S. Haullers

French Polynesia

4.2 French Polynesia (France) OCT

Number of islands:	118 islands
Population:	283 019 inhabitants (2008)
Area:	3 660 km²
Population density:	77,3 inhabitants / km²
GDP/inhabitant:	11 000 €/ inhabitants
Unemployment rate:	13% (1996)
Economic activities:	Agriculture, fishing, pearl farming, tourism

French Polynesia is a French overseas territory in the South Pacific. It consists of 118 islands spread over a maritime area of 2.5 million km² (an area the size of continental Europe). The territory is made up of five archipelagos: the Society Islands, the Marquesas Islands, the Austral Islands, the Tuamotus Islands and the Gambier Islands. It has 34 volcanic islands and 84 atolls. With a population of 283,019 (2008) spread over an area of 3,660 km² of emerged lands, French Polynesia's population density is relatively low (77.3 inhabitants/km²), and very unequal depending on the islands. Tahiti has approximately 160,000 inhabitants, of whom 100,000 are in the capital Papeete.

Fishing and coprah cultivation (dried coconut pulp) are the two principal traditional economic activities of French Polynesia. In 2001, the territory exported 2,400 tonnes of fish and 25,000 tonnes of coprah (PECE 2006). Recently, pearl farming has begun to occupy an important place on the territory's commercial balance sheet, and is now the primary export. Tourism is also an important industry; today, with some 210,000 visitors a year, it accounts for 20 to 25% of the territory's GDP. Despite this apparent diversity of activities, the economy of French Polynesia depends in part on national subsidies (and to a lesser extent, on European subsidies).

4.2.1 Current state of biodiversity

Terrestrial biodiversity

Because of the extreme remoteness of French Polynesia, its biodiversity is at once poor in terms of species numbers, but extremely rich in terms of terrestrial endemism (Meyer and Salvat, 2008). The rate of endemism is 100% for some biological families, such as gastropods, for example. French Polynesia is part of a global biodiversity hotspot which includes Micronesia, Polynesia and Fiji. The high islands of French Polynesia are home to high altitude rainforests, which are rich in endemic species and as yet relatively well preserved. They are home to the iconic Rough Tree Fern, the *Cyathea*, and an extremely diverse terrestrial malacofauna (more than 320 species of gastropods, almost all of which are endemic). These islands are also home to 893 indigenous species of vascular plants (58% of which are endemic) and 31 species of terrestrial birds (of which 22 are endemic). The coral islands for their part are less rich on account of their humus-devoid limestone coral soils and exposure to high levels of sun and air salinity. They have less than a hundred species of indigenous plants. However, the seabird life of these islands is very diverse (27 nesting species). Some atolls of the Tuamotus islands are home to some of the last remaining populations of coconut crab (*Birgus latro*), an excessively consumed, and now threatened, species.

Dan Polhemnus

Endemic plants in Moorea's mountains

Marine biodiversity

With 20% of the planet's atolls, French Polynesia is home to the most diverse coral reef formations in the world. The 12,800 km^2 of reefs in the territory have 176 species of corals, 1,024 species of fish and 1,160 species of molluscs (Salvat et al., 2008). These reefs are among the most well-studied reefs in the world thanks to two research stations on the

IUCN/Jean-Philippe Palasi

Clown fish *(Amphiprion chrysopterus)* in Moorea's lagoon

Island of Moorea, CRIOBE (*Centre de Recherche Insulaire et Observatoire de l'Environnement*) and the Gump Station of the University of California, Berkeley. Three species of marine turtle: the Leatherback turtle, (*Dermochelys coriacea*), the Green turtle (*Chelonia mydas*) and the Hawksbill turtle (*Eretmochelys imbricata*) lay their eggs on the beaches of French Polynesia; however, the threat of poaching remains high. Since 2002, the waters of French Polynesia have been classified as a "sanctuary for marine mammals". They are host to 11 species of dolphin, two species of sperm whale, two species of Blainville's beaked whale (Ziphiidés), and the iconic Humpback whale (*Megaptera novaeangliae*). The territory also numbers several marine nature reserves, such as the seven atolls Aratika, Kauehi, Fakarava, Niau, Raraka, Taiaro, and Toau on the Tuamotus Islands (a UNESCO "Man and Biosphere" Reserve), the Scilly and Bellinghausen atolls, as well as a marine protected area on the Island of Moorea. The total surface of the terrestrial protected areas (natural parks, reserves) only amounts to 2% of the territory; the management of these resrves is hindered by a lack of human and financial capacity (Meyer, 2007).

Current threats

Invasive species, both plant and animal, are a major cause of terrestrial biodiversity loss in French Polynesia. Today, there are almost twice as many introduced species of vascular plants (1,700) as indigenous species (893 species) (Gargominy, 2003). About 600 introduced species are naturalized and 70 are invasive (Meyer, personal communication). If many introduced species are thankfully inoffensive, some are a real scourge. For example, the Miconia or Velvet tree (*Miconia calvescens*), introduced to Tahiti in 1937 as an ornamental species, currently covers 70,000 hectares of Tahiti, or approximately two-thirds of the island (Gargominy, 2003). Similarly, rats, cats, dogs and wild pigs are found throughout the high altitude islands; goats and sheep exercise considerable pressure on the plant cover. Alone, a single species of introduced carnivore snail (*Euglandina rosea*) has completely destroyed 57 species of snail of the Partula genus (see Box 4.3). The Glassy-winged sharpshooter (*Homalodisca vitripennis*), a wood-eating insect introduced in 1998, spread like wildfire with serious economic and social repercussions before being brought under control as part of a biological eradication programme (Petit et al., 2007). The Little fire ant (*Wasmania auropunctata*), a highly toxic species for humans, was introduced recently in Tahiti and is spreading throughout the island.

After invasive species, the second most important threat in French Polynesia is the direct destruction of the natural habitats. The main areas concerned are the coastal areas of Tahiti, but also the coastal areas of the Society Islands. For example, the Temae wetland, in the north-east of Moorea, has been almost completely destroyed to make way for an international golf course and a residential area. And this despite the fact that it was the only lake on the Island of Moorea and one of the last remaining wetlands in the Society Islands. In fact, the site had been listed in the "Directory of Wetlands in Oceania" (Scott, 1993) where it was included because of its ecological importance (rainwater retention, protection of the lagoon, habitat for migratory birds).

French Polynesia's coral reefs, on the other hand, are well preserved, particularly those of the outer slopes of the Tuamotus Islands. The latter are perfectly conserved because they are entirely devoid of human impacts. Only the reefs in certain areas of the Society Islands have suffered massive degradation as a result of land reclamation around the fringe reefs, dragnet fishing to extract "coral soup", hyper-sedimentation of land-based materials caused by erosion of the hillsides, and pollution from domestic and agricultural waste-water.

4.2.2 New threats resulting from climate change

Impacts on marine biodiversity

Given its geomorphology, French Polynesia is one of the territories most at risk from rising sea levels. A large number of islands are at very low altitude and therefore particularly vulnerable to rising waters (see Box 4.1). French Polynesia has experienced seven coral bleaching episodes in the last 20 years. Although none have resulted in the extreme levels of morality observed in the Indian Ocean in 1998 or the Caribbean in 2005, significant losses of coral were nonetheless observed. In 1991, a bleaching episode resulted in 20% mortality among the coral colonies on the outer slopes of Moorea (Salvat, 1992). In 1994, a similar bleaching episode affected the region, but most of the colonies were able to regenerate without suffering excessive losses. Finally, in 1999 a last episode of bleaching affected Polynesia; mortality rates varied from one island to another (Salvat et al., 2008). Successive bleaching episodes lead to a decline in the number of lagoon fish and thus of the entire tropical marine food chain. Erosion of the beaches could also affect the turtle populations that depend upon these habitats to reproduce.

Impacts on terrestrial biodiversity

The well preserved, endemic species-rich subalpine ecosystems are without doubt the terrestrial habitats most at risk from variations in temperature and rainfall patterns (see Box 4.2). Climate change could cause plant species to migrate towards higher altitudes and result in a general

Box 4.1: Submerged Atolls?

Atolls are among the most complex and fascinating geological structures of the planet. These ring-shaped tropical islands, which sometimes exceed 10 kilometres in diameter, enclose a lagoon in their centre and are home to an exceptional diversity of marine life. It takes 30 million years for an atoll to form. First, a volcanic island emerges from the ocean. Little by little it is colonized by reefs of fringe coral. Once the volcano is extinct it becomes more dense, gradually sinks into the ocean and eventually disappears beneath the surface of the water. Only the ring of coral remains since it regenerates as the volcano subsides. An atoll therefore is the imprint of an island, or a fossil island, made up of a ring of reef and coral islets, built on a thick layer of dead coral. The flaky soils of these islands are not engulfed by the waves as the living corals shield them from erosion.

Atolls are the islands most at risk from the effects of climate change. The degradation of the corals as a result of bleaching and acidification could destroy the physical barrier which shelters these islands from heavy ocean swell. Atolls are made of coral; if the latter disappear, these islands too will be condemned to vanish. Furthermore, rising sea levels are likely to accelerate the deterioration of these islands. Atolls never rise more than 2 or 3 metres above sea level. They are therefore particularly vulnerable to both temporary and permanent changes in sea level. If the rise is gradual, healthy corals could continue to grow and possibly follow the water level, but degraded corals would be incapable of doing so.

With 84 atolls, Polynesia is home to 20% of the world's atolls. The human populations who inhabit these islands are at risk from climate change. They could be forced leave their atolls and seek refuge on higher islands or continents. In the neighbouring islands of Tuvalu, there is already talk of "climate refugees". Since 1993 these islands have experienced a rise in sea levels of approximately 2 millimetres a year, caused by the El Niño weather system (Church, 2006; IPCC 2007). They have lost 3 metres of beach front, their crops are inundated for five months of the year, and salt water has seeped into the water tables. The impact of tropical storms on the coast is becoming more and more violent, and whole populations have already had to be temporarily evacuated from their islands during very high tides.


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Fakarava atoll in Tuamotus

degradation of the ecosystemic equilibrium. These changes will take place to the detriment of the fragile indigenous species and will likely lead to the expansion of invasive species into hitherto uninfested areas. The Euglandina carnivore snail, for example, cannot develop above a certain altitude (about 1,400 metres). This threshold is likely to rise with increasing temperatures. The upward migration of invasive species towards higher altitudes will have a major impact on the indigenous fauna and flora; especially on the remarkable French Polynesian malacofauna which is mostly limited to the last remaining zones of preserved mountain forests (see Box 4.3).

Box 4.2: Subalpine Forests of French Polynesia: Precious and Threatened Ecosystems

Tahiti is the only island in the South Pacific to possess tropical subalpine forests. These habitats are limited to three summits above 2,000 metres and do not exceed a total area of 125 hectares. Subalpine zones are characterized by extreme climatic conditions, with low average temperatures (<14°C), a wide range of temperature variations, and inferior rates of rainfall than lower altitude mountain zones. The characteristic vegetation of these ecosystems, known as orophile or mountain vegetation is very rigid with small, tough leaves. Almost entirely devoid of direct human-induced degradation, subalpine forests are of tremendous biological importance. Inaccessibility and climate have limited the destruction of these habitats and the spread of the many of the invasive species found at sea level. These habitats therefore have a remarkable flora and fauna, which are rich in endemic species. However, these subalpine regions are also vulnerable to a rise in temperatures. A recent study has shown that an average rise in global temperatures of 3°C between now and the end of the century would destroy 80% of alpine havens, and lead to the disappearance of one-third to one-half of all alpine plants in the world (Halloy and Mark, 2003).

Marie Fourdigniez

Subalpine forest in Pito Hiti, Tahiti

A project for the long-term monitoring of the composition and functioning of Tahiti's subalpine vegetation is currently being carried out by the Research Delegation of the Territory. An inventory of subalpine flora, to be undertaken every 5 to 10 years, will allow accurate appraisal of the impacts of climate change on these forests. It will also enable potential changes in the ecosystem to be accurately observed. Potential modifications include changes in the spatial distribution of mountain flora, changes in seasonal behaviour, and new invasions by alien species, or even the complete extinction of indigenous species (Meyer and Taputuarai, 2006).

Box 4.3: Endemic Snails and Climatic Variations

Terrestrial gastropods are one of the jewels of Polynesian fauna. More than 320 species were inventoried and 100% of native species are endemic (Gargominy, 2003). These species are of major interest for the general study of natural evolution and speciation (evolutionary process through which new species develop). However, most of these species are under severe threat (IUCN Red List), especially from a predatory snail introduced from Florida (*Euglandina rosea*). The latter was originally introduced to combat *Achatina fulica*, another species of invasive snail which was wreaking devastation among local crops. The Euglandina has already caused the extinction of 57 endemic species of the *Partula family*, including all the species from the Island of Moorea (Pointier and Blanc, 1985).

The remaining species of French Polynesian snails are now mostly confined to high altitude areas where neither *Euglandina*, whose altitudinal threshold is believed to be between 1,300 and 1,500 metres (Gerlach, 1994), nor the invasive Miconia plant, which does not grow above 1,400 metres, have been able to evolve. As a result, the spatial distribution of indigenous French Polynesian gastropods is extremely limited. For instance, the main populations of some snail species are confined to an area of less than 2 km² (Gargominy, personal communication). An increase in temperatures brought about by climate change could critically endanger the last remnants of endemic species. Rising isotherms would both decrease the gastropods' area of occupancy and lead to the upward migration of the predatory snail towards higher altitudes (Gargominy, 2008).

Olivier Gargominy

Predator snail (*Euglandina rosea*) feeding on an endemic snail species

Box 4.4: Pearl Farming: A Delicate Process

In French Polynesia more than 7,000 people depend directly upon the production and sale of Pacific black pearls for their livelihoods. This market accounts for 80% of the territory's exports. This delicate pearl, produced mainly in the atolls of the Tuamotus Islands, requires very specific temperature and water-quality conditions. By increasing the temperature and the acidity of the ocean, climate change could have serious consequences for pearl production in Polynesia. The actual impact of climate change on pearl farming in the region is still largely unknown; however several studies have confirmed the existence of potential impacts. In 2000, the Cook Islands in New Zealand experienced exceptionally dry conditions, with an absence of wind and important increases in temperature. These conditions reduced the level of oxygen in the lagoons and led to an increase in diseases affecting oysters; the result was massive mortality among the pearl-producing oysters. The resulting economic losses for the region have been estimated at Euros 22 millions in loss revenue. The oysters could also be vulnerable to increasing acidification of the oceans, caused by a rise in the concentration of CO_2 in the water. It has been demonstrated that calcification of the Pacific Oyster (*Crassostera gigas*) diminishes in direct proportion to the increase in the acidity of the sea water (Gazeau et al., 2007).

Mila Zinkova

Black Pearl and its shell

tjpsi

Pearl farm in Fakarava, Tuamotus

Box 4.5: Ciguatera: Coral Degradation-Related Food Poisoning

Ciguatera is a common form of food poisoning in tropical regions. It is caused by the ingestion of lagoon fish infected by dinoflagellates – photosynthetic micro-algae that form on coral debris. These dinoflagellates produce powerful neurotoxins, which accumulate in herbivorous marine animals and are subsequently transmitted up the food chain by carnivorous fish (Bagnis, 1992). Dinofalgellates occur naturally on coral reefs but become a problem when their density hits critical levels. Ciguatera is caused by the ingestion of a large quantity of these neurotoxins. It is often referred to in the Pacific as the "itching illness" because it causes serious bouts of itching. Throughout French Polynesia there are on average 800 to 1,000 cases of the disease per year (ONERC 2006). A high rate of mortality among the corals caused by bleaching could lead to a spread of ciguatera (Kohler, 1992). The surface of dead corals is an ideal breeding ground for algae and thus for the proliferation of related epiphytes like dinoflagellates (Quod, personal communication). Greater studies are however needed in French Polynesia and elsewhere to establish with certainty the link between coral bleaching and an increase in ciguatera.

Grant Hutchinson

Bleached corals are ideal substrates for ciguatera development.

Socio-economic implications

A large majority of the population of French Polynesia lives in the narrow coastal strips. A rise in sea levels could therefore have disastrous consequences on these urban settlements and hence on the economy of the territory. A simulation of rising sea levels carried out on the site of Tahiti international airport illustrated their potential impacts. Tahiti airport, like many in French Polynesia, has been built on a coral reef. A rise of 88 centimetres in the sea's level (the top end of IPCC projections) would result in the complete submersion of the airport and of part of the surrounding town of Faaa where it is situated. The economic impacts would be very serious for the territory; degradation of the beaches and coral reefs would impact upon the tourist industry which is largely dependent on these natural resources. Pearl farming, a very delicate process with a high value added, would also be disrupted by a change in the environment (see Box 4.4). Finally, climate change presents a risk to public health in Polynesia, through, for instance, a rise in the number of vector-borne infectious diseases such a dengue fever (see Box 2.5), or the proliferation of the micro-algae responsible for ciguatera, food poisoning caused by ingesting infected fish (see Box 4.5).

Responses to climate change

Box 4.6: Moorea Island: A Model Ecosystem for Global Change Science

The island of Moorea, embedded in the natural laboratory of French Polynesia, is emerging as a model ecosystem to understand ecological processes in the context of local and global change. The "Moorea Ecostation" unites the Centre de Recherches Insulaires et Observatoire de l'Environnement (CRIOBE; EPHE-CNRS) and the Richard B. Gump South Pacific Research Station (UC Berkeley) in collaboration with French Polynesia. Inspired by the model organism approach of molecular biology, an international consortium recently launched the ambitious "Moorea Biocode Project" (MBP) to genetically "barcode" every non-microbial species on Moorea. Aimed at stimulating a revolution in ecology for the benefit of conservation, the MBP will sample from the coral reef to the mountaintops to produce a verifiable (vouchered) "All Taxa Biotic Inventory" (ATBI) of the entire ecosystem by 2010. It will also help build the informatics services needed for ATBI and biocode-enabled research in other model ecosystems. During a pilot project in 2006, the team already identified and sequenced most of Moorea's fish (457 species inventoried to date) and made a start on the rich marine invertebrate fauna (>1,000 sampled so far) as well as terrestrial insects, lizards, and ferns (Davies, 2008).

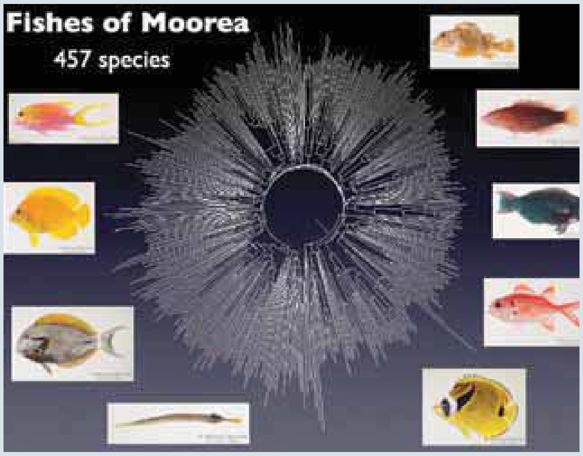
Jérôme Petit

Insect collected in Moorea

The goal of Biocode, in Moorea and eventually in other model ecosystems, is to provide new tools for understanding fundamental ecological processes using a whole-system approach. The resulting genetic observatories will enable scientists to better quantify the impacts of global change. Model ecosystems should also bridge research and management, stimulating innovative new practical solutions for conservation and providing powerful learning laboratories for sustainable development.

Jérôme Petit

Entomologist team of the Biocode project



Chris Meyer

Pylogenetic tree of the fish species collected in Moorea