

A NEW CALEDONIAN GLASSHOUSE IN PARIS – CHALLENGES AND OPPORTUNITIES

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ABSTRACT

This chapter discusses the renovation of the public glasshouses (Les Grandes Serres) at the Muséum national d'Histoire naturelle, Paris (MNHN) and particularly the creation of a glasshouse presenting the rich and unique flora of New Caledonia, a French overseas territory in the Pacific Ocean. The displays demonstrate past and current scientific studies carried out by MNHN researchers in all fields of natural history. Current concerns over the degradation of the biodiversity of the region have led to the decision taken by the Department of Botanical and Zoological Gardens to display this ecosystem. Five of the most threatened or important ecosystems of the archipelago have been recreated in the glasshouses and have full disabled access. The reopening of Les Grandes Serres was a landmark for the 2010 International Year of Biodiversity at MNHN.

INTRODUCTION

The public glasshouses (Les Grandes Serres) of the Muséum national d'Histoire naturelle (MNHN) are situated in the heart of the Jardin des Plantes, Paris (see Fig. 1) which was reopened to the public on June 2010 after having been closed for six years and undergoing renovations for five of those (Joly *et al.*, 2010). This project was initiated by long-term collaborations which mobilised many teams in many fields. It was a partnership project that required modern technology, know-how and considerable funding and was a real challenge for everyone involved, including gardeners, botanists, directors, architects, scenographers and specialised companies. The renovation was an opportunity not only to improve the security of the glasshouses but also to create better access for visitors with disabilities. It also enabled the Department of Botanical and Zoological Gardens (DJBZ) to redefine its themes and concepts. One glasshouse is dedicated to five specific ecosystems found on the island of New Caledonia in the Pacific Ocean. The unique New Caledonian flora is now presented in Paris in this theatrical showcase (Delmas & Larpin, 2010) in one of the two superb metal and glass pavilions built by Charles Rohault de Fleury between 1834 and 1836.

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Fig. 1 Aerial view of Les Grandes Serres during refurbishment. Photo: Patrick Lafaite.

ONE PROJECT WITH FOUR CHALLENGES

The principal task was the renovation of all the glasshouses. The large tropical glasshouse, and the gallery contiguous to it, built by René Berger in 1934, had never been renovated since they were constructed and more recently the corrosion of the metal components had made them hazardous. A restoration programme was therefore essential. The two pavilions, designed by the architect of MNHN, Charles Rohault de Fleury, were built between 1834 and 1836 and restored in 1980. They were in a better state than the tropical glasshouse but also required some renovations. This work started in 2005 and was completed in 2007 under the direction of Jean-François Lagneau, Chief Architect for Historic Monuments (see Figs 2 & 3).

The glass panels from the main glasshouse were removed and renewed and the gallery had to be completely dismantled. The metal structure was treated for rust and the damaged parts replaced, then repainted. The pavilions underwent similar treatment except for the glass panels which had been replaced in the 1980s. Heating, electricity and the water supply were renovated and a mist system was installed to increase the atmospheric humidity of the main glasshouse (see Fig. 4).

While the renovation work was being carried out as many plants as possible were transferred to the tropical glasshouses of the satellite garden of Jardins des Plantes at the Chevreloup Arboretum near Versailles. The larger specimens remained in place and had to be protected during the winter. This was done by framing the whole glasshouse under plastic cover and by providing a temporary heating system. Amazingly, only one plant died!



Fig. 2 The Art Deco monumental entrance of the main glasshouse in 2006. Photo: Denis Larpin.



Fig. 3 The Art Deco monumental entrance of the main glasshouse a few weeks before its reopening in 2010. Photo: Manuel Cohen.



Fig. 4 In 2006, the Tropical Rainforest Glasshouse was a huge tangle of scaffolding imprisoning the trees and palms. Photo: Denis Larpin.

The second task was to provide access to all the glasshouses for all of our visitors. During the previous administration only two out of the four monumental glasshouses were opened to the public. To open all four to all visitors, circulation had to be modified and access made compatible with safety regulations (see Fig. 5). Two lifts were installed as a result. From the start of the project, a number of associations working with the disabled were consulted in order to cater for the requirements of all visitors whether visually, aurally or mentally disabled.

The third task was to source the plants. In the Tropical Rainforest Glasshouse, large trees and many other plants had been planted decades ago but it was necessary to significantly enrich the flora, especially the under-



Fig. 5 The large central path crossing the New Caledonian Glasshouse being installed. Photo: Maïté Delmas.

story. In the three other glasshouses, where new ecosystems or displays had been created, we had to acquire all the plant specimens. Many of them were sourced from our own tropical collections. In Europe, the Royal Botanic Garden Edinburgh (RBGE), the Royal Botanic Gardens, Kew and the Botanical Garden of the City of Paris supplied us with rare and beautiful plants. Other plants came from commercial nurseries or from collections within scientific institutions and environmental associations.

The fourth and final task concerned one of the main missions of MNHN: the diffusion of scientific knowledge through education and awareness-raising programmes. The exhibition of beautiful plants is undoubtedly a pleasant experience for the visitor; however, it is essential that museums are also able to provide scientific information that is easily accessible to the visitor.

In all the glasshouses, a ‘museographic device’ accompanies the visitor. This is very discreet and takes the shape of a steel ribbon, a sort of liana, which carries the informative panels and the sensory or pictorial creations such as picture booklets, models of fruit and sounds (see Fig. 6). In addition, larger panels and screens are displayed throughout which provide complementary information.

Four glasshouses are now open to the public. The largest of these presents the flora of the tropical rainforest, with two trails for visitors to follow: one for economic plants and the other displaying plants competing for light. In the newly created Desert and Arid Land Gallery many succulents and other xerophytes show adaptations to the lack of water and intense heat of these hostile environments. One of the pavilions, designed by Rohault de Fleury,



Fig. 7 'Ariadne's Liana' with information panels, picture booklet and small screen in front of the mine maquis area in the New Caledonian Glasshouse. Photo: Denis Larpin.

formerly housed a collection of Australian, New Zealand and South African plants. However, thanks to the expertise of an MNHN palaeobotanist, Dario De Franceschi, the glasshouse is now devoted to the history of terrestrial plants through geological times and presents plants belonging to very ancient families and fossil casts of extinct groups. The second pavilion features the archipelago, ecosystems and culture of New Caledonia (see Fig. 7).

WHY BUILD A GLASSHOUSE FOR THE FLORA AND HABITATS OF NEW CALEDONIA?

Before its renovation, the glasshouse was home to a collection of plants and xerophytes from Mexico and other arid countries. These plants are generally well represented in botanic garden collections. In this project, the choice to replace this collection was guided by the wish to display an exceptional, fragile and rarely displayed flora with a long-standing research tradition at MNHN. Some key specialists of this French overseas territory, known locally as the ‘caillou’,⁴ based in metropolitan France at MNHN, have



Fig. 6 The former Succulent Plants Glasshouse (now the New Caledonian Glasshouse). Photo: Denis Larpin.

⁴ A French word for ‘stone’ sometimes used to refer to the main island of New Caledonia.

finally persuaded us to embark on this adventure. What a challenging choice to dedicate this glasshouse here in Paris to that archipelago on the other side of the world!

A unique archipelago and flora

In 1774, James Cook discovered the archipelago of New Caledonia in Oceania which he named after his homeland of Scotland. With an area of 19,058 km², it comprises Grande Terre, Quatre Iles (Ouvéa, Lifou, Tiga and Maré), Iles Belep, Ile des Pins and a few remote islands. Attached to France in 1853 as part of the French overseas territories, the statute of New Caledonia was redefined in 1999 on the basis of the Noumea Agreement (1998) which increased its autonomy.

With an exceptional flora and fauna (respectively 76 per cent and 72 per cent of endemic species) and a number of different environments, it is the smallest of the world's hotspots of biodiversity, ranking third after Hawaii and New Zealand for the number of endemic species. It has five endemic families: Amborellaceae, Oncothecaceae, Paracryphiaceae, Phelliniaceae and Strasburgeriaceae, and one hundred and six endemic genera which include *Arthroclianthus*, *Austrotaxus*, *Beauprea*, *Codia*, *Pancheria* and *Strasburgeria* (Jaffré *et al.*, 2004). This unique flora claims the world's only parasitic conifer, *Parasitaxus ustus*, and nearly two-thirds of the world's species of *Araucaria* species, all of which are endemic. The threats to New Caledonia's ecosystems are numerous and include fires, land development, industrial exploitation such as intensive nickel mining, forest destruction and the spread of invasive non-native plant and animal species.

For their exceptional beauty, diversity and richness in coral and fish species, the lagoons were granted UNESCO recognition in July 2008 under the name 'Lagoons of New Caledonia: reef diversity and associated ecosystems'.

MNHN research studies on the biodiversity of New Caledonia

By choosing to present the flora of New Caledonia, the DJBZ is building on links forged over decades with MNHN researchers in botany, ethnobotany, ecology, marine and terrestrial animal biodiversity with the archipelago. For more than 150 years, MNHN botanists have studied and contributed to the knowledge of the archipelago's flora and habitats, which has resulted in a large number of publications such as the *Flore de la Nouvelle Calédonie et Dépendances* with a consequent enrichment of the Paris Herbarium (Morat, 2010).

Guillaumin (1911, 1926 and 1957) and Aubréville (1967) were great contributors to and specialists in this flora. More recently the disciplines investigated and research programmes carried out have included taxonomic treatments, on Anacardiaceae (Hoff, 1997), Cunoniaceae (McPherson & Lowry, 2004), Elaeocarpaceae (Tirel, 1982) and Fabaceae (Nielsen *et al.*, 2005). Recent studies have been carried out by Labat and Sarthou on insular endemism and speciation of the *Arthroclianthus/Nephrodesmus* complex (Labat & Sarthou, pers. comm.), Hernandiaceae (Jérémie, 1988), Icacinaceae

(Villiers, 1980), Malvaceae (Morat & Chalopin, 2005), Myodocarpaceae (Lowry *et al.*, 2004), Oncothecaceae (Morat & Veillon, 1988), Orchidaceae (Hallé, 1977; Pignal, in press), Paracryphiaceae (Jérémié, 1996), Pittosporaceae (Tirel & Veillon, 2002), Rubiaceae (Achille, 2006; Mouly & Achille, 2007), Sphenostemonaceae (Jérémié, 1997) and Tiliaceae (Tirel, 1996).

These taxonomic studies have also included bryology (Thouvenot & Bardat, 2010) and mycology by Mouchacca (studies by Roger Heim, who was Director of MNHN from 1951 to 1965; Buyck, 2004; Mouchacca, 2000; Mouchacca & Zucconi, 1994).

Other significant collectors in New Caledonia include current and former MNHN botanists such as Barrabé, Barrau, Florence, Gaudeul, Munzinger, Raynal and Tronchet, and famous MNHN correspondents such as Boiteau (1981), Lecoufle, LeRat and of course McKee, one of the best New Caledonian flora specialists (McKee, 1966, 1994; Morat, 1995).

Collaboration opportunities involving MNHN taxonomists and ecologists in national and international projects in New Caledonia include the International Conifer Conservation Programme (ICCP) based at the Royal Botanic Garden, Edinburgh (Gardner, 2003), the systematic and evolution dynamics of araucarias, the composition and characterisation of the native flora of New Caledonia (Jaffré *et al.*, 2004; Morat *et al.*, 1994) and the threatened plants and habitats of New Caledonia (Bouchet *et al.*, 1995; Gargominy *et al.*, 1996; Jaffré *et al.*, 1998, 2010; Lowry, 1998; Munzinger *et al.*, 2008).

The New Caledonian animal biodiversity is also well studied at MNHN. Research fields include the marine biodiversity of coral reefs (Beck *et al.*, 1992; Bour *et al.*, 1994; Joannot, 1990, 2003 and 2008; Joannot & Bour, 1988), taxonomy and natural history of insects such as cockroaches (Grandcolas, 1997; Grandcolas *et al.*, 2002), crickets (Desutter-Grandcolas, 2002), lace bugs (Guilbert, 2004, 2008; Murienne *et al.*, 2009) and springtails (Deharveng & Bedos, 2002), ichthyology – the study of fish – (Keith, 2002; Keith *et al.*, 2010; Seret, 1987), malacology – the study of molluscs – (Bouchet & Kantor, 2004; Bouchet & Marshall, 2001; Bouchet *et al.*, 2009; Kantor & Bouchet, 2007; Lozouet, 1991; Pernice *et al.*, 2009; Vidal & Kirkendale, 2007) and herpetology – the study of reptiles – (Ineich, 2009; Ineich & Rasmussen, 1997). Important biogeographical evidence on the origins of the biodiversity of New Caledonia have also been published (Grandcolas *et al.*, 2008). This list is far from exhaustive.

The new glasshouse has been a real opportunity for some of these researchers to contribute their specialist knowledge to an iconic project and to make their studies known to the public.

LANDSCAPE DESIGN AND EDUCATIONAL TARGETS

Links between man and plants in the culture of New Caledonia

Passing through the impressive rockery of the Tropical Rainforest Glasshouse, an elegant space is devoted to the presentation of New Caledonian culture and of the Kanak

people, their history and economy. Aspects of the rich Kanak culture are presented through graphic designs and original totems. Two magnificently carved wooden pillars, which are traditionally found at the entrance of huts in New Caledonia, will be installed in the future to mark the entry of the main glasshouse.

Small screens reveal the blue lagoons, the ochre and red colours of the mine maquis contrasting with the luxuriant vegetation of the rainforest and the coastal columnar pines (*Araucaria columnaris*) of the seashores. A sound recording recalls the intricate relationships of the New Caledonian people with the flora.

A partnership between MNHN, the Government, the Congress and the three provinces (North, South and Loyalty Islands) of New Caledonia and the Maison de la Nouvelle-Calédonie in Paris has helped to finance the landscape design including the hard landscaping of this glasshouse and the acquisition of many of the plants.

Information and interpretation for visitors

Information for the visiting public using text, maps, photographs, scents and short stories has been placed on a steel ribbon which runs through all the glasshouses and is referred to as 'Ariadne's Thread', requiring the public to use all their senses. Small screens on the liana display an innovative technology simulating plant growth which has been applied to three of the New Caledonian plants. It was developed by the 'Amap' French scientific team (botAnique et bioinforMatique de l'Architecture des Plantes, 2010). In the background, the five alcoves in the wall of the glasshouse are equipped with five high-definition screens – one for each ecosystem. These display a selection of outstanding photographs of New Caledonian plants.

Evoking the flora New Caledonia

Careful selection of the plant species and design of the landscape help the public to grasp the essence of the local ecosystems. Additionally, the interpretation highlights other aspects of the environment in each habitat, focusing on:

- in the rainforest – endemism
- in the dry forest – plant richness and extreme threats
- in the mine maquis – mining and subsequent soil degradation, the rate of endemism and the exceptional plant adaptations
- in the savanna – the biological invasions, transitions and degradation of habitats
- in the mangrove – the importance of the fauna and on environmental threats

This glasshouse has become a public information platform for the flora of New Caledonia and habitats but also for the conservation, research and educational activities and programmes of MNHN and its collaborating partners, such as Programme de Conservation des Forêts Sèches de Nouvelle-Calédonie (PCFS), Institut Agronomique

Néo-Calédonien (IAC), Institut de Recherche pour le Développement (IRD) and Maison de la Nouvelle-Calédonie in Paris (MNC).

SOURCES OF PLANTS FOR THE DISPLAY

Royal Botanic Garden Edinburgh

One of the most difficult aspects of the project was the acquisition of living plant specimens. We initially made a request to our colleagues in the botanic garden community. Staff at RBGE were generous and helpful, offering some gems from their exceptional collection of ferns and tropical conifers and we are particularly grateful to them. A trip to Scotland was organised in February 2010. David Rae, Martin Gardner, Louise Galloway, Natacha Frachon, Andrew Ensoll and others welcomed us and helped us choose some very interesting species. Two months later, Louise and Natacha made a 'home delivery' and arrived in Paris with a truckload of plants (see Fig. 8). These included some invaluable ferns and New Caledonian endemic conifers such as *Acropyle pancheri*, *Araucaria schmidii*, *Falcatifolium taxoides*, *Podocarpus lucienii*, *P. sylvestris*, *Retrophyllum comptonii* and *R. minus*.

France and the USA

The botanic garden Jardin des Serres d'Auteuil, Paris has also contributed to the project by sending a large palm, *Chambeyronia macrocarpa*, and other species. The Conservatoire Botanique National de Brest has also donated valuable endemic species of the dry forest. Several New Caledonian araucarias and agathis, raised from seeds in the 1980s, were already present in the collections at MNHN. Species of Araliaceae, Casuarinaceae, Fabaceae, ferns and orchids also came from MNHN collections. Lastly, other interesting species were provided by the Montgomery Botanical Center, in Miami, Florida (Husby *et al.*, 2008).

New Caledonia

A detailed search for plants for display from New Caledonia and occurring in the five habitats and of particular interest to MNHN, was carried out by Christian Papineau, who was in charge of the PCFS at that time (Institut Agronomique néo-Calédonien – Centre de recherche Nord, 2004; Papineau & Blanfort, 2008).

Most species of Myrtaceae, Cunoniaceae, Proteaceae and Euphorbiaceae, four important plant families of the archipelago, and many other species in the collection, come from SIRAS Pacifique, a company which specialises in the restoration and rehabilitation of mining sites. Species from the families Apocynaceae, Arecaceae, Casuarinaceae, Fabaceae, Lamiaceae, Moraceae, Pittosporaceae, Rubiaceae, Sapindaceae, Sapotaceae and Sterculiaceae come from five different nurseries (Eriaxis, Mango, La Nea, Tipinga

and Tuaiwa). Additionally, unique species from the dry forest and the mangrove were generously offered, respectively by PCFS and Point Zéro/Baseline Environmental Association. Most of the plants were obtained on the condition that distribution outside the MNHN was restricted.

ADMINISTRATIVE AND ACCLIMATISATION CHALLENGES

The plants, mostly endemic taxa, were to be airshipped from the archipelago, a complex and highly risky situation due to the long trip and, later, to their acclimatisation. The first set of plants, provided by SIRAS Pacifique, arrived in October 2008. These plants, mostly of small size, were sent bare-rooted, as stipulated by phytosanitary regulations. Most of them are still being cultivated in the propagation area and are growing slowly. It soon became evident that we would need to obtain more and larger plants, and so in May 2010, two additional shipments took place, but they were significantly more complicated than the first one.

Once the first problem of sourcing large plants was solved it took several months to solve the second challenge. Authorisations were required to transfer the larger plants to metropolitan France. These needed to be transported in their pots with their substrate. The plant health regulations are very strict; soil must be sterilised and in the end a vapour-sterilised peat was used by the veterinary, food and rural affairs department in New Caledonia (DAVAR) to transfer the plants to Paris. Phytosanitary certificates were issued in New Caledonia. Additionally, importation and exportation CITES certificates were necessary for some species.

The plants were transferred with the help of International Consulting Import (ICI), which dealt with the treatment, conditioning, administrative matters and shipment of the plants. Finally, at Charles de Gaulle airport in Paris, the plants underwent a phytosanitary inspection and were declared pest- and disease-free. The medium-sized plants arrived, alive, only two days before the official opening, which was just enough time to plant them into the beds as planned and ensured a reasonable plant cover in the glasshouse (see Fig. 9).

Unfortunately, most of the specimens destined for the mangrove display died from climatic shock. It is now thought that if younger plants had been transported they would have adapted better to the conditions. New attempts to establish these plants will be made in the future. In other areas of the glasshouse, half of the niaoulis (*Melaleuca quinquenervia*) and the large *Chambeyronia macrocarpa* rainforest palm died. A few other tree species suffered from transplantation shock and their survival has become questionable. This said, more than 90 per cent of the plants survived and, one year on, the plants are growing steadily. More time will be necessary for them to thrive and flower.

FIVE DIFFERENT SCENES WITH RARE AND VALUABLE SPECIES

From the entrance, one can feel the contrast between the reconstituted habitats. One of the challenges was to include plants from the archipelago which grow there in very different



Fig. 8 Louise Galloway, Denis Larpin and a member of MNHN garden staff removing the plants from the van. Photo: Maïté Delmas.



Fig. 9 MNHN garden staff preparing the dry forest area a few hours before the official reopening of the glasshouses. Photo: Denis Larpin.



Fig. 10 A spectacular view of the New Caledonian Glasshouse landscaping, central path and scenography devices from the metallic roof structure. Photo: Manuel Cohen.



Fig. 11 The waterfall separates the dense rainforest area planted with ferns, palms, conifers and young trees from the dry forest area vegetation in the New Caledonian Glasshouse. Photo: Denis Larpin.

soils, light levels, wind, temperatures and moisture conditions from each other in a unique and limited space (less than 200m²). The New Caledonian Glasshouse is a showcase to present an exceptional and fragile flora and habitats through five distinct evocations: the rainforest, the dry forest, the mine maquis, the savanna and the mangrove (see Fig. 10). A waterfall was created to add attractiveness and provide additional humidity, and a small river helps to delimit the five areas (see Fig. 11). The water from this river spouts out of carved, coloured and realistic-looking rocks and runs through the glasshouse to the mangrove.

The rainforest

With an annual rainfall of more than 1,500mm, the New Caledonian rainforest is a paradise for botanists, with more than 2,000 higher plant taxa and 82 per cent endemics (Jaffré *et al.*, 2004). The rainforest covers 4000km² (21 per cent of the archipelago). Conifers, palms, tree ferns and orchids are characteristic elements of the flora, most of them endemic, along with many trees and shrubs, herbs, mosses, lichens, epiphytes and parasites. The humus and root systems hold the soil (acid, ultramafic or alkaline) and play an essential role in resisting erosion.

Iconic species planted include the shrubby *Amborella trichopoda* (Amborellaceae), said to be the most ancient flowering plant on the planet. A protected animal species, the Kagu, is the emblem of the territory and it is the only surviving bird in its family. Pictures of this bird can be seen in the booklet available for visitors.

New Caledonia has around 40 endemic conifer species, several of which are displayed in the rainforest area. The genera planted include *Acmopyle*, *Agathis*, *Araucaria*, *Falcatifolium*, *Podocarpus* and *Retrophyllum*. One of the tallest tree fern species in the world, *Cyathea intermedia*, has been planted. Palm species planted include endemic species such as *Alloschmidia glabrata*, *Chambeyronia macrocarpa*, *Cyphophoenix elegans* and several *Kentiopsis* species. The tree and shrub species belonging to several families are represented, including Araliaceae, Cunoniaceae, Hernandiaceae, Myrtaceae, Pandanaceae, Pittosporaceae and Rubiaceae. Common traditional garden and resource plants are planted here, such as *Colocasia esculenta*, known as taro.

The dry forest

The sclerophyllous or dry forest receives less than 1,100mm annual rainfall and comprises more than 450 higher plant taxa among which 57 per cent are New Caledonian endemics and 13 per cent are dry forest endemics (Jaffré *et al.*, 2004). Here there are no palms or conifers and only a few orchid species but a wealth of remarkable rare, ornamental and medicinal plants grow in this habitat. The fauna is also rich but still little known; numerous endemic species of insects, birds, reptiles and gastropods live in this unique environment.

The dry forest, located on the west coast of Grande Terre, the largest island, is one of the most threatened ecosystems on the planet; only 50km² remain. It is highly reduced and

fragmented because of human activities such as fires, firewood extraction, agriculture, industrial activities, urbanisation and the spread of invasive exotic species. Since 2002 the PCFS has been charged with producing an inventory and preserving, restoring and sustainably managing the remnants of the dry forest which is now considered to be an ecological and economical heritage. Some very rare species are now protected and propagated as a result of this work, such as the emblematic *Pittosporum tianianum* that has been saved from extinction.

Some characteristic species are planted in the glasshouse, such as *Pittosporum brevispinum*, *P. coccineum*, *Terminalia cherrieri* and the tallest tree species in the dry forest, *Turbina inopinata*, a pink flowering vine with trumpet-like flowers, *Ixora margaritae*, a rare and small monocaulous and cauliflorous shrub with abundant pink flowers, and other botanical treasures such as *Arthroclianthus sp.*, *Jasminum sp.*, *Oxera pulchella*, *O. sulfurea* and the New Caledonian endemic rice, *Oryza neocaledonica* (see Fig. 12).



Fig. 12 Part of the mine maquis area with several species of Cunoniaceae, Myrtaceae, Proteaceae and conifers in the New Caledonian Glasshouse. Photo: Denis Larpin.

The mine maquis

The mine maquis receives 800 to 4,000mm annual rainfall and spreads over 4,500km². This covers 24 per cent of the archipelago, mostly in the south of Grande Terre. It hosts more than 1,200 higher plant taxa with an exceptional

rate of endemism of 90 per cent (Jaffré *et al.*, 2004). In this unique plant assemblage grasses, sparse shrubs and trees recolonise after the repeated passage of fire and the slow destruction of the rainforest. Mine maquis plants grow on ultramafic soils, with high concentrations of minerals normally toxic to plants, such as nickel, chrome, iron and cobalt. It is incredible that plants manage to survive and even grow in this environment. The plants are slow-growing but remarkably adapted to these hostile conditions and are essential to prevent erosion. Nickel accumulation has even been observed in some species like *Geissois pruinosa* (Cunoniaceae). Today, it is common that sites destroyed by mining activities are being restored by planting species that have the ability to detoxify the soils.

The display offers the visitor a concentrated glimpse of the mine maquis with rarely seen endemic species (see Fig. 13). We planted them against a contrasting background



Fig. 13 The dry forest plants in the foreground, the large wall screens and the rainforest area in the background in the New Caledonian Glasshouse. Photo: Denis Larpin.

of powdered laterite of local origin. Laterite is a soil type rich in iron and aluminium which is formed in wet and tropical areas. This area is home to unique conifers such as *Retrophyllum minus* (bois bouchon) with very light wood, *Neocallitropsis pancheri*, *Araucaria muelleri* and *Dacrydium balansae*. Other characteristic mine maquis families are represented: Myrtaceae (such as melaleucas, metrosideros, xanthostemons), Proteaceae (beaupreas, grevilleas and stenocarpus) and Cunoniaceae (codias, cunonias and geissois).

The savanna

The north and west coasts of Grande Terre receive more than 1,000mm annual rainfall. There, the savanna spreads over 6,000km² (31 per cent of the archipelago) and consists of fewer than 100 higher plant taxa, with only 8 per cent endemics (Jaffré *et al.*, 2004). It is a secondary formation which replaces the humid and dry forests after their degradation, mainly after fires. The typical herbaceous plants, trees and shrubs of the savanna grow on all types of soils, except on mine soils, in the plains and hillsides. *Melaleuca quinquenervia*, known as niaoulis or the paper bark tea tree, forms large stands and has striking white bark, and is a characteristic tree of the savanna. However, there are also

exotic species which are locally abundant and invasive; these include *Lantana camara*, *Psidium guajava*, *Leucaena leucocephala* and *Acacia spirorbis* (gâïac). Invasive animals also threaten local biodiversity; these include wild pigs, rats, goats, the electric ant, the little fire ant and the rusa deer. The latter was introduced in 1870 and is now part of a monitoring programme.

The glasshouse display of the savanna will require additional planting in the future. Informative panels, photographs and sensory devices complement the presentation by communicating the numerous benefits of the niaouli for local people. The leaves produce gomenol, an essential oil with numerous medicinal properties. Niaouli honey is also highly prized and the wood is valued as charcoal and used in wall and boat constructions. The characteristic bark, the 'peau de niaouli', is still used in ritual ceremonies.

The mangrove

The New Caledonian mangrove receives more than 1,000mm annual rainfall and covers 200km² (1 per cent of the archipelago). It is composed of very few tree and shrub species which form large populations. This ecosystem is a wealth of biodiversity: birds, fish (more than 250 species) and crustaceans abound. It constitutes a hidden and priceless treasure under the permanent threat of urbanisation, mining pollution and many other risks. Here again, some species are used by the local people: the bark of *Bruguiera gymnorhiza* (bruguiera), for example, rich in tannins, is used to paint the hair of the great bats during the local ceremonies and the wood of many species is invaluable for charcoal production and construction.

As in the nearby savanna, one needs imagination to feel transported into the New Caledonian mangrove in the glasshouse. It has been difficult to reproduce the demanding environmental conditions here for really successful cultivation. Typical mangrove plants have been introduced: *Sonneratia alba*, *Bruguiera gymnorhiza*, *Avicennia marina* and *Rhizophora apiculata* amongst other characteristic species, but most of these have failed. We will start again by introducing younger plants, which should adapt more easily to the soft unsalted and unheated water of the glasshouse.

For the time being, in the pages of a booklet available to visitors, the famous 'Cœur de Voh' appears. This is a heart-shaped fragment of the forest so often photographed for popular publications and postcards and is located on the north-west coast of Grande Terre. Other iconic pictures are proposed, such as the characteristic roots of the mangrove trees emerging from the mud as stalagmites or plunging into the mud.

CONCLUSION

At long last the magnificent historical glasshouses of the Jardin des Plantes in Paris have reopened to the public. In addition to giving the public an experience of several contrasting environments, they demonstrate the study and preservation of biodiversity

by MNHN researchers and make links between research studies, conservation initiatives and *ex situ* collections (Delmas *et al.*, 2011). The New Caledonian Glasshouse is particularly emblematic of this, presenting in a nutshell the exceptional biological richness of this archipelago, emphasising major environmental threats and presenting local conservation projects.

The first stage of this long adventure ended in June 2010 with the official opening to the public (see Fig. 14). Since this date, visitors have been flowing to the Jardin des Plantes in great numbers. For the staff, the work goes on with the necessary adaptations and improvements to the plantings and the museography. The visitor's patience is also required as the plants will need time to grow. In a few years' time, the plants from the different strata will flourish and expand; the tree crowns will emerge and perhaps reach the 15m dome. The plants are settling in and the structured and diverse undergrowth has already started erasing the sharp edges of the paths. This is a cause for optimism for the team of gardeners in charge of this precious heritage.

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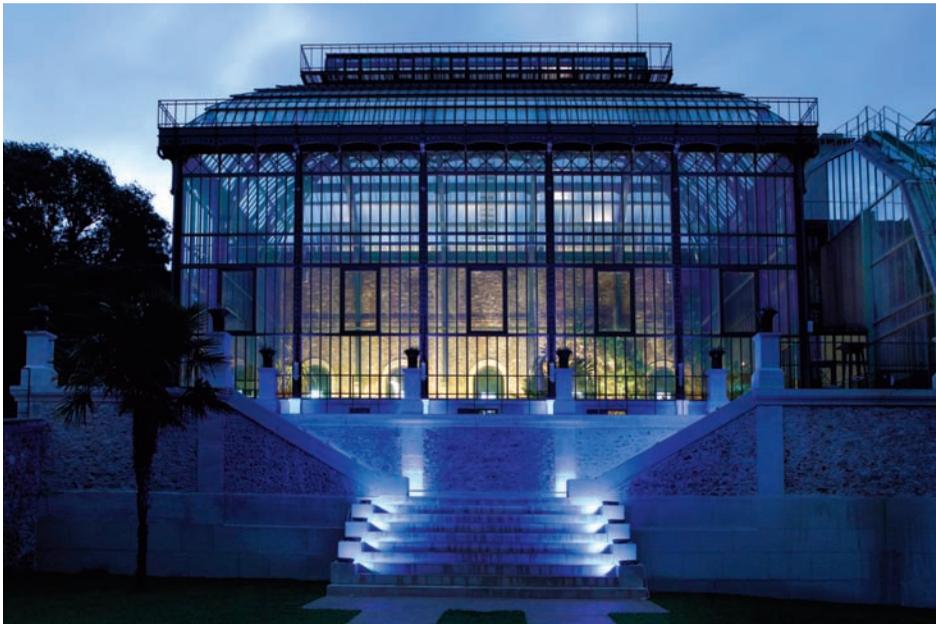


Fig. 14 An evening view of the New Caledonian Glasshouse in June 2010. Photo: Manuel Cohen.

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