

Annual report

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Philippe Lazar, Chairman of the Board of Trustees and Jean-Pierre Muller, Director General of the IRD

Geopolitical by nature

The IRD's international policy is not just an important aspect of its activity as it is in other French research institutes; it is its very *raison d'être*.

France has two research institutions specialising in development¹, a "selective advantage" over our competitors in other developed countries that is worth cultivating. The reason lies no doubt in the particular history of France's overseas expansion and its sublimation in the decolonisation policy begun at the end of the Fourth Republic (1944-58) and completed under the Fifth.

The IRD's presence in the French overseas dependencies is thus a key component of its overall policy. It gives us real legitimacy and an exceptional capacity to address problems that arise in other countries in the same regions. Examples are French Guiana in Amazonia (a very strong link with Brazil and the other countries of the Southern Cone); the French Antilles in the heart of the Caribbean and Central America; New Caledonia and French Polynesia, in the strategically important southern Pacific; and Réunion Island in the Indian Ocean, close to sub-Saharan Africa and Madagascar.

Scientific legitimacy

To conduct research for development we have to carefully examine what our partners, whether French overseas dependen-

cies or foreign countries and institutions, expect of us scientifically and technically.

This was the concern at the heart of the reform at the IRD. The direct consequence is the creation of five scientific departments. The IRD now has three research departments: Earth and Environment, Living Resources, and Societies and Health. It also has two important new "transfer" departments: Support and Training for Scientific Communities in the South, and Expertise and Consulting.

Making the last two into official departments is a crucial feature of the reform. If we are going to ask our partners to have the same quality requirements in research as we do (which implies a consistent but restrictive choice of options), we must be able to help them find credible answers to the urgent development questions they face. In the long term, this means contributing more to training their scientific elites, while helping them resist the temptations of the brain-drain to the North, the price often paid when developed countries help train Southern staff. In the short term, we must make available the expertise the world scientific community possesses for taking all kinds of operational decisions that cannot wait for the slow, unpredictable findings of genuine research.

Our policy in 1999 had three closely linked objectives:

- to develop world-standard research in

The French institute for scientific research for development co-operation (long known as Orstom) was radically restructured by the Decree of 5 November 1998, which clearly defined it as an institute "of research for development" (IRD). During 1999 reforms were introduced to enable the IRD to fulfil all its redefined missions.

partnership with Southern teams and French research and higher education establishments; in 1999, this included a public call for proposals for new research units (URs) and service units (USs), for which no fewer than 117 valid applications were received (96 URs and 21 USs);

- to fully harness our capacities for training and supporting scientific communities in the South, particularly teams of young researchers;

- to fast-track the development of procedures for collegial expertise, consultancy and the economic, social and cultural use of the IRD's research.

Each of these three broad sectors is specifically covered in the report.

Closer partnerships with French research and higher education

The November 1998 reform of our statutes radically altered the IRD's formal organisation and operations, and opened it up to universities and other public establishments of higher education and research. The IRD can now more effectively fulfil the specific missions it has been given. In 1999, our partners had a chance to participate directly in the scientific life of the IRD, since our electoral colleges were for the first time open to all *bona fide* researchers, thus doubling the number voting in our scientific evaluation commissions. We also signed a large number of co-operation conventions with universities, which should result in the

establishment of mixed or part-mixed research units⁽¹⁾.

In 1997, the mission statement I received as the new Chairman of the Board of Trustees expressly requested that a significant number of newly vacant posts should go to staff from other universities or research bodies who wished to work for several years in countries of the South or French overseas dependencies. This policy continued in 1999, but in fact has aroused little interest among its intended audience. Only twenty or so outside applications were received for the fifteen research posts open. In early 2000, we were at last allowed, after years of repeated requests, to finance not only multi-year placements but also missions of 2-10 months, and this may well change matters. Our colleagues from universities and other research bodies who want to work at the IRD will not be obliged to leave their usual posts for periods of time they may find excessive.

Internal adaptation

Management of tenured staff at the IRD is being considerably improved. Reference standards are being defined for the scientific, technical and administrative aspects of research work, so that it can adapt to the world demand for scientists. In 2000, the evaluation commissions' analyses of future needs will be taken more into consideration, and this should make adaptation easier by providing a scientific basis for the redeployment the Government requires of us.

The IRD reform also opens up a second form of career advancement for researchers, under regulations applicable to all French research establishments, whereby activities other than actual research can be recognised. Two "research and applications management" commissions were set up in 1999, alongside four new "sectoral scientific commissions";

their total membership is now over one hundred – one researcher in eight. This is a significant step towards raising the status of tasks that are essential for the IRD, particularly Collegial Expertise and training and support for scientific communities in the South, both of which need to be managed and not merely promoted.

Last year, the IRD greatly simplified its administrative procedures. Improvements under study or already implemented include redefining the IRD's central services, decentralising management responsibility, redefining the role of the IRD's territorial "centres", increasing the coherence of the internal information system, and pooling certain functions with other public research and education establishments.

Lastly, special emphasis was laid on the IRD's "social" action (in-service training, working conditions, hygiene and safety).

Better information and communication

As a research institution, the IRD consults and contributes to databases, geographic and cartographic information systems, and electronic communication networks. We use and help develop modelling and simulation procedures. We are deeply involved in modern forms of acquiring, processing and transferring information, analysing and synthesising.

New developments on the communication front include

- a bimonthly newsletter, "Sciences au Sud", whose first issue came out in mid-1999. It has already earned a name as an effective source of information on all IRD activities, open to contributions and debate from partners in North and South;
- closer relations with our parent ministries and other ministries not formally connected

to us but which are directly concerned by our actions (such as the Ministry of Overseas Dependencies);

- more sustained contact with all the media;
- better publicised relations with society at large, particularly our first "Young people and development" clubs and active participation in debate on "hot" issues on which we are recognised specialists.

Ethics and professional conduct are crucial, and the Board of Trustees has scheduled thorough discussion of these questions in 2000. This is essential for any research body, but even more so for an institution such as ours that is directly confronted with the major international inequalities that affect humankind. ■

Philippe LAZAR

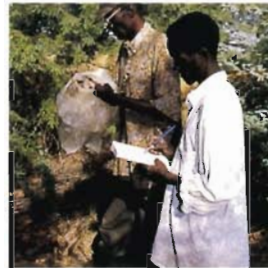
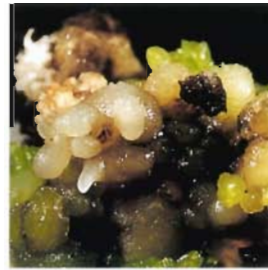
Chairman of the Board of Trustees

(1) The other is the Centre for international co-operation in agronomic research for development (Cirad)

(2) This is a feature specifically connected with the way IRD facilities are spread around the world

The IRD's three missions

Chapter 1



RESEARCH

EARTH

AND

ENVIRONMENT



Water is a scarce resource in the Sahel (Kaolack region, Senegal)

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The Earth and Environment department covers the Earth and environment sciences, doing research "upstream" of the IRD research that is more specifically designed to assist development in the countries of the South.

The Earth's solid crust, hydrosphere and atmosphere are the natural mediums in which man and all living things live and breathe. Some of the regions where the relationship between humans, their environment and the Earth is most delicately balanced are precisely those where development is not greatly advanced and is still largely dependent on natural resources. Development, though desirable and necessary, is likely to cause irreversible damage to environments that are fragile by nature.

The IRD's research teams in this sphere are organised around major issues: the climate, its variability and impact; water and its availability; the Earth's crust, its resources and natural hazards; and the biosphere and its relations with these environmental parameters.

The climate, its instability, variability and impact at different temporal and spatial scales

This issue is now a clear research priority. The effects of climatic variations on developed

and developing societies is a decisive factor for many branches of the economy and conditions the very future of society. Farming, energy, housing, water resources, and even tourism and health can be affected. A conceptual consensus has emerged over the past decade, based on a new awareness that the problems raised in studying the interactions between atmosphere, hydrosphere and biosphere are planet-wide and multidisciplinary. The tropical regions are a priority for research, because they occupy a third of the globe, play a key role in climate dynamics because of their closeness to the equator, and are particularly sensitive to the effects of variations in the climate.

The IRD's aim in this field is to observe and understand current and past climate changes in the tropics, take part in the study of their basic mechanisms (involving mainly the interactions between the tropical ocean and atmosphere, which determine these variations and make it possible to predict them), and evaluate their environmental impact, especially as regards water resources and forest vegetation at local and regional levels. The IRD conducts its research jointly with partners from North and South, under national programmes that are themselves part of major international operations. IRD teams work with the other French and

foreign institutes in the field in tropical regions, and help to ensure that Southern researchers are fully involved in the work.

Water resources: dynamics and use

Rational water management and maintaining adequate water quality are among the main preconditions for sustainable development in low-income countries and key issues for the twenty-first century. With the continuing increase in agricultural production, which is still the essential foundation of economic and social development in low-income countries, it has become an obvious necessity to optimise the way natural systems - water, soil, vegetation - are used, without endangering their sustainability. To work out solutions, the variability of water resources in time and space must be characterised and predicted. So research is conducted into the physical and chemical behaviour of components of drainage basins, from the local scale to the regional. Water is considered from three angles: as a weathering agent (interactions with the exosphere, soils in particular); as a medium transporting matter (mineral balances, etc.) and as a renewable resource (quantity, quality, etc.) Of the teams working in this sphere, some study water, some mainly soil and rock, and others the interactions between the two.

The geodynamic approach to mineral resources and natural hazards

In many developing countries, exploration of the bedrock has scarcely begun. Prospecting for mineral resources requires models developed from studying internal and surface geodynamics.

Natural hazards are a constant threat for people in many developing countries; only prediction and education can lessen the danger. Programmes on this issue seek to reconstitute the geodynamic history of the regions concerned and define the causes and the types of process that trigger such destructive events as earthquakes, eruptions, landslides and floods.

These are the reasons for the IRD's pure research in geology and geophysics, the following in particular:

- reconstituting the geodynamic processes and history of target regions, to discover how they control the distribution and nature of mineral deposits and hazard zones;
- designing regional predictive models for exploiting metal ores and fossil fuels;
- defining the types and causes of triggering process and forecasting destructive events.

EXAMPLES

■ PIRATA: monitoring the climate of the tropical Atlantic

A science and technology project

PIRATA (Pilot Research Moored Array in the Tropical Atlantic) is an observation network for monitoring changes in ocean conditions in the tropical Atlantic. The purpose is to complement the TAO (Tropical Atmosphere-Ocean Array) already established in the Pacific. TAO and PIRATA are part of the same global system of real-time meteoro-oceanic observations, which transmits its data daily by satellite, using the Argos

system. The data are thus immediately available on the Internet and the Global Telecommunications System (GTS).

TAO Pacific has proved its worth, making a major contribution to improvements in forecasting of the El Niño event. PIRATA should improve understanding of the role of the tropical Atlantic in the world's climate, especially its regional effects. We know that the temperature variations of the Atlantic ocean are linked to drought or excessive rainfall in the northeastern Brazil and Sahelian Africa, but a whole set of processes remains to be elucidated if seasonal forecasting is to improve. So in the three-year pilot phase, most of the data will be used in research that will provide the basis for deciding whether to continue with the network.

TAO and PIRATA observations are currently being used in European and American national weather models; later on, they will help to establish the initial high quality atmospheric and oceanic information for use in coupled ocean-atmosphere models for worldwide seasonal climate forecasting.

Each of these networks consists of an array of ATLAS instrumented buoys moored to the ocean floor (twelve moorings in the original PIRATA array); a scientific committee decides where they are to be sited in the Atlantic. The moorings are in fact autonomous oceanographic and weather stations that provide real-time data to fill the information gap on tropical ocean regions, which are among the main driving forces in the world's weather system. Sensors on the moorings measure the main variables in energy transfer at the air-sea interface: wind, air temperature and humidity, solar radiation and precipitation.

Temperature and salinity profiles of the deeper ocean layers, very important in longer-term climate fluctuations, are also measured and transmitted in real time. Each mooring has twelve-months of autonomous energy supply, so electronic and mechanical maintenance requires a total investment of about ninety boat-days a year for the whole array.

An international programme: IRD plays a key part

PIRATA is a multinational programme. On the French side it is one of the key components of the ECLAT programme (Etudes du climat sur l'Atlantique tropical), the French contribution to the international CLIVAR programme (Climate Variability and Predictability) in which IRD is one of the main participants. Internationally, PIRATA is recognised, supported and approved by all the major international climate research programmes. IRD's partners in the programme are the Brazilian Instituto de Pesquisas Espaciais (INPE) and Directoria de Hydrografia e Navegação (DHN), Météo-France and CNRS/Insu in France, and the US National Oceanic and Atmospheric Administration (NOAA).

The three countries share the financial cost and the technical, logistic and human input for installing and maintaining the array. Of the twenty ATLAS systems needed for the project's initial phase (1997-2001), the United States has paid for ten, Brazil and France for five each. The IRD paid for three of these. Brazil and France are solely responsible for the ship time and logistics for deployment and servicing of the array. Brazil services after the western half of the array and France the eastern part (Gulf of Guinea). PIRATA-France operations are based in Abidjan, Côte d'Ivoire, using the IRD's oceanography vessel *Antéa*.

PIRATA activities 1997-1999

The programme began in September 1997; during the initial phase of installing the array, ten oceanographic surveys lasting eight to twenty days each were performed, five of them by France. By the end of the PIRATA-France survey of January 2000, the entire programmed network of twelve Atlas moorings should be in place. Nineteen buoys have already been moored, ten of them by France in the Gulf of Guinea. The oldest site (Gavotee, 10°S-10°W) (see figure 1) has now been serviced twice, and a time series of more than two years' data is available from this mooring.

Data return has been satisfactory, although two moorings in the equatorial part of the Gulf of Guinea have been lost. Information and an interactive display of weather and ocean data is available on IRD's PIRATA website. Besides seasonal variability, one can already display such climatic phenomena as the formation of a

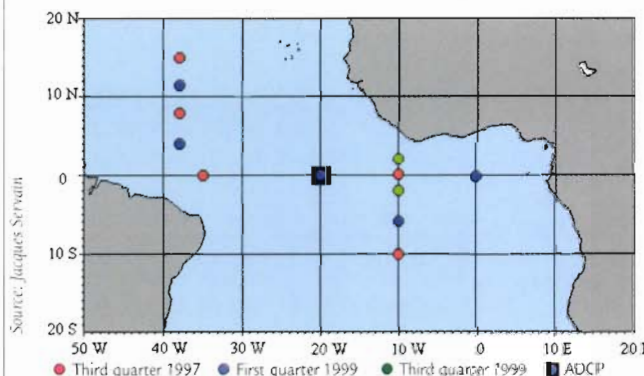


Fig. 1 - Positions of PIRATA buoys in the Pacific

salinity barrier layer in the west of the basin in Spring 1998, and differences in sea surface temperatures between 1998 and '99 (see figure 2).

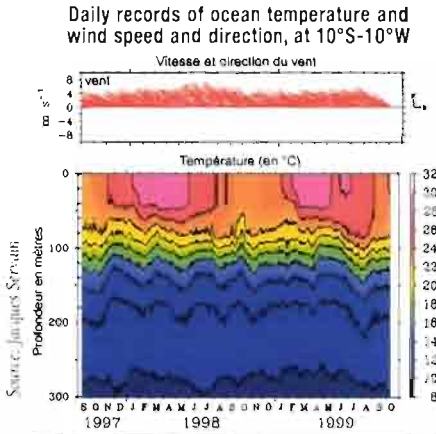


Fig. 2

Towards a permanent PIRATA network

At the PIRATA group meeting in Miami in May 1999, it was proposed that the current coordination arrangements between Brazil, France and the USA continue after 2001, up to 2006. This extra five-year "consolidation period" should make it possible to make the original array permanent; it is hoped that it will then be taken over by the operational oceanography programmes that are gradually being set up in the countries concerned. The meeting also considered gradually developing three geographical extensions to the array from 2001, on an experimental basis. Two of these extensions would be on the African fringe of the Atlantic basin, one off the coasts of Morocco, Mauritania, Senegal and Guinea, the other off the coasts of Gabon, Angola, Namibia and South Africa.

PIRATA on the Web:
<http://www.brest.ird.fr/pirata.fr.html>

Green ocean: simulating ocean productivity

Photosynthesis is the basis of primary marine production, and also one of the processes that determine how much carbon dioxide the ocean can absorb. It governs ocean fertility and controls the supply of fishery resources. So it is hardly surprising that marine photosynthesis has long been the subject of intensive research, and that coupled ocean-circulation/photosynthesis models are currently being developed in most oceanographic laboratories.

To achieve photosynthesis, phytoplankton employs a group of molecules that can har-

ness the energy of photons, once these have been harvested by pigmentary antennae (the best known of these pigments being chlorophyll *a*). The excitation this generates reaches the photosynthesis reaction centre, a group of molecules arranged in such a way that an electron is then detached from its original position. This highly reactive electron reduces a molecule of CO₂. The yield of the system varies according to species and environmental conditions.

The models are based on quite a simple principle:

- Through a series of biological reactions, the carbon so reduced is distributed between primary production (phytoplankton), zooplankton, small pelagic creatures and organic debris; one of the essential goals of the ship-borne surveys is to determine how and how fast this happens.
- Carbon in these different forms (and the associated nitrogen or phosphorus) are transported by the currents described in the ocean circulation model.

Coupled models of this kind are designed to simulate (a) what happens to the carbon dioxide in the ocean-atmosphere system, with its inputs and losses (carbon "sources and sinks") and (b) the dynamics of the organic carbon reservoirs, some of which are food for species exploited by humans while others are exploited directly.

IRD research into primary marine production first focused on tropical systems, which are characterised by a surface layer where there is light but none of the nutrient salts essential for photosynthesis, and an underlying dark, cold, dense layer with abundant nutrient salts. The two layers are separated by a density barrier called the pycnocline. In these systems, the intensity of primary production depends either on nutrient salts diffusing upwards through the pycnocline, or on the pycnocline itself rising towards the surface. The extreme case is found in tropical upwellings, where the pycnocline reaches the surface. Upwellings occur on the eastern fringes of the oceans (off Mauritania, Namibia, Peru and California) and along the equator. At the end of a long biological process, the nutrient-rich water in the well-lit ocean surface becomes densely populated by fish.

During this exploratory phase, IRD's oceanographers made a major contribution to understanding these mechanisms. The research was based on the concept that in these tropical systems with their fairly high sea temperatures, biological reactions are rapid and biomass, characterised by the concentration of chlorophyll, stabilises at a level that matches the rate of supply of nitrate, which is an essential nutrient. Under these conditions, at constant biomass, input of nitrate to the ecosystem necessarily results in a loss of organic matter that compensates for new production. Knowledge about the new production is therefore important, since it is this new production that determines the carbon sink and the transfer of nutrients to higher levels in the food chain. The first joint research between biologists and ocean circulation experts was aimed at modelling the new production in terms of nitrate consumption by the plankton.

More recent IRD research has concentrated on the equatorial Pacific, the region that has the best advantages: it is under continual observation by moorings and merchant ships; the ocean circulation models give particularly realistic results there, it is subject to the El Niño alternation, the understanding of which has made much progress; and modelling of carbon and nitrate fluxes in this region confirms the process studies conducted a few years earlier under the international Joint Global Ocean Flux Study. Observations and models have shown that this region, though well supplied in nitrates, uses them slowly and is therefore unusually unproductive; like the Antarctic and North Pacific, it is nitrate-rich but chlorophyll-poor. One spin-off from this work concerns tuna distribution: the models developed were used to simulate the distribution of the tuna's food, and changes in that distribution over time in relation to El Niño events.

These early successes apart, it has to be admitted that the biological side of the models is an outrageously simplified representation compared to the ocean's real biological diversity. Over the past decade, it has become evident that the biochemistry of the ocean is not just a matter of carbon, nitrate and chlorophyll. Scientists have observed that lack of iron in the ocean is often a

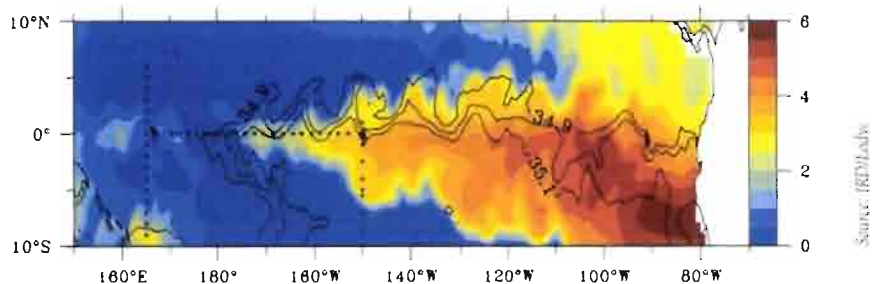


Fig 3 - Simulated new production of organic carbon in October 1994

limiting factor for primary production, that some of the nitrogen needed for primary production can come from the atmosphere, and that the most productive species also need silica. To incorporate this complexity in a model, one must take account of different phytoplankton groups, each with specific behaviours. Continual dialogue between modellers and experimental biologists is also essential: with molecular biology, detailed pigment analysis, bio-optics, etc., the biologists now have the tools required for rapid progress.

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■ Moving forests: tropical forest ecosystems since the ice age

Although they seemed to have remained stable since the last ice age, in fact the dense intertropical forests and their bordering savannas have undergone major changes in distribution, structure and composition over the past ten thousand years, mostly as a result of climate variations.

The IRD, CNRS, Cirad and CEA joined forces for the Ecofit programme (Écosystèmes et paléo-écosystèmes des forêts intertropicales), to study a number of continental forest sites, using a variety of methods, to reconstitute forest dynamics since the start of the Holocene. The programme included study sites in the Amazon (Brazil and French Guiana) and Africa (Congo, Cameroon, Gabon). The results show that these regions suffered climatic disturbances long before the much-publicized impact of modern human activity. They have also provided a deeper understanding of how these changes have shaped today's distribution of plant species and biodiversity in the regions concerned.

As the climate changed, dry episodes occurred at different times in the Amazon and central Africa. When the forest reached its greatest expansion in Africa, around 6000 years BP, the Amazon forest was shrinking. Between 3000 and 4000 BP, the reverse happened: Africa's dense forests shrank while the Amazon forest was growing. This is due to the North Equatorial trade winds; during the ice ages that preceded the Holocene, vegetation changes were synchronous throughout the world.

How intensely and how fast vegetation responds to climate change varies according to the vulnerability of the ecosystem and the type of climate processes involved. In Central Africa, the vegetation took several centuries or millennia to react; this may partly be because the rainfall regime was also changing slowly. In the Amazonian Guiana, different mechanisms seem to have been at

work: the vegetation responded quickly to a rapid succession of short, acute crises which destabilised the vegetation formations. In Africa, such crises can come in addition to the slower changes, causing sudden fluctuations that dry out wetlands and cause gaps to appear in the forest cover, especially in the very humid areas of Cameroon.

Intertropical rainforest ecosystems today still show the imprint of past climate change. The anomalous presence of islands of savanna within Central Africa's forest area is due to a shift to a drier climate that began around 5500 years BP. This caused a gap to appear in the forest cover in Congo, and made the Cameroon forest more vulnerable around 2000-2500 BP. When the climate became wetter again, the forest was able to advance again from its refuge areas into the bordering savanna; measurements in both Congo and Cameroon suggest that it took between 500 and 1000 years for the forest to regain the lost ground. The floral composition of the forests also bear witness to past crises. In French Guiana, where the forest still bears the marks of the last dry episodes 600 years ago, species whose seed is quickly dispersed by wind or animals are abundant, whereas species with heavy seeds or seeds that animals do not eat are found only in small areas, having regained only a small part of their lost territory. One such species, the palm tree *Astrocaryum sciophilum*, has advanced only a few hundred metres from the valleys where it had survived.

However, the postulated existence of large, isolated forest refugia hundreds of kilometres apart during the cold, dry episodes of the Pleistocene does not satisfactorily account for the present-day floral composition of the forests; nor does it match the

reconquest potential established by measuring the present-day rate of advance of forest-savanna or inter-forest ecotones. The reconquest phenomena observed can only be explained by the existence of micro-refugia. Physicists at the CEA tested this hypothesis with models, and their results fit very well with field observations.

The Ecofit programme was also the opportunity for further research into the relationship between humans and forest. The natural advance of the forest into savanna land obviously increases the area of land under forest cover: but does this compensate for increasing deforestation? The answer seems to depend on population density, distance from towns, and type of forest use. Research has shown that in Central Africa, the establishment of savanna areas within the forest between 2500 and 2000 years BP coincided with the expansion of iron-working in this region, which spread throughout the area between 2450 and 2100 BP. It seems likely that the break-up of the large tracts of forest helped the new technology spread, as the breaks in the forest cover always appear before iron-working arrives. It seems unlikely that the iron-smiths themselves cleared much forest, given how few they were. The results of simulations in the Congo show that 10% of the annual biomass production of the Bateke plateau forests would have been enough to supply the furnaces.

These examples illustrate the wide range of questions about forests and their evolution that IRD researchers have been examining. The relations between humans and their environment in equatorial regions prove to be more complex than they seem at first sight; the first results of the Ecofit programme allow us to look at the issue from a different angle from the over-simplified but widely publicized view of mankind as predator on the forest.

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Chromolaena odorata invades food crops in the forest (Kandara, Cameroon)

Water resources and climate change

The dynamics and use of water resources are among the key issues facing us in the 21st century. Water availability will depend more and more on climate variations partly caused by human activity. Given the climate oscillations and global warming that are beginning to make their mark and will amplify in the course of this century, in-depth study of the relations between water resources and climate change is now a necessity.

This is a crucial issue for tropical regions, and three IRD programmes are looking into it. The first - Iccare (Identification et conséquence d'une variabilité climatique en Afrique de l'Ouest non sahélienne) - concluded with an international conference in Abidjan in late 1998. The second - HiBAm (Hidrologia e Geoquímica da Bacia Amazônica) - was the subject of a major international conference in Manaus, Brazil, in late 1999. And the third - Catch (Couplage de l'atmosphère tropicale et du cycle hydrologique) - moved into an active phase in 1999, when international co-operation began.

Iccare

The Iccare programme examined the humid regions of West and Central Africa. The work revealed that the recent drought observed and studied in the Sahel also had serious repercussions further south, especially in forest areas. While areas along the Gulf of Guinea coast are still the wettest, rainfall volume has fallen considerably and



This tree has withstood erosion of the banks of the river Bani in Mali, sending roots down to draw groundwater since the river is no longer perennial.

the isohyets have moved a long way south. Up to the end of the 1960s the 1600 mm isohyet matched mean rainfall in the forest zone; in the '70s, that match already no longer applied, and this trend amplified during the '80s, when some forests were receiving no more than 1200 mm of rain a year. The rainfall deficits recorded in the countries of the area studied are generally about 20% - a highly significant trend, therefore, and one which has major implications for the region's stream flow. Surveys in some hundred catchments throughout the zone show that since the early 1970s, mean annual discharge has in many cases declined by at least 30% and in some cases more than 60%. The decrease applies to both high and low water regimes. It is not hard to imagine the possible effects on farming, public water supply, hydroelectric power generation and water engineering systems in general.

HiBAm

Under an agreement signed in 1994 with Brazil's National Council for Scientific and Technological Development (CNPq), the HiBAm programme is jointly run with the University of Brasilia and the Brazilian national electricity agency. Also involved are Bolivian institutions (the national weather and hydrology service and the Universidad Mayor de San Andrés) and Ecuador's national weather and hydrology institute. While the core purpose of HiBAm is to learn more about the processes and mechanisms that control the hydrology and geochemistry of the waters of the Amazon basin, the programme also aims to evaluate the river's discharge into the Atlantic. It is also working to determine the impact of climate fluctuations, for example the effects of El Niño, on variations in the catchment's hydrological and geochemical regimes. A network has been set up to transmit hydroclimatic data by satellite, and reference stations specially equipped to measure flows of water and sediment have been installed. To develop a hydrodynamic model for forecasting flood levels and sediment transport, a project using satellite technology was recently launched to estimate the absolute altitudes of the catchment's hydrological stations. HiBAm's results also provide a basis for diagnosing water contamination, particularly by mercury from gold mining, which is an increasingly worrying problem in the Amazon.

Catch

The purpose of the Catch programme is to document and model inter-annual and ten-year variations in different terms of the hydrological cycle, across a region of Africa that covers 9° in latitude and 5° in longitude. The emphasis is on studying the



Taking a water sample from CLD-2 sampler coupled with a CTD probe.

coupling of atmospheric and surface processes. Two enhanced observation sites have been chosen: one in the Sahel (the Niamey square degree, where the Hapex-Sahel surveys of 1991 and 1993 were conducted), and one in Benin. Most of the work in 1999 focused on Benin, where an intensive two-year survey was in course of preparation on the 11,000 km² upper Ouémé basin. This survey is part of the Coordinated Enhanced Observing Period organised by the World Climate Research programme for 2001 and 2002. Catch was selected as a reference site for Africa, in a planet-wide network of six sites. In 1999 the work of installing the long-term monitoring system, begun in 1997, continued.

It now has some sixty numerical data acquisition devices monitoring rainfall, stream flow and water table fluctuations. The team operates in close partnership with Benin's water authority (Direction de l'Hydraulique du Bénin). Other Catch projects under way are modelling rainfall regimes and the disruptions of the seventies and eighties, studying the East air streams and their possible role in triggering convection, and using Meteosat to monitor the meso-scale convection systems which produce most of the region's rainfall. Once completed, all these studies will be used to validate a regional climate model that is to be coupled with a hydrological model, both models are at the development stage. At present, Catch involves concerted action by researchers from the CNRS, the IRD, Météo-France and the CNES. Collaboration is also beginning with science academies in France and the USA, and with NOAA in the USA.

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■ Supergenic chemical weathering and auriferous mineralisation in eastern Senegal

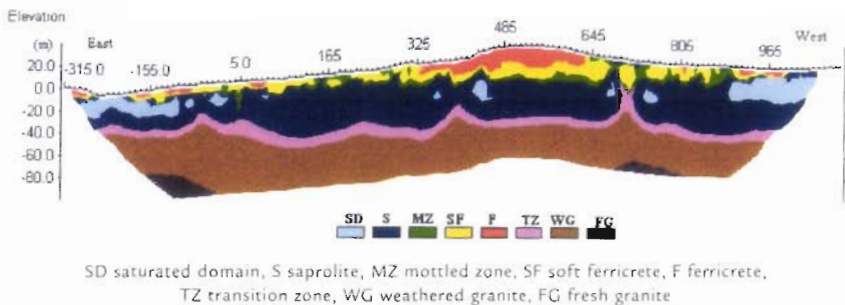
West Africa's Proterozoic and Birimian formations (dating from 2.2m years ago) have great potential for mining in the region. Most of these formations are covered by lateritic material, in the broad sense of the term, formed by intense geochemical transformations that cause the parent material to become geochemically and mineralogically homogenous. Laterisation affects both bedrock and transported material, making it difficult to identify the underlying rock and its associated minerals from surface images.

Determining how the surface material was formed requires a thorough understanding of the erosion and weathering processes that have affected the terrain over geological time. To do this one must find out the thickness and characteristics of the different supergenic overburden horizons (i.e. the horizons formed at the surface through contact with surface water and atmospheric agents), according to the geological, structural and geomorphological situation.



A few grams of harvested gold in the bottom of a metal bowl (eastern Senegal)

Two- and three-dimensional analysis of weathered horizons by electric resistivity tomography gives a continuous image of the geoelectrical characteristics of a terrain. By varying the distance between the electrodes, one obtains either greater detail in the surface levels or greater depth of investigation, down to a depth of a hundred metres. Taking geological data obtained from series of boreholes and *in situ* resistivity measurements in the different facies, one can correlate the tomographic image with the lithology. The images obtained provide information on the geometry of the different weathered horizons, the fresh rock, and the



Electro-stratigraphic cross section through laterite and underlying rock, Tenkoto region, eastern Senegal

topographical surface. By close analysis of these relationships one can distinguish material formed by geochemical weathering *in situ*, from deposited overburden material. As geochemical weathering affects rocks differently according to their nature, it is possible to identify and situate with precision the contacts between rocks of different types, even though these contacts are hidden at the surface by the lateritic overburden. Scientists can also use the geoelectrical image to distinguish water-saturated zones and monitor changes in and transit of solutions from season to season.

Using gold as a tracer complements the geophysical results and gives greater detail. Being malleable and little subject to weathering, gold records and keeps the trace of its transport in the shape of its grains and the effects of periods of intense weathering in its surface states. Research in Burkina Faso and Senegal show, for example, that the distribution and morphology of gold particles differs according to whether it is found directly above a mineralisation in material that has weathered *in situ* or on the periphery, or in material that has been transported and deposited. In the field, gold particles extracted from materials of various origins –glacis overburden, colluvium, alluvium– are analysed at increasing distances from their supposed source. However, it is hard to avoid sampling populations of different origins. To solve this problem, laboratory experiments are being conducted with gold particles straight from the vein, using abrasion to recreate experimentally the different transport conditions, varying the type of material, sediment load and abrasion time.

A final stage of the project will define the statistical relationship, with regard to overburden material, between intrinsic factors (thickness and volume, nature and origin of the mate-

rial, morphology of the gold particles) and extrinsic factors (geomorphology, geology, numerical model of the terrain). A spatial model for predicting the horizons in question can then be proposed. This will make it possible to reconstitute the history of the landscape and so interpret more efficiently the geochemical image obtained from surface samples.

This is a collaborative project with French and Senegalese universities. Under joint supervision by Senegalese teacher-researchers and their French partners, students and teacher-researchers from various countries of the region are being trained in surface geology, geomorphology and surface geophysics.

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Woman panning (Tenkoto, eastern Senegal)

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■ Paleomagnetism and deformation of the Earth's crust in the central Andes

Paleomagnetism is the study of the remanent magnetism of rocks, which reflects the direction of the Earth's magnetic field at the time the rock was formed. It is this branch of the earth sciences that produced the main quantitative data to establish tectonic plate theory (the theory of continental drift and expanding ocean floors). Comparing the remanent magnetism of rocks of a known age with the direction of today's magnetic field is an excellent way of discovering what rotations and displacements a rock has undergone since it was formed.

For several years now, the IRD's Andean geodynamics team has been conducting combined geology and paleomagnetism research to achieve a better understanding of the deformation processes at work in the Andes and quantify the accompanying displacement of blocks of the Earth's crust. Under a cooperation agreement between the IRD and the University of Chile, a paleomagnetism laboratory has been set up in the University's geology department.

One of the most striking features of the Andes cordillera is the very marked bend between Peru and Chile, level with the town of Arica. This bend, the Bolivian orocline, occurs in the region where the cordillera is widest (about 850 km wide) and where the Bolivian altiplano lies – the second largest plateau in the world after the Tibetan plateau, and with an average altitude of over 3600 m. The continental crust beneath the plateau is over 60 km thick. In the last ten years, it has been shown that the main reasons for this thickening are compression and lateral shrinkage of the crust due to tectonic movements. From seismic data from oil prospecting, IRD geologists have estimated that the region has been shortened by 200 km over the past 20 million years in the eastern part of the chain. One major problem is to find out whether the bend in the chain has resulted from differences in the degree to which its eastern edge has been shortened, or to some other mechanism.

The first results from the central Andes confirmed the hypothesis. At the Arica bend, clockwise rotations were identified in Chile and anticlockwise rotations in Peru. But the paleomagnetic data came from samples from a small number of sites, mainly along the western fringe of the chain between the Pacific coast and the present-day volcanic chain, and mainly from rocks dating from the Mesozoic (before the Cretaceous-Tertiary boundary some 66 million years BP). To test the different hypotheses as to how the Bolivian orocline and Altiplano were formed, researchers conducted paleomagnetic studies with a dense cluster of sam-



Snow-capped volcanoes in northern Chile

© IRD/Claude Dejoux

pling sites including 120 in Bolivia and 250 along the fore-arc in northern Chile. To quantify the displacements over time, samples were taken from rocks whose ages ranged from the Mesozoic to the Miocene. The scientists were mainly seeking to link up the interpretation of these paleomagnetic data with local and regional tectonic data.

The rotations recorded along the Chilean fore-arc are all clockwise, but they vary widely in degree (up to 60°), showing that this fore-arc has not been subjected to a uniform rotation as might be suggested by a deformation model based on simple bending of the Andes chain. The other important finding concerns the age of the rotations: they occurred before the Miocene and are linked to the tectonic deformation that took place from the Cretaceous to the Oligocene. Currently available data on the lower to mid Miocene (in the Chilean fore-arc) do not show any significant rotation of this part of the chain, and this is confirmed by data from Peru. On the Altiplano, the rotations are more recent. A detailed paleomagnetic study of the Corque sedimentary basin in Bolivia shows that the entire basin has rotated anticlockwise by 10.8 ± 3.5 since 9 million years ago. There is a very clear correlation between the direction of shortening and the rotation, and two conclusions can be drawn from this. On the one hand, the more the direction of structural features like faults and fold axes differs from the perpendicular with respect to the direction of convergence of the Nazca and South American plates, the stronger the rotation; on the other hand, major rotations correspond to more local deformations that are less significant at the regional scale.

The absence of uniform rotation in the fore-arc contradicts the hypothesis that deformation and the formation of the Puna

Altiplano were caused by simple bending of the whole margin. Part of the bend of the Bolivian orocline as it exists today was formed during a period running from the upper Cretaceous to the Eocene, before the main phase of uplift of the Altiplano. During the Neogene, the fore-arc of southern Peru and northern Chile acted as an anchor point. The eastward-spreading deformation caused the main structures of the chain to rotate, anticlockwise in the northern branch of the orocline and clockwise in the southern branch.

The strong rotations the IRD research has revealed in Chile had not been foreseen by most structural interpretations, yet they are one of the principle features of the deformation. This advance in our knowledge of the region's geodynamics is a notable contribution to understanding the evolution of the Andes, and the results will be useful for mineral prospecting. The copper porphyry found in Chile, the world's foremost copper producer, formed along the main deformation zones; so quantifying displacements using paleomagnetism data is extremely helpful to prospectors. More thorough knowledge of the magnetic properties of rocks in relation to mineralisation processes improves the interpretation of magnetic anomalies identified, for example, from the airborne magnetic surveys that are now an essential tool in mineral prospecting. Directly linked to discovering non-renewable mineral resources, this is the most practical strand of the research. ■

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RESEARCH

LIVING
RESOURCES

Banana plants cultured in vitro

© IRD/Alain Rivat

In the countries of the South, people mainly meet their needs by utilising biological, natural and renewable resources. National economies largely depend on such resources, be it through fishing, fish farming, crop farming, stock herding or harvesting forest products. Food apart, uses include wood, genetic resources, biotechnology, medicinal plants and molecules, etc. So the “living resources” theme is certainly a core theme for innovative scientific research.

Under pressure from constantly growing needs, resource scarcity and environmental degradation are worsening fast. The notion of sustainable development sprang from an increased awareness of the interdependent dynamics between environment, living beings and the various uses made of them at different scales. Sustainable resource use requires an understanding of the natural and human-induced processes (changes and innovations) involved in the ecological dynamics of resource diversity and use patterns. This means studying living resources in their environmental context: their biotopes (physic-chemical environment) and biocenoses (the entire set of living organisms in an ecosystem).

All the Living Resources department’s research takes this ecological approach, with

an eye to the new paradigm of global change. The department’s research programmes fall into two major groups: those concerning “Terrestrial ecology and biodiversity (plants, animals and microbes)” and those investigating the “Ecology, biodiversity and fish resources of continental and marine waters”.

Terrestrial ecology and biodiversity (plants, animals and microbes)

This theme calls on the skills of microbiologists, soil scientists, phytovirologists, geneticists, and scientists in other fields again. The work falls into three broad fields: combined microbiology and biotechnology, dynamics, conservation and uses of biodiversity; interactions among living organisms (plants, insects and small mammals) and their relations with the environment.

Combined microbiology and biotechnology

Fermentation in solid or liquid media by bacteria or filamentous fungi is harnessed to develop economic uses for tropical farming products and by-products. IRD teams and their partners are developing new knowledge and processes for waste upgrading (detoxification, production of aromatic compounds, etc.), biodepollution (biofilters, methanisation) and economic uses of

extremophilic bacteria (biosurfactants for recovering crude oil, producing stable enzymes in extreme conditions, possible useful genes, etc.).

Dynamics, conservation and use of biodiversity

Plant genetics research is going on at three levels:

- **Genetic resources:** developing methods of conservation, *in vitro* culture and cryoconservation; observing gene flows between cultivated and wild species and between introduced species (genetically modified or not) and established species (whether crops or weeds).
- **Genomics:** functional analysis of the genomes of tropical plants; collections of insertion mutants; sequencing and mapping of rice chromosome 12 (at the Génopôle in Montpellier).
- **Post-genomics:** identifying, characterising, cloning and transferring useful genes; reproductive biology of plant species; research on apomixis and seed development; plant physiology, rhizogenesis, plant-symbiont relations, plant-parasite relations.

To study living beings, one must get to know their whole range of diversity. That is the main reason for collections, though they also

serve as a starting point for systematics and biosystematics research. The IRD gathers and conserves collections of plants (in Polynesia and French Guiana) as well as insects and nematodes for these purposes.

Interactions among living organisms (biocenology): plants, insects, small mammals and their relations with their environment

The purpose of studying relations between plants and parasites or pests in natural or cultivated tropical environments is to gain an understanding of these complex systems. To understand the functional role of biodiversity, a precise inventory of the species that make up a biocenose is first required. To model these systems and try to predict how they will develop, IRD scientists investigate the physiological relations between pathogens or parasites and host plants, and between predator and prey.

Other researchers are examining the internal processes at work in tropical soils, and what happens to them when cropping systems become more intensive. These concern mainly

- how fertility builds up in land left fallow, and development of new methods for managing fallow land in West Africa;
- how changes in cropping systems affect biological soil processes through their impact on soil fauna, and the effects of soil fauna population dynamics on soil fertility and crops;
- processes of carbon storage and constitution/reduction of available soil organic matter stocks, and their role in soil fertility.

Interactions between societies and their environments are a specific field of research; IRD scientists analyse patterns of use of secondary tropical forest and agroforests, and the functions and management of protected areas such as national parks and sacred groves, and their surrounding areas.



Algal coral (Nosy-Be, Madagascar)

Ecology, biodiversity and fish resources in continental and marine waters

Several IRD teams are working on inventories of biodiversity among living aquatic organisms in marine, brackish and continental environments, and seeking to understand the biological processes that govern populations and communities under different environmental constraints or utilization conditions. This work, which involves close partnership with other French and non-French research bodies, focuses on the following questions:

- Species and communities exploited by humans are subject to natural stresses such as environmental fluctuations and to induced stresses such as pollution and exploitation. What are the physiological processes (such as growth and reproduction) and the ethological mechanisms that enable them to adapt or respond?
- What are the genetic characteristics that determine the phenotypic plasticity of a population, and what factors (interactions between genome, individuals, populations, environment) lead to speciation?
- What individual based models are best able to represent and simulate these interactive processes?

On the strength of the international renown of its tuna research, and in formal partner-

ship with Ifremer and the University of Montpellier II at the future joint research centre on tropical and Mediterranean fishery at Sète, the IRD will shortly be mustering the competencies and resources to establish a research and monitoring unit on tuna fishing and population dynamics.

Any quest for sustainable development must be based on understanding the economic processes and governance of production systems that exploit living resources and the environment. Several IRD teams are investigating these subjects.

The Living Resources department research takes a forward-looking and proactive approach, with sustainable development as the goal. It seeks to identify the essential management and governance conditions for ensuring the biological, economic and social co-sustainability of the ecosystems on which mankind and its future depend.

EXAMPLES

■ Génoplante: functional analysis of the rice genome

The Génoplante programme is a partnership between the French public research institutes CNRS, Inra, Cirad, IRD and universities, and private firms Aventis,

Biogenma and Bioplante. The aim is to advance knowledge of plant genomes and develop applications in variety improvement. G enoplante is investigating economically important species such as wheat, maize and oilseed rape, and two "model" species, rice (*Oryza sativa*) and *Arabidopsis thaliana* (known as wall cress, thale cress or arabis); both plants have quite small genomes, which should make it easier at a later stage to access genes in species with more complex genomes. The IRD is working on the rice genome, in collaboration with university teams, a CNRS team in Perpignan and, thanks to new equipment acquired through G enop le Languedoc-Roussillon, with a Cirad team in Montpellier. Some fifteen scientists from the public institutes are involved, along with scientific and technical staff funded by the industry partners.

Sequencing rice chromosome 12

This project is the French contribution to the international rice genome sequencing programme, which involves a consortium of laboratories. The aim is to decipher the rice genome and identify the genes that make it up. The actual sequencing is done by G enoscope, the French national sequencing centre at Evry; the IRD is involved at the preparation stage. The rice genome is reproduced by fragments in bacteria, in the form of bacterial artificial chromosomes or BACs. The task is then to identify the BACs that belong to chromosome 12 and put them in order so as to reconstitute the chromosome. In a pilot operation, a preliminary assembly of BACs containing a million base pairs (1Mbp) has been achieved. G enoscope is now sequencing this assembly.

Building up cDNA libraries

Researchers are also establishing cDNA libraries corresponding to the coding parts of the genome that are expressed at different stages of plant development, or when the plant reacts to such stresses as heat or pathogen attack. The cDNA will be used to link particular functions with particular sequences obtained from the sequencing work. These will be used to build gene "chimeras" which, when expressed in plants where they have been introduced by genetic transformation, will enable the researchers to validate the genes' functions.

More specifically, the IRD is developing cDNA libraries from plants and cell suspensions inoculated with rice pathogens. The aim here is to identify the genes that govern the plant's resistance and defence mechanisms to pathogens.



G enoplante laboratory, Montpellier

Establishing and characterising a collection of insertion mutants for functional analysis of the genome

The purpose of this project is to produce mutated plants by genetic transformation. In these plants, a gene is rendered defective by inserting into it a fragment of foreign DNA. The resulting plant has a modified function or appearance: decolouration, for example, if a gene involved in photosynthesis has been modified. Given that rice has an estimated 20,000 genes, a minimum of 100,000 mutants must be produced to obtain at least one insertion into each gene.

The IRD is working on phenotype evaluation, (anomalies in growth or development, architecture, fertility, pigmentation or pathogen resistance) and on molecular char-

acterisation of the mutants. Establishing and utilising this collection of mutants is a major strand of the G enoplante programme for identifying the key genes in cereals. It will enable scientists to associate with certainty a particular function with each modified gene.

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■ Fallowing in tropical Africa

A typical land use system in tropical Africa involves cultivating a plot for five to fifteen years and then leaving it fallow as soon as yields and soil fertility begin to decline or the crop has become infested with weeds or parasites. The fallow period can last from ten to thirty years depending on climate; during this time, soil fertility builds up as shrub or woodland savanna take over. The fallow land is used for gathering wood and small fruit and grazing livestock. The natural vegetation protects the soil from erosion and allows the soil fauna to become more active after a period of cultivation; the soil regenerates as organic matter and nutrient content build up. Fallowing also plays a part in weed and parasite control and the social management of the land.

This system of alternate cropping and fallowing worked well until quite recently. But with population growth, a more sedentary lifestyle and recent droughts, the proportion of land under cultivation has greatly increased. As a result, fallow periods are considerably shorter, while wood and herbaceous forage plants are exploited more intensively. Bush fire also takes its toll, slowing the soil's natural biological regeneration. Evaporation and erosion increase: this is land degradation.

To ensure that farming can be sustainable in tropical Africa, it has become necessary to



Fallow land in the Sahel

develop a suitable way of managing fallow land or find alternative methods such as introducing a forage crop break or planting fast-growing nitrogen-fixing trees. As a rule, however, these methods do not sufficiently take account of community land uses, social factors or land use rights; and they do not always match up to the local community's hopes. In practice, they have slowed down the transition to continuous cultivation that will very soon be essential to meet increasing needs for wood and fodder.

For the past six years, under the "fallow" programme, a multidisciplinary network of researchers, teachers, decision-makers and planners has been conducting research, training, applications and expertise on "the shift from systems that include fallowing to continuous cultivation: consequences for natural resources and their management". The countries involved in this region-wide project are Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Mali, Niger and Senegal. The IRD handles coordination under the auspices of Coraf; other research and higher education bodies in the project are CNRST (Burkina Faso), Irad (Cameroon), Cnar (Chad), CNRA (Côte d'Ivoire), IER (Mali), the Faculty of Agronomy and Humanities (Niger), Isra, Ucad (Senegal), Cirad/Forêts, Cirad/Tera, Cirad/IEMVT, Cefe/CNRS (France), NRI (United Kingdom), the University of Oslo (Norway), and various international bodies or donor agencies: the European Union, the French Development Cooperation Ministry, CTA, CRDI, Unesco and Icrad.

The programme mainly involves applied research towards improving or optimising fallowing, or replacing it with other practices. As cultivable land becomes ever more densely occupied, the researchers propose "improved fallowing" methods for maintaining the indispensable functions of fallow land: restoring soil fertility, producing wood and forage, etc. The methods are often developed on research stations and have to be tested under real life conditions, locally or regionally, to identify the conditions under which farmers can assimilate the proposed innovations and adopt them as their own.

There is also more basic research, aimed at identifying the ecological processes that condition maintenance of an acceptable level of biodiversity and soil fertility when agriculture becomes more intensive. At present this work involves sociologists, demographers, agronomists, geographers, plant ecologists and soil biologists.

Information and training are also essential components of the project. Frequent scientific and technical outreach meetings are held when actions are being implemented under the project; conferences, seminars and workshops have been held; and scientists

also disseminate information to the general public via radio broadcasts and videos. Lastly, a very important international seminar on "Fallowing in tropical Africa", attended by two hundred researchers and decision-makers, was held in Dakar on 13-16 April 1999, to assess the research under way and the results from the first phase of the project.

Among other output, the project has generated some hundred publications, state-of-the-art synopses and about thirty theses. It has also been an important framework for training graduates from North and South for their post-graduate degrees.

A second four-year phase has begun; it will run from 2000 to 2003.

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■ Pioneer farming and deforestation in Madagascar

Deforestation in southwestern Madagascar is advancing at an extremely fast pace. Rural immigration has increased, all the alluvial lands are now occupied, maize has been promoted as an export crop and for the domestic market; as a result, huge tracts of land have been cleared for farming, in a largely uncontrolled manner. In this sub-humid region with its long dry season, farming methods are now partly based on slash-and-burn pioneer agriculture, combined with pastoral livestock grazing, the regular passage of fire, and resource-wasteful use of the forest (wood for burning and building).

Two research programmes, conducted in partnership between IRD and the Centre National de Recherches sur l'Environnement (CNRE), with backup from CNRS researchers and more recently also Inra, are

addressing these issues from complementary angles. The "Deforestation and farming societies in Madagascar" programme (Despam) began in 1994; it concerns the social phenomena connected with deforestation, and particularly focuses on interactions between migration dynamics and land use rights issues, and their impact on how people view forest environment and management. Since 1996, the "Management of rural land and environment in Madagascar" programme (Gerem) has been investigating the inter-relationships between production systems and ecosystems; it focuses on natural resource utilization practices, the ecological dynamics connected with these practices, actor strategies, and land use management. All the research relies on collaboration between scientists in different spheres (ecologists, agronomists, geographers, anthropologists) and on selecting research sites that are characteristic of the major environment types and current farming and land use patterns. The work has received financial support from the SEAH committee of PIREVS-CNRS.

As well as improving our knowledge of the on-going processes in question, a current research goal is to produce reference documents and make decision aids available to resource conservation and rural development actors. The work is fully in line with the priorities of the 1997-2002 second phase of Madagascar's Environmental Action Plan (PAE).

The social science research has shown that the deforestation goes hand in hand with profound changes in the way people see their forest land, so that new land occupation strategies are emerging. The forest is no longer sacred; it is now seen primarily as a source of income. There are conflicts over land use, and sometimes violent clashes, between migrants and indigenous communities.



Firewood and charcoal, Madagascar

As the forest is felled, social groups and territories are reshaped. In this fast-changing situation, as migrants move into land hitherto protected and conserved and seek to make a living from it, social and ceremonial innovations show that societies' relationship with their environment is changing radically.

The main cause of the deforestation is extensive slash-and-burn maize growing. This is a system that gives high yields and a high level of labour productivity for a few years after the land is cleared; but is not sustainable. Weeds increasingly invade the fields, the physico-chemical properties of the soil deteriorate, and after a few years' cultivation yields plummet and farmers move on, abandoning their fields to clear new land. Under this system, unlike the traditional model of shifting agriculture in the humid tropics, abandoned land cannot be regarded as true fallow, as it is rarely brought back into cultivation. With the regular passage of grazing herds and bush fire preventing forest regrowth, it turns into savanna. Grasses become a permanent feature of the ecosystem, making it impossible to return to a slash-and-burn system even when the land has been abandoned for many years. As a result, areas briefly used for crop farming are turned over to livestock. The agro-ecological process thus profoundly reshapes the organisation and functionality of farming country.

Students have played a big part in the Despam and Gerem programmes. Three doctorate theses have been presented, five others are in preparation, and some forty Malagasy and French students have written their dissertations for first or post-graduate degrees. Exposés, seminars and training courses have been organised throughout the life of the programmes.

An important public workshop giving an initial assessment of both programmes was held in Antananarivo on 8-10 November 1999, jointly organised by CNRE and IRD, with help from the French Development Cooperation Ministry. The scientific results were presented and put in perspective with findings from other parts of Madagascar. One day was devoted to debating how to utilize the research findings and the relationship between research and development, focusing on three topics: land use rights and resource management, agricultural development and the dynamics of production systems, and environmental actions and policies. The proceedings of the workshop will be published at the end of the first quarter of 2000.

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Damage to cassava by the grasshopper *Zonocerus variegatus*

■ Feeding habits and biological control of the grasshopper *Zonocerus variegatus*

Grasshoppers and locusts are major crop pests in Africa. Often, they appear in the fields suddenly and unexpectedly. They are the ultimate mobile pest hazard, striking apparently at random. As crop species are only a few of the many plants they eat, they breed and spend most of their life cycle outside farmers' fields. This means that farmers cannot do much to control them directly or predict their proliferation, and may be the reason why insecticide treatment is often ineffective. Grasshoppers can attack a wide range of crop species and the type and scale of damage also varies widely. These insects are a real and constant menace, and the effects are especially spectacular because it appears so unexpectedly.

The variegated grasshopper, *Zonocerus variegatus* (Linnaeus, 1758), has colonised most manmade environments in humid intertropical West Africa over the past hundred years, attacking a growing number of crops. Since 1989, under a programme called Lubilosa* - a French acronym for "biological grasshopper and locust control" - an international team from the IITA (International Institute of Tropical Agronomy) has been developing an insecticide in which the active ingredient is an entomopathogenic fungus. *Z. variegatus* is one of the key targets for the new biopesticide. To use it effectively, a detailed understanding of the insect's ecology and feeding habits is required. On the strength of its long experience in ecological studies of pests, and of the variegated grasshopper in particular, the IRD conducted a joint research programme with IITA/PHMID (IITA/Plant Health

Management Division). Working in Benin between 1995 and 1999, the researchers investigated the grasshopper's feeding patterns and considered how to use the findings to improve biological control.

The field study of *Z. variegatus*' diet revealed an unexpected picture of the grasshopper's ecology. The literature lists 250 plant species in 71 different families that may be eaten by *Z. variegatus*, but observations in the wild showed that each *Z. variegatus* population concentrates on a mere twenty or so species. The dietary range is widest at the beginning of the dry season, when the majority of the grasshoppers are in their juvenile stages but there is less vegetation available. So the main cause of the wider dietary range is neither the general supply available (which is most varied in the rainy season), nor the ageing of the insects (which is accompanied by a broader dietary range in many insect species).

The variegated grasshopper's feeding habits are conditioned, temporarily and to a greater or lesser extent, by the plants available to it. After a few weeks this gives way to a new conditioning when a new set of edible plants becomes available. This is the reason for the succession of different feeding habits over time, or consumption cycles, observed in the field. A protocol for analysing the attraction of *Z. variegatus* to different plants was constructed, taking these observations into account. A number of plant species were tested to find one which, combined with the mycopesticide, would act as a bait, attracting the grasshoppers to places where they can be more easily dealt with.

The scientists particularly investigated several plants common in the fallow land bordering fields, or which farmers plant along field edges. Of these, *Chromolaena odorata* seems less attractive than *Vernonia amygdalina* or *Heliotropium indicum*. *C. odorata*, which was suspected of playing an active role in grasshopper proliferation, can no longer be considered the essential driving force in *Z. variegatus* population growth.

At the end of the dry season, when the grasshopper populations are very dense, sexually active adults concentrate in particular places where most mating and egg laying then takes place. There are various factors that lead to the insects moving to these sites. It is thought that the males emit an aggregation pheromone, though this has not yet been analysed. The same breeding grounds are used from year to year, and are an essential factor for localising and regulating *Z. variegatus* populations. The insects may

* Joint project involving IITA (International Institute for Biological Control), IITA (International Institute for Tropical Agronomy) and DFPV (Département de Formation et Protection des Végétaux).



Adult *Zonocerus variegatus* grasshoppers on cotton plant

disappear from a given site because of human activity such as land clearance or burning, or owing to natural causes. There is a parasitic diptera, *Blaesoxipha filipevi* Rohdendorf (1928), which lays its eggs on grasshoppers, sometimes juveniles but mainly adults when they are gathered at breeding sites. The larvae bore into the body of the grasshopper and develop there in six days. Two to six parasite larvae can often be seen on the same grasshopper; the maximum observed was thirteen larvae on one male.

The parasites cause considerable damage to the host and can even kill it, and *Z. variegatus* may die out in areas where the parasite is abundant. Grasshopper control strategies must therefore take account of the role of this parasitic diptera as a natural agent for regulating grasshopper populations.

The case of *Z. variegatus* is a good illustration of the new perspective scientists have on insect pests. Pests must be considered within the dynamic whole of their biotic and physical environment, not merely from the standpoint of their relationship with crops. For biological control programmes to move towards greater efficiency in regulating endemic pests, they must take new conceptual approaches incorporating ecological parameters.

The ecological *Z. variegatus* programme which IRD researchers suggested for an IITA/PHMD station has demonstrated the value of this kind of scientific partnership; continuous, fruitful dialogue developed between basic and applied research. The programme was also an opportunity to educate young Beninois and French agronomists about these issues while training them in research.

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■ Multi-purpose use of aquatic resources in the reservoirs of semi-arid Pernambuco

For the eighteen million inhabitants of the drought polygon that covers nearly a million square kilometres of the northeastern Brazil, upland dams and reservoirs called "açudes", are the main source of water during low water periods, which are unpredictable in their frequency and duration. In the Pernambuco State alone, over 12,000 reservoirs have been created since the beginning of the 20 century to provide public water supply, irrigation and fishing. Just 36 of these reservoirs have capacities of more than 10 million m³ and account for 86% of the region's surface waters.

The "Açudes" project

IRD was a partner in the "Açudes" programme on "Utilisation of aquatic resources in the reservoirs of semi-arid Pernambuco", which ran from 1995 to 1999 under an agreement with Brazil's National Council for Scientific and Technical Research (CNPq). The Brazilian partner institutions were the Federal Rural University (UFRPE) and the Federal University (UFPE) at Recife, capital of Pernambuco State. The programme brought together scientists, decision-makers and managers, and was designed to study the functioning and dynamics of the upland reservoirs and identify the most relevant information for optimising their use, particularly for extensive fish farming.

As the geography of the semi-arid parts of the northeastern Brazil was structured by the expansion of extensive livestock farming combined with subsistence crop farming, fishing in the reservoirs was seen as an

emerging productive sector as early as the 1940s. Over a hundred million small fry were introduced into the large public reservoirs and fishing became a common activity, though it has declined in the past decade since the government ceased its involvement. However, the efficiency of poisoning fish without scientific criteria needs to be analysed and more rational models of fish management identified.

Water quality

To assess the potential of the reservoir's aquatic environment one must identify the factors that control its productivity- and its trophic potential. This in turn requires a sound knowledge of how the "açude" ecosystem functions. Studies of the reservoirs' food chain and functioning (energy interactions between organisms) began in 1997 with seasonal monitoring of the dynamics of communities of bacteria, phytoplankton and zooplankton. The drought that began in 1997 has reduced the water in the large public reservoirs to less than 10% of their capacity. Water supply problems have been accentuated by a high degree of eutrophication of the reservoir water. In view of the chlorophyll and phosphorous levels in particular, most of the reservoirs studied have been classified as hypereutrophic ecosystems, i.e. excessively rich in nutrients. The new environmental conditions caused a toxic cyanobacterium called *Cylindrospermopsis raciborskii* to proliferate (bloom) until it accounted for as much as 98% of the algal community. The dynamics of the algal community are directly controlled by physico-chemical factors (pH and nutrient concentrations), and indirectly by the omnivorous fish populations, while the zooplankton community is mainly affected by predator-prey relations. Team action in partnership with the Pernambuco Institute of Technology (ITEP) and the Water Resources Secretariat (SRH) was decisive in setting up a water quality monitoring programme on some fifty supply reservoirs in 1998. The main issue was to analyse and predict the processes that determine toxic cyanobacteria bloom.

Fish ecology

There had been no monitoring or characterisation of fish communities in the reservoirs of the semi-arid northeast since the National Department of Drought Control Structures (DNOCS) stopped its pioneering work in the State of Ceará ten years ago. The "Açudes" programme revealed wide variations between different reservoirs in their fish biology, pointing to a need for differentiated fish management. Experimental catches enabled the researchers to develop empirical fish biomass evaluation models

from a set of characteristics of each reservoir (morphology and surface area of the body of water, nature and structure of the bottom) and the number of carnivorous species.

Depending which omnivorous and carnivorous species are introduced, one can optimise either fishery output or water quality for public water supply. To develop further expertise in the matter, studies were run with mesocosms - fish tanks and experimental enclosures - to quantify the effects of trophic interactions among omnivorous fish species on water quality and species growth. Combinations of species with different feeding habits were tested, with Nile tilapia (*Oreochromis niloticus*, a filter feeder), common carp (*Cyprinus carpio*, which feeds on particles in sediment), common curimatás and pacu (*Prochilodus cearensis* and *P. marginatus*, which feed on particles in suspension), tambaqui (*Colossoma macropomum*) and tambacu (*C. m. x Piaractus mesopotamicus*), which are both omnivorous. From the results, the team can propose a model for short-cycle mixed fish farming (with a cycle of a few months) that is suitable for local semi-arid conditions. Because of the low cost and the high natural productivity of these ecosystems, the model can be used by small producers in enclosures within medium-sized reservoirs.

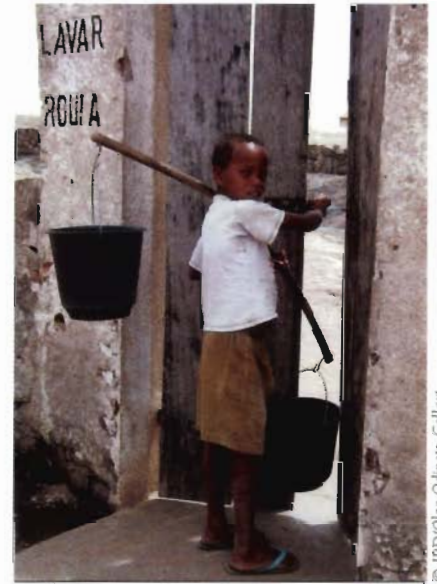
Analysis of fishing in the reservoirs showed that it is part of a multi-activity system characteristic of rural semi-arid Pernambuco, designed to minimise climatic and economic risks. Typically run on a small scale, fishing suffers from the variability of management decisions, rudimentary infrastructures and a lack of organised local markets. Growing interest in fish farming using floating cages suggests that the institutions involved in development policy-making will favour a transition from subsistence fishing to market-driven fishing.

Farming

The easiest way to use the reservoirs for farming is by flood recession cropping. The açude feeds the aquifer, which supplies water for the crops grown along the gently-sloping reservoir banks. This system can be defined as a complex hydraulic system because of the interdependence of transfer processes between the reservoir water and the farmland. To assess the agricultural potential of land above the water line, a special study was made of the dynamics between salt and water (e.g. salt concentrations) in the groundwater of two reservoirs. After two years of continuous monitoring, the researchers were able to quantify lateral transfers between reservoir and aquifer, and propose a three-dimensional model of the functioning of the porous medium.

Health

Many infectious diseases in tropical countries are water-borne, their etiological agents being either transmitted by vectors that live or breed in water, or transmitted directly. The multiplication of reservoirs might give cause for concern that epidemics or endemics could develop. The populations of two pilot sites were examined for intestinal schistosomiasis, malaria, dengue fever, intestinal worms, amoebiasis and leishmaniasis. Children's nutritional status, access to health care and demographic data were taken into account as health indicators. No pathology linked to the spread of the reservoirs was observed. All in all the people are in good health, the only important endemic identified being Chagas' disease, which is not water-borne. The increased incomes that come, among other factors, from irrigated farming cannot but foster an improvement in the population's health status in the long run.



Fetching water, Alagoinha, Brazil

© IRD/Olga Olinete-Collart

Water management

With the new water management policy passed by parliament in 1997, the central government and Federal institutions have withdrawn from this sector. Priorities are now set, and dams and other structures built, by catchment committees and councils of users, who are major protagonists in decision-making.

From research into the availability, access and ownership of water resources conducted in 1998-9, it emerged that the drought, far from affecting the whole community and reducing social inequality, actually increased it and worsened the imbalance in the region's economy. Participative management programmes are limited by the failure to take account of cultural factors, including the population's heavy historical dependency on the State.

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■ Small- and medium-scale behaviour of tuna

Pelagic fish, especially tuna, are known to aggregate around floating objects, such as natural debris or manned-rafts (namely the fish aggregating devices or FADs). Small-scale fisheries exploit aggregations around anchored FADs in coastal waters, while drifting FADs are used by industrial fleets in the open sea. Because this is such a widespread practice throughout the world's tuna fisheries, IRD teams undertook research programs aiming at a better understanding of tuna behaviour around FADs in the Atlantic, Pacific and Indian oceans.



© IRD/Marc Boury

The Ingazeira dam during the 1998 drought (Brazil)



A yellowfin tuna (*Thunnus albacares*) caught by experimental trawling is brought aboard the Alis during the ECOTAP programme (French Polynesia)

In the first experiments, ultrasonic tags were put on tuna to observe their horizontal and vertical movements in the vicinity of anchored FADs. Some fifty fish were tagged, mainly in the Indian and Pacific oceans. First of all, it was shown that the vertical distribution of some physical and chemical parameters (temperature and dissolved oxygen) controls the swimming depth of tuna because of effects on their physiology. In the vicinity of a floating object, tuna change their swimming pattern and tend to swim closer to the surface. On the other hand, the different experiments revealed a wide variety of horizontal movement patterns in relation to FADs: thus, this process cannot be described in a simple way. In a second type of experiment, monitoring of tagged tuna was combined with simultaneous observations of their prey using scientific echo sounders. This demonstrated that the biological environment has a significant effect on both horizontal and vertical tuna movements. Furthermore, the use of the sounder provided key information on the behaviour of tuna aggregations as a whole rather than simply following individuals: the biomass aggregated during the day is often greater than at night. Different models of individual tuna behaviour were developed from the observations, to represent their movements and shift from the individual to the aggregation scale, while integrating the FAD and the environmental surroundings.

At a larger scale, the IRD has also studied the behaviour of the tuna schools that gather in

“clusters” that can cover some tens of thousands of square kilometres. The processes leading to the formation of these clusters are closely linked to the tuna’s life history, particularly its reproductive cycle and the search of forage-rich areas. Clusters related to reproduction gather considerable biomass of adults in the surface layers, though this mainly concerns the large yellowfin tuna, *Thunnus albacares*, which forms single-species schools in equatorial regions; these regions are less turbulent in the spawning season, so that fish larvae are not scattered so quickly and have a better chance of survival. Tuna, which grow quickly and have a high metabolic demand, make seasonal migrations to forage-rich areas (Cape Lopez and Senegal in the Atlantic, Somalia and the Arabian Sea in the Indian Ocean) where they gather in multi-species shoals of similar-sized individuals. These migrations from breeding to feeding grounds are the result of an adaptation to habitat variability across the whole ocean basin.

Nonetheless, it seems possible that human activity has somewhat modified this movement pattern in recent years. In the Indian and Atlantic oceans, owing to permanent monitoring of landings and of the size composition of catches (set up by the IRD), significant changes in the species composition of schools have been identified since the early 1990s. These changes might be due to the massive deployment of drifting floating objects (some thousands) in the high seas by the purse seiners fleets. Gathering schools, the FADs ensure regular, large catches for

the seiners. In such a new context, and especially in the equatorial zone, free-swimming multi-species schools of small tuna have become much scarcer as the FAD aggregations have increased. This situation may become worrying from several standpoints. In the first place the schools associated with FADs mainly consist of immature fish; secondly, assuming a strong and lasting attraction and provided that there is a great number of FADs, the hypothesis put forward is that the natural cycle of feeding migrations can be altered, with a negative impact on growth and natural mortality. The hypothesis of such an “ecological trap” by a high density of FADs remains to be verified, however; given the serious implications for fish stock conservation, this will be the subject of research in the next few years.

Why tuna aggregate around floating objects is still a topical scientific question. One IRD team has suggested that floating objects are “meeting points”: single tuna or small groups navigate towards such objects for a better chance of meeting other individuals and forming schools reaching the critical mass that will give them better security against predators and make it easier to hunt for food. Another hypothesis, the “log-indicator” one, postulates that floating objects act as indicators of forage-rich waters because of their natural drift towards retention zones. Forthcoming research, based on field experiments, will make a critical analysis of the different hypotheses. ■

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Installing an instrumented buoy (with echo sounder) on a FAD in French Polynesia

RESEARCH
SOCIETIES
AND
HEALTH



Vaccination in Niakhar, Senegal

The Societies and Health department, formed when several earlier programmes were merged, seeks to highlight (a) the importance of the health of peoples and individuals for development, and (b) the urgent need to take account of social factors, in the most general meaning of the term, in any and all development projects, especially when implementing health programmes and evaluating existing health systems.

The department works both upstream and downstream of development research. On the downstream side it studies the precise impact of actions directed at a society. On the upstream side, whatever the development programme, there ought to be a prior analysis of lifestyles and representations that will help or hinder a projected action. There are ample examples in recent history, in fields ranging from irrigation and changes in farming systems to education and health systems, of programmes that have failed to achieve the intended results because they matched neither the local community's wants nor their real possibilities.

This is the angle from which the department's research themes should be viewed. These themes are control of the major viral and parasite endemics, nutritional problems,

the urban question, and analysis of societies. All take a multi-disciplinary approach, so there are many cross-links between them.

Combating major viral and parasite endemics

For many years the IRD has been studying the most worrying parasite diseases (malaria, trypanosomiasis, bilharzia, leishmaniasis etc.) and certain viral infections (hepatitis, AIDS, etc.). The aims are to elucidate their natural cycles of infection, using the most modern methods in molecular biology and entomology (the latter having been the institute's founding discipline), and to develop preventive and therapeutic treatments. IRD researchers closely combine laboratory work with epidemiological surveys (cohort monitoring, comparisons between several countries, etc.).

The parasite diseases have been well known for decades but are raising new challenges: they have returned to areas where surveillance has slackened owing to political instability and resource scarcity; and areas where the infectious agents or insect vectors have developed resistance to the commonly used drugs are spreading.

Because the IRD is established in many countries with different and changing epi-

demiological situations, it is also conducting research into "emerging diseases": virus diseases that were already known, but which have changed their clinical profile (such as hemorrhagic dengue fever in Southeast Asia), the new forms having only recently been detected and recognized.

AIDS is a "recent" infection, and the involvement of several teams working on this issue illustrates the multi-disciplinary way the department works. The teams are addressing the issue of this disease from different angles, ranging from precise characterisation of viral strains to local patterns of development of the epidemic. They are also studying available or possible control methods: prevention, treatment, vaccines, and individual and community strategies.

Malnutrition

Malnutrition research follows the same logic, especially as the deficiencies it leads to considerably weaken resistance to infection, in young children and pregnant women particularly. The researchers analyse the causes, indicators and diagnosis of malnutrition and its impact on growth. These programmes include physiology and biochemistry research, along with surveys on diet, consumption patterns and the strategies families employ to avoid malnutrition.

The urban question

The urban question has replaced rural studies as a priority theme for research at the IRD, reflecting the increasing concentration of the Southern countries' populations in towns. The research concerns the problems of the mega-cities, most of which are shared with major cities in the North: environment and health, transport, crime, drugs, corruption etc. The main focus is on the following aspects:

- families' economic strategies and the emergence of new forms of poverty under the impact of each country's political crises and the globalisation of the international market;
- action taken by governments, regional and international organisations to improve taxation, law and order and trade, and to manage the social question or the ratio between the active and inactive populations.

These analyses are based on gathering statistical data and helping Southern governments acquire the necessary data management tools, and drawing up atlases and detailed maps, a task that requires the skills of geographers and demographers with a sound command of the latest computer and remote sensing technologies.

Analysing societies

The department seeks to analyse societies in depth: their human resources, their needs regarding education, professional training and health, the cultural frameworks and their conceptions of heritage that shape their preferences for meeting these needs. These issues merge with that of the forging of national and community identities that has come to the fore since the collapse of the USSR and the Berlin Wall.

The forging of these identities (with variable involvement by governments) has involved language, ideology, architecture and other



APT Artworks ran an AIDS prevention campaign in South Africa's seven largest towns, with the help of local artists. Batho, a township of Bloemfontein

factors that reflect a general need for a sense of heritage. Their emergence suggests that cultural diversity is as important as natural diversity, and indeed that the two interact closely.

The examples below are intended to illustrate the department's activities and not, of course, to represent them exhaustively.

EXAMPLES

■ Preventing mother-to-child transmission of HIV-1: a comprehensive programme in West Africa, from research to operational practice

Under its AIDS programme, the IRD has been taking part in research on the transmission of HIV from mother to baby in West Africa since 1994. The core of the programme has been a clinical trial (ANRS 049 - Ditrane project) funded by the ANRS and conducted in Abidjan (Côte d'Ivoire) and Bobo-Dioulasso (Burkina Faso). The trial was directed by Inserm's Unit 330 and coordinated by the IRD in Abidjan. It was conducted in collaboration with the Yopougon university hospital (CHU), Cedres, the laboratory of the Treichville CHU in Abidjan, and the Muraz centre and the Sanou Sanon hospital in Bobo-Dioulasso.

In developing countries, HIV-1 is transmitted from mother to baby in 20-30% of cases. This can occur during pregnancy, during the birth or during breast feeding, but in most cases it seems to happen in the last weeks of pregnancy or the first few days of the baby's life. So the focus was put on developing medical treatment during this period.

The main aim of the Ditrane project was to evaluate tolerance to zidovudine (AZT) treatment and its efficacy in preventing transmission in populations where most women breast-feed. In the countries of the North, zidovudine has proven its efficacy in preventing mother-to-baby transmission with a long, complicated and costly course of treatment. The treatment tried in Africa was for less than a month, administered entirely orally to the mother from the 36 week of pregnancy (300 mg twice a day until the birth), with an additional orally-administered 600 mg twice a day for the first week after the birth. This short regime was assessed double-blind against a placebo, i.e. with neither doctor nor patient knowing whether the treatment given was AZT or the placebo.

Important findings covering the whole intervention process

In late 1988, six months after the randomised clinical trials (random distribution of subjects in the groups compared), the results showed that, with babies six months old and mostly still being breast-fed, the short zidovudine regime had reduced HIV transmission from mother to baby by 38%. Despite the babies' exposure to breast milk, at twelve months the reduction in transmission rates was still 34%. In Thailand, a similar regime in non-breast-feeding women showed a reduction of 50% of the transmission.

A number of other aspects were explored in addition to these important findings. Pre-treatment factors examined were: reasons for accepting or rejecting the HIV test, prevalence of anaemia, stages in the process from HIV-positive pregnant women being informed that they were infected with HIV up to the treatment to prevent mother-to-baby transmission. Post-treatment studies were on: low fertility in HIV-positive women, the problem of infected women's desire to have more children, the cost of

pediatric AIDS, and advice and monitoring concerning the infant's feeding of HIV-positive mothers.

Adaptive changes to the programme

In a one-year trial from October 1995 to October 1996, women were tested for tolerance to and acceptance of the short zidovudine regime. This phase of the program verified a good level of tolerance to the product and confirmed that HIV infected women who are aware of that fact during pregnancy do want to take treatment to protect their babies, and do take the medicine prescribed. It also proved possible to simplify the procedures for inclusion and monitoring of women and babies before moving on to the stage of evaluating the efficacy of zidovudine as a drug. The programme monitored four hundred pregnant women.

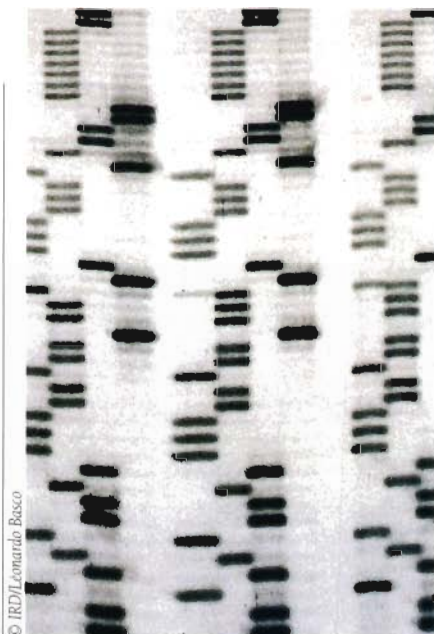
Since February 1998, the programme has treated over a hundred more women with zidovudine to prevent mother-to-child transmission. From October 1998 to April 1999, while waiting for the international therapeutic solidarity fund to start, the programme was able to continue the short-regime treatment in Abidjan on a more operational basis in partnership with Unicef and the Côte d'Ivoire national AIDS control programme. The HIV diagnosis test, the short AZT regime for infected pregnant women, and alternatives to breast feeding for women who choose not to breast-feed, were provided free of charge.

The IRD is now working with the Côte d'Ivoire national AIDS control programme and Unicef to set up public health programmes to reduce mother-to-baby HIV transmission in several towns in that country.

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Combating drug-resistant malaria

Plasmodium falciparum, the species responsible for the potentially fatal form of malaria, is gradually developing resistance to anti-malarial drugs. Drug resistance is a major public health problem, and concerns a growing number of drugs. The situation is especially alarming as only a few new anti-malarial drugs are currently being developed. Following an appeal by the WHO and health ministers of 102 countries for a world malaria control strategy, the IRD is committing more resources into its research programmes on anti-malarial drug resistance, notably in the evaluation of the efficacy of currently available drugs or pre-clinical testing of novel candidate drugs, and the analysis of the molecular basis of drug resistance.



DNA sequencing reveals a mutation of the resistance gene

This research was conducted in close partnership with one of the leading research centers in Francophone Central Africa, Oceac (Organisation for the Coordination of Endemic Disease Control in Central Africa) in Yaoundé, two CNRS (National Centre for Scientific Research) research units (in Montpellier and Gif-sur-Yvette) and the Institute of Tropical Medicine of the French armed forces health service in Marseille (IMTSSA). Financial support for the research projects and for training of African technicians, researchers, doctors and students was provided by the WHO, the French Research Ministry, the French Aid and Cooperation Fund, the Universities Agency for the French-speaking World (AUF; formerly Aupelf-Uref), the European Union and pharmaceutical firms.

The IRD's work confirmed that chloroquine is now only slightly effective in Central Africa. Of the drugs currently available at affordable prices for local populations, amodiaquine and, to a lesser extent, sulfadoxine-pyrimethamine are suitable for treating chloroquine-resistant malaria. As regards new anti-malarial drugs, the most significant results were obtained with pyronaridine, both *in vitro* and in clinical trials (which demonstrated good tolerance and high efficacy against chloroquine-resistant malaria in Cameroon). As a result of IRD's research, developing pyronaridine to international standards and bringing it onto the market have become one of the WHO's priorities.

IRD researchers screened many new compounds using the *in vitro* model of *P. falciparum*. Some of them were identified as potentially useful candidates, especially a new class of compounds that inhibit the parasite's phospholipid metabolism, developed by the CNRS in Montpellier.

As part of its mission to transfer new technology in the field, the IRD introduced a new programme on the genetic analysis of drug-resistant genes. The sequence data allowed the researchers to confirm or weaken certain hypotheses on drug resistance. They have excluded the role of some parasite's genes in the emergence of drug resistance and confirmed that there is a link with other genes. Genes, identified after a thorough evaluation of correlation between *in vitro* and *in vivo* data, are now being used as markers for drug resistance. In future, these markers may be used to improve the epidemiologic description of drug resistance, and monitor its development in time and space.

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Malaria in pregnancy: how can it best be treated?

Immune defence mechanisms are temporarily depressed during pregnancy, while in children they develop gradually during the first few years of life. This makes pregnant women and small children particularly vulnerable to malaria infection: they are the most high-risk groups among populations exposed to malaria around the world.

The IRD is studying the impact of the disease on the mother-and-child duo in widely differing bio-geographical situations: the Sahel, Sudanian savanna, equatorial forests and uplands. In the past ten years over 7000 pregnancies have been studied and many cohorts of pregnant women and children have been monitored in Burkina Faso, Cameroon, Madagascar and Senegal - all these being countries where the disease is endemic.

On the public health side, it was found that in zones where the endemic is stable, such as Burkina Faso and Cameroon, pregnant women are indeed more susceptible to malaria infection than the general public, especially if it is their first pregnancy (depending on the zone, parasites are present in the placentas of between 10% and 50% of women giving birth), but maternal morbidity is not particularly high apart from anaemia, which is often mild. The only major repercussion is that placental infestation increases risk for the newborn baby owing to low birth weight, an indirect cause of neonatal morbidity and mortality.

In zones where the endemic is not stable (on the margins of Madagascar's high plateaux), the risk of malaria infection is markedly lower but the clinical impact on the mother is much more acute, probably because her immunity is less well developed. Where there is placental infection, the risk of a low birth weight is quintupled.



A pregnant woman has her health check-up, Cameroon

These findings show that, whatever the intensity of transmission, malaria is a major risk for newborn babies and should be prevented by administering a prophylactic treatment as soon as pregnancy is confirmed. Such preventive treatment is effective if properly administered, but this can be a problem because pre-natal follow-up is poor in developing countries. Furthermore, the spread of malaria parasites' resistance to the least toxic and most affordable drugs such as chloroquine and the sulfadoxine-pyrimethamine combination has to be taken into consideration in each country and area specifically, in close collaboration with the local health authorities.

On the biological side, the latest IRD research in Cameroon has investigated the "sequestration" process, the trapping of parasite-carrying red blood cells in the villi of the placenta, which may explain why, in countries where the endemic is stable, infection is more frequent and more intense during a first pregnancy than in later pregnancies.

The presence of mature parasites in the placental blood of the mother would suggest that the parasites may be trapped in the placenta because the red blood cells that carry them adhere to the cells coating the placental villi. Called cytoadhesion, this phenomenon has been much studied in connection with cerebral malaria, an often fatal form of *P. falciparum* malaria, which involves a bond between the molecules (ligands) on the surface of the parasite-infected blood cells and other molecules, the receptors, on the surface of blood vessels.

After making an *in vitro* culture of syncytiotrophoblasts - the cells that coat the placenta - the team revealed the presence on these cells of a receptor involved in cytoadhesion of cells in the tissue coating the blood

vessels (endothelium): chondroitine sulphate A or CSA. The team then demonstrated that the only ligand that could be found for this receptor was on parasites taken from pregnant women (as opposed to men or non-pregnant women) and that it is therefore probable that the sequestration of the parasites in the placenta is due to adhesion to the CSA of the syncytiotrophoblasts. Lastly, monitoring Cameroonian women during two successive pregnancies, the team found that the pregnant women's antibodies against the parasite were more abundant in the second pregnancy than in the first, and that malarial infestation of the placenta was followed by the development of immune response cells which specifically recognised a strain of parasite that adheres to the CSA.

These studies, showing the existence of a sub-population of parasites specially adapted to the placenta and of a process involving CSA by which parasite-bearing red blood cells become trapped, open new prospects for prevention. This could either be direct prevention by a molecule administered during pregnancy, or could involve a vaccine based on the parasite ligand and adhering to the CSA in its place. Integrating this approach with field research by epidemiologists, it should be possible in the near future to considerably improve pregnant women's protection against malarial infection and above all reduce the impact on newborn babies. This is a priority public health objective, since an estimated two billion individuals are currently exposed to this disease, which causes an estimated two to three million deaths a year, mainly among young children.

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■ Recession and nutrition in urban Africa

For fifteen years now, the international community has been concerned about the impact on health and nutrition of the various economic difficulties that developing countries have endured and the resulting structural adjustment policies. The IRD's Nutrition laboratory, a WHO collaborating centre, has been studying trends in the nutritional situations of African cities since the mid-1980s. Recently it focused more particularly on the nutritional consequences of the 12 January 1994 devaluation of the CFA franc, which concerned fourteen African countries. It was feared that this 50% devaluation of the local currency would have an impact on health and nutrition, especially in urban areas where poverty is increasing constantly and where the population, who are very dependent on the monetary system to acquire their staple foods, were already in a vulnerable position due to several years of recession. Yet there have been very few studies of the impact of the devaluation.

IRD researchers conducted two similar nutritional surveys in two city centre districts of Brazzaville, capital of Congo, before and after the devaluation. Both surveys took samples of children aged 4 to 23 months (the sample sizes being respectively 2623 and 1583) and their mothers and families. A synthesis of the surveys was published recently in the WHO bulletin*; it reveals a significant deterioration in the nutritional situation.

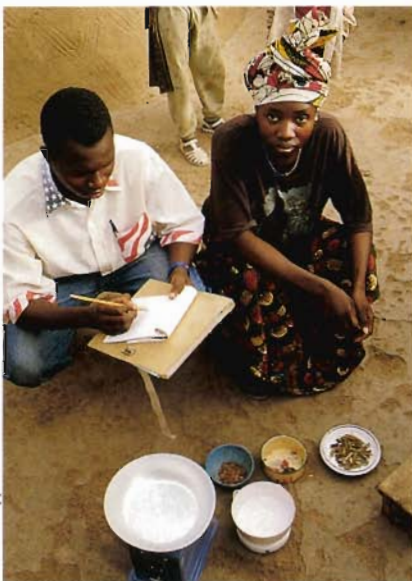
In children, the "height-for-age" index, below a certain threshold, defines statural growth retardation, or "stunting". This index is regarded as a reflection of the individual's general living conditions and one of the best approximate indicators of a country's socio-economic development. In Brazzaville, the stunting worsened significantly between 1993 and 1996, from 12.1% to 15.5%. Another index, the "weight-for-height" index, which below a certain threshold defines "wasting", is more sensitive to recent changes in nutrition or the child's state of health. The percentage of wasted children also increased significantly in Brazzaville after the devaluation of the CFA franc, from 6.0% to 8.8%.

Among the possible causal factors for the nutritional deterioration in young children, the foremost is the nutritional status of their mothers, which had also declined since the devaluation: their body mass index fell by an average 1.3 kg/m², i.e. a loss of 3.3 kg for a

* Deterioration in the nutritional status of young children and their mothers in Brazzaville (Congo) following the devaluation of the CFA franc. Y. Martin-Prével, F. Delpeuch, P. Traissac, J.-P. Massamba, G. Adoua-Oyila, K. Coudert and S. Treche - Bulletin of the World Health Organization, 2000, 78 (1), p. 108-118.

1.6-metre woman. As a result there was also a decline in their children's birth weights, a factor which aggravates retardation in statural growth. However, statistical analysis showed that the maternal factor was only part of the story. The children's diets also played a part: households reported that they had completely stopped buying a certain number of products that had become too expensive (chicken for 51% of households, bush meat for 50%, freshwater fish for 30%). A sharp deterioration in the quality of complementary foods was also observed: the foods given to children aged 4 to 11 months were less often suited to their specific needs (gruel or special dish); imported commercial flours, of better nutritional quality than those produced locally, were used less often than before. It is now recognised that a low-quality complementary food is an important factor of malnutrition in young children. Another survey, analysed with the World Bank, revealed that household food expenditure fell by 40% after the devaluation.

As regards public health factors, an increase in the prevalence of childhood diarrhoea from 8.0% to 11.0% was recorded in Brazzaville, reflecting a deterioration in hygiene and environmental conditions. A considerable drop in attendance at preventive health services (growth monitoring, vaccinations) was also recorded. Here several factors were involved: health services were of poorer quality and less accessible socially and financially, so that mothers were less inclined to have their children monitored; mothers were overworked, and more often obliged to bring in extra income to the family and so having less and less time to devote to their children. The analysis also showed that the drop in attendance at preventive health services had a major mediating effect on the drop in the "height-for-age" index observed in the children.



© IRD/Philippe Chevallier

Weighing food as part of a food survey in Bissa country

On the whole, these studies showed that, apart from results considered positive in terms of macro-economic indicators, the devaluation of the CFA franc had an undeniably negative impact on the well-being of the population, at least in the short term. The longer term effects may also be negative, given what is now known about the repercussions of childhood malnutrition throughout a person's life: reduced learning ability, lower productivity in adulthood, increased susceptibility to chronic illness, etc. This has direct implications for public policy and argues for special intervention in the nutritional field, especially in situations of economic and social hardship.

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■ Territory, mobility and identity dynamics: surveys in town and forest in Pacific Colombia

The Pacific coast of Colombia is an equatorial zone of rainforest, rivers and mangrove swamps, stretching for 800 km from Panama to Ecuador. About 90% of the population is black ("nativos"), the remaining 10% being Amerindian with a few whites.

The new situation in Pacific Colombia

Pacific Colombia remained isolated from the economic and cultural mainstream for very many years, but since the early 1980s a combination of developments has disrupted the old pattern:

- Agro-industrial plantations, logging operators and traders are increasingly dominant in the region's new organisation, while the earlier system, based on mining, gathering and small-scale farming has collapsed;
- Rural out-migration has accelerated and shantytowns have sprung up in the coastal towns Tumaco and Buenaventura and the regional capital, Cali, where the Afro-Colombian population is now estimated at 27.5%;
- In 1993 the government introduced the so-called "ley de las negritudes" ("Blackness Law", or Law n° 70), which was intended to ensure that the new principles of multicultural and pluri-ethnic emphasis in education and land tenure, introduced by the 1991 Colombian Constitution, were applied in the Pacific region;
- The region is beleaguered by drug traffickers who force the farmers to grow coca, and by guerrillas and paramilitary forces that compete for control of the coca-growing areas, giving protection while extorting a profit.

This influx of new economic and political actors on a massive scale has created a terri-

torial mosaic in the region, endangering the nation's multi-cultural project in a country where civil war and violence were already deeply ingrained. To gain an understanding of the particular situation of the region, which had been little investigated previously, an IRD team conducted multi-disciplinary research in 1996-1999, in partnership with the CIDSE (Centro de Investigación y Documentación Socio-Económica). The research was based at the Universidad del Valle in Cali. Surveys on migration and living conditions were conducted in Cali and cultural, sociological and political information was gathered in coastal areas, mainly around the coastal towns of Tumaco and Giuapi in the south.

Changing relations between territoriality and mobility

Previously accustomed to high mobility and uncertain access to land, the Pacific coast populations settled more permanently in the twentieth century, in step with the region's successive modernisation phases. Little by little, the creation of large plantations and extensive grazing lands, infrastructure building and boundary-marking for land that has only now been declared black or indigenous "community" land, have engendered a more static relationship with geographical space than before. New settlements have sprung up, ranging from farm-workers' camps and roadside villages to towns, helping to give the territorial aspect a central place in social and political life -just when the farmers have lost their former pattern of land tenure and find themselves without any real home ground with which to identify.

Between integration and segregation: the black and mulatto people of Cali

As regards the specifically "racial" aspect of segregation, the forms and intensity of social and spatial segregation vary from group to group. While Afro-Colombians as a whole have suffered only mild residential segregation, those individuals seen as black are far more sharply affected. As regards professional discrimination the survey's findings were unequivocal: 65% of respondents, whatever their colour or tint, asserted that this is practiced, and 55% that black people are the most frequent victims. Twenty-four per cent of black and mulatto respondents described discrimination against themselves, and this percentage was 32% among people with a black phenotype.

Undecided identities

Identity groups are inseparable from the contexts where they arise and the issues they crystallise around. Since Law 70 was passed

in 1993, to have access to land a person must demonstrate their cultural and territorial identity. Overnight, the black people of the Colombian Pacific became an "ethnic group" by law, the notion of black identity being based on the collective and ethnic model of the Amerindians in the "resguardos" (reserves). Marking out the boundaries of uncertain territories, the actors defined a new culture by transforming the region's various beliefs and collective memories.

For people long excluded from national society, this neo-communitarian strategy could mark the beginning of a minimum recognition of their existence and rights. But it could also lead to a new form of confinement, restricting people's individual access to citizenship in the long run. As soon as one shifts the focus from the collective to the individual, existential aspect, this "black" identity is more ambiguous: is it racial? ethnic? cultural? When people were asked directly how they identified themselves in terms of skin colour, they tended to neutralise racial cleavages: instead of saying "negra, mulata, blanca", 53% used such euphemisms as "canela, trigueña, café", etc. Responding to the question of ethnic membership in the national census, it was in the Choco administrative Department in the first quarter of 1993 that the greatest numbers declared a "black identity" -i.e. precisely the time and place where gaining access to rights was most important to "black communities". And in our survey, the way people identify themselves clearly depended on the interview situation. If the respondent saw the investigator as a black person, they gave a "blacker" response, talking more about racial discrimination and describing their own skin colour as darker. But if they saw the interviewer as white, they gave "whiter" responses. From the outset, the research programme made an effort to involve the people concerned in conducting surveys and presenting results. This put some representatives of community territories and ethnic, cultural or local organisations in an ambiguous position, part of the research subject but also involved in the research. Nonetheless, training the "local" and "community" survey interviewers and researchers proved to be one of the programme's most promising results.

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■ Identity issues: ethnic minorities in Laos

Tragic conflicts around the world are a daily reminder that identity issues weigh heavy in the development balance. This problem is the core focus of the IRD's "identity issues and strategies" programme. All over the world, people are seeking to assert their eth-



Ta Oy minority, Saravane province, Laos

nic, cultural, religious or regional identities; the international organisations regularly relay their claims, and governments must now take account of them in their development policies. In Latin America, Africa and Australia, for example, as territorial, economic or cultural demands multiply, so do ethnic or indigenous-group organisations that tend to become unavoidable political forces. Elsewhere, latent identity issues can come into the open in a more limited way - in Southeast Asia, for example, where governments generally think it necessary to keep tight control over ethnic dynamics.

This is particularly the case in Laos, where almost half the population is classed as belonging to the "ethnic minorities" that people the hills (two-thirds of the country's land area). Managing its multi-ethnic population a major political preoccupation for the government, which must take account of linguistic and religious aspects as well as development issues. There are forty-eight officially recognised ethno-linguistic groups; unlike the Lao "majority", most of the "minorities" are not Buddhist; and disparities in development levels are growing.

All the indicators show that the economic and social gap between lowlanders and highland minorities is widening. Having access to communications, the lowland people are increasingly being drawn into a market society while the highlanders stay in their remote homelands in worsening living conditions: nearly 30% of the population lives in villages or districts that are inaccessible a large part of the year.

The Lao government has recognized the problem and is trying to draw the ethnic minorities into the national development through integration policies:

- economic integration: at the same times as it tries to drastically reduce the practice of slash-and-burn farming, the government is

trying to push villagers from a subsistence economy towards a market economy;

- territorial and social integration: to reduce the isolation of some minorities and give them access to health and education services etc., a policy has been introduced to relocate villages, in the lowlands or along communication routes (earth tracks or rivers);
- cultural integration, with the promotion of a national culture (essentially based on Lao culture). The Lao language, which many highlanders still speak poorly, is promoted (the Ministry of Education does not allow teaching in minority languages), and national or regional folk dance, song and handicrafts are encouraged and are supposed to condense the whole country's multi-ethnic cultural heritage.

These integration policies are hampered by numerous factors, partly because development decision-makers know little about the minority cultures and partly because proactive attempts to implement policy are often inappropriate and have the opposite effect to the one desired.

It was against this background that from 1993 to 1999 the IRD supplied expertise, to gather basic ethnographic knowledge of some particularly little-known ethnic groups and provide a clearer identification of problems arising from the integration policies. The researchers conducted field work among the Austro-Asian minorities (the oldest inhabitants of this part of Asia) in Saravan and Sekong in the south of the country and Oudomxai and Luang Namtha in the north. The programme results showed that some of the official objectives for health and education were unsuitable; they helped to define and set up a non-formal education policy, including the use of local languages, better suited to the situation of the hill communities. Above all, through a multi-

disciplinary study in six provinces, involving ethnologists, economists and agronomists, it revealed the adverse effects of the village relocation policy. These include irreversible social and cultural disruption among the minorities, and often disastrous economic results as land use pressure increases in the valleys and food security problems worsen.

This study made a real impact; the UNDP published a report, and the government decided to organise a national conference on the issue. The IRD programme also initiated discussions and reflection on how to protect the cultural heritage of ethnic minorities in Laos, leading to an international seminar in Vientiane under the auspices of Unesco. In all its fields of work, the IRD made sure to involve local institutions (the education, health and culture ministries), which were aware of the problems and glad to have outside expertise available. There was also collaboration with NGOs such as Médecins sans frontières and Écoles sans frontières, and long-term formal consultancy was supplied to international United Nations organisations, mainly the UNDP and Unesco.

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■ **The Madio project in Madagascar: statistical information and democratic debate on economic policy**

The scientific partners in the Madio (Madagascar-Dial-Instat-Orstom) project are the Malagasy National Statistics Institute, Instat, and the IRD. The aim is to study the conditions for success in the dual process of economic and political transition now under way in Madagascar. The project was introduced in late 1994 and the first phase was completed in mid-1999; financing agreements with the European Union and the French Development Cooperation Ministry provided a total of five million French francs.

From a group of eight researchers at the start, the Madio team increased to twenty in 1999, with seven from the IRD, two from Instat and eleven on contract, including nine



The MADIO project

Malagasy statistician-economists. Dial's researchers also work in close collaboration with the project.

Madio works on two fronts: promoting economic analysis in Madagascar and rehabilitating the country's statistics system according to five main functions: statistical surveys, establishing macro-economic models, economic studies, designing a policy for utilisation and dissemination of results, and helping to train local managers.

The project has achieved positive results in all these fields. Its many scientific achievements are solidly established, while its social usefulness and the recognition it has won have been praised by all the main partners and users*. It has been an important contribution to the economic analyses and statistics financed by donor bodies in recent decades.

Most of the implicit functions one can expect of a cooperation project were fulfilled, such as high productivity, innovation, making a demonstration for the professional environment, and reproducibility by local staff. Besides the figures themselves, the fact that at Instat's request the project's financial backers agreed to extend the programme for three more years (1999-2001) is clear proof of the recognition it has won.

Innovation and knowledge dissemination: mobilising civil society

Innovation was at the heart of the project's activities: producing and disseminating new knowledge, methodologies and original forms of organisation, etc. In particular, Madio proposed an original way of linking statistics production, economic analysis and dissemination. Statistics production was put at the service of economic analysis, and this technical knowledge in turn was subordinated to disseminating and publicizing the information. The effort that went into utilisation of the survey results, with economic studies, public presentation, publication of a journal, etc., paid off well. Survey results were produced in real time, and the thematic

analyses based on them aroused much interest, generating positive feedback in the form of fresh resources for further surveys.

The Malagasy media were keen to obtain the project's scientific results, publishing about 500 press articles about them. This too had a boomerang effect: the authorities took a lively interest in the issues Madio raised. This way, bringing civil society into the process fulfilled a dual function: project outputs were tested by the judgement of the demand side (a direct expression of its social usefulness), and generated demand that the State provide results from its policies.

Capacity-building for scientific communities of the South

Among the many lessons to be drawn from the Madio experience there is one of special interest to the IRD: capacity-building for scientific communities in the South, in Africa especially. Rather than rely on a few confirmed research professionals (exceptional people, many of whom received their training before the crisis of the 1980s), the project decided at the outset to form a team of young graduates and give them practical training in research skills. The IRD researchers were deeply involved in this work.

Since mid-1999, Madio has moved into a new phase, with local researchers taking over after the withdrawal of expatriate IRD researchers. This will test a new form of partnership, with short support and follow-up missions in place of the usual permanent technical assistance. Apart from financial support from the project's donors, the IRD's contribution to the project will rely on a more "horizontal" partnership, as associate research laboratory to a Malagasy research unit currently being formed.

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Fertilising vanilla in Madagascar

© IRD/Isabelle Droy

© D.R.

* Le projet Madio à Madagascar. Stateco (Insee, France), n° 94-95, 2000, 215 p.

EXPERTISE
AND
CONSULTING



Centimetre-range emerald in a calcite cavity (Cosquez, Colombia)

To fulfil the missions the IRD was given in the 5 November 1998 Decree, we need to make two types of economic use of our work: "contribute to the economic, social and cultural progress of developing countries", and achieve the best economic return on our research findings by acquiring intellectual property rights and creating businesses under the July 1999 innovation law.

The Expertise and Consulting department assists the IRD's operational units in organising Collegial Expertise, filing patents, setting up businesses and making best use of competencies through consultancy work.

Collegial Expertise

As the world becomes ever more complex, so too does decision making. The decision-maker needs access to a comprehensive review of knowledge concerning the issue to be decided, so as to cope impartially with pressures and lobbying of all kinds. Producing comprehensive reports on the state of the art, with a working summary of available solutions and differing opinions, is a task for research professionals who cover all the disciplines the problem involves.

The IRD acquires the means to answer any fair inquiry from decision-makers who need a report on the issues, knowledge and gaps in knowledge affecting a question to be decided; this is a practice first developed by

Inserm. These state-of-the-art reports with summaries of knowledge available throughout the world, drawn up by a group of internationally renowned experts from within the IRD or outside, are called "Collegial Expertise".

The first Collegial Expertise reports, undertaken in 1999, covered the following questions:

- How can the control of malaria and other water-related vector-borne diseases be integrated into development projects with environmental impact in Cameroon? The question to be examined by the group of experts is whether consideration of these diseases at the design stage of a development project might lower healthcare costs without increasing project costs.
- Mercury in Amazonia: the contribution of human activities to mercury contamination of people and the environment. Mercury is naturally present in the soil of the Amazon basin, but is only toxic in the form of methyl mercury. This form is produced in an anaerobic aquatic environment, and then progressively accumulates through the aquatic food chain. Although gold washing is one source of methyl mercury, the major sources appear to be deforestation and conversion of forest to farmland, laying bare the ground and so making the mercury in the soil available for methylation.

Economic return on research findings

Intellectual property

Filing patents both protects our research findings so we can retain control of their use, for our partners' benefit particularly, and protects our partners' interests when they cannot afford to file and maintain patents or have no legal status to do so (as in the case of local communities). One example is the patent on the gene for rice yellow variegation held jointly with WARDA.

At present the IRD handles 33 basic patents (6 filed in 1999) and 5 trademarks (2 registered in 1999).

In compliance with its missions, the IRD acquires funds through co-operation contracts with major biotechnology and other industrial firms. Often, these involve innovative forms of co-operation between public research and private enterprise.

One significant example is an agreement with four rubber companies, for research into a rubber-tree disease (see box). Another is a major contract between the IRD, CIMMYT in Mexico City and the Limagrain, Pioneer and Novartis seed companies, for research into maize apomixis; developing countries should benefit from the findings of this work.

Some contracts can increase the impact of findings up to tenfold. An example of this is the work that began in 1999 with Proteus, a firm that holds an enzyme screening patent. The IRD possesses extensive collections of bacterial strains, particularly extremophilic strains, and is studying their taxonomy, through the co-operation with Proteus, the IRD can more quickly discover the industrial potential of its strains.

Thirteen new application contracts were signed with the private sector in 1999, showing that findings from basic research can directly meet demand from industry. One illustration is the study of emerald deposits carried out as part of the IRD's geodynamic study of the Andes. An ion microprobe developed to study the formation of the solar system was used to determine the O^{18}/O^{16} ratio of the emeralds, which is a specific signature of each deposit. With this test, the producing countries can certify the origin of their gemstones. Now that a contract has been signed between the CNRS, IRD and the gemmology laboratory of the Paris Chamber of Commerce (sole body in France competent to authenticate gemstones), the laboratory will be able to regain its former position as a world-class expert.



© IRD/Genève/ Michon

In a traditional agro-forest under rubber trees

Agreement with rubber companies for research into a rubber-tree disease

In 1999, companies that own or manage tropical rubber plantations became aware that bark necrosis is becoming more and more widespread. The IRD had already done research on this topic in Africa in 1982-87, finding out about the biological characteristics of the disease. Other studies covered the biochemical characteristics of the bark and latex and soil-plant relations.

This knowledge and the new methods and tools for molecular analysis now available make it possible to resume the research, now further justified by the international economic repercussions of this disease.

On 17 November 1999, the Institut Français du Caoutchouc, Michelin, Socfinco and the Société Internationale de Plantations d'Hévéa signed a co-operation agreement with the IRD to find ways of alleviating the effects of dry cuts on rubber trees. The IRD's work will involve about ten researchers in different fields: physiologists, phytopathologists, agrope-dologists, virologists, geneticists, etc.



© IRD/ Yves Savillan

Apomixy does not generate uniformity, as can be seen from these two very different Tripsacums. The large one is *T. andersonii*, the small one *T. meridionale*

Business creation

In partner countries, it is important to make economic use of research findings locally when they are of immediate value to local communities and, in partnership with local operators, this can lead to the creation of small firms, solving a particular problem and creating viable jobs at the same time. Three enterprises have been created in Vietnam and one in Mali to produce food supplements.

In France, the Innovation Law permits innovative enterprises to be created to make economic use of research findings. For example, Probiotech was registered in 1999 and operates from the premises of the IRD centre in Montpellier.



© IRD/Tangy Joffre

Example of *Gymnostoma deplancheanum* shrubland in a mining area of New Caledonia

Making economic use of competencies

The IRD's economic exploitation of its scientific and technical competencies is at present mainly in the form of consultancy, i.e. co-operation for a fixed period with contractually defined results. Our policy at the IRD is to aim for forms of co-operation that are likely to generate scientific spin-off for us, rather than do work that can equally well be done by private consultancies.

Co-operation with private enterprise

Consultancy may be either

- institutional, when the request is made to the IRD *per se*, whose scientific guarantee is required. In this case, it is the IRD that signs the contracts, organises the team of consultants and approves the final report; or
- private, when IRD consultants are put in touch with "customer" firms or organisations. In this case, the IRD takes no responsibility, but authorises the staff member to carry out the consultancy required.

An "IRD Consultant" procedure handles requests for consultancy. With team incentives, a proportion of the revenues is allocated to the research funds of the team concerned.

In 1999, 35 consultancy operations were authorised, 11 of which were private consultancies. The main fields covered were the environment in the widest sense (15) (inventory, impact study, resources), health (7) and fisheries (4).

Institutional consultancy included:

- Mapping wetlands on the coast of French Guiana

To prepare for forthcoming quarrying work, these wetlands were classified into three vulnerability groups according to water dynamics, type of vegetation and soil. Maps were produced from the regional remote-sensing laboratory's collection of satellite images and a classification of the various types of environment identified. (Contract with the French Guiana department Environment Directorate)

- Erosion control in the Caravelle nature reserve, Martinique

The Martinique regional nature park has set up an erosion-control system to stop the spread of bare areas, restore stripped topsoil and natural plant cover, and reduce sedimentation in the coral shallows of the Baie du Trésor. The consultancy report on erosion control stressed the role of vegetation and the importance of developing and restoring it, and the need for some specific research. (Contract

with the Martinique regional nature park)

- Inventory of flora at a future mineral works in New Caledonia

To have its pilot factory for processing nickel-bearing laterite approved, Inco asked the Nouméa IRD centre to assess the risk to vegetation near a doline intended to receive industrial effluent, and to lay out a permanent array of plots to monitor vegetation during the factory's lifetime. (Contract with Inco)

Making economic use of scientific information

The IRD possesses a large number of scientific databases of widely varying size and nature. Some - on climatology, seismology, hydrology, fisheries, etc. - are of strategic value for research, industry and development bodies.

The Fines/Fiores database lists the research directors, researchers and graduate scientific and technical support staff who may be called upon for consultancy work. IRD staff volunteer to have their names listed. In 1999, 88 names were added, making a total of 468. This amounts to 47% of all IRD staff in the staff categories concerned; research directors have the highest representation (69%), while only 13% of *ingénieurs d'études* are listed in the database. ■

SUPPORT AND TRAINING
FOR SCIENTIFIC
COMMUNITIES
IN THE SOUTH



Geophysics students learn to look for water in a Sahelian environment

© IRD/Michel Dubliant

Through the department of Support and Training for Scientific Communities in the South, the IRD is giving new impetus to its policy of helping to build up research potential among its partners in the South.

The department's aim is to encourage the creation of a high-quality scientific fabric in the countries of the South, both to help them in their process of development and ultimately to build real partnerships on an equal footing between teams in North and South.

Rather than merely transferring knowledge, the department intends to focus on stabilising centres of scientific competency; it has begun to take an overall, collective approach to the support it offers. For example, support or training for individuals (doctoral and post-doctoral grants) should help strengthen an existing or emerging research team or laboratory.

Support for teams and institutions will make them more effective by improving their material and scientific environment.

With this overall vision, support actions will be coherent and complementary, both scientifically and geographically. But arrangements of this kind can only be effective if they are based on excellence, so it is essential to have proper procedures for *ex ante* and *ex post* assessment.

The needs of the Southern scientific communities are many and varied; to respond to them, the department must support institutions, strengthen teams and laboratories, and help individuals. It must work not only with IRD researchers but also the whole French scientific community, partners in the South, donors and development co-operation agencies. 1999 was a year of transition. We had to ensure continuity in the

forms of support we offer our partners in the South while reorganising procedures to achieve greater consistency in IRD action.

In 1999, the IRD committed FF 9.3m to individual support, broken down as follows:

- Support for doctoral students (FF 4.8m): 121 research scholarships were awarded to 58 students from sub-Saharan Africa, 15 from North Africa, 41 from South America, and 7 from Asia. They worked on their theses under programmes run by the IRD and its partners.
- In-service training grants (FF 1.5m): these allow Southern scientists to take diploma courses or retraining, according to the needs of our partner institutions; 47 such grants were awarded (32 Africans, 7 South Americans, 8 Asians).
- Support for research (FF 2.7m): grants were awarded to researchers who wanted to exchange with other scientific commu-

Grant recipients in 1999

	In-service training	Scientific placements	Scholarships	Total
Sub-Saharan Africa and Indian Ocean	27	33	58	118
Latin America and Caribbean	7	22	41	70
North Africa and Middle East	5	3	15	23
Asia / Pacific	8	3	7	18
Industrialised countries			7	7
	47	68	121	236

nities, participate in discussion groups, help plan co-operative programmes, or have access to the laboratories and technologies they needed for their research. Sixty-one researchers from the South were given grants.

Thanks to a one-million-franc grant from the Ministry of Foreign Affairs, operating assistance was provided for Southern researchers working in association with the IRD, mainly in Africa. Twenty-five projects were approved out of the 54 submitted for assessment after a call for proposals.

The department has begun to develop other forms of support for scientific communities in the South. In 2000, its first full working year, the department's objectives will be strengthened and focused more clearly on the central task of strengthening and stabilising centres of competence in the countries of the South. All grants, even those to individuals, will be aimed at building up teams in the South. Stress will be placed on ways of encouraging regional co-operation in the South: training in their own regions, scientific postings, exchanges, etc. To that end, the DSF has reorganised its system of scientific co-operation and support for Southern partners into three strands: support for individuals, support for teams, and support for institutions or networks.



Demonstrating rain simulation methodology to managers and technicians from the Ministry of Agriculture in Quito

© IRD/Jean Asseline

Support for individuals

Initial training, for DEA or doctoral students.

■ *pre-doctoral internships*

The department can finance DEA internships that fit into the research programme of the IRD tutoring team.

■ *research scholarships*

These are two- or three-year scholarships for doctoral students from countries in the South.

In-service training

This training is for non-French researchers, engineers and technicians. The programme and schedule are specified (12 months consecutively or spread over 4 years) and the training leads to a diploma or certificate.

Support for research

This support is intended for young or experienced professionals, with the aim of consolidating scientific communities in the South and encouraging scientific exchanges. Host teams may be at the IRD or elsewhere.

Scientific placements in 1999

	Recipients	N° of months
Sub-Saharan Africa and Indian Ocean	63	198
Latin America and Caribbean	30	88
Arab countries and Middle East	12	37
Asia / Pacific	11	28
Industrialised countries	7	15
	123	366

There are three types of support:

■ *Short scientific placements*

These last at most 12 months (consecutively or spread over 4 years), and enable researchers from the South to be posted to France or another country, so as to encourage scientific exchanges and co-operation between teams.

■ *Post-doctoral grants*

These grants enable recent PhDs of recognised quality from developing countries who have not yet been appointed to a research institution to remain within the French research system for two years, renewable once.

■ *South-South mobility*

These postings are intended to encourage scientific exchanges between developing or emerging countries in the South, and co-operation between these countries and French scientific institutions. They last two years, renewable once, and help to develop networking among centres of competence in particular regions.

The final quarter of 1999 was spent devising the applications system for these types of

support, using new assessment procedures that, according to the type of grant, take into account not only the scientific quality of a candidate's application but also their membership of a team and the likelihood of strengthening a centre of competence.

Support for teams

Priority goes to support for young research teams, and is not necessarily linked to the IRD's research priorities and programmes.

To that end, the department houses the secretariat of the scientific partnership grouping Aire développement. A joint creation of eight research bodies, this grouping identifies and supports young research teams in the countries of the South. After inviting applications, Aire développement selects research teams and helps them for six years, with interim assessments every two years. This financial and scientific support is intended to help the teams join their own country's scientific community and be recognised in the international scientific community.

The French Ministry of Foreign Affairs has asked the IRD and the African council for the development of social sciences in Africa

(Codesria) to manage and lead a project to revitalise the social sciences in Africa. Applications will be invited for teams of researchers from North and South to work on innovative topics. This project will identify and support social science teams and centres of competence in sub-Saharan Africa.

The IRD has also been asked by the Ministry of Foreign Affairs to handle the administration and organise the scientific management of its Campus programme. Campus supports research projects designed and executed in partnership by African and French university teams.

Institutional support

This strand of DSF activity is at present under construction. Initially the department will be supporting a few pilot projects to help training systems or research laboratories, in order to explore what forms of support might later be proposed in calls for proposals. This support would be contractualised and last 2-4 years. ■

Partners

Chapter 2



THE IRD
AND
ITS PARTNERS



Latimeria menadoensis, the new coelacanth species discovered in Indonesia

© A. Tjabrawidjaja

By the very nature of its development research mission, the IRD is bound to form numerous partnerships of different kinds. Its status as a research establishment naturally requires it to maintain close ties with the scientific communities of France, the French overseas dependencies, countries in North and South, and international bodies.

France

The IRD is increasingly integrated into the French scientific community via its active partnerships with universities and major public and private research establishments. These relations are a way of mobilising the community for more co-operation with countries in the South, and also foster access to training in research.

The IRD takes part in French national programmes, scientific partnerships, joint laboratories and joint research units.

Examples are:

- 8 national programmes involving the Earth and Environment and Living Resources departments;
- 17 research partnerships (*Groupements de recherche* or GDR), scientific interest partnerships (*Groupements d'intérêt scientifique* or GIS) and public interest partnerships (*Groupements d'intérêt public* or GIP);
- 15 joint laboratories and joint research

units, mainly with Cémagref, Cirad, Ensam, Ifremer, Inra, Météo-France and the University of Provence.

In 1999, four initiatives were taken to strengthen the relationship with institutions in France:

- voting rights in the IRD's evaluation and research management commissions and its scientific council were extended to all researchers concerned with development, thus virtually doubling the electorate;
- 30 researchers from universities and research bodies were working on IRD premises, 19 of them new to the IRD;
- new agreements were signed with the CNRS, the Conference of University

Presidents, the Grandes Écoles conference and numerous universities. Since 1998 there have been 18 new agreements. They confirm reciprocal voting rights, lay down a new framework for scientific co-operation, declare the partners' intention to develop training and support for scientific communities in the South, and encourage guest posts and tutorship for students and researchers from these communities;

- a call was issued for proposals to set up new research and service units, with preference going to partnerships with universities and public research establishments. Altogether, 117 proposals were submitted for evaluation (96 research units, 21 service units).

National programmes

Programme national d'étude de la dynamique du climat, PNEDC (*climate dynamics*)

Programme national "Processus biogéochimiques dans l'océan et flux", PROOF (*biochemical processes in the ocean, and fluxes*)

Programme national déterminisme du recrutement - Globec-France, PNDR - Globec (*recruitment determinism*)

Programme national d'études côtières, PNEC (*coastal studies*)

Programme national de recherche en hydrologie, PNRH (*hydrology*)

Programme national sur les risques naturels, PNRN (*natural hazards*)

Programme de recherche sols et érosion, PNSE (*soils and erosion*)

Programme national de télédétection spatiale, PNTS (*satellite remote sensing*)

Research partnerships (*Groupements de recherche, GDR*)

GDR Ecofit

GDR Ecologie des sols tropicaux

GDR Métallogénie

GDR Marges

GDR Interférométrie

GDR Géoscope

Partnerships of scientific interest (GIS) or public interest (GIP)

GIS	Aire développement	Agence pour l'investissement dans la recherche à l'étranger (<i>foreign research investment</i>)
GIS	Amérique latine	(<i>Latin American research</i>)
GIS	Ceped	Centre français sur la population et le développement (<i>population and development</i>)
GIS	Dial	Développement des investigations sur l'ajustement à long terme (<i>long-term adjustment</i>)
GIS	Géno plante	(<i>plant genome</i>)
GIS	Silvolab	Etude des bases physiques et biologiques du fonctionnement et de l'aménagement des écosystèmes forestiers tropicaux humides : application à la Guyane (<i>tropical rainforest ecosystems: physical and biological bases of their functioning and management, as applied to French Guiana</i>)
GIS	Aquaculture	Aquaculture tropicale et méditerranéenne (<i>tropical and Mediterranean aquaculture</i>)
GIS	BRG	Bureau des ressources génétiques (<i>genetic resources</i>)
GIP	Ecofor	Ecosystèmes forestiers (<i>forest ecosystems</i>)
GIP	Hydrosystèmes	Connaissance et gestion des hydrosystèmes (<i>knowledge and management of hydrosystems</i>)
GIP	Medias-France	Réseau de recherche régionale sur les changements de l'environnement global dans le bassin méditerranéen et l'Afrique subtropicale (<i>regional research into environment change in the Mediterranean basin and subtropical Africa</i>)

Joint laboratories

CBGP	Centre de biologie et de gestion des populations (<i>biology and population management</i>)	Inra, Ensam, Cirad
CMS	Centre de météorologie spatiale Lannion (<i>satellite meteorology</i>)	Météo-France
Gamet	Groupe aquaculture (<i>aquaculture</i>)	Cémagref, Cirad
Iltab	International Laboratory of Tropical Agricultural Biotechnology	TSRI (San Diego)
Lasaa	Laboratoire mixte de schlérochronologie des animaux aquatiques (<i>schlerochronology of aquatic animals</i>)	Ifremer
LMI	Laboratoire de microbiologie (<i>microbiology</i>)	Agroindustrial Biotechnology Research Institute in Marseilles, Inra, Méditerranée and Provence universities
LPE	Laboratoire population - environnement (<i>population and environment</i>)	University of Provence
LPRC	Laboratoire de phytovirologie des régions chaudes (<i>phytovirology of hot regions</i>)	Cirad
LSTM	Laboratoire des symbioses tropicales et méditerranéennes (<i>tropical and Mediterranean symbioses</i>)	Cirad, Ensam, Inra

Joint research units

GBE	(<i>geofluids, hydrologic basins</i>)	CNRS, University of Montpellier I
Génétique moléculaire des parasites et des vecteurs	(<i>molecular genetics of parasites and vectors</i>)	CNRS
Géosciences Azur	(<i>geology and geophysics</i>)	University of Paris VI, CNRS, MST
Lodyc	(<i>climatology and dynamic oceanography</i>)	CNRS, University of Paris VI
LTHE	(<i>transfers in hydrology and environment</i>)	CNRS, INPG (Grenoble), UJF
Regards	(<i>economic, geographical and anthropological research into recomposition and development of the South</i>)	CNRS

Co-operation agreements 1998 - 1999

Universities	Grandes Écoles and other institutions
Conference of University Presidents	Conference of Grandes Ecoles
Aix-Marseille I	Ecole normale supérieure, Paris
Aix-Marseille II	CNRS
Aix-Marseille III	Muséum national d'histoire naturelle (MNHN)
Bourgogne - Dijon	Ecole des hautes études en sciences sociales (EHESS)
Montpellier II	Ecole nationale supérieure des mines de Paris (ENSMP)
Nantes	
Nice Sophia Antipolis	
Orléans	
French University of the Pacific - Tahiti	
Paris VI	
Paris X	
Picardie - Amiens	
Versailles Saint-Quentin	

The French overseas dependencies

In setting up a special representative body for the overseas dependencies (the "Délégation à l'Outre-mer" or DOM), the decree of 5 November 1998 unambiguously stated the importance given to the IRD's work in France's tropical dependencies, and the value of these tropical regions for the scientific advances the IRD is concerned with.

The French tropical overseas dependencies are changing fast. Constitutional changes for greater autonomy, responsibility, initiative and representation are intended to ensure sustainable development for these regions, preserve their local identities, and wholeheartedly support the French language.

The IRD's opportunities for action are strengthened and enriched as new partners emerge. These partners are usually mainly concerned for their immediate environment, and need support if they are to enter the world of international competition in all fields, including scientific research. In these parts of the world the idea of co-competition/competition is already a reality.

The IRD's presence is ensured by its centres in French Guiana, Martinique-Caribbean, Réunion, New Caledonia and French Polynesia. In addition, the "Alizé" network of sites in the overseas dependencies is being put together to co-ordinate research, expertise and consultancy, training and support for scientists.

French Guiana

The IRD has been in French Guiana since 1946, which makes this the oldest and largest research centre in the Department. Its four core competencies are aquatic ecosystems, Amazonian biodiversity, social sciences and remote sensing.

Interesting examples of the centre's work include the Beque programme to establish

ecological bases for measuring water quality in Guiana (in 1999 the Regional Environment Directorate, Diren, put the IRD in charge of this programme), and the consultancy contract between the IRD, the national forestry authority (ONF) and the Asarco mining company to study the vegetation before mining begins at a site on Kaw mountain (see box).

The centre continues to play an important regional role, working with scientific teams from Brazil, Surinam and Guyana in such programmes as Ecolab (study of coastal ecosystems), indigenous Amazonian languages, and Tramaz (Amazonian medicinal plants).

Martinique-Caribbean

In 1999, the Fort de France centre officially became the Martinique-Caribbean IRD centre. The aim is twofold: to confirm the IRD's presence in Martinique, and to develop regional co-operation in the Caribbean in all the fields of IRD competence that are relevant for developing these islands while preserving their fragile ecosystems. There are two research laboratories: one studying the biology and organisation of tropical soils and one studying nematodes. The centre continues to make an effective and sustained contribution to the creation of Martinique's agronomy research unit (Pram) where it will be working with Cirad, Cemagref, and Inra from mid-2001.

Réunion

The IRD centre on Réunion Island is responsible for operational management of the SEAS receiving station (satellite-aided surveillance of the environment), processing, archiving, and disseminating satellite images to be used in producing sea surface temperature maps. These data are not only transmitted in real time to French fishermen in the Indian Ocean, but are also used in research, training and communication, e.g. for the

Environmental impact study for mining projects and the conservation of

French Guiana's natural heritage

The botanical inventory carried out at the Asarco mining site on Kaw mountain, found a number of rare species whose range does not extend beyond this mountain and its foothills; they include a new species of palm-tree of the *Bactris* genus. One of the two populations recorded is threatened with destruction because of the mineral resources beneath its habitat. *In situ* conservation measures have been taken, in close consultation with officials of the mining company. In addition, forty or so seeds from this palm-tree have been sent to specialist botanical gardens and conservatories (Belfast, Berlin, Kew, Nancy, Paris and Utrecht) and two seedlings have recently been donated to the greenhouses at the Chèvreloup arboretum near Versailles.

study of the impact of El Niño in the Indian Ocean (teaching workshop at the Lycée Lislet Geoffroy in Saint-Denis de la Réunion). IRD researchers also take part in research into the effects of temperature change on the whitening of coral off Réunion and in the Indian Ocean as a whole.

New Caledonia

The Nouméa centre is IRD's second largest outside France and the largest in the overseas dependencies. It also acts as the IRD's representative body for the South Pacific. Its three core competencies in research are oceanology (climatic variability, geosciences, fisheries, lagoon ecosystems), terrestrial biology (botany, plant collection, microbiology, agricultural soil science, entomology), and natural substances of biological interest (both terrestrial and maritime).

The Nouméa IRD has the following priorities: to be a centre for research into the natural and human environment of tropical islands working closely with the University and New Caledonia research establishments; to take part in the Zonéco project (inventory of marine and mineral resources in New Caledonia's exclusive economic zone); to set up joint research units with local, national and international partners; and to provide long-term postings for researchers, and research training for technicians and students (mainly from Vanuatu and Fiji).

Apart from the climate study the Nouméa IRD has been conducting since 1965, two other types of research are worthy of note: Ecotrope (see box) and terrestrial natural substances. The latter includes a study of kava, "a new plant and a new fashion": its origin (two-thirds of its bio-diversity is to be found on Vanuatu), geographical range (none in New Caledonia, but some in Polynesia and Wallis & Futuna), a survey of New Caledonian kava drinkers (economic data, health effects, etc.).

The IRD and the University of New Caledonia undertook a consultancy contract on Lifou Island in the Loyauté group, in partnership with the Province of the Islands;



Bringing up the catch in French Polynesia (ECOTAP)

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called "Adage-Lifou", the contract was to investigate "sustainable water resource management taking a concerted approach to the environment".

In June 1999, the first young people's science club project was launched, and two clubs were formed at the Lycée La Pérouse in Nouméa to raise pupils' awareness of what research is all about.

French Polynesia

The Papeete centre has a number of programmes underway. In 1999, after four

years' research in partnership with Ifremer and the Polynesia marine resources services, it concluded the Ecotap programme on Polynesia's tuna resources, in which tuna behaviour was studied using sonar and catch sampling. The IRD is also taking part in the general programme of research into mother-of-pearl and has identified the overall plankton yield of various atoll lagoons and estimated their capacity to produce oysters for both pearls and mother-of-pearl.

Meanwhile Zeopolyf (Economic zone of French Polynesia) is a joint programme with partners including the University of French Polynesia and the marine resources service (SRM), to estimate the fishery resource potential around seamounts and deep island slopes. In the field of medical entomology, the IRD is engaged in a pest control programme in partnership with Polynesia's Louis Malarde medical research institute. With its ethno-archeological programme in the Marquesas Islands it also made a major contribution to the understanding of French Polynesia's cultural heritage.

ECOTROPE

(Pacific coastal ecosystems under the impact of terrestrial events and human activities)

The 1999 schedule included two special operations to measure benthic metabolism, primary pelagic production and microbe production.

Two geographical areas were selected: the south-west section of the New Caledonian lagoon, and Suva Bay, Fiji.

The field work was done with a team of Australian researchers and students from James Cook University. They gathered data on currents, particle loads, sediments and modelling, to determine the distribution of sediment in a coastal bay and the processes responsible. The data obtained were pooled and analysed for joint publication.

In 1999 the programme produced two final scientific and technical reports for the IRD-Ifremer-GIE Recherche Aquacole agreement. The reports describe the impact of fish-farm effluent on the coastal environment.

Countries of the South

Since the IRD's mission specifically concerns the countries of the South, it naturally works in close co-operation with the scientific communities in these countries, working with experienced researchers and trainees alike. Most of the operations are located in tropical and Mediterranean countries, and 36% of the IRD's researchers are posted outside France, usually in partner universities or research centres.

In 1999 a great deal of work was done to structure all these varied partnerships by forming three regional networks: Irdal for Latin America, Irdam for Africa and Madagascar, and Irdem for the Mediterranean. These networks will make sure operations are better co-ordinated, develop Collegial Expertise and achieve synergies in training and support for the scientific communities of the South.

● Latin America

Brazil and Mexico are the IRD's two major partners, and the IRD co-operates on a large scale with the Andean countries' scientific communities.

Brazil

Under the IRD-CNPq co-operation arrangement, three new programmes started up in 1999:

- ocean-atmosphere interactions with the Centro Técnico Aeroespacial (oceanography);
- bioconversion for food purposes of Brazilian agro-industrial products and by-products, with the Universidade Federal do Paraná (food biotechnology);
- vector-borne diseases, particularly Chagas' disease, with the Fundação Oswaldo Cruz (health).

The programme on "Economic use of fishery resources in the Açudes of Pernambuco", begun in 1996 with the Federal Rural

University and the Federal University of Pernambuco, was concluded in 1999 (see "Optimising the use of aquatic resources in the reservoirs of semi-arid Pernambuco", p.18). Amazonia was the IRD's major research area, with 15 projects and an international symposium held jointly with the Agencia Nacional de Energia Eletrica on 15-19 November 1999 in Manaus, entitled "Hydrological and Geochemical Processes in Large River Basins". The symposium reported on ten years' work in the Amazonian basin (see "HiBam", in "Water resources and climate change", p.10). The creation of a spatial analysis unit at the Museu Goeldi in Belem with support from the IRD Cayenne centre helped to develop regional co-operation along the Cayenne-Macapa-Belem axis. The April 1999 visit by Claude Allègre, the French Minister in charge of research, confirmed the major place the French government accords Brazil in its scientific co-operation policy.

Mexico

The IRD completed two programmes on water management and soil-atmosphere interactions in the semi-arid Northern zone, and strengthened co-operation:

- in biotechnology, on the genetic diversity of traditional maize varieties in Mexico,

complementing the current programme on apomixis;

- on migration issues, with the launch of two major demographic surveys,
 - on the impact of migration on small-scale farming in Tuxtlas in south-east Mexico, together with the Centro de Investigaciones y Estudios Superiores en Antropología Social;
 - in the West of the country, together with the University of Guadalajara, on the regional impact of returning emigrant workers.

Andean countries

In Bolivia, the programmes on water resources and geodynamics (tropical glaciers particularly) were extended. Co-operation in health matters included a new partner, the Instituto Nacional de los Laboratorios de Salud.

In Chile, the general scientific co-operation convention with the University of Chile was renewed for a third four-year period.

In Colombia, after the completion in mid-1999 of programmes undertaken with the Del Valle University (see "Territory, mobility and identity dynamics: surveys in town and forest in Pacific Colombia", p.25), a new



Tungurahua, in moderate activity, spews out ash (Ecuador)

co-operation began with the Externado University on mobility and forms of urban management.

In Ecuador, where the Tungurahua and Guagua Pichincha volcanoes have become more active again, the IRD strengthened its programme on volcano hazards. A convention was also signed with the Catholic University of Ecuador to launch a research programme into the potato moth.

In Peru, the IRD extended its activities to hydro-meteorology, taking part in work on El Niño on the country's Pacific coast, at the request of the Peruvian government.

In Venezuela, a joint programme on the management of urban services was set up in September 1999, with the Institute for Higher Education in Administration.

Central America

In May 1999 a rider was added to the agreement with the Centro Agronómico Tropical de Investigación y de Enseñanza in Costa Rica, to add a one-year extension to the coffee bush biotechnology programme.

● Mediterranean basin

Co-operation with Tunisia and Egypt was consolidated in the fields of hydrology, biotechnology, social sciences and health. Since a number of research and service units have expressed an interest in the Mediterranean basin, teams are likely to be set up in the near future in Morocco, Jordan, Syria and Palestine.

● Africa

West Africa

West Africa has traditionally been a region where the IRD is very active and we have researchers in eight countries: Benin, Burkina Faso, Côte d'Ivoire, Guinea, Ghana, Mali, Niger and Senegal. Overall, 1999 saw a decline in staff numbers as some major

programmes came to an end. However, the IRD continued its research, training and modernisation work in partnership with the region's research institutes and higher education establishments.

In Côte d'Ivoire the steering committee to revitalise Franco-Ivoirian co-operation in agronomy research held its first meeting.

In Burkina Faso, two programmes on integrated water resource management and healthcare in Mossi rural areas were completed in 1999. The programme on the dynamics of dry savanna ecosystems was strengthened and two social science programmes on decentralisation and school enrolment began this year.

The nine current programmes in Niger deal with agriculture and health. Two were completed in 1999 and a new one began. The IRD Niger centre also plays a major part in disseminating scientific and technical information and Internet use.

In Senegal, two programmes were completed this year, one on the management of agro-pastoral areas and one on the epidemiology of simian retroviruses. Two others reached their half-way points: the consequences of shorter fallow periods in tropical Africa (Senegal, Mali, Niger and Burkina Faso) (see "Fallowing in tropical Africa", p.15) and the development of irrigated agriculture in the middle valley of the River Senegal.

The Cheikh Anta Diop University in Dakar (UCAD) has become our main partner, and following the World Bank initiated restructuring of the Senegal Agronomy Research Institute (ISRA), the IRD has pulled out of the *in vitro* crop laboratory and opened its satellite image processing unit (Utiis) to other partners.

Since January 1999, the IRD's representative in Senegal has been responsible for a region covering Mauritania, Cape Verde, The Gambia and Guinea-Bissau. One agreement has already been signed with the University of Nouakchott, and another is being prepared with the Medical Research Council in The Gambia.

Central Africa

Cameroon is the main focus of IRD activity in the region. Current programmes with regional implications cover health (malaria, sleeping sickness, health systems, AIDS) and forest ecosystems. The recommendations of the May 1998 consultation meeting on Collegial Expertise have been put into practice. The first meeting was held in Paris in October 1999, on "Integrating the control of malaria and other water-related vector diseases into development projects with environmental impact in Cameroon".

East Africa

Research in Kenya with Moi University and the UNHCR on the project for a regional monitoring unit for refugees continued, as did the programme on the genetics and biology of freshwater fish in lacustrine ecosystems (Lake Victoria) with the National Museum of Kenya.

South Africa

A recent Franco-South African call for proposals for joint research programme financing has led to three new programmes, on:

- sugar cropping, with the South African Sugar Association Experimental Station in KwaZulu-Natal province;
- aquatic biodiversity, with the TLB Smith Institute of Ichthyology;
- sustainable development in towns, with the University of Durban-Westville Institute for Social and Economic Research.

● Madagascar

The 8 consultation meeting between the Madagascar Ministry of Scientific Research and the IRD was held in Antananarivo in January 1999. It assessed the projects completed and underway, which mainly concerned: continental waters, management of rural space and the environment, deforestation and peasant societies in Madagascar ("Pioneer farming and deforestation in Madagascar", p.16), the impact of structural adjustment (see "The Madio project in Madagascar: statistical information and democratic debate on economic policy", p.27), health and the environment.

● Asia

Vietnam

A framework co-operation agreement between the IRD and the CNST (national centre for natural sciences and technology) was signed in May 1999. It confirms a shared intention to extend our fields of co-operation and make use of the results of the programme on "Geographical databases for improved management of land and the environment", which has been under way since 1995 in partnership with the Institute of Geography.



Large-scale forest clearance in Betsako, south-western Madagascar

Laos

A framework co-operation agreement between the IRD and the National University of Laos was signed in November 1999. It gives institutional form to our two-year-old co-operation with the faculty of agriculture and forestry.

The IRD and the National Institute for Agronomy Research joined forces to organise

a regional workshop to examine the results so far of research into erosion control in Laos, Thailand and Vietnam, and put them in a regional perspective. The workshop was held in Luang Prabang on 7-9 December 1999.

India

At a Franco-Indian seminar held in Hyderabad on 22-23 March 1999, over a dozen water-related topics of common interest were selected. Researchers from the IRD and the Indian Institute of Science (IISc), Bangalore, met in July to propose forming a Franco-Indian water sciences unit (Cefirse) and an agreement in principle was signed on 21 November in Bangalore during the visit of the French Minister of Research. The scientific objective of this unit is to study the hydro-bio-geochemical processes that determine the quality of groundwater and surface water in areas subject to considerable human pressure.

● Pacific

The IRD's office in Vanuatu was officially closed on 31 December 1999 after twenty uninterrupted years of service. Co-operation will be coordinated from New Caledonia,



Rice fields in the village of Khoi, North Vietnam

and the documentation centre now comes under the University Agency for the French-speaking Community, which will open it to the public in its new premises.

Countries of the North and multilateral organisations

All research, particularly development research, now has an international dimension. Consequently the IRD has systematically formalised its relations with research bodies and universities in most European countries, Canada, the United States, Australia and New Zealand. The IRD also works closely with European Union and multilateral bodies which operate in fields of common interest in research and development via major international programmes on, say, the climate, agriculture, and health. Our partners are mainly the European Union, World Bank, FAO, WHO and WMO. Relations are also developing significantly with the Consultative Group on International Agricultural Research (CGIAR).

European relations

Since 1990 we have been diversifying and extending our actions with the European Commission. The INCO programme is the favourite of IRD teams, with 33% of their grant applications accepted. In the last competition concerning developing and Mediterranean countries (INCO/DEV-INCO/MED), the IRD's project for the conservation and management of heritage in the cities of Cairo and Aleppo was selected.

In 1999 a number of contracts were signed with the Research Directorate-General.

- under the applied socio-economic research programme: "The bazaar economy in large Euro-Mediterranean cities";
- under the INCO/DC programme:
 - performance of a system connecting farm produce supply to urban consumer markets;
 - "Science in Africa at the end of the 20 century: record and prospects; impact of EU S&T co-operation".

Four contracts were signed with the Fisheries Directorate-General:

- "Efficiency of tuna seiners and real effort";
- "Tuna, sampling, statistical systems";
- "Biological sampling of European tropical tuna-fishermen's catches in the Atlantic and Indian Oceans";
- Coordination of meetings of the Inter-American Tropical Tuna Commission.

Partnership with international organisations

In response to an appeal in October 1997 from the Consultative Group on International Agricultural Research (CGIAR) for closer co-operation with research in industrialised countries, a number of projects involving the IRD have been selected for the advanced research platform, Agropolis:

- improving starch quality and resistance of cassava to bacterial rust, by genetic techniques;
- evaluation of the pathogenicity of rice

yellow mottle virus, with a view to deployment and perpetuation of natural resistance to the disease in rice.

As part of the 1999 European Forum in Wageningen and the call for proposals for innovative types of research partnership, three proposals from the IRD in co-operation with a number of partners were selected to be presented to the first plenary session of the World Forum in Dresden in May 2000:

- coconut palm: somatic embryogenesis for propagating high-performance resistant coconut palm;
- rice: use of the potential of the African species *O. glaberrima* for sustainable production in Africa;
- fallowing: research into improving and managing fallow in West Africa.

Co-operation with CGIAR research centres increased. On natural resources, there were new staff postings and the IRD took part in the seminar to position the centres on this sphere of work, while on genetic resources and biotechnology a new research programme began on gene flows between apomictic and wild maize. In 1999, 18 researchers and engineers were posted to international centres, 9 in each of the above two fields of study. ■

People and resources

Chapter 3



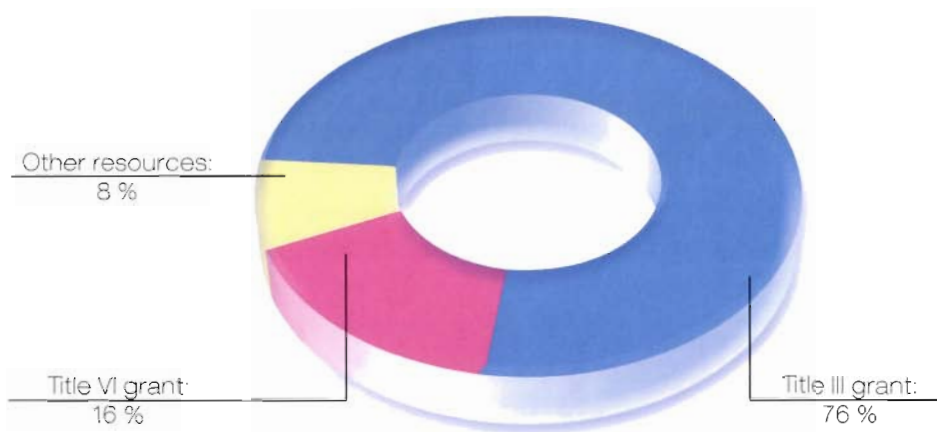


Budget Resources

The IRD's initial budget in 1999 was FF 1.138 billion, 1.7% up on 1998 (FF 1.117 bn). Most of this comes as State grants. These had declined significantly in 1996 and 1997, and stabilised in 1998; in 1999 grants rose, the increase breaking down as follows:

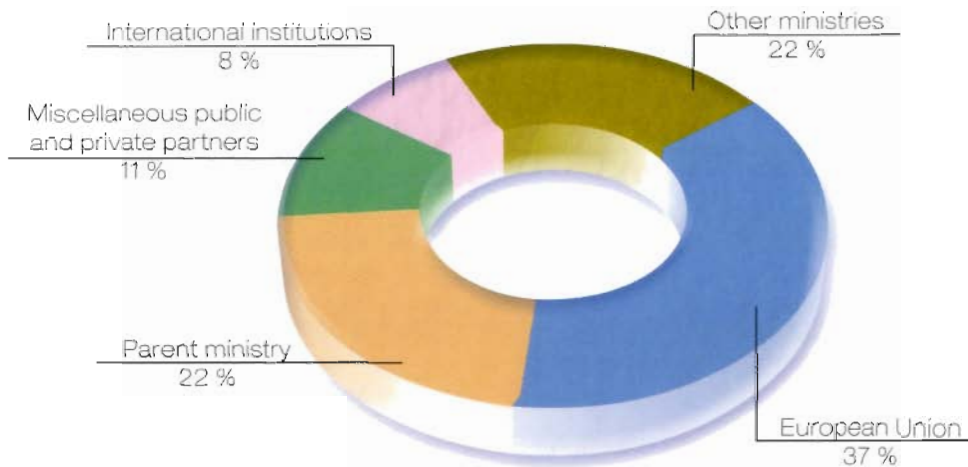
- Title III grant: + FF 19.6m (ordinary expenses: staff, training, welfare)
- Title VI grant: + FF 1.7m
- other resources: - FF 0.3m

The IRD's own resources, mainly from research contracts, amount to over 8% of its revenues, and over 30% if staff costs are excluded. An increasing proportion comes from European Union contracts.



Initial budget 1999

46



Activity-related income 1999

Expenditure

Staff costs in 1999 were FF 869m, 76% of the initial budget, as in 1998. These costs cover salaries and social security contributions, expatriation and distance allowances, welfare and training. Training expenditure was maintained.

The breakdown of expenditure between items in 1999 was similar to that in 1998, given the requirement to finance expatriation which is a major expense for the IRD.

Staff costs (FF m)	1997	1998	1999
Salaries of tenured staff	568	576	599
Social security contributions	172	173	172
Staff covered by union agreements, of which	54	52	52
* locally recruited staff	34	33	33
* other (ships' crews, CES/CEC job creation schemes)	20	19	19
Temporary staff (grantees, trainees, freelancers, CSN/VAT)	20	19	19
In-service training and welfare	18	19	19
Taxes and obligatory provisions	19	12	8

Operating expenses and investment

This item was FF 196m in 1998 and FF 199m in 1999, including FF 60m obtained from external funding of research contracts.

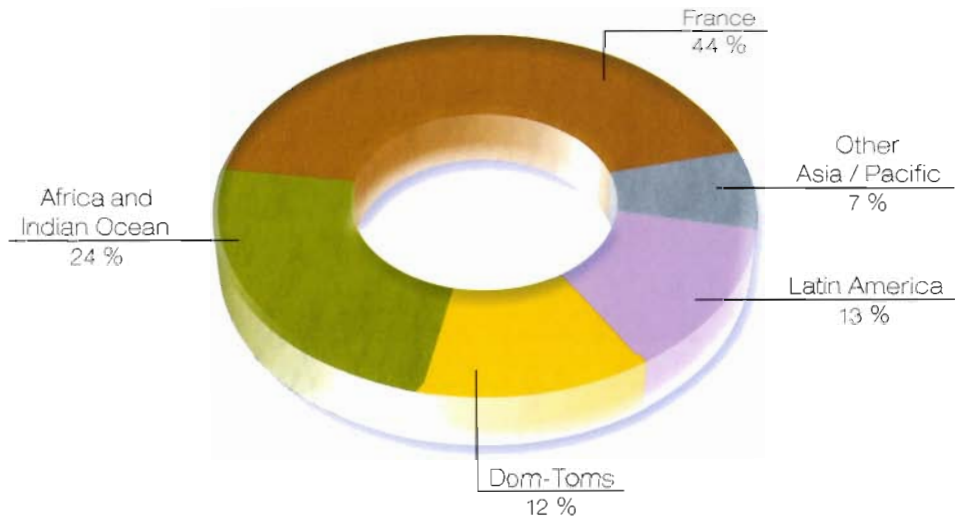
The breakdown was as follows:

	1998	1999
Building, capital equipment and incentive actions	15	9
Indirect and logistical expenditure, of which	114	112
* centre operation budgets	44	40
* head office and administration	17	16
* general expenses: leases, insurance, travel expenses for postings, management IT	38	39
* consulting, transfers, communications, IST	15	17
* basic support for research units	67	78

This budget structure reflects the IRD's own organisational and geographical structure, with a high proportion of recurring expenses compared with performance-based expenditure. Of the recurring expenses, 60% goes to indirect expenditure and logistics, more than to basic support for research teams.

The 1999 budget demonstrates the IRD's intention to favour basic support to research units by increasing this item by FF 11m (+16.4%).

The breakdown by region illustrates the IRD's policy of pursuing research with its partners, while strengthening its centres in France.



Breakdown of operating expenses and investment by region in 1999

Staff

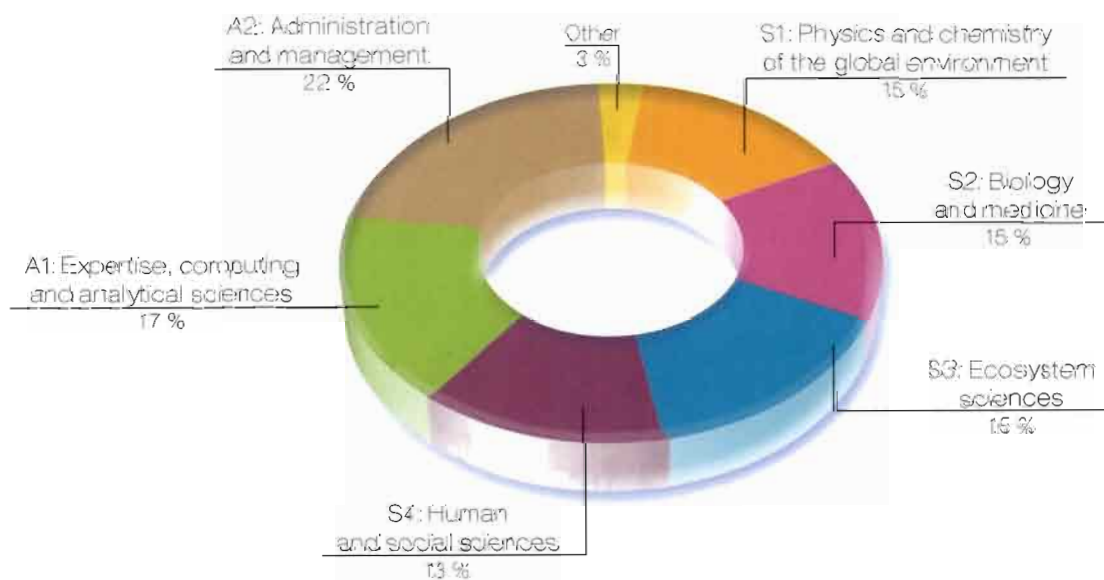
Tenured staff were 1,528 in 1999, similar overall to the previous year. After two years with virtually no recruitment, 14 posts as directors of research and 11 as researchers were opened to competitive entry in 1999. For technical and support staff, 10 posts were opened to external competition and 26 to internal

While the number of research staff remained stable from 1998 to 1999, the number of technical and support staff increased significantly. The fall in administrative staff numbers is due to the upgrading of some posts to senior non-research and technician grades.

Tenured staff					
	1996	1997	1998	1999	1998-1999
Research staff	814	807	783	781	0 %
Senior non-research staff	311	298	304	322	6 %
Technicians	287	286	277	296	7 %
Administrative	174	172	167	129	- 23 %
Total	1 586	1 563	1 531	1 528	

Breakdown by scientific commission

The breakdown of tenured staff within the new commissions set up in November 1999 is shown in the following diagram.

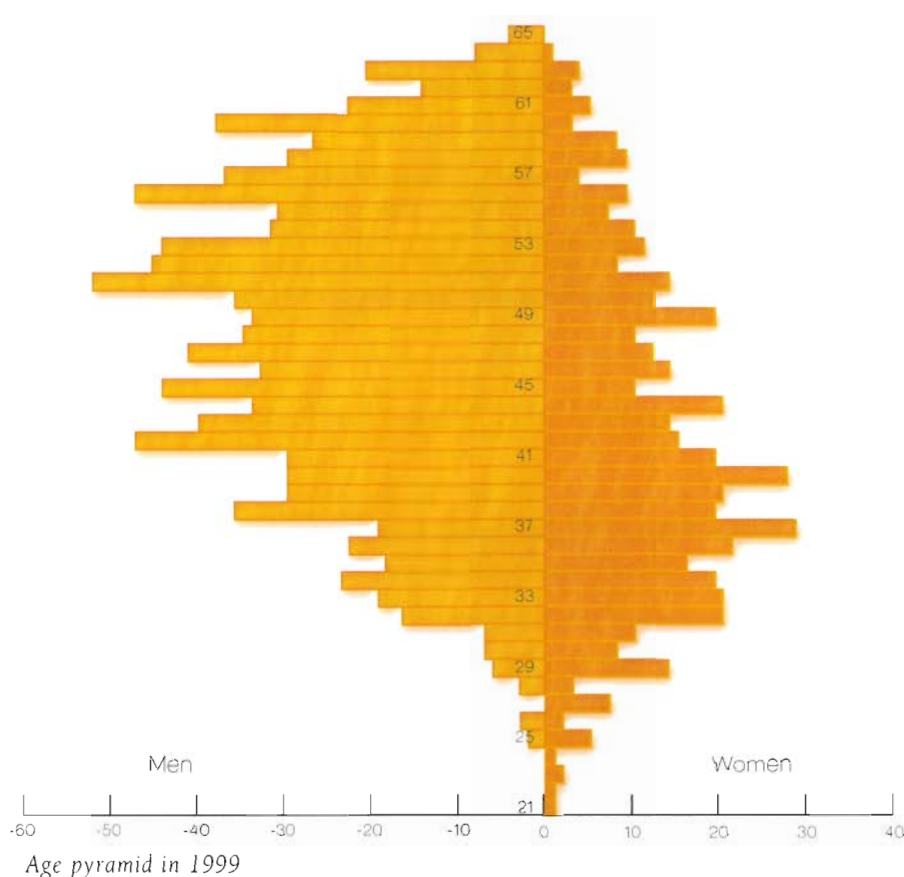


Breakdown of tenured staff by scientific commission in 1999

Breakdown by age and sex

The age pyramid of IRD tenured staff is highly skewed for both age and sex. The number of women has, however, regularly increased over the years, most recently from 30.6% at end 1998 to 31.7% at end 1999. Naturally the imbalance is greater in the older age groups.

Note too that there are relatively few staff under 32 (the “pyramid” is actually more a diamond shape). The average age for all tenured staff is 46.4, including 48.3 for research staff and 44.4 for technical and support staff of all grades, which matches the general trend for research bodies in France.



Tenured staff by grade and sex in 1999

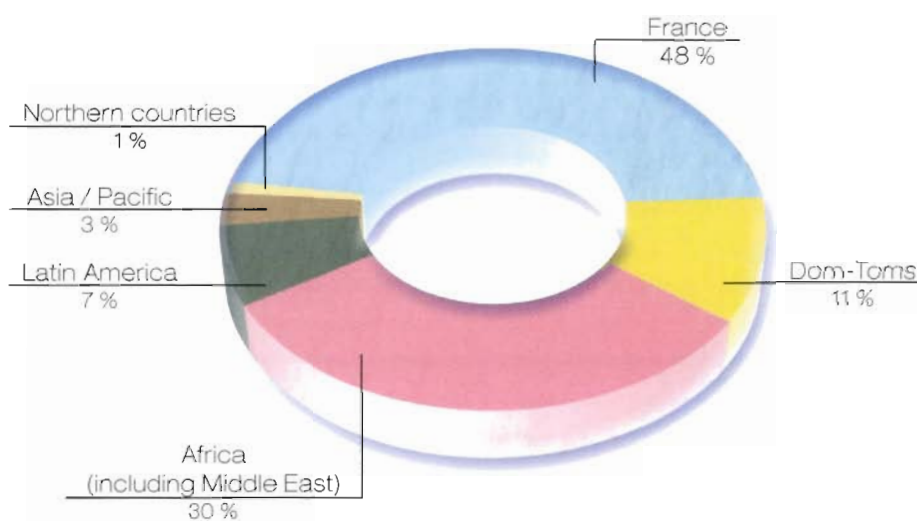
Category	Men	%	Women	%	Total
Research staff	676	86.6 %	105	13.4 %	781
Senior non-research	199	61.8 %	123	38.2 %	322
Technicians	155	52.4 %	141	47.6 %	296
Administrative	13	10.1 %	116	89.9 %	129
Total	1 043	68.3 %	485	31.7 %	1 528

Staff by region

Most staff in France works at the Bondy, Orléans, Montpellier and Brest centres, and at the head office; the rest are assigned to external structures.

Posting a high proportion of staff to the overseas dependencies and other countries is one of the main reasons for the IRD's existence. Although the proportion fell from 40% at the end of 1998 to 36% at the end of 1999, this is pending the creation of new research and service units, so that there have been few new postings abroad while some earlier ones have not been renewed.

Africa is still our main focus, both for the number of expatriates and the recruitment of local staff. The French overseas dependencies (Dom-Toms) are the second region outside France itself, and Latin America the third. Asia and the Pacific take fewer staff. This regional distribution reflects the IRD's differentiated approach, with its own research centres in the Dom-Toms and Africa, and staff posted to local research bodies in Latin America and Asia.



Staff by region

Staff by region in 1999				
Region	Tenured	Non-tenured	Total	%
France	978	130	1 108	48
Dom-Toms	168	95	263	11
Africa (including Middle East)	225	480	705	30
Latin America	106	68	174	7
Asia / Pacific	36	23	59	3
Northern countries	15	0	15	1
Total	1 528	796	2 324	100 %

Percentage of tenured staff posted outside France 1995-99					
	1995	1996	1997	1998	1999
Research staff	49.5	49.4	45.6	45.5	41.1
Total	39.4	42.1	40.2	39.0	36.0



IN-SERVICE
TRAINING

To achieve the institutional priorities laid out in the 1998-99 training plan, nineteen collective cross-disciplinary courses were held on the following subjects:

- adaptation to co-operation and partnership objectives, so that staff can work more effectively with the countries of the South (economic and social problems in the South, languages, seminar for IRD Representatives);
- scientific tools, to enhance the scientific excellence of research staff and senior non-research staff (statistics, monitoring units, spatialised data processing);
- management and promotion of research: capacity-building for project management, communication and promotion of scientific results (applying for financing),

internal communication, oral and written, design and production of videos;

- improvement of institutional and social cohesion, to achieve recognition of the professional status of mid-rank executives and operatives, particularly in Categories B and C (annual review, awareness of research conditions in the South among technical and support staff in France, professional assessments and follow-up);
- technical tools and working methods, in order to adapt to new technologies and forms of work organisation (office IT, Internet, e-mail); there is a special course for secretarial work;
- safety (first aid, fire drill, training for members of local hygiene and safety committees).

To upgrade skills and increase the cohesion of work teams, there were collective courses for each structure:

- in the research programmes: collective training projects (Resources, Environment, Development department (RED). 10, Living Conditions and Development department (CVD): 7);
- in the research support structures: 11 projects.

The budget allocated to the 1998-99 in-service training plan was FF 7,410,000, plus FF 180,000 for grants for locally recruited staff to attend courses outside their home countries, and FF 410,000 for limited-term contracts under the CES and CEC job creation schemes. ■

SCIENTIFIC INFORMATION
AND
COMMUNICATION



Sorting soil fauna at a science morning; French cultural centre, Dakar

© IRD/Alan Braumun

The Scientific Information and Communication unit disseminates information and research findings to the scientific community, the media and the general public. A number of new initiatives were taken in 1999.

Communication

Sciences au Sud is the IRD's bimonthly newsletter for its partners in North and South. The first two issues came out in 1999. Abstracts in English and Spanish are enclosed with each issue. Its print-run of 10,000 copies reaches a wide readership. The monthly in-house *Lettre IRD* came to an end with its 107 issue, in July 1999.

The media relations service regularly supplies the press, radio and television with information about research findings and the major scientific subjects of topical interest covered by the IRD. Some twenty press releases were circulated in 1999. Articles based on them are reproduced in the IRD's daily and weekly press reviews (*Recherche et Développement*).

The IRD head office ran a number of exhibitions for staff and visitors on topics such as: "Eclipse" (June-August), "Littoral" (August-September), "The 10,000th photograph" (October-November).

Twenty-three scientific news sheets (*Fiches d'actualité scientifique*) were produced in French, English and Spanish for the press, radio and television, and the IRD's main institutional partners in Northern and Southern countries. These aroused wide interest, leading to more than fifteen articles or radio items, for example, based on the sheets on "A new genus of bacterium", "Effects of earthworms on Amazonian soils", "Identification of a new species of coelacanth", "Chimpanzee and baboon behaviour with regard to drinking water".

An IRD presentation brochure was published in French, English, Spanish and Portuguese, and the IRD's first two reference documents.

Our website, essential in the modern world, was extensively redesigned this year in form and content, reflecting recent changes at the IRD. The new site was presented to the public in March during the Internet Festival in France. There were 8 million hits in 1999, twice the previous year's score.

Scientific culture Symposia

The information and communication unit helped to organise 28 symposia in 1999 at a total cost of FF 1.03 million, plus FF 220,000

from the international relations unit for participation by Southern partners. Among the main symposia were:

- "Climate and health", Bamako, Mali;
- "Andean Geodynamics, ISAG 99", Göttingen, Germany;
- "Hydrological and geochemical processes in large river basins, HiBAm", Manaus, Brazil;
- "III SIBAC, international seminar on biotechnology for the coffee industry", Londrina, Brazil;
- "Fallowing in tropical Africa: its roles, management, alternatives", Dakar, Senegal;
- "Tuna fishing and fish aggregation devices", Martinique;
- "Small African mammals", Paris;
- "Reproductive health in developing countries", Abidjan, Côte d'Ivoire;
- "Vector-borne diseases and human sciences: 25 years of co-operation", Abidjan, Côte d'Ivoire;
- "Surveys and information systems", Abidjan, Côte d'Ivoire.

Projects for young people

Projects for young people were given particular emphasis this year. These are mainly Youth Research Development clubs where secondary school pupils can learn more about research. Eight have been set up, including clubs in New Caledonia, Mexico

and Madagascar, and seven more are planned. There are also six science workshops operating with IRD support, in Brest, Montpellier, French Guiana, New Caledonia, Senegal and Vanuatu. This activity involves twenty or so IRD researchers and about 300 school pupils).

Shows and exhibitions

The IRD took part once more in shows relevant to its areas of competence; the international Paris Agricultural Show (running the research conference stand, which included Inra, Acta, Cirad, and Cneva); the Paris Book Fair and the first national education show. During Science Week, the IRD had a stand at the Val-de-Marne Forum just outside Paris on the topic "Roots of the future", and took part in a presentation of scientific imaging together with CNRS, Inserm, Institut Pasteur, and AP-HP (Assistance publique - Hôpitaux de Paris). The IRD was a major partner in the "Global garden", when the main hall at the La Villette exhibition centre was turned into a huge greenhouse from October 1999 to January 2000.

Indigo image database

This database of over 10,000 still photographs taken and labelled by researchers is extensively used.

In 1999

- visitor facilities were improved;
- a travelling exhibition, "The database's 10,000 photo", displayed 100 selected pictures;
- an information day on "Scientific images, from pinhole to digital" was organised

with the Institut Pasteur, and attended by 130 participants.

Indigo's website: www.serimedis.tm.fr

Documentation

Our documentation staff are at work where research begins and ends, retrieving information and recording results.

In 1999, the documentation unit's main activity was to use new information technology to improve its services.

The unit put a great deal of work into the information and communication department's Infothèque (information library) project (general architecture, digitisation, documentary tools).

Full-text retrieval has been extensively improved: the database contains 6,000 digitised IRD documents, totalling some 300,000 pages. They can be accessed via an information server that came on-line this year.

The documentation website is being completed; it will give easy access to all the information stored via the Internet.

We have begun to subscribe to electronic versions of scientific magazines (23% of paid subscriptions); at the same time, subscription management has been rationalised and centralised at the Bondy and Montpellier centres.

The Horizon bibliography database now contains 51,500 references to papers by IRD

scientists, and increase of 3,000 over the course of the year. Documentary support for documentation centres in the tropics and financial resources were both increased.

Website: www.ird.fr/inst/documentation

Publications

The Publications department has been working to improve the editorial quality of published books, which are now more severely selected, with a greater emphasis on joint publication with French or other partners, and a wider range of partner publishers.

The IRD continues to provide support by contract to seven external journals (*Aquatic Living Resources*, *Cybiurn*, *Oceanologica Acta*, *Autrepart*, *Aseanie*, *Natures-Sciences-Sociétés*, *Politique africaine*) which often publish work by IRD scientists.

Seventeen books were published in 1999; four of them published jointly with Karthala, *Espaces* 34 and Cirad. Among IRD imprints, "A travers champs" produced two books, "Colloques et séminaires" four, "Didactique" two, "Faune et flore tropicales" two, while three were published separately.

Progress is also being made in reaching a wider public, as shown by the success of already published titles such as *Palmiers de l'Eldorado*, *Flore de la Polynésie française*, *Le ver de Guinée*, *Atlas des pêcheries thonières tropicales*, and, more recently, *Fruits d'Océanie*, *Réfugiés et déplacés*, and *Les poissons des eaux continentales africaines*.

Infothèque: a digital library for the environments and human societies of the tropics and the Mediterranean

The information and communication department (DIC) launched a major project in 1999 entitled "Infothèque of tropical environments and societies", to give on-line access over the Internet to the IRD's fund of knowledge and current research. The main purpose is to make this knowledge available to the scientific communities in the South, giving help at the same time with training courses and equipment for using the new technologies.

The Infothèque covers all the information and communication fields handled by the DIC and will contain articles, books, maps, photographs, complex databases such as plant inventories and population and hydrological statistics. Southern partners will be involved in putting together this digital library and agreements are sought with all those working on topics covered by the project.

The Publications department continues to represent the IRD at many scientific and cultural events, and has links on selected websites such as Decitre, BOL and Alapage. A selective catalogue of 350 titles can be consulted on the IRD site.

Website: www.ird.fr/fr/instit/ist/editions

Applied cartography laboratory

The applied cartography laboratory, set up as an IRD resource centre for geographical information, capitalises information (thematic maps, base maps, aircraft and satellite imagery) and digital mapping and electronic dissemination skills. Its mission is to combine proven capacity in editorial production with documentary capitalisation of geographical information and support for research and training for researchers from the IRD and its partners, and doctoral students (15 trainees a year).

The year's main map publishing achievements were the completion of the *Atlas de la Province Extrême-Nord Cameroun* and the production of a socio-economic atlas of Colombia, published locally by the IRD's partners CRECE and DANE. Multimedia publishing included a CD-ROM version of the Atlas of north Cameroon, and a regularly updated website presenting the laboratory's work.

In documentation, the 13,000 titles in the map library are still being converted to electronic form, so that the file can be consulted from the website, and later the maps themselves as part of the *Infothèque des Sciences du Sud* project; a similar project is being studied for an inventory of the IRD's large stock of aerial photographs.



© Entretiens de Bichat

Awarding the Grand Prix for medical and surgical films at the Entretiens de Bichat event, September 1999

Image and sound

In 1999 the IRD pursued its new policy for audio-visual and multimedia output, in close co-operation with the scientific departments, representatives and financial and legal services; this has given the IRD a higher profile in the broadcasting media and significantly increased the number of co-productions.

Twenty-eight ideas for productions or co-productions were examined during the year. Eighteen films were completed, of which eleven were broadcast on French national channels (TF1, France 2 and 3, TV5, La Cinquième, ARTE, Canal+) and rebroadcast on major international networks; four were shown at events for the general public and three on specialist circuits (national education system, embassies, etc.).

The following films were produced:

- *Fleuve Sénégal, les eaux du partage*, co-produced with the Cité des Sciences, Paris;
- *La guerre des mouches*, co-produced with France 2;
- *Les chasseurs d'orchidées*: looking for orchids and new pharmaceutical compounds in the province of Yunan, China, co-produced and broadcast by Canal+;
- *Le kala azar*: first part of a multimedia documentary on forms of leishmaniasis, made in Bolivia and Brazil, co-produced with the WHO and Rhône Poulenc.

Other output included:

- Participation in four films in the "Familles" television series: *Tanna* (Vanuatu), a film in homage to Joël Bonnemaison, co-produced

with TV channel La Cinquième;

- TV magazine partnership with France 2: *Les nouveaux mondes* in Vanuatu,
- Films to support researchers: *Le maïs et la cendre* in partnership with EHESS, *Camps de réfugiés au Kenya*.

A number of films were made to coincide with major exhibitions held in Paris in 1999. Subjects included "The Bateke, painters and sculptors of Central Africa", "The river's words: harps of Central Africa", "The Global Garden" and "Oceanopolis" (five films on coral reefs for the opening of the tropical pavilion in May 2000).

Five films received ten prizes between them: *Les yeux de l'espoir* (five prizes in 1999 at the Entretiens de Bichat, Paris, and the 3rd FIFI, Narbonne), *Nioro du Sahel* (Bronze Dolphin, Biarritz), *Fleuve Sénégal, les eaux du partage*, *Neblina, montagne de brumes and Vanuatu*, *le peuple du feu* (Slovakia).

Video training courses were held for IRD staff.

Publications by IRD researchers in the *Science Citation Index*

The SCI-IRD database of IRD papers cited in the SCI since 1986 is regularly updated. In 1999, analysis of the database revealed the following facts:

- the number of IRD articles cited in the SCI increases steadily, although our number of researchers is virtually stationary;
- more publications are being jointly signed with external teams;
- co-operation with Southern teams is growing;
- more publications are appearing in non-French journals;
- "Rank A" publications are a large part of total production;
- The proportion written in English is growing.

Appendices



Board of trustees

Chairman: Philippe Lazar

Representatives of parent ministries**Ministry for education, research and technology**

Vincent Courtillot, *director of research*
 Thierry Simon, *director, international relations and co-operation*

Ministry of foreign affairs

Pierre Jacquemot, *director for development and technical co-operation*
 Yves Saint-Geours, *director of scientific, academic and research co-operation*

Ministry for the economy, finance and industry

Lucien Scotti, *budget office*

Secretariat of state for overseas dependencies

Alain Puzenat, *deputy director of economic, social and cultural affairs*

External members

Bernard Bachelier, *director general, CIRAD*
 Jean Cases, *director, environment and mineral processing laboratory, Institut national polytechnique de Lorraine, Nancy*
 Alain Chetaille, *director, department of policies and research, Agence française de développement*
 Pierre Guarrigue-Guyonnaud, *ambassador, permanent secretary for the South Pacific*
 Axel Kahn, *director, Unit 129, INSERM*
 Hélène Lamicq, *President, University of Paris XII, Val-de-Marne*
 Thérèse Saint-Julien, *professor, University of Paris I, UMR "Paris", CNRS*
 Jean-Jacques Salomon, *honorary professor of technology and society, CNAMTS*

Staff representatives

Didier Brunet, *SNPR-IRD-FO, soil scientist, IRD Brasilia*
 Alain Casenave, *SNPR-IRD-FO, hydrologist, IRD Ouagadougou*
 Francis Gendreau, *STREM-SGEN-CFDT, demographer, chairman of the board of CICRED (International Committee for Co-operation in National Demographic Research)*
 Hanka Hensens, *SGPO-CGT-IRD, documentalist, IRD Montpellier*
 Roger-Claude Lemoine, *STREM-SGEN-CFDT, STREM trade union official*
 Sevastianos Roussos, *STREM-SGEN-CFDT, microbiologist, University of Provence-Marseille*

Scientific Council

Chairman: Alain Pavé, Professor

Appointed members

Albert Autran,	<i>former deputy director for geology of France, BRGM</i>
Daniel Cadet,	<i>director for international relations, CNRS</i>
Georges Calas,	<i>professor; University of Paris VII, mineralogy and cristallography</i>
Pierre Chardy,	<i>professor, University of Bordeaux I, marine biology</i>
Claude Combes,	<i>professor, University of Perpignan, parasitology</i>
Alain Dubresson,	<i>professor, University of Paris X, geography</i>
Josué Feingold,	<i>director of research, INSERM</i>
Serge Garcia,	<i>director, fishery resources division, FAO fisheries department</i>
Patrick Guillaumont,	<i>professor, University of Clermont I, CERDI</i>
Philippe Lacombe,	<i>professor in rural economics, ENSAM, Montpellier</i>
Hubert Manichon,	<i>director, CIRAD-CA</i>
Ndiaga Mbaye,	<i>executive secretary, CORAF</i>
Michel Petit,	<i>director, agriculture department, World Bank</i>
Marcel Raffy,	<i>professor, University of Strasbourg, imaging, information technology and remote sensing sciences, chairman of CS 7, IRD</i>
Georges Vachaud,	<i>director of research, CNRS, laboratory for the study of transfers in hydrology and the environment, Grenoble</i>

Elected members representing the scientific committees and CSATA

Louis Martin and Jacques Récy:	CS 1
Jean-Claude Leprun and Jean-Claude Olivry:	CS 2
Philippe Dufour and Pierre Fréon:	CS 3
Yves Gillon and Antoine Cornet:	CS 4
Jean-Louis Frézil and Bernard Maire:	CS 5
Robert Cabanes and Philippe Waniez:	CS 6
Francis Laloë and Jean-Yves Martin:	CS 7
Philippe Mathieu and Jean-François Turenne:	CSATA

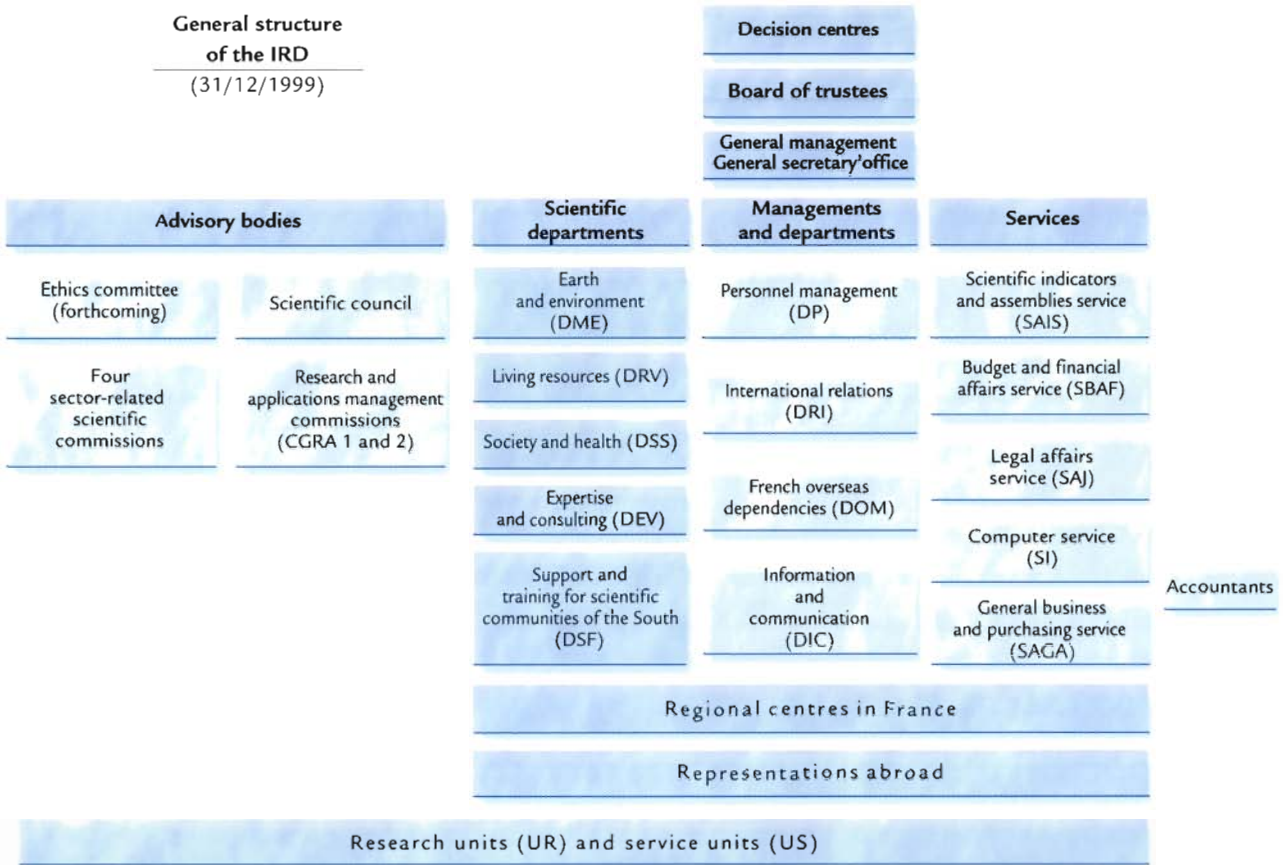
Chairmen of scientific committees and CSATA (till 7 October 1999)

Michel Diament:	CS 1	<i>geology-geophysics</i>
Pierre Ribstein:	CS 2	<i>hydrology-soil science</i>
Daniel Gerdeaux:	CS 3	<i>hydrobiology-oceanography</i>
Gérard Fabres:	CS 4	<i>plant sciences</i>
Jean-Louis Frézil:	CS 5	<i>biological and biochemical sciences applied to humankind</i>
Guy Pontié:	CS 6	<i>social sciences</i>
Marcel Raffy:	CS 7	<i>computing, communications and analytical sciences</i>
Jacques Noel:	CSATA	<i>technical and administrative activities</i>

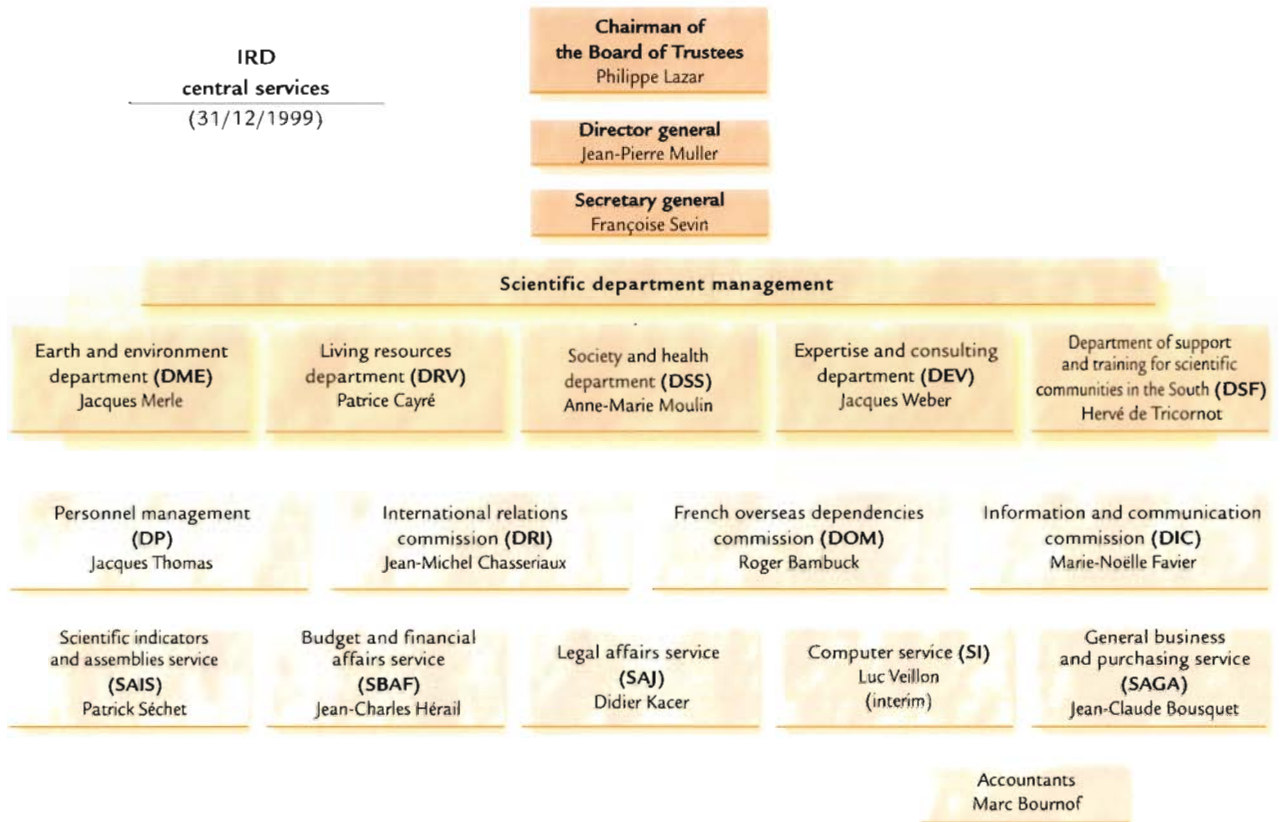
Chairmen of sector-related scientific committees and committees for research management and its applications (since 8 October 1999)

Michel Diament:	CSS1	<i>Physics and chemistry of the global environment</i>
Louis Thaler:	CSS2	<i>Biological and medical sciences</i>
Gérard Fabres:	CSS3	<i>Ecological systems sciences</i>
Jean Copans:	CSS4	<i>Human and social sciences</i>
Rémy Pochat:	CGRA1	<i>Expertise and analytical sciences</i>
Jean-Claude Bessemoulin:	CGRA2	<i>Administration and management</i>

GENERAL STRUCTURE



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THE IRD IN FIGURES

The Institut de Recherche pour le Développement is a public scientific and technological institution under the joint authority of the French research and development cooperation ministries.

The IRD has a total budget of FF **1.12** billion, **76 %** of which covers payroll costs. It has:

- 2,300** employees of whom
 - 1,530** are tenured staff, including:
 - 780** research staff, **750** senior and intermediate non-research staff
 - 750** other grades
- 36 %** of permanent staff posted overseas, mainly in Africa, the Dom-Toms and Latin America
- 30** visiting research associates, **19** of whom are new researchers from universities and research institutes
 - Establishments in **25** tropical countries
 - 5** sites in mainland France and **5** in the Dom-Toms
 - 7** new research contracts with the European Union
 - 18** new co-operation agreements with universities and research institutes signed in 1998 and 1999
- 117** research and service unit projects under evaluation
 - 8** national programs
 - 17** partnerships of scientific or public interest (*"Groupements d'intérêt scientifique"*, *GIS*, *"Groupements d'intérêt public"*, *GIP*)
 - 2** Collegial Expertise contracts in progress
- 33** patents, **6** of which were registered in 1999, **5** trade marks, **2** of which were registered that year
- 13** new transfer contracts
- 35** consultancy contracts
- 17** books published within a catalog of more than **400** titles
- 51,000** IRD researchers' publications listed in the Horizon bibliographic data base
- 10,000** photographs illustrating IRD research

The IRD around the world

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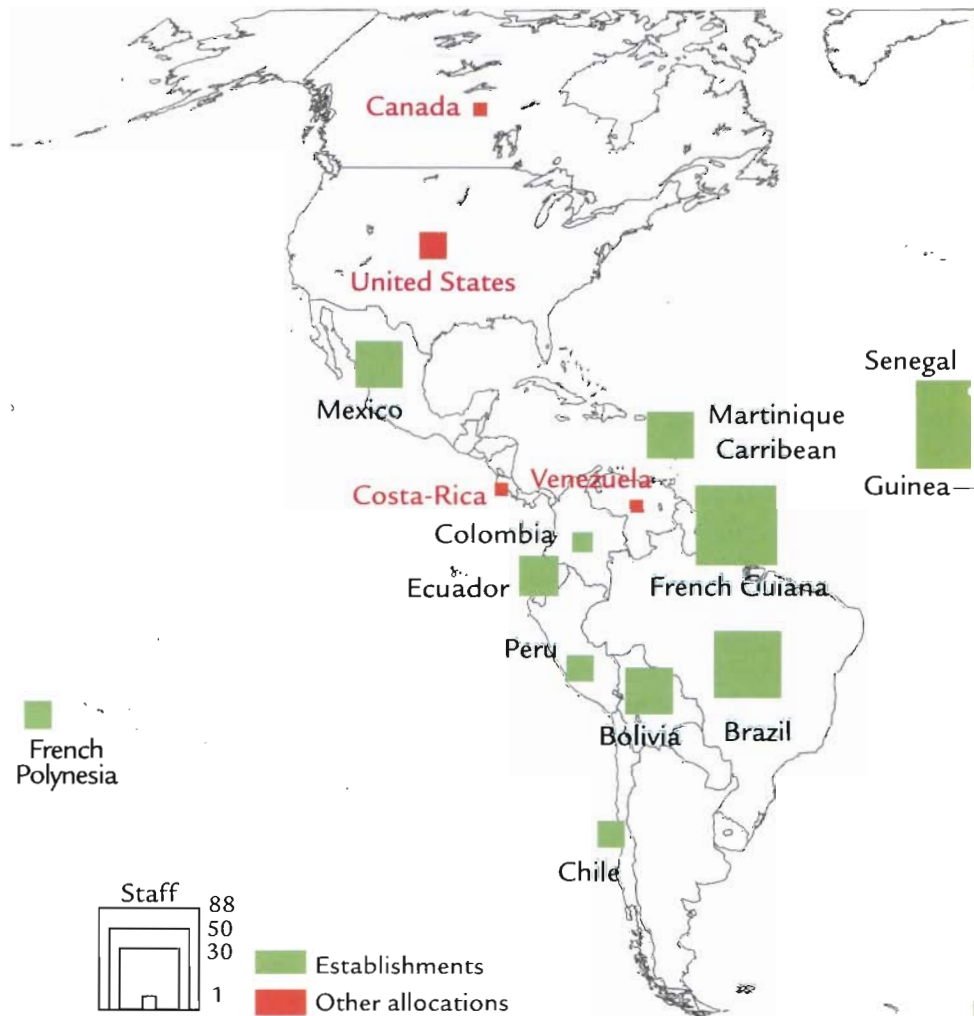
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Breakdown of staff budget at 31/12/1999

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Other countries

Bolivia

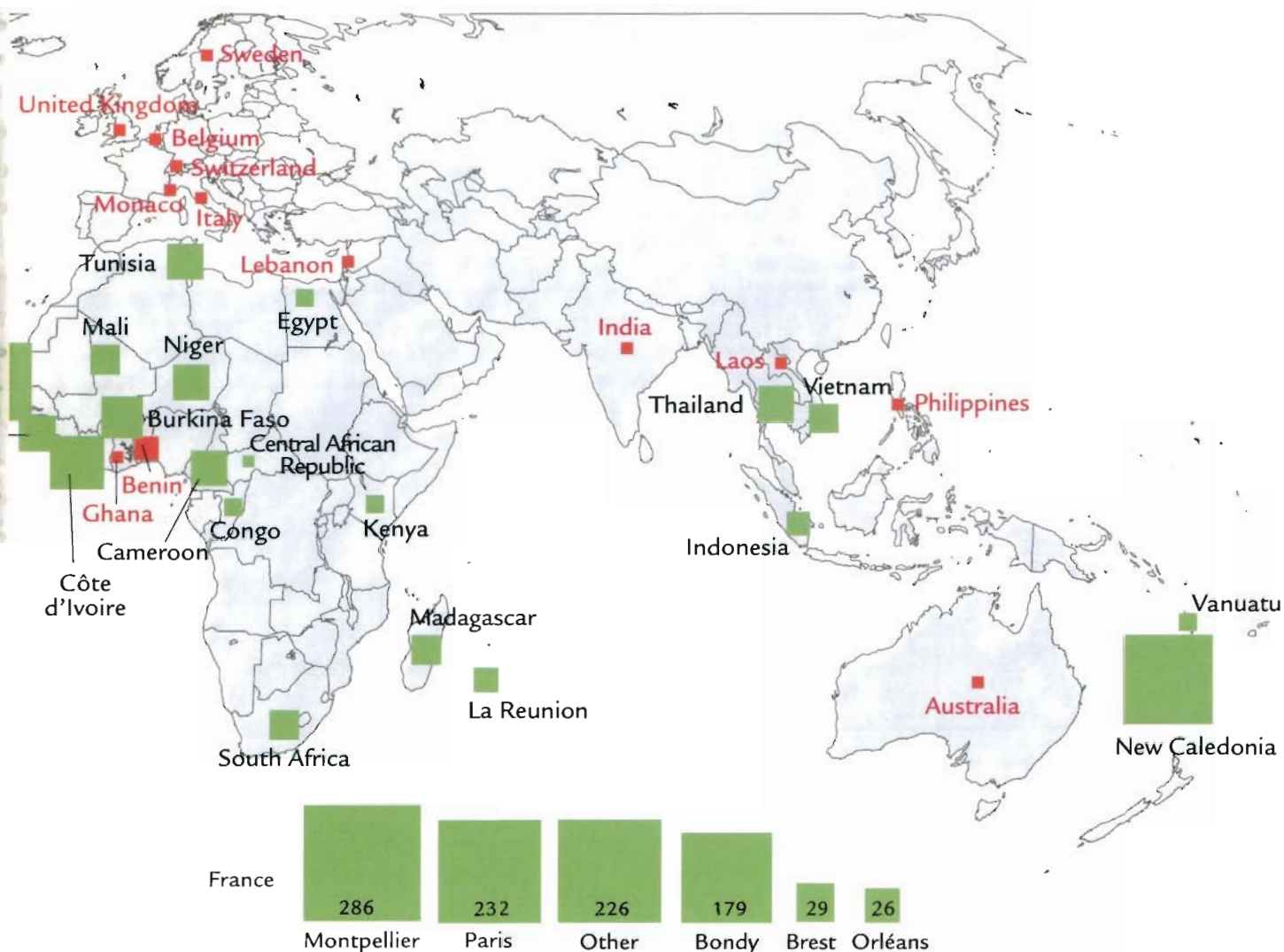
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Document issued by the IRDs Delegation à l'information et à la communication - © IRD July 2000
Co-ordination Marie-Noëlle Favier - Editor Laurence Porgès - Illustrations Claire Lissalde and Danielle Cavanna - Design Rigaud & Associés

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Illustrations taken from Indigo Base, the IRD's image data base



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