarioides*, *Neocallitropsis pancheri* and *Podocarpus novaecaledoniae*.
Nearby can be found *Agathis ovata* and *Araucaria bernieri* (see p.26).

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cana), and yellow guava (*Psidium guajava*) has colonised grassy slopes. *Schinus terebinthifolius* is abundant in places, forming roadside thickets, and both castor oil (*Ricinus communis*) and tobacco weed (*Solanum mauritianum*) are frequent. Rubber vine or liane de Gatope (*Cryptostegia grandiflora*: Asclepiadaceae) is a tall climber from Madagascar and East Africa that has invaded disturbed sites (Lowry 1996).

March 20

We visited **Parc du Lagon de Bourail**, Baie de Tortues, to see a startling stand of *Araucaria columnaris* (see p.17). The population comprises some 300 trees, with heights of 42 m; no regeneration was evident. Associated plants were *Pandanus tectorius*, *Cycas celebica*, *Planchonella cinerea*, *Excoecaria agallocha*, noni or fromager (*Morinda citrifolia*), and *Cupaniopsis* sp. Here *Cycas celebica* grows 8-10 m tall and is the only cycad native to New Caledonia where it is limited to strand lines and littoral forests. It also occurs in Borneo, the Moluccas, Tonga, Fiji, and Vanuatu (Hill, K. 1996; de Laubenfels 1998). A spectacular hole through the coastal rock (Roche Percée) is an added attraction.

At Petit-Couli, we were privileged to visit a local Kanak garden, fringed with *Araucaria columnaris*, which has been widely planted in villages throughout New Caledonia. On the road from La Foa across to the east coast, we stopped to view a population of *Araucaria biramulata*, standing out prominently above the general vegetation on very steep slopes. Roadside banks had colonising faux teck (*Carpolepis laurifolia*), and the forest margins had much *Alphitonia neo-caledonica*, a *Weinmannia*, and trees of the Apocynaceae.

Nickel mining was evident everywhere, and at times the road followed the route of the 11 km-long conveyor belt which carries the nickel ore down to Thio, where it is refined into ferro-nickel matte at the SLN (La Société le Nickel) Doniambo smelter in Nouméa. We inspected a small population of *Araucaria scopulorum* (see p.20), one of the shortest species in the genus, on a rocky site near a river. *Araucaria montana* could be seen high up on ridges. Wayu (*Gymnostoma chamaecyparis*) was very prominent in the maquis minier vegetation on ultrabasic soils, together with *Dracophyllum ramosum*, *Grevillea exul* (generally white flowers), *G. gillivrayi* (rose-coloured flowers), *Geniostoma*, *Xanthostemon*, and *Geissois*.

On ultrabasic hills with laterite nodules (red soil) we encountered an amazing population of *Araucaria rulei* (see p.20). In one spot we observed the very curious *Dacrydium araucarioides* with its araucaria-like foliage; it is only a small tree, 4- 6 m tall. Fernland of bracken (*Pteridium esculentum*) and *Dicranopteris linearis* was prevalent on the higher slopes – a consequence of degradation of the maquis vegetation by fire and mine spoils (Mueller-Dombois & Fosberg 1998).

We returned to Poe Beach over the range from Houaïlou, a coastal town on the western side of Province Nord. Lychee (*Litchi chinensis*) is grown quite extensively in this area. Further up the east coast, especially in the Hienghène district, coffee is an important cash group. The traditional food crop is the yam

(*Dioscorea alata*), though taro and cassava are also still grown. At the Col des Rousettes on rather dry ridge crests at c. 450 m there are some 20 m-tall stands of *Nothofagus aequilateralis*, sometimes coexisting with emergent *Agathis moorei* on soils derived from metamorphic rocks (Dawson 1966; McQueen 1983).

March 21

We travelled north from Bourail to Poya, and then to the Kopéto mine of Le Nickel – SLN on the **Boulinda Massif**, where silicate nickel laterite is mined. At 760 m we encountered *Araucaria rulei* again, growing as the only tree above typical ultrabasic maquis and short forest. *Gymnostoma* was particularly abundant on rocky slopes, and beside the road were clumps of *Joinvillea plicata*, a curious monocot regarded as the closest plant to the grasses. The mining company plants the nitrogen-fixing species *Casuarina collina*, *Acacia spirorbis*, and *Alphitonia neocaledonica* for stabilisation of roadsides.

At c. 900 m there was a fine population of *Araucaria biramulata* growing emergent above a mixed hardwood canopy (20 m tall), but which included *Podocarpus sylvestris* and *Falcatifolium taxoides*, and large, impressive trees of *Gymnostoma poissonianum* and *Montrouziera*. Pitcher plant (*Nepenthes vieillardii*) and fan fern (*Schizaea dichotoma*) were common. In the understorey were shrub species of *Zygogynum* (Winteraceae) and *Styphelia* (Ericaceae). At around 1000 m *Araucaria montana* occurs on ridge tops, appearing in the distance prominently on the skyline.

At 1000 m on **Mont Kaala**, overlooking the rock-crushing plant, we visited a population of *Araucaria montana*. A feature of this species was the good regeneration occurring, despite it being precarious on account of the mining. The soils seemed to be acid, judging by the presence of plants such as *Gleichenia dicarpa*, *Sticherus flabellatus*, *Lycopodium deuterodensum*, bracken (*Pteridium esculentum*), and sedges such as *Schoenus*, *Lepidosperma perteres* (rhizomatous, and resistant to fire), *Baumea deplanchei* and *Costularia arundinacea*. Notable shrubs included *Bikkia macrophylla* (Rubiaceae), with large red lantern flowers, *Exocarpos neocaledonicus* (Santalaceae), *Metrosideros francii*, and *Cunonia lenormandii*, with pink flowers. The commonest roadside trees at lower elevations are *Pinus caribaea*, *Eucalyptus camaldulensis*, *E. grandis*, and *E. robusta*.

March 22

We visited the New Zealand war cemetery at Bourail where trees of note included *Cassia fistula*, *C. javanica* and *Eucalyptus saligna*. On one tree we noticed the introduced climbing cactus, *Hylocereus undatus*.

We then went up to the botanical reserve on ultramafic bedrock at the top of **Mont Do** (1150m), passing treeless short maquis with fern and sedges on the way up. The summit is a cool, cloudy place with an annual rainfall of c. 1690 mm. *Nothofagus codonandra* occurs here in montane forest in association with emergent *Araucaria laubenfelsii* – a classic site for this conifer where it is regenerating itself freely in the absence of disturbances such as fire, and the subject of some recent ecological studies (Rigg *et al.* 1999; Enright *et al.* 2001; Perry *et*



Araucaria scopulorum, between Col d'Amieu and Houaïlou. (p.18) Below: *Agathis lanceolata*, Parc Provincial de la Riviere (p.23).



A. rulei between Col d'Amieu and Houaïlou. Below: *Parasitaxus usta*, Mt.Koghi. The host plant for this curious parasitic conifer is *Falcatifolium taxoides*. (see p.27).





Above: *Araucaria humboldtensis* on Mt Humboldt, emergent above evergreen montane forest. (p.30)
Below: Houp (*Montrouziera cauliflora*), one of the biggest trees in the New Caledonian rainforest.
Seen here at Col d'Amieu (p.29).

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al. 2001). The surface soil is very acidic, with a pH of c. 3.9. Other trees or shrubs in the forest include *Cunonia montana*, *Falcatifolium taxoides*, and *Phelline lucida*.

Much of the vegetation on Mont Do is maquis, sometimes with emergent *Araucaria laubenfelsii*, with the main shrub species being *Dracophyllum ramosum*, *D. verticillatum* and *Styphelia cymbulae* (Ericaceae), *Scaevola balansae* and *S. beckii* (Goodeniaceae), *Babingtonia leratii*, *Metrosideros nitida* and *Tristaniopsis glauca* (Myrtaceae), *Symplocos montana*, *Rapanea diminuta* (Myrsinaceae), *Podocarpus sylvestris*, *Codia discolor* and *Cunonia montana*, *Myodocarpus fraxinifolius* and *Polyscias pancheri* (Araliaceae), *Wikstroemia indica* (Thymeleaceae), *Hibbertia emarginata* (Dilleniaceae), *Ascarina rubricaulis* (Chloranthaceae), and the fern *Sphenomeris deltoidea*. The lichen *Cladina confusa* was prominent on the ground, with *Lycopodium deuterodensum*, *Schizaea*, and *Cheilanthes*, and the sedge *Costularia arundinacea* was abundant.

All five species of *Nothofagus* in New Caledonia occur in the cool upper montane forests with high, evenly-distributed rainfall (Read *et al.* 1995), and belong to the subgenus *Brassospora*, elsewhere occurring only in New Guinea (Hill, R. 1996).

Our group then visited the nursery centre and complex at **Port-Laguerre** (30 m), some 30 km north of Nouméa, operated by Service des productions végétales et forêts, Direction du développement rural, Province Sud. Our chief guide was Thierry Azaïs. This is the old CIRAD- Forêt base, where much research has been done on species introduction. Some fine old trees can be seen here, notably teak (*Tectona grandis*), mahogany (*Swietenia macrophylla*), kapok (*Ceiba pentandra*), and *Podocarpus subtropicalis* – a rare species native to Mt Emei, Sichuan, China, but according to David de Laubenfels frequently cultivated (as *P. neriifolius*).

Some 19, 000 seedlings are grown here. The main species are *Casuarina collina*, *Acacia spirorbis* and *Alphitonia neocaledonica* for revegetation of mined areas, and *Pinus caribaea*, sandalwood (*Santalum austrocaledonicum*), bois de rose (*Thespesia populnea*), bois bleu (*Hernandia cordigera*), and *Swietenia mahogani*. Of the Araucariaceae, all local species except *Araucaria scopulorum* and *A. subulata* are cultivated. The main *Agathis* species are *Agathis moorei* and *A. lanceolata*. Curiously, it is *A. moorei* that has long, lanceolate leaves, those of *A. lanceolata* being more bluntly ovate. The most striking *Araucaria* was *A. muelleri*, with large, flattened leaves resembling *Araucaria* sens. str. *A. nemorosa* has fine, feathery foliage. Cross grafting has been done in an endeavour to have some of the less accessible species available for seed collection. Examples of these were *Agathis corbassonii* on *A. moorei*, *Agathis montana* on *Araucaria columnaris*, *Agathis montana* on *Agathis moorei*, *Agathis montana* on *Agathis corbassonii*, and *Agathis montana* on *Araucaria rulei*.

At the government headquarters in Nouméa we were accorded a reception by the Province Sud government, with a welcome from Jean-Claude Briault, 3rd Vice-President of Province Sud, and had the opportunity to meet some local botanists, notably Tanguy Jaffré and Jean-Marie Veillon of Laboratoire de

Botanique et Écologie Appliquées, Institut de recherche pour le développement (IRD), and other invited guests, including Paul de Dekker, President of the University of New Caledonia, Hilary Shekleton, the British Consul-general, and Cécile Hillyer, New Zealand Consul-general.

March 23

We travelled about 60 km out to the **Parc Provincial de la Rivière Bleue** (9045 ha, estab. 1980) in the Grand Massif du Sud, where much of the land has been degraded by mining and logging. A scheme on 110 ha of maquis land at Ouenarou has resulted in plantations of *Agathis ovata* (pl. 2000), *A. lanceolata* (1964, 1986, 2000), *A. moorei* (1959), *Araucaria muelleri* (2000), *A. nemorosa* (2000), *A. columnaris* (2000), *A. subulata* (1986), pommaderis (*Alphitonia neocaledonica*), gum oak (*Arillastrum gummiferum*), faux noyer (*Neoguillauminia cleopatra*: Euphorbiaceae), and *Acacia spirorbis*. *Pinus caribaea* plantations have done very well on better soils, but very poorly on degraded sites. There are some good plantations of the main kauri in this region, *Agathis lanceolata* (p.20).

At the Ouenarou Forest headquarters are demonstration plots of the *Araucaria* species planted 1980/81, with *A. laubenfelsii* looking particularly good. The two species with the coarsest foliage are *Araucaria muelleri* and *A. rulei*. A grafted seed orchard of *Agathis lanceolata* dates back to the time of Michel Corbasson (1957-58). Old trees here include *Eucalyptus grandis*, *E. microcorys*, *E. botryoides*, *Acacia mangium*, *Corymbia citriodora*, *Paraserianthes falcataria*, and *Elaeocarpus angustifolius*.

The rain forest is very species-rich, and has emergent *Araucaria bernieri*, and both *Agathis lanceolata* and *A. ovata*. A huge kauri (*A. lanceolata*) has been retained, and is a famous tourist attraction (see p.20). *Dacrydium araucarioides*, *Libocedrus yateensis*, *Podocarpus novae-caledoniae* (seen on a river bank), and *Gymnostoma webbiana* are sprinkled through the forest. Other trees noted were *Symplocos arborea*, *Hibbertia lucens*, *Scaevola balansae*, *pomaderris* (*Alphitonia neocaledonica*), *Cerberiopsis candelabra*, *Beccariella sebertii* (Sapotaceae), *Meryta coriacea*, *Myodocarpus fraxinifolius*, *Garniera spathulaefolia* (Proteaceae), azou (*Bureavella wakere*: Sapotaceae), *Crossostylis* (Rhizophoraceae), the strongly buttressed *Sloanea koghiensis*, *Cryptocarya transversa*, *Fagraea berteriana*, *Geissois hirsuta*, *Hybanthus neocaledonicus*, and *Pandanus pancheri*. Palms were common – *Actinokentia divaricata*, *Basselinia gracilis*, *B. pancheri*, *Brongniartikentia vaginata*, *Burretioakentia grandiflora*, *Campecarpus fulcitus*, *Chambeyronia macrocarpa*, and *Cyphokentia macrostachya* (Hodel & Pintaud 1998).

The Pitcher plant (*Nepenthes vieillardii*) abounds here on the forest floor, with *Joinvillea plicata* and *Lomandra insularis*, which has a strange tufted shape on a short trunk. A common low climber on tree trunks was *Freycinetia graminifolia* (Pandanaceae). A plant was located of the root parasite *Daenikera corallina* (Santalaceae), and near it, examples of *Dacrycarpus vieillardii*, *Dacrydium lycopodioides*, *Prumnopitys ferrugineus*, and *Decussocarpus comptonii*. A beautiful flowering shrub on a riverbank was *Xanthomyrtus myrtifolia*, together with



Dick van Hoey Smith cuts the Society's 50th Anniversary cake at the Araucariaceae conference.

scandens was observed on *Agathis ovata*.

An unusual bird, the kagu or cagou (*Rhynochetos jubatus*) can be found here, frequenting picnic sites. It is a flightless member of the order Gruiformes (cranes, rails, coots) and is the sole member of the family Rhynochetidae.

March 24

Today we travelled south from Nouméa, and visited some maquis areas on degraded mined sites. Prominent shrubs included *Cloezia buxifolia*, with small yellow flowers, *Codia obcordata*, and *Xanthostemon aurianticum*. There is much *Gymnostoma* woodland in this area.

At **Col de Yaté** there is a marvellous population of *Agathis ovata* growing at 400 m on lateritic slopes. The trees are squat, 6-9 m tall, with flat-topped crowns, and the bark is thick and deeply fissured – perhaps an adaptation to fire. This species is only found in the south of the country in isolated small stands at 150-1150 m elevation on gravelly lateritic soils, and it commonly grows emergent above maquis scrub - as on this site - or in closed forest as observed the previous day. Mature trees at Col de Yaté are estimated to be c. 400 years old (Enright & Goldblum 1998). Another distinctive feature of this species is the white, waxy male catkins. Growing also on this site was much native bamboo (*Greslania montana*), *Gymnostoma deplancheanum*, *Dacrydium araucarioides*, and a bushy *Podocarpus* which David de Laubenfels will be describing as a new species. A ground fern, *Stromatopteris moniliformis* (Gleicheniaceae) was common here.

On the coast at Yaté, which has a much wetter climate than Nouméa's, the Melanesian villages have some tropical fruit trees such as mango (*Mangifera indica*), jak fruit (*Artocarpus heterophyllus*), papaya (*Carica papaya*), and bread-fruit (*Artocarpus altilis*), but these do not seem in New Caledonia to be as commonly grown as in other parts of the Pacific. We encountered for the first time in the south a natural stand of *Araucaria columnaris*. It was growing on a steep rocky headland, and with it were *Pandanus tectorius*, *Planchonella cinerea*, and *Alphitonia neocaledonica*. A shrub, *Ixora cauliflora*, with masses of white flowers borne on the naked stem, caught people's attention. The *Araucaria columnaris* trees here generally had straight trunks, in contrast to the typically bent trunks in the Isle of Pines populations.

On the ironstone cap of the **Goro Plateau** we visited a site of *Araucaria muel-leri*. It was growing here with *Dacrydium araucarioides* and *Gymnostoma deplancheanum*, together with various broadleaved shrubs, including *Eugenia*, *Psychotria*, *Solmsia calophylla* (Thymelaeaceae), *Styphelia pancheri*, and *Dracophyllum ramosum*. The sedge *Costellaria* was frequent. We were joined here by Stefane McCoy, a local botanist (*ex* Australia) working as an ecologist for INCO (International Nickel Company of Canada), based on the Goro Plateau. McKoy has made extensive studies of the fire ecology in this area (McKoy *et al.* 1999). Dr Neal Enright of Melbourne University is undertaking population studies of this relict stand of *Araucaria muelleri*; the trees are thought to be at least 350 years old. They are only 5-10 m tall, and grow on almost pure iron ore (pH 5-6). The indurated laterite or iron 'carapace' gives rise to a strange 'moonscape', like a lava flow, and the maquis is quite stunted and sparse. A stream had a small population of the rheophytic podocarp *Decussocarpus minus* (syn. *Nageia minor* or *Retrophyllum minus*). The site is also ironstone, subject to periodic flooding.

The Goro Plateau nickel mining operation is based on oxide laterite (in contrast to the silicate laterite of the Koniambo Plateau). The richest nickel-bearing layers generally lie at least 10 m below the surface layers which are predominately limonite (hydrated iron oxide). These iron-rich and nickel-rich layers also have a considerable amount of cobalt, but a much lower magnesium content than the silicate laterite.

A further coastal site was visited at **Port-Boisé**, with *Araucaria columnaris* growing with some interesting coastal trees, including bo-oupe (*Serianthes calycina*) – a large leguminous tree with reddish flowers; candelabra tree (*Cerberiopsis candelabra*); the remarkable *Eugenia bullata*, tree heliotrope (*Argusia argentea*), blue vitex (*Vitex trifolia*), *Pandanus tectorius* (with prominent stilt roots), and *Hernandia nymphaefolia*. *Cerberiopsis* is peculiar in that it is monocarpic – that is, it dies after flowering. There were local patches of mangrove (*Rhizophora stylosa*), and oriental mangrove (*Bruguiera gymnorhiza*). Inland were small stands of the rare *Araucaria nemorosa* (Waters 2002) growing within rain forest with much *Tristaniopsis* – a conspicuously smooth-barked tree. *A.nemorosa* seems to be a shade-tolerant species. Secondary forest margins had much *Commersonia bartramii* (Sterculiaceae), and *Homalium austro-*

caledonicum (Flacourtiaceae), and a nice example was found of the parasitic plant, *Korthalsella disticha*.

March 25

We started today's excursion by inspecting a stand of *Araucaria luxurians* on the coast south of Nouméa near Plum and Mont Dore, although some of the group thought that the trees might in fact be *A. laubenfelsii*. This locality has been colourfully described by David McInnes-King (2000). Inland, there are quite extensive plantations on the **Plaine des Lacs** of *Pinus elliottii* and *Pinus caribaea*. Some have done well, but others show signs of extreme nutritional imbalance. At Champ de Bataille *Agathis lanceolata* had been planted under a nurse crop of *Paraserianthes falcatoria*, and looked vigorous and healthy. There were also successful plantations of *Arillastrum gummiferum*. On steep, bush-clad slopes there were emergent *Araucaria bernieri*, and some *Agathis lanceolata* – both genera in the same stands.

A rocky river-bank site was visited, featuring *Neocallitropsis pancheri*. The trees were 2-4 m tall, and there was also a great deal of *Gymnostoma deplancheanum*, and *Dacrydium araucarioides* in the vicinity, plus the usual suite of broadleaved maquis trees – *Alphitonia neocaledonica*, *Alstonia coriacea*, *Beccariella sebertii* (recognised in the field by the leaves with prominent veins and brownish fulvous pubescence on the young leaves), *Dracophyllum involucreatum*, *D. verticillatum*, *Grevillea exul*, *Styphelia cymbulae*, *Xanthostemon aurantiacus*, *Tristaniopsis glauca*, and *Lomandra insularis*.

We visited the Coro Nickel revegetation nursery with Stefane McCoy. Numerous local trees are being grown in polybags, for planting out on land scraped for mining. Two species that seem to transplant out and grow on particularly well are *Gymnostoma deplancheanum* and *Grevillea exul*. Species cultivated are *Myodocarpus fraxinifolius* (Araliaceae), *Comptonella drupacea* (Rutaceae), *Syzygium ngoyense* (Myrtaceae), *Osmanthus austrocaledonicus*, *Arillastrum gummiferum* (Myrtaceae), *Cunonia deplanchei*, *Xanthostemon aurantiacus* (Myrtaceae), *Beauprea gracilis* (Proteaceae), *Solmsia calophylla* (Thymeleaceae), *Austrobuxus carunculatus* (Euphorbiaceae), *Guettarda eximia* (Rubiaceae), *Ilex sebertii*, *Guioa villosa* (Sapindaceae), and *Archidendropsis granulosa* (Fabaceae: Mimosoideae).

At **La Chute de la Madeleine** botanical reserve, Plaines du Lacs, there was a remarkable assemblage of conifers – *Agathis ovata*, *Decussocarpus minus*, *Neocallitropsis pancheri*, *Podocarpus novae-caledoniae*, *Dacrydium araucarioides*, and *D. guillauminii* (see p.17). Freshwater marshes here and throughout the Plaine des Lacs are dominated by *Xyris pancheri* (Xyridaceae), an endemic rush-like monocot, and *Schoenus brevifolius* (Cyperaceae), and several shrubs were also present, such as *Melaleuca brongniartii*, *Babingtonia leratii* (formerly *Baeckea ericoides*), *Xanthostemon aurantiacus*, *Homalium kanaliense*, *Cloezia aquarum* and *Pancheria communis*. The herbaceous layer, which is absent on gravelly soil but continuous on alluvial soil, comprises the Cyperaceae *Costularia xyridioides*, *Schoenus brevifolius*, *Chorizandra cymbaria* and *Tricostularia*

guillauminii, and *Xyris pancheri* and *X. neocaledonica* of the Xyridaceae. A curious aquatic fern, *Blechnum francii*, grows underwater. Also seen here was *Oxera inodora*, with white flowers, one of the petals forming a frilly lip.

March 26

Today we visited **Mont Koghi** on the outskirts of Nouméa. At the auberge there are penned Javan rusa deer (*Cervus timorensis russa*) – a mammal introduced long ago to New Caledonia from Java, and now numbering c. 120,000 head. The Galatea herd of rusa deer in New Zealand is of New Caledonian stock, from an introduction made in 1908.

Mont Koghi has some splendid rainforest, rather reminiscent of the New Zealand bush. Prominent big trees here are *Montrouziera cauliflora*, arbre du Koghi (*Sloanea koghiensis*) with huge plank buttresses and bullate leaves, bois tabu (*Fagraea berteriana*), bois d'ail (*Dysoxylum bijugum*), tamanu du sud (*Calophyllum montanum*), chene rouge (*Cunonia* spp.), *Alstonia plumosa* (plentiful at the Auberge), azou (*Buraevella wakere*), cerisier bleu (*Elaeocarpus angustifolius*), azou graines bleues (*Elaeocarpus speciosus*), *Hernandia cordigera*, and faux acajou or goudronnier (*Semecarpus atra*) – a much feared, toxic tree. *Hernandia cordigera* is a commercial timber species, and one of the trees used locally for making canoes (pirogues). There were common smaller trees of the Araliaceae (*Schefflera* and *Myodocarpus*), impressively tall tree ferns (e.g. *Cyathea novae-caledoniae*), *Marattia attenuata*, several palms (*Actinokentia divaricata*, *Burretioakentia koghiensis*, *B. viellardii*, *Campecarpus fulcitus*, and *Chambeyronia macrocarpa* – Hodel & Pintaud 1998), extensive stands of *Melaleuca quinquerivra*, tangles of umbrella ferns (*Dicranopteris linearis*, *Gleichenia dicarpa*), the club-moss *Lycopodiella cernuum*, and the curious fern, *Dipteris conjugata*. Ferns and also *Selaginella hordeiformis* were numerous on the ground, but there seemed to be no or few herbaceous dicots – a constant feature of all forest and maquis sites we visited. The only member of the Melastomataceae in New Caledonia – *Melastoma denticulatum* – is found commonly in this area.

Four of the group ventured high up into the mountain and located populations of *Falcatifolium taxoides*, and its root parasite, *Parasitaxus usta*. *Xeronema moorei* was also spotted on high rocky bluffs.

At the Nouméa Botanical Garden we took the opportunity to view a fine display of the New Caledonian Araucariaceae, and many other species.

March 27

A second group went back to Mont Koghi to see *Falcatifolium taxoides* and *Parasitaxus usta*, the only known parasitic gymnosperm (see p.20). It grows up to 2 m tall, and is of a dark wine-red colour, with abundant glaucous cones. It lacks roots and grows directly out of the roots or lower trunk of its host (Kopke, Musselman & de Laubenfels 1983). *Pandanus* was plentiful in this locality, and the fern *Blechnum obtusatum* grew abundantly in the rocky stream course. Other plants noted along the way were *Oplismenus hirtellus* (Gramineae) in forest, *Agathis lanceolata*, strangler fig (*Ficus* sp.), another fig

with dense bunches of small cauliflorous fruit on the lower trunk (*Ficus racernigera*), *Joinvillea plicata*, *Montrouzieria verticillata*, *Styphelia*, *Dracophyllum*, *Acsmithia pubescens*, *Grevillea*, *Metrosideros*, and *Cunonia macrophylla*.

Other members of the group visited the Tijabaou Cultural Centre at Tina on the outskirts of Nouméa, designed by Renzo Piano. John Dawson gave a lecture in the evening on the vegetation and flora of New Caledonia.

March 28

We had a day-trip by plane to the **Isle of Pines**. The island is mainly of ancient raised coral, but with a central elevated ultrabasic rock interior. Much of the forest has been heavily exploited, the main local hardwood timber trees being kohu (*Intsia bijuga*) and buni (*Manilkara dissecta*). Sandalwood (*Santalum austrocaledonicum*) was once heavily exploited. The calcareous substrate (as in the Loyalty Islands) supports a quite different flora to that of the ultrabasic and schist substrates of the Grand Terre. Apart from *Cycas seemannii* and *Araucaria columnaris*, gymnosperms are absent, and there are no Cunoniaceae, Ericaceae or *Gymnostoma*, and fewer Araliaceae, Cyperaceae and Myrtaceae. Common genera include *Diospyros*, *Eugenia*, *Austromyrtus*, *Cupaniopsis*, and *Arytera* (Lowry 1996). Bois tabou (*Fagraea berteriana*) and raporé (*Mimusops elengi*) are fairly common trees.

The buni tree is large and handsome, with a spreading crown. We saw buni timber, which is hard and yellowish, being used for cross members in dug out canoes. Historic sites are traditionally marked with a totem fence of kohu stems, sometimes carved. The wood is exceedingly durable.

Pin colonnaire (*Araucaria columnaris*) is the main dendrological icon of the Isle of Pines, and occurs commonly right on the coast in groves. Some are 45 m tall. The timber is used locally for general carpentry, and particularly for dug-out canoes.

A feature of the Isle of Pines is the rampant growth of weed trees on roadsides and in thickets, the principal species being *Schinus terebinthifolius*, thorny poinciana (*Caesalpinia sepiaria*), *Leucaena leucocephala*, *Lantana camara*, *Psidium guajava*, Mauritius hemp (*Furcraea foetida*), and *Melia azedarach*. *Pinus caribaea* and *P. elliottii* occur in extensive plantations, and *Melaleuca quinquenervia*, as on Grande Terre, is widespread.

Coastal plants abound, and some of the species identified were noni (*Morinda citrifolia*), *Calophyllum inophyllum*, coconut (*Cocos nucifera*), *Scaevola sericea*, *Excoecaria agallocha*, Chinese lantern tree (*Hernandia nymphaeifolia*), *Acacia simplex*, *Erythrina variegata* (an impressive shade tree), *Argusia argentea*, *Sophora tomentosa*, *Myoporum tenuifolium*, *Pemphis acidula* (Lythraceae), *Suriana maritima* (Surianaceae), *Ficus microcarpa* var. *hillii*, and the mangrove *Bruguiera gymnorhiza* with its characteristic knee-like roots. Altogether there are 12 species of mangrove in New Caledonia, comprising *Rhizophora* (5 spp.), *Bruguiera* (1), *Lumnitzera* (2), *Sonneratia* (1), *Avicennia* (1), *Xylocarpus granatum* and *Heritiera littoralis* (Mueller-Dombois & Fosberg 1998). At **Vao**, at the site of the historic Catholic church we found a tree of otaheite apple (*Spondias cythera*) – an edible

fruit related to the mango, and several magnificent specimens of *Araucaria cunninghamii*.

An interesting and edible local snail (*Placostylus fibratus*) is harvested from the bush by local people for sale to restaurants in Nouméa; this genus also occurs in New Zealand. The common introduced giant African snail (*Achatina fulica*), however, which we frequently saw on the Grande Terre, is inedible, and in fact is a serious plant pest.

Our tour of the island took in the main settlement, Vao, the Baie des Pirogues where some canoes were under construction by the local people, and Kuto, where we had a wonderful buffet lunch beside the Beach.

After lunch Rosemary and Graeme Platt walked past the ruins of the prison - a legacy from the penal settlement period - towards the jetty at Kuto Bay. In the distance the tops of a grove of *Araucaria columnaris*, towering over the canopy of a broad-leaved coastal forest in the foreground, could be seen, and invited closer inspection. The walk along the raised and undermined coral coastal shelf to the end of the peninsula proved to be one of the highlights of the visit to the Isle of Pines. The seaward end of the peninsula was populated with the most spectacular grove of *A. columnaris* that we were to visit. The raised coral shelf was lined to its overhanging lip with a dense belt of this *Araucaria* - no more than 80 metres deep, running parallel to the foreshore. As is typical with this species, each tree had a gently sweeping 'S' bend in its trunk as it reached skyward. In the shade of the tall trees on the weathered coral, thousands of *Araucaria* seedlings - many up to half a metre high - were battling each other for a place in the sun. A few scattered *Pandanus tectorius* and bushy *Myoporum* shared the bony coral foreshore. The tropical sun sank as we headed back to Kuto beach, and the return flight to Nouméa.

March 29

Amborella trichopoda has survived for at least 130 million years and it is generally acknowledged to be the oldest angiosperm on earth—the most primitive flowering plant alive today. It occurs on the Plateau de Dogny, Sarraméa, and some of us visited Mme Suzanne and M. Gérard Moglia, at **Col d'Amieu**, where we saw *Amborella* growing in the forest. It is locally fairly common in this district, and is a somewhat sprawling shrub or small tree in the understory of tall mixed rainforest on a schist substrate. *Amborella*, a monotypic, dioecious, vessel-less shrub from New Caledonia, has been recognised as the first branch of angiosperm evolution ('the sister to all other extant angiosperms'), followed by the Nymphaeales and then Illiciaceae, Schisandraceae and Austrobaileyaaceae.

The Moglia's garden is full of cultivated fruit trees and ornamentals, including *Cunninghamia lanceolata*, *Araucaria bidwillii*, ylang ylang (*Cananga odorata*), macadamia, pomegranate, vine, olive, avocado, various citrus fruits, and, surprisingly, peaches and pears.

The forest at Col d'Amieu has a gigantic specimen of *Montrouzieria cauliflora*, 7.5 m in circumference (see p.21), and plentiful *Elaeocarpus angustifolius*- a

successional tree. Another big tree found in this forest is *Calophyllum calendonum*. The large proteaceous trees hêtre rouge (*Sleumerodendron austrocaledonicum*) and hêtre (*Kermadecia sinuata*) occur in the vicinity. The tree ferns *Cyathea intermedia* and *C. novaecaledoniae* are particularly large in this area, and there is also an abundance of elephant fern (*Angiopteris erecta*) and *Marattia attenuata*. The large moss *Spiridens vieillardii* (Spiridentaceae) grows on the trunks of tree ferns. The fern *Histiopteris incisa*, which also occurs in New Zealand and Australia, is common on disturbed forest margins, together with the edible Asian thimbleberry (*Rubus rosifolius*), the prickly *Solanum toroum*, both introduced plants, and *Trema cannabina*.

Araucaria humboldtensis has its habitat high on the flanks of the summit slopes of the Massif du Humboldt. At 1618 m, **Mont Humboldt** is the second highest mountain in New Caledonia, and is located twenty minutes' flying time by helicopter, north/north-west of Nouméa's Magenta Airport.

Derek Spicer, Lachie Andrews, and Rosemary and Graeme Platt chartered one of these machines to visit the *Araucaria humboldtensis* trees. Except for the fertile valley floors leading into Nouméa with their orchards, the ranges of hills we flew over were clothed in the typical sparse open low maquis vegetation. As we approached Mont Humboldt, a large cloud-bank to the north was spilling over the summit ridge, down through the steeply sloping *Araucaria*-dominated forests. The very distinctive flat-topped *Araucaria humboldtensis* trees at first looked like groves of tree ferns with tall clean trunks in the distant mist. As the mist came and went, we were able to fly back and forth along the southern slopes of the summit peak, photographing the trees. The wet cloud forest of mixed tree species was dominated by emergent *Araucaria* trees (p.21). A hut could be seen on a saddle a few hundred metres below the summit peak. The ever-threatening cloud-bank precluded any possibility of landing on the mountain to allow a ground inspection of the *Araucaria* trees and their companions. Returning in the direction of Nouméa, the pilot landed the helicopter on a lower ridge, at an altitude of about 800 m, near a grove of sparsely scattered *Araucaria rulei*, their distinctive white trunks gleaming in the sunlight. The maquis vegetation surrounding the *A. rulei* was lower and more sparse than normal on the ironised mineral-rich ridge. While *A. rulei* is, for the most part, a lean nutrient-deprived tree, this grove contained a couple of magnificent specimens - by far the best we were to see. A few large old distinctive male pollen cones lay spent on the ground under the trees. After 45 minutes, we were back at the airport, highly stimulated by another great adventure amongst the *Araucaria* trees. In the evening, Thierry Azaïs presented each member of a group with a poster and booklet, specially put together for us.

March 30

Amongst the planted shade trees and ornamentals in Nouméa are *Samanea saman*, *Delonix regia*, *Cassia javanica*, *Khaya senegalensis*, *Schefflera actinophylla*, *Spathodea campanulata*, *Tabebuia pallida* (and perhaps also *T. impetiginosa*), *Tamarindus indica*, *Mangifera indica*, *Terminalia catappa*, *Grevillea robusta*, *Tamarix*

aphylla, *Caesalpinia pulcherrima*, *Barringtonia asiatica*, *Ficus prolixa*, *Plumeria acutifolia*, *Plumeria rubra*, *Araucaria columnaris*, *Roystonea regia*, *Phoenix dactylifera*, *Syagrus romanzoffianum*, *Caryota mitis* and *C. urens*, *Washingtonia robusta*, *W. filifera*, *Cocos nucifera*, *Veitchia merrillii*, *Pritchardia pacifica*, *Chrysalidocarpus lutescens*, and *Eucalyptus deglupta*, *E. camaldulensis* and *Corymbia citriodora*. A curious, fastigate form of *Erythrina variegata* is often encountered near towns. On the way to the airport we visited a nursery, Pacifique Jardin, operated by M. Ramieu and Catherine Jarossay. Trees growing wild by the road leading there included *Melaleuca quinquenervia*, *Casuarina collina*, and *Syzygium cuminii*, an introduced tree with an edible fruit.

This enterprise propagates a wide range of tropical herbs, shrubs, palms, and trees for the local market. The main trees grown are *Araucaria columnaris*, *Agathis lanceolata*, *Swietenia mahagoni*, and various tropical flowering trees, such as *Samanea saman*, *Delonix regia*, *Cerbera odollam*, *Cassia fistula*, *Cassia javanica*, *Tabebuia pallida*, *Paraserianthes falcataria*, *Jacaranda mimosifolia*, *Peltophorum pterocarpum*, *Albizia lebbek*, *Barringtonia asiatica*, *Lagerstroemia indica*, *Brachychiton acerifolius*, *Terminalia mantaly* from Madagascar, and *Bauhinia purpurea* and others such as *B. monandra*, *B. tomentosa* and *B. variegata*.

Popular shrubs and climbers include *Antigonum leptopus*, *Caesalpinia pulcherrima*, *Gardenia taitensis*, *Murraya paniculata*, *Allamanda cathartica*, *Bougainvillea spectabilis*, and *Pyrostegia venusta*.

The nursery has an impressive collection – reputedly the world’s biggest, with some 400 cultivars – of croton (*Codiaeum variegatum*). This ornamental shrub, commonly cultivated in the tropics, has colourfully variegated red, green, and yellow leaves, which vary greatly in size and shape.

Summary and evaluation

This tour was hugely successful in familiarising us with the indigenous New Caledonian flora and vegetation, and with the ecology and distribution of the Araucariaceae. For the dendrologist and general botanical traveller, several features stood out.

- The wealth of exotic tropical shade and flowering trees and palms in the towns, such as *Delonix regia*, *Cassia javanica*, *Samanea saman*, and the splendid *Khaya senegalensis* – a common avenue tree in Nouméa.
- The widespread tropical Pacific trees and shrubs of the coastal strands, such as *Acacia simplex*, *Casuarina equisetifolia*, and *Hibiscus tiliaceus*.
- The weedy thicket-forming introduced shrubs of roadsides and disturbed forest margins, such as *Leucaena leucocephala*, *Schinus terebinthifolia* and *Melia azedarach*.
- The Australian look to the vegetation on the drier, western side, such as *Acacia spirorbis*, *Melaleuca quinquenervia* and *Casuarina collina*.
- Except for some areas of cattle ranching, the general lack of cultivated land.
- The scarring of the land through nickel mining.

- The great importance of certain families such as the Casuarinaceae (Jaffré *et al.* 1994), Apocynaceae, Myrtaceae and Cunoniaceae in the maquis and moist evergreen forest vegetation on ultrabasic soils.
- The curious candelabra-like habit of many trees e.g. *Cerberiopsis*, *Gymnostoma*, and many *Araucaria* (Veillon 1978, 1980).
- The prevalence of bullate (bubbly, blistered surface) leaves in many unrelated genera, e.g. *Cunonia bullata* (Cunoniaceae), *Eugenia bullata* (Myrtaceae), *Nothofagus codonandra* (Nothofagaceae), *Elaeocarpus bullatus* (Elaeocarpaceae), and *Sloanea koghiensis* (Elaeocarpaceae).
- The wealth of native conifers, most of which have a restricted distribution, and with the exception of *Araucaria*, are generally scattered or mixed with broadleaved species (de Laubenfels 1972; Farjon 1995; Jaffré 1995; McInnes-King 2000).
- Evolutionarily significant plants, such as *Arillastrum gummiferum*, considered to have affinities with *Eucalyptus*; *Joinvillea plicata*, the mostly closely related living monocot to the grasses; and *Amborella trichopoda*, perhaps the most primitive of all woody dicotyledons.
- The almost complete absence of native herbaceous plants.
- The abundance of the Cyperaceae in the maquis vegetation.
- The critical importance of geology in shaping the vegetation and distribution of species.
- The abundance of pteridophytes, and with some 31 species of ferns and fern allies being identical to those found in New Zealand.

Each day had its dramatic moments as new sites were visited, and new species seen. There were many highlights, especially our first meetings with *Araucaria rulei* in the north and *A. muelleri* in the south; the impressive stands of *naris* on the Isle of Pines; the strange furrow-barked, flat-topped *Agathis ovata*; the most curious of all conifers – the parasitic *Parasitaxus usta* and the rheophytic *Decussocarpus minus*; some gigantic individual trees of *Agathis lanceolata* and *Montrouzieria cauliflora*; the spectacular buttresses of *Sloanea koghiensis*; the great variety of beautiful maquis shrubs of genera such as *Xanthostemon* and *Cunonia*; and for those fortunate to see it, *Amborella trichopoda* – an unassuming forest shrub that was sensationally revealed to the botanical world at the XVIth International Botanical Congress in 1999 at St Louis, Missouri, USA as the most primitive of all living woody flowering plants (Barkman *et al.* 2000; Parkinson *et al.* 1999; Qiu *et al.* 1999).

References

- BARKMAN, T. J.; CHENERY, G.; MCNEAL, J. R.; LYONS-WEILER, J.; ELLISON, W. J.; MOORE, G.; WOLFE, A. D.; DEPAMPHILIS, C. W. 2000: Independent and combined analyses of sequences from all three genomic compartments converge on the root of flowering plant phylogeny. *Proc. Natl. Acad. Sci. USA*, Vol. 97, Issue 24, 13166-13171, November 21, 2000.
- BROOKS, R. R. 1987: *Serpentine and its vegetation*. Croom Helm, London. 454 p.
- BROWNLIE, G. 1969: *Flore de la Nouvelle-Calédonie et Dépendances*. No.3 Pteridophytes. Aubréville, A, ed. Mus. Nat. Hist., Paris, France. 307 p.
- DAWSON, J. W. 1966: Observations on *Nothofagus* in New Caledonia. *Tuatara* 14(1):1-6.
- DAWSON, J. W. 1981: The species rich, highly endemic serpentine flora of New Caledonia. *Tuatara* 25(1):1-6.

- DE LAUBENFELS, D. J. 1972: *Flore de la Nouvelle-Calédonie et Dépendances*. No. 4. *Gymnosperms*. Aubréville, A., Leroy, J-F., eds., Mus. Nat. Hist., Paris, France. 168 p.
- DE LAUBENFELS, D. J. 1996: Gondwanan conifers on the Pacific rim. pp. 261-265 *in* *The origin and evolution of Pacific Island biotas, New Guinea to Eastern Polynesia: patterns and processes* (eds. A. Keast & S. E. Miller). SPB Academic Publishing, Amsterdam.
- DE LAUBENFELS, D. J. 1998: A taxonomic revision of the genera *Cycas* and *Epicycas* gen. nov. (Cycadaceae). *Blumea* 43:351-400.
- ENRIGHT, N.J.; GOLDBLUM, D. 1998: Stand structure of the emergent conifer *Agathis ovata* in forest and maquis, Province Sud, New Caledonia. *Journal of Biogeography* 25(4): 641-648.
- ENRIGHT, N. J.; RIGG, L.; JAFFRÉ, T. 2001: Environmental controls on species composition along a (maquis) shrubland to forest gradient on ultramafics at Mont Do, New Caledonia. *South African Journal of Science* 97:573-580.
- FARJON, A. 1995: Threats to conifers in New Caledonia. *Species* 23:25-26.
- FARJON, A. 2001: *World checklist and bibliography of conifers*. Royal Botanic Gardens, Kew. 309 p.
- HILL, K. D. 1996: Cycads in the Pacific. pp 267-274 *in* *The origin and evolution of Pacific Island biotas, New Guinea to Eastern Polynesia: patterns and processes* (eds. A. Keast & S. E. Miller). SPB Academic Publishing, Amsterdam.
- HILL, R. S. 1996: The riddle of unique southern hemisphere *Nothofagus* on southwest Pacific islands: its challenge to biogeographers. pp 247-260 *in* *The origin and evolution of Pacific Island biotas, New Guinea to Eastern Polynesia: patterns and processes* (eds. A. Keast & S. E. Miller). SPB Academic Publishing, Amsterdam.
- HODEL, D. R.; PINTAUD, J-C. 1998: *The palms of New Caledonia*. Kampon Tansacha, Nong Nooch Tropical Garden, Thailand. 119 p.
- JAFFRÉ, T. 1988: *Vegetation et flore de la Chute de la Madeleine. Etude en vue d'une proposition de mise en réserve*. Laboratoire de Botanique, ORSTOM. 11 p.
- JAFFRÉ, T. 1995: Distribution and ecology of the conifers of New Caledonia. pp 171-196. *in* *Ecology of the Southern conifers* (Enright, N. J., Hill, R. S., eds.). Melbourne University Press.
- JAFFRÉ, T.; GAUTHIER, D.; RIGAULT, F.; MCCOY, S. 1994: Endemic Casuarinaceae on New Caledonia. Ecological and nutritional characteristics. *Bois et Forêts des Tropiques* 242: 31-43.
- JAFFRÉ, T.; MORAT, P.; VEILLON, J-M.; RIGAULT, F.; DAGOSTINI, G. 2001: Composition and characterisation of the native flora of New Caledonia. *Documents Scientifiques et Techniques II 4, Volume special*. Institut de recherche pour le développement. Nouméa. 121 p.
- KOPKE, E.; MUSSELMAN, L. J.; DE LAUBENFELS, D. J. 1983: Studies on the anatomy of *Parasitaxus ustus* and its root connections. *Phytomorphology* 31:85-92.
- LOWRY, P. P. II. 1986: Diversity, endemism and extinction in the flora of New Caledonia: a review. pp. 181-206 *in* C.-I. Peng and P. P. Lowry II (eds.), *Rare, threatened, and endangered floras of the Pacific Rim*. Institute of Botany, Academia Sinica, Monograph Ser. No. 16, Taipei. [<http://www.mobot.org/MOBOT/research/newcaledonia/>]
- MACKEE, H. S. 1985: *Les plantes introduites et cultivées en Nouvelle-Calédonie*. Muséum National d'Histoire Naturelle Laboratoire de Phanérogamie, Paris. 159 p.
- MCINNES-KING, D. 2000: *Tree dinosaurs: Araucaria. The masthead species of Gondwanan flora*. David McInnes-King, Larnook, NSW. 183 p.
- MCKOY, S.; JAFFRÉ, T.; RIGAULT, F.; ASH, J. E. 1999: Fire and succession in the ultramafic maquis of New Caledonia. *Journal of Biogeography* 26:579-594.
- MCQUEEN, D. R. 1983: Notes on the ecology of *Nothofagus aequilateralis* in New Caledonia. *Tuatara* 26(2):62-69.
- MORAT, P.; VEILLON, J-M.; MACKEE, H. S. 1984: Floristic relationships of New Caledonian rain forest phanerogams. pp. 71-128. *in* F. J. Radvosky, P. H. Raven and S. H. Sommer (eds.) *Biogeography of the Tropical Pacific*. Bishop Museum Special Publication 72.
- MORAT, P.; JAFFRÉ, T.; VEILLON, J-M. 1995: Grande Terre. New Caledonia, France. pp. 529-536 *in* S. D. Davis, V. H. Heywood & A. C. Hamilton (eds.) *Centres of Plant Diversity. Vol. 2 Asia, Australasia and the Pacific*. The World Wide Fund for Nature (WWF) and the World Conservation Union (IUCN).
- MORAT, P.; JAFFRÉ, T.; VEILLON, J-M. 2001: The flora of New Caledonia's calcareous substrates. *Adansonia sér.* 3 23(1):109-127.
- MUELLER-DOMBOIS, D.; FOSBERG, F. R. 1998: *Vegetation of the tropical Pacific islands*. Springer, New York. 733 p.

- O'NEILL, T. 2000: New Caledonia. *National Geographic* 197(5):54-75.
- PARKINSON, C. L.; ADAMS, K. L.; PALMER, J. D. 1999: Multigene analyses identify the three earliest lineages of extant flowering plants. *Curr. Biol.* Dec 16-30, 9(24):1485-1488.
- PERRY, G. L. W.; ENRIGHT, N. J.; JAFFRÉ, T. 2001: Spatial modelling of landscape-scale vegetation dynamics, Mont Do, New Caledonia. *South African Journal of Science* 97:501-509.
- READ, J.; HALLAM, P.; CHERRIER, J-F. 1995: The anomaly of monodominant tropical rain forests: some preliminary observations in the *Nothofagus*-dominated rain forests of New Caledonia. *Journal of Tropical Ecology* 11:359-389.
- RIGG, L. S.; ENRIGHT, N. J.; JAFFRÉ, T. 1999: Stand structure of the emergent conifer *Araucaria laubenfelsii*, in maquis and rain forest, Mont Do, New Caledonia. *Australian Journal of Ecology* 23:528-538.
- QIU, Y-L; LEE, J.; BERNASCONI-QUADRONI, F.; SOLTIS, D. E.; SOLTIS, P. S.; ZANIS, M.; ZIMMER, E. A.; CHEN, Z.; SAVOLAINEN, V.; CHASE, M. W. 1999: The earliest angiosperms: evidence from mitochondrial, plastid and nuclear genomes. *Nature* No. 25 402(6760):358-359.
- SCHMID, M. 2000: *Fleurs et plantes de Nouvelle-Calédonie*. Les éditions du Pacifique. Times Media Private Ltd, Singapore. 164 p.
- SETOGUCHI, H.; OSAWA, T. A.; PINTAUD, J. C.; JAFFRÉ, T.; VEILLON, J. M. 1998: Phylogenetic relationships within Araucariaceae based on *rbcL* gene sequences. *Amer. J. Botany* 85(11):1507-1516.
- THORNE, R. F. 1965: Floristic relationships of New Caledonia. *University of Iowa Studies in Natural History* 20(7) :1-14.
- VEILLON, J-M. 1978: Architecture of the New Caledonian species of *Araucaria*. in *Tropical trees as living systems*. (ed. P. B. Tomlinson and M. H. Zimmerman), pp. 233-245. Proc. 4th Cabot Symposium. Cambridge University Press.
- VEILLON, J-M. 1980: Architecture des espèces néo-calédoniennes du genre *Araucaria*. *Candollea* 35:609-640.
- WATERS, T. 2002: Population status and conservation biology of *Araucaria nemorosa* de Laub. *Abstracts of International Dendrology Society Araucariaceae Symposium*, Auckland, New Zealand, p 41.

Nomenclature

Plant names follow Jaffré *et al.* (2001), with the exception of conifers, which follow Farjon (2001). On the advice of D. J. de Laubenfels, we have used here the name *Decussocarpus minus* (syn. *Nageia minor*) rather than *Retrophyllum minus*, and likewise, *D.comptonii* rather than *R.comptonii*.

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Annex 1: Casuarinaceae in New Caledonia

Casuarina equisetifolia L. Johnson subsp. *incana* (Benth.) L. Johnson. Abundant on beaches. Widespread in the Pacific, but not considered indigenous to New Caledonia.

Casuarina collina Poiss. ex Panch. & Sieb. Bois de fer, ironwood. Common throughout, especially in tall riparian communities. Also common on the dry west coast side in secondary forests.

Gymnostoma chamaecyparis (Poiss.) L. Johnson. Wayu. Poor ultramafic soils. Shrub maquis. Occurs on drier steep slopes of the ultramafic massifs. Associated with hypermagnesian soils below 600 m elevation, at the base of ultramafic massifs.

Gymnostoma deplancheanum (Miq.) L. Johnson. On ultramafic terrain, with high levels of Ni, Mg, Mn, Cr, Fe, and Mn, on ferrallitic ironstone and gravelly soils. Higher rainfall sites of southern Grande Terre, at 200-1000 m elevation.

Gymnostoma glaucescens (Schlechter) L. Johnson. Occurs in forest. Up to 15-20 m tall. On alluvial soils.

Gymnostoma intermedium (Poiss.) L. Johnson. Occurs in forest. Up to 15-20 m tall. Ultramafic soils. In montane ultramafic vegetation. Mainly 700-1000 m elevation on eroded slopes, and ferrallitic gravelly soils.

Gymnostoma leucodon (Poiss.) L. Johnson. Riparian sites. Restricted to the Southern Massif.

Gymnostoma nodiflorum (Thunb.) L. Johnson. It occurs on non-ultrabasic substrates, usually alluvial soils of volcano-sedimentary origin. Mainly in the northern half of the Grande Terre.

Gymnostoma poissonianum (Schlechter) L. Johnson. Occurs in forests, up to 15-20 m tall. Secondary rain forests, 200-700 m, on eroded slopes.

Gymnostoma webbianum (Miq.) L. Johnson. Mainly in the northern half of the Grande Terre.

Annex 2: Araucariaceae in New Caledonia

Agathis corbassonii de Laub. Corbasson's kaori, kaori rouge. N Grande Terre. Tree to 40 m. Scattered in areas of lowland moist forest, 300-700 m, on non-ultramafic substrates. It is exploited for its timber, most heavily at a local level.

Agathis lanceolata (Sebert & Pancher) Warb. Kaori de forêt. Type near Mont Koghi, at 200-1100 m elevation. Typically growing as an emergent in subtropical rain forest on ultramafic soils in the southern parts of the island. Large timber tree to 40 m and 2.5 m diameter. The tallest of the genus in New Caledonia. Good stands in the Ni Valley north of Noumea.

Agathis montana de Laub. Mont Panié kaori. Mont Panié, Mont Colnett, Mont Ignambi, NE Grande Terre. Tree 15-20 m, with a large, flattened crown. 1000-1600 m altitude. Forms monospecific stands in summit forests. Not found on ultramafic rocks.

Agathis moorei (Lindley) Masters. Kaori blanc, Moore kauri. Pembe to Thio and Dumbea to Prony at elevations of 200-1000 m. Tree to 25 m tall. Elevations of mostly 300-600m, but up to 1000 m. On soils from metamorphic rocks, including shales, sandstones, and schists. Lowland rain forest.

Agathis ovata (C. Moore) Warburg. Dwarf kauri, kaori de montagne, kaori nain. S Grande Terre: Mont Humboldt to Montagne des Sources, 150-1000 m. Grows in small stands, generally very open, or sometimes in forest. On ultrabasic laterite carapace in fire-swept maquis vegetation, on arid exposed ridges. Usually solitary. Shrub from 1-8 m tall or tree to 25 m.

Araucaria bernieri Buchholz. Bernier's araucaria. Poum, and from Canala to Plaine des Lacs, 100-700 m. To 50 m. Generally occupies steep slopes and debris slips in deep valleys and gullies. Good forests of this species occur on ultramafic rocks at the Rivière Bleue Park. Also Mont Dzumac. A columnar tree emergent above rain forest. Often associated with *Agathis lanceolata*.

Araucaria biramulata Buchholz. Biramule araucaria. Western side of Grande Terre. Type from Mois de Mai, 300-1050 m. Mont Kaala, 1000 m. Mont Do. Col d'Amieu. A columnar tree to 30 m. tall, with numerous, spreading branches.

Araucaria columnaris (J. R. Forst.) Hook. Cook pine, pin colonnaire. Isle of Pines, Loyalty Islands, Grande Terre. Maximum growth and abundance at the edge of the sea, in dense evergreen forest on ancient raised coral reefs. Commonly planted all over New Caledonia, and grown in the tropics as an ornamental. Grows to 60 m and 1.5 m diameter on the Isle of Pines, forming dense pure stands of striking columnar habit, standing above stunted forest on cliffs, exposed the prevailing winds. These populations, which mostly form narrow strips of a few dozen metres wide, are among the most spectacular plant formations of New Caledonia. "La marque déposée de la Nouvelle-Calédonie".

Araucaria humboldtensis Buchholz. Humboldt araucaria. Mont Humboldt, Mont Mou & Montagne

des Sources, 750-1500 m. Occurs on the southern portion of the island, on ultramafic substrates. A tree 6-15 m tall, with steep branches forming a flattened, candelabra-like crown.

Araucaria laubenfelsii Corbasson. de Laubenfels araucaria. At 400-1300 m, southern mountains around Nouméa: Mont Mou, Montagne des Sources, Mont Dzumac, Mont Do. At Mont Do Botanical Reserve, this species receives an average rainfall of 1690 mm per year (more if fog drip is accounted for), with a precipitation maximum in February (avg. 255 mm) and minimum in September (45 mm). It occurs on ultramafic soils in both maquis and as an emergent in upland rain forest. In both habitats is evidently regenerates more or less continuously in response to small-scale disturbances including fire (in maquis) and blowdown (in maquis and rain forest). It does not form closed stands. On Mont Do massif, on ultramafic soils as an emergent tree in rain forest and also in maquis vegetation. A columnar tree 10-50 m.

Araucaria luxurians (Brongn. & Gris) de Laub. Coast araucaria. S Grande Terre: along the coast, 0-200 m. Local in maquis and forests. Sensitive to fire. Able to grow on brown hypermagnesian soils, with very high Mg and low Ca levels. A columnar tree to 30 m tall.

Araucaria montana Brongn. & Gris. Mountain araucaria. Throughout the Grande Terre on crests of mountain ridges, and plateaux, often visible from a great distance. 300-1300 m. Columnar tree 10-40 m tall. Branches numerous and spreading.

Araucaria muelleri (Carrière) Brongn. & Gris. Mueller araucaria, pin candelabre. S Grande Terre: Mont Koghi to Montagne des Sources, 150-1000m. A tree 10-25 m. tall, with a candelabra-like crown, but trees on ironstone substrate on the Goro Plateau are stunted.

Araucaria nemorosa de Laub. Boisé araucaria. Southern Grande Terre: Port-Boisé, to 10 m altitude. Known only from a six small stands near the coast, Bay of Port-Boisé in the extreme south. Emergent in rain forest. A tree to 15 m tall, with an oval or conical crown. On serpentine.

Araucaria rulei F. Muell. Rule araucaria. Central and southern Grande Terre, 150-1200 m. On serpentine soils. Generally occupies sites containing nickel ore. A tree to 30 m tall but usually much smaller, with an open crown of candelabra branching.

Araucaria schmidii de Laub. Schmid araucaria. NE Grande Terre: Mont Panié, rare, 1500-1630 m. Only found as an emergent above low forest on the escarpment slopes bordering on the summit plateau of the Mont Panié Range. Not found on ultramafic rocks. A tree to 30 m tall, with numerous ascending branches.

Araucaria scopulorum de Laub. Rock araucaria. NE Grande Terre: Poum, Dothio, Cap Bocage, Houailou, 0-200 m. Small tree 5-20 m, with an oval crown. On rocky serpentine sites.

Araucaria subulata Vieillard. Narrow-leaf araucaria. S Grande Terre: Ignambi; Canala; Mont Dzumac; Montagne des Sources, 320-1900 m. A straight columnar tree to 50 m tall. Ultramafic soils.

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