PROCEEDINGS OF A WORKSHOP ON BIODIVERSITY DYNAMICS ON LA RÉUNION ISLAND

ATELIER SUR LA DYNAMIQUE DE LA BIODIVERSITE A LA REUNION

SAINT PIERRE – SAINT DENIS

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WORKSHOP ON BIODIVERSITY DYNAMICS ON LA RÉUNION ISLAND

The research officer, Monique Rivier, at French Embassy in Pretoria, after visiting La Réunion proposed to fund and support a workshop on Biodiversity issues to develop collaborations between La Réunion and South African researchers. To initiate the process, we decided to organise a first meeting in La Réunion, regrouping researchers from each country. The meeting was coordinated by Prof D. Strasberg and Dr S. Baret (UMR CIRAD/La Réunion University, France) and by Prof D. Richardson (from the Institute of Plant Conservation, Cape Town University, South Africa) and Dr M. Rouget (from the South African National Biodiversity Institute, Cape Town, South Africa).

Organisation committee: S. Baret / I. Nänni / T. Le Bourgeois / T. Pailler / M. Rouget / D. Richardson / J.M. Sarrailh / D. Strasberg

Context

La Réunion is a French overseas department and a European region with high ecological and evolutionary importance due to its biogeographic situation in the Indian Ocean, volcanic origin, ecosystem diversity and high endemism level.

Like on most islands, loss of biodiversity has been rapid but among the Mascarene archipelago, La Réunion remains relatively well preserved with large areas of intact mountain habitats and with low alien invaders pressure on native biotas (no feral ungulates, monkeys, mongoose, …).

Research activities are very recent especially on terrestrial biodiversity issues. Interest from decision makers to sustain research is growing as conservation and land management options are being discussed for a National Park project with local development constraints (see http://www.parc-national-reunion.prd.fr/index2.html).

Researchers are few and scattered in institutions but the creation of a new institution (UMR) has regrouped 20 researchers in one laboratory covering four major issues: Genetics of cultivated plant species, phytopathology, entomology and ecology.

Potential for research and facilities are quite large. Training in biology attracts many students (50-100) in BSc at the University (Sciences Faculty: 100 lecturers, 20 Professors, 2,000 students). Funding for graduate grants are available at a regional or national level.

Recent cooperation agreements (for economy, research) have been signed directly between La Réunion and South-Africa, and former agreements exist with the surrounding Indian Ocean countries (Madagascar, Mauritius, Comoros, and Seychelles).

Main Objectives

The main objectives of this workshop were:

- To produce a report on Ecological Research on La Réunion based on recent findings, and research proposal from a South-African perspective.

- To build a framework and programme in order to maintain and develop exchanges and cooperation between both countries (students training, post-docs, research programs and meeting).

ATELIER DE TRAVAIL SUR LA BIODIVERSITE A LA REUNION

A la suite de sa visite à la Réunion, la Conseillère scientifique de l'Ambassade de France en Afrique du Sud, Monique Rivier a proposé de soutenir et financer un atelier scientifique sur les problèmes de la biodiversité afin de développer les collaborations scientifiques entre La Réunion et l'Afrique du Sud. Ainsi, nous avons décidé d'organiser un premier atelier de travail rassemblant 8 à 10 chercheurs de chaque pays ainsi que les principaux acteurs de la gestion de la biodiversité.

La coordination de cet atelier est réalisée conjointement par Pr. D. Strasberg and Dr. S. Baret (UMR CIRAD/La Réunion University, France) et par Pr. D. Richardson (Institute for Plant Conservation, Cape Town University, South Africa) et Dr. M.

Rouget (National Botanical Institute, Cape Town, South Africa).

Comité d'organisation: S. Baret / I. Nänni / T. Le Bourgeois / T. Pailler / M. Rouget / D. Richardson / J.M. Sarrailh / D. Strasberg

Contexte

La Réunion est un département français d'outre mer et une région européenne ultra-périphérique qui présente un grand intérêt écologique et phylogénique du fait de sa situation biogéographique dans l'Océan Indien, de son origine volcanique récente, de la diversité de ses écosystèmes et de son haut niveau d'endémisme.

Comme dans la plus part des îles, la perte de biodiversité a été rapide mais parmi les îles de l'archipel des Macareignes, La Réunion demeure relativement bien préservée et présente encore de vastes surfaces de milieux indigènes encore peu soumis à la pression des espèces exotiques envahissantes.

Les activités de recherche dans ce domaine sont très récentes, particulièrement dans le domaine de la problématique de la biodiversité terrestre. L'intérêt croissant des décideurs pour une recherche durable va de paire avec les engagements et les orientations pour la gestion et la conservation des milieux dans le cadre du projet de Parc National, prenant en compte les contraintes locales de développement (cf. http://www.parc-national-reunion.prd.fr/index2.html).

Les chercheurs dans ce domaine sont encore peu nombreux et dispersés dans différentes institutions. Cependant la création d'une nouvelle unité mixte de recherche a permis de rassembler une vingtaine de chercheurs au sein d'une même structure et d'une même équipe travaillant sur 4 domaines majeurs : écologie, entomologie, phytopathologie et génétique des résistances aux agresseurs.

Le potentiel de recherche et les équipements sont importants. Les formation en biologie attirent de nombreux étudiants (50-100 en maîtrise) à l'Université (Faculté des Sciences: 100 Maîtres de conférence, 20 Professeurs, 2000 étudiants). Le financement de bourses de thèses est possible au niveau national et régional.

De récents contrats de coopération (économique et scientifique) ont été signés directement entre l'Afrique du Sud et la Réunion et d'autres collaborations existent avec les pays de l'Océan Indien (Madagascar, Maurice, Comores, Seychelles).

Objectifs de l'atelier

- Produire un rapport sur l'état de la recherche dans le domaine de la biodiversité à la Réunion en regard des récents travaux et des perspectives actuelles dans ce domaine en Afrique du Sud.

- Construire un programme de travail et un calendrier permettant de poursuivre et de développer les échanges et les coopérations déjà engages entre les deux pays (encadrement et formation d'étudiants, accueils de post-docs, programmes de recherche communs, ateliers de travail).

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[2] National Botanical Institute of Mascarene / Conservatoire Botanique National de Mascarin

[3] Office National des Forêts / Forestry Service

[4] The National Park will be set up in 2006 (A group of persons organize it settlement)

WORKSHOP ON BIODIVERSITY DYNAMICS ON LA REUNION ISLAND

PROGRAM

Gabriel de Taffin (Regional Director of CIRAD[1] Réunion) and Bernard Reynaud (Director of Plant Protection Pole) introduced the workshop.
The workshop was organised in two main sessions: (Session 1) Ecology, evolution and systematics and (Session 2) Biological invasions and conservation planning.
Local institutions also presented their work in a special session (Session 3) and on the field.
Finally, a synthesis was given at Region Reunion with local politicians and all the participants (Session 4).

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Chairman: Thierry PAILLER
Co-chairman: Serge QUILICI

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Co-chairman: Stéphane BARET

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Chairman: Mathieu ROUGET
Co-chairman: Jean Michel SARRAILH

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Session 1: ECOLOGY, EVOLUTION AND SYSTEMATICS

EVOLUTION AND ECOLOGY OF POLLINATION SYSTEMS IN SOUTH AFRICA

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The flora of South Africa is not only diverse in terms of number of species, but also replete with highly specialized pollination systems. These are associated with characteristic patterns of convergent evolution among unrelated plants that share common pollinators. In this talk, I will focus on three topics that have been a particular focus of South African researchers in the past few years. 1. *Pollinator-driven speciation.* Studies at several levels, from phenotypic selection on individuals, to comparison among ecotypes and mapping of pollination systems onto species-level phylogenies, support the "pollinator-shift" model of pollinator-driven speciation proposed by Stebbins. 2. *Batesian floral mimicry.* This unusual form of deception in plants is closely associated with specialized pollination systems. 3. *Disruption of plant-pollinator mutualisms.* Specialized pollination systems would be expected to be vulnerable to changes in habitats and population size. Studies show an effect of both habitat fragmentation and population size on the reproductive ouput of individuals. The latter is an example of the general Allee effect that may be even more important than genetic factors for survival of small populations.

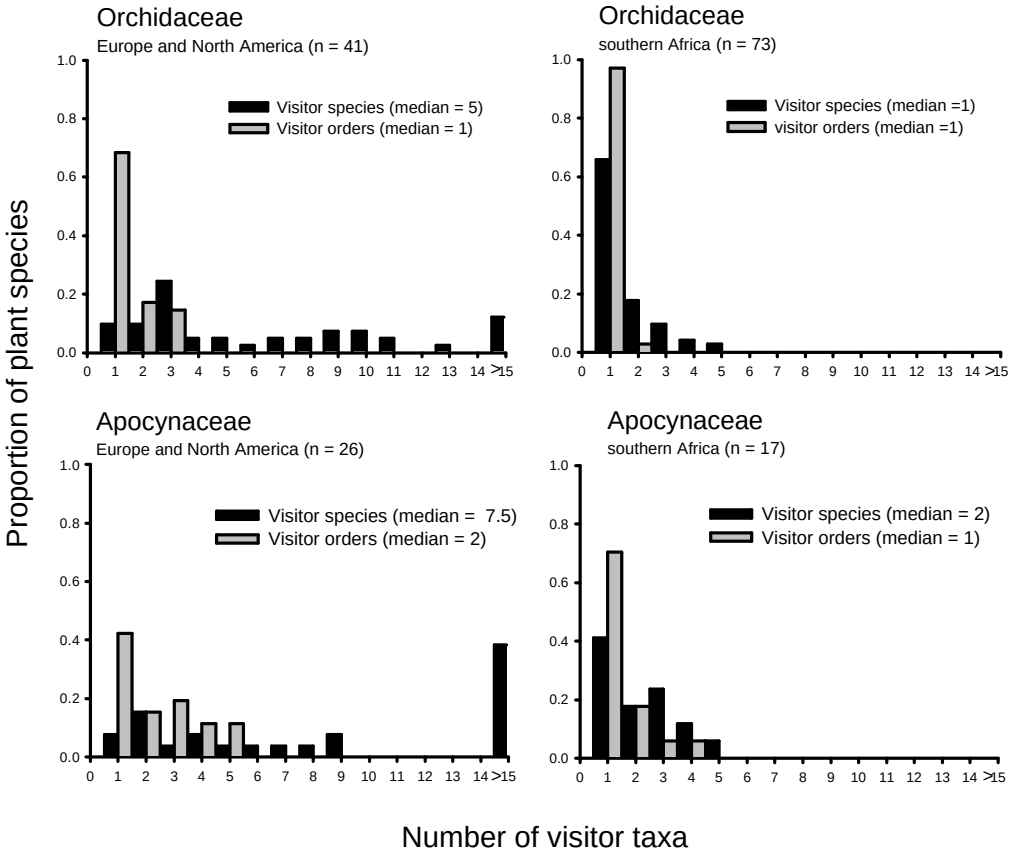

Figure 1. Comparisons of levels of pollination system specialization in two plant families represented in southern Africa and Europe/North America.

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LOSS OF SPHINGID POLLINATION IN LONG SPURRED ORCHIDS IN A TROPICAL OCEANIC ISLAND

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Oceanic Islands are known for their lack of specialised pollinators or entire taxa of pollinators. Thus, plants with floral morphologies requiring certain pollinator types or species would have difficulties becoming established in their absence, unless they are able to self-pollinate. Self-pollination provides reproductive assurance when outcross pollination is limited, which occurs when mates or visits by pollinators are scarce. The ability to self-pollinate is a common features of oceanic islands plants.

Reunion island is a part of Mascarene archipelago. It is an oceanic island that has emerged 3 million years ago. Previous studies on the plant reproduction on native taxa have led to the conclusion that the Baker's law, which predicts an absence of self-compatibility, is poorly verified as many self- and heteromorphic incompatible heterostylous species have been reported mainly in woody species. These studies have shown that plant pollinator interactions are quite diverse. For examples, the distylous *Gaertnera vaginata* is pollinated by a small sphingid species (*Macroglossum milvus*), the distylous *Erythroxylon laurifolium* is pollinated by bees (*Megachile* sp.) and the tristylous *Hugonia serrata* is pollinated by Butterflies (*Papilio phorbantha*). Reunion island is also characterised by a high richness in orchid species as more than 130 species are reported. More than 10 of these 130 species are long-spurred Angraecoids orchids (Pailler; unpublish). Reunion Island flora has been shown to originated by more than 80 % from Madagascar which is the nearest landmass situated 800 km west and Africa. Ungoing phyllogenetic studies show that long-spurred Angraecoids orchids presents on La Réunion derived also from Madagascar. In Madagascar about 10 % of orchids are long-spurred and most of these are from the Angraecoids tribe. Reunion island is also characterised by the presence of 16 native species of sphingids. This offers the opportunity to study the Angraecoid-sphingid interaction in this tropical oceanic island. Long-spured Angraecoids orchid are konwn to be sphingid-pollinated since the discoverry of *Xanthopan morgannii* var *paedicta* a madagascan long-tongue sphingid founded bearing pollinia of *Angraecum sesquipedale* 40 year after its prediction by Darwin. Many other relevant studies have been performed on the Angraecoid-sphingid interaction since that time. The Angraecoid orchid that are sphingid pollinated bears flowers that are long-spured (from 10 to 30 cm), pure white, producing relatively large amounts of nectar (reward), and producting a sweet scent at dusk (attractant). Sphingids that pollinate such species have long-tongue, fly at dusk over long distances, locate the flower at long distance by the scent emitted, locate the flower at short distance by its white colour and visit the flower to the nectar it contains. Nilsson (1985) reveals the existence of monophily which means that one orchid species (*Angraecum arachnithes*) is pollinated by only one sphingid species (*Pangogena lingens*). This author also shown that this sphingid can visit up to six orchid species at the same time in the same site (Nilsson 1987).

The goal of this study is to describe the pollination biology and ecology of two long spured Agraecoid orchids from Mascarene Island: *Jumellea recta* and *Jumellea stenophylla*. We ask us the following questions:
Do *Jumellea recta* and *Jumellea stenophylla* have the typical floral features of sphingophilous species? To answer this question, we study the floral scent production, the nectar quantity and quality, the spur length of these two species. Do *Jumellea recta* and stenophylla depend of a pollinator to reproduce? Does it exist in Reunion Island sphingid that could theorically pollinated long spurred species? Do this two long-spurred species use the service of pollinators to reproduce in the natural habitats?

TAXONOMIC RESEARCH IN ACAROLOGY

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Mite (Acari) samples collected during surveys conducted since 1980, on La Reunion by Drs. Bernard Aubert, Serge Quilici, Serge Kreiter, Agathe Richard and Jean-Francois Vayssieres were identified by acarologists (M.K.P. Smith Meyer and E.A. Ueckermann) of the ARC-Plant Protection Research Institute and the results are reported here. To date 25 families consisting of 60 genera and 107 species of phytophagous and predatory mites were recorded from La Reunion. This excludes the seven families, eight genera and 14 species of saprophytic oribatids, which play an important role in the decomposition of organic materials in soil. According to the results accumulated over the years about 40% of the mites species seems to be endemic to La Reunion (described and undescribed new species) and the rest are introduced officially (Biological control programmes) or naturally (ex. wind).

The predatory mite fauna of La Reunion consists of 18 families (Phytoseiidae, Anystidae, Bdellidae, Hemisarcoptidae, Tydeidae, Cunaxidae, Eupalopsellidae, Stigmaeidae, Ascidae, Macrochelidae, Parasitidae, Erythraeidae, Smarididae, Raphignathidae, Acarophenacidae, Laelapidae, Protodinchidae and Eupodidae) and 84 species, but the biological control potential of most are still unknown. The family Phytoseiidae is the best-researched family because members of this family are well known for their control of crop pests and some species are even commercially reared in Europe. Thirty species of this family are recorded from the island of which eight were described as new. The following species were found in association with crop pests on the Island: *Amblyseius largoensis* (Muma) were found in association with the tenuipalpid *Raoiella indica* Hirst, *Phytoseiulus persimilis* Athias-Henriot with the tetranychids *T. neocaledonicus* André and *T. urticae* Koch, *Neoseiulus bayviewensis* (Schicha) with *Tetranychus urticae* and *N. barkeri* Hughes with *T. evansi* Baker & Pritchard and *T. rooyenae* Meyer. *Phytoseiulus persimilis* and *Euseius ovaloides* (Blommers) were the most commonly found species on the island; however, the latter is an ineffective predator and primarily polliniphagous and only secondary predaceous.

Anystis baccarum (L.) has a worldwide distribution and found most commonly on the island. This voracious species feeds on a wide range of small arthropods but is difficult to rear because of its cannibalism. Besides *Anystis baccarum*, an apparently new *Erythracarus* sp. (=*Bechsteinia*) was also collected in citrus orchards at Bassin Plat.

Two undescribed polyphagous species of the genus *Bdellodes* (Bdellidae) also pitched up regularly during surveys and were found in association with *Brevipalpus phoenicis* (Geijskes) (Tenuipalpidae), tetranychids, eriophyids, tarsonemids and psylla.

All members of the genus *Hemisarcoptes*, family Hemisarcoptidae, feed on armoured scale insects and their hypopi (phoretic deutonymph) are phoretic on ladybirds, which also feed on the same prey. *Hemisarcoptes coccophagous* Meyer is a predator of red scale in citrus orchard in South Africa. An undescribed species of this genus was collected on vegetables on the island and it may be worth the while to evaluate its control potential.

Most members of the family Tydeidae are predators of eriophyid species, but can also feed on eggs of spider mites, pollen and can also be fungi and nematophagous. Nine species were recorded from the island but most are possibly new species

Cunaxids are fast-running generalist predators feeding on a wide range of small arthropods and even nematodes. They hunt their prey and fasten them with silken threads, whereas others snare or ambush their prey. Eight species were collected from the island of which most are possibly new.

The Eupalopsellidae are represented by two species on La Reunion. Members of this family are often associated with armoured scale insects.

Stigmaeids live on plants and on soil surfaces and feed on eggs and immature stages of the Tetranychidae, Tenuipalpidae and other mites infesting commercial crops. Six species were recorded from the island of which three may be new.
Some members of the family Ascidae, like the family Phytoseiidae, also live on plants where they prey on other mites and small arthropods. Four apparently new species and *Proctolaelaps lobatus* DeLeon were collected during surveys.
Members of the families Macrochelidae (three species) and Parasitidae (one species) prefer habitats rich in decaying organic material including manure where they prey on nematodes and other small arthropods. Macrochelids can also contribute to the control of houseflies.
The nymphs and adults of the families Erythraeidae (apparently two new species) and Smarididae (apparently one apparent new species) are free-living predators of other small arthropods. However, their larvae are parasitic usually on insects.
The Raphignathidae is one of 10 families of the superfamily Raphignathoidea. Species of most of these families are predaceous with the possible exception of the families Raphignathidae and Cryptognathidae. So far only one possible new representative of the family Raphignathidae was collected from the island.
Both the Protodinychidae and Acarophenacidae are represented by only one possible new species on the island and members of both are associated with beetles. Species of the former usually occur in seashore or aquatic habitats.
Species of the genus *Pseudoparasitus* are predators of other arthropods in soil, litter and moss.
The family Eupodidae are represented by only one possible new species. Members of this family may be predaceous, fungiphagous or phytophagous
The phytophagous mites are represented by five families (Tetranychidae, Tenuipalpidae, Eriophyidae, Tarsonemidae and Tuckerellidae), 14 genera and 20 species. Many species of the families Tetranychidae, Tenuipalpidae and Eriophyidae, in this order, are worldwide known as pests of crops and their damage can have serious consequences if these mites are not controlled. Members of the family Eriophyidae cause plant deformations, which include galls, erineum, witch's broom, etc., whereas the Tetranychidae and Tenuipalpidae cause discoloration leaves with their needle-like chelicerae. Eventually the leaves die and drop-off. The tenuipalpids species *Brevipalpus phoenicis* is the vector of the much feared leprosies virus in Brazilian citrus orchards. Ten tetranychid, three tenuipalpids, four eriophyid, two tarsonemid and one tuckerellid specie were reported from the island, most of them are well known pests of crops and in orchards. Two species of the Tetranychidae and one of the Eriophyidae are apparently new.
The two species of the family Acaridae, *Tyrophagus putrescentiae* (Schrank) and *T. neiswanderi* Johnston & Bruce are mainly saprophagous, graminivorous, fungivorous and phytophagous. However, *T. putrescentiae* can also prey on eggs of insects and on nematodes. The genus *Calvolia* of the family Saproglyphidae, are also saprophagous and fungiphorous and their nymphs are usually phoretic on bees and wasps.
Mite sampling on La Reunion mainly concentrated on vegetation/crops/orchards. I am sure there are still new/known species on the vegetation that await discovery. However, knowledge of the soil mites is still fragmentary and this habitat also has a rich diversity of mites and other arthropods.

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CURRENT STATUS OF KNOWLEDGE ON ENDEMIC ENTOMOFAUNA FROM HIGHLANDS OF LA RÉUNION

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The status of knowledge on the entomofauna of La Réunion appears quite variable depending on the insect order considered. While Coleoptera and Lepidoptera have received sustained attention, it is only recently that some other groups such as Odonata, Dictyoptera, Thysanoptera or Hemiptera Auchenorrhyncha have been extensively studied. Other important orders such as Diptera and Hymenoptera appear to be far less known and will require extensive studies in the future.

Within the on going process of the creation of a National Park in the highlands of La Réunion, a series of studies was initiated by the "Mission Parc National des Hauts de la Réunion", aiming at synthetising the current knowledge on various groups of plant and animals. CIRAD was in charge of the work on entomofauna.

In collaboration with the Natural History Museum, the Insectarium of La Réunion and some individual specialists, an attempt was made to synthetize the current status of knowledge on the different insect orders based on existing literature records. The attention was focused on four groups (Odonata, Hemiptera Auchenorrhyncha, Coleoptera, Lepidoptera) selected on the base of their knowledge status or their possible interest as bio-indicators. All endemic taxa from La Réunion or from the Mascarenes were listed and their known geographical distribution precised. The corresponding database was used with GIS to draw maps of areas showing a particular interest for the conservation of these endemic taxa.

Further studies should be conducted to extend to database to all orders of insects and other group of arthropods.

INSECT DIVERSITY CONSERVATION – WITH SPECIAL REFERENCE TO THE MASCARENES

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Despite being enormously speciose, insects are under threat as are many other taxa. Predicitions are that as many as a quarter may go extinct over the next few decades. Impacts vary, but habitat loss and threats from invasive aliens are top of the list. Many of the impacts are synergistic, with global climate change apparently now impacting on certain insects in the northern hemisphere. In southern Africa and in Mascarenes there is strong evidence that various synergistic impacts are conspiring to threaten a variety of invertebrates. Among these, is a combination of factors such as impact of invasive alien trees, removal of indigenous forest canopy and pollution of streams. These impacts are particularly great on aquatic faunas where the streams are short (owing to small island size) and yet in heavy demand for human use. In some cases, we are not sure why some species have declined so dramatically. This is the case with the Seychelles Giant Millipede which formerly has played a major role in soil formation on several Seychelles islands. In other instances, such as the Frégate Island Giant Tenebrionid beetle, the threat is known and direct, from rodents. Not all invasives have been harmful. The Indian cockroach *Pycnoscelus indicus* is invasive yet is a mainstay diet item for the threatened Seychelles Magpie Robin and endemic skinks.

Evidence is also accumulating that conservation efforts on these islands is closely related to health of sea life. Sea birds, for example, bring in a huge amount of organic material which gets cycled on the islands. The decline of the coral reefs in 1998 may be resulting in a delayed, incipient impact on the terrestrial ecosystems. Restoration efforts, at least in the Seychelles, are proving to be immensely valuable in bringing back local biodiversity. The reason lies in the fact that many local endemics have, by definition, small local ranges. This means that point restoration at a small spatial scale can have an immediate beneficial effect. This parallels the situation in the Western Cape, where thought-to-be extinct Odonata (dragonfly) species have 'reappeared' through removal of invasive alien trees. We are terming this 'extinction reprieve', and is an achievable goal in the Indian Ocean Islands context. These restoration activities are a positive response to the dramatic declines of various taxa listed on the 2004 Red List and The Global Species Assessment. This restoration effort is a major goal of the IUCN/SSC Southern African Invertebrates Specialist Group, which has jurisdiction as a Red Listing Authority in the Mascarenes as well as on the African mainland.

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INSECT DIVERSITY AND CONSERVATION IN SOUTH AFRICA

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Most conservation planning in South Africa is based on plant, biome and vegetation type data, and additional attempts to preserve processes relating to plant evolution.
This is partly due to the availability of relatively complete floral datasets. In contrast, equivalent data for the fauna is generally lacking, and typically, inclusion of these data is restricted to vertebrates. Insect (and other invertebrate) data is generally omitted from such conservation planning, in spite of its overwhelming contribution to diversity and the mutualisms that exist between plants and insects. An additional consequence of this is that unique (ancient) evolutionary lineages amongst the insects are not conserved. Part of the problem is that insect type data are problematic. There are a huge number of taxa involved, with incomplete taxonomy and distributions. In addition, hotspot analysis of insect data for species richness and endemism seldom show concordance with that of equivalent plant data.
This report focuses on the use of mapping to incorporate insect data into conservation planning. Examples are taken from two South African biomes that are justifiably renowned for their floral species richness and endemism. Conservation planning within these two biomes (the Succulent Karoo and Fynbos) is largely floral-based, and the nature of the unique insect fauna is generally not appreciated. Two approaches can beemployed; the first uses very large combined data sets from a number of taxa, in the hope of showing some pattern in terms of richness and endemism hotspots. As an example, grasshopper distribution within South Africa (excluding Acrididae) does not show any particular pattern, with hotspots scattered at random. Separate analysis of parts of the entire data set show clearer patterns, with a distinct western (arid) fauna showing high levels of endemism, even to family level e.g. the endemic family Lithidiidae. In addition, there is an eastern (Afrotropical) element showing lower levels of endemism.
The insect fauna of the more mesic fynbos biome is characterized by having a very strong Gondwanan signature (with some intrusion of Afrotropical elements). A hotspot analysis using various level taxa, from species through families to Orders shows a similar pattern, with foci in the southwest at the intersection of the north-south and east-west mountain chains. There is a sharp drop-off in taxon richness towards the north-east. Associations with habitat and vegetation type can be observed using simple correlation analysis. Results indicate that the majority of species occur on cells having Table Mountain sandstone geology (the Cape Fold mountain system), but also that many of the species occur at lower altitudes, in coastal forest. This type of correlation analysis can be used to define the various relictual habitats in which the Gondwanan taxa occur.
The last example uses a large data set of plant taxa largely endemic to the fynbos biome (but which do occur elsewhere in South Africa), and overlays this with a fairly complete dataset for a speciose group of flower- associated beetles (Hopliini). In this case, one might expect some degree of concordance in the distribution of the two groups. Hotspot analysis for richness indicated good congruence between the two data sets, an unusual finding that might be restricted to insects having close and obligate associations with host plants. Such examples provide suitable surrogate taxa for conservation policy. Scale is an important consideration in the application of the mapping exercises, as is the selection of taxa to be used. In most cases much useful data can be gleaned from existing distributional records in museum and the literature.

AUCHENNORRHYNCHA (INSECTA HEMIPTERA) AS POSSIBLE BIOINDICATORS OF DISTURBED/UNDISTURBED HABITATS IN REUNION ISLAND: A MODEL STUDY IN MARE-LONGUE FOREST

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Insects and their ecological data represent a powerful tool for measuring global change. At a more local level, conservation, management and restoration of tropical forests require a sound knowledge of their biodiversity associated to a careful monitoring. In Reunion Island, regular sampling using Malaise and aerial Malaise traps were conducted from February 2001 to January 2002 in intact and disturbed habitats in the lowland rain forest of Mare-Longue in order to provide useful new tools for a better monitoring of this diversified area of high biological interest.

9612 adult Auchenorrhyncha whether planthoppers (Hemiptera Fulgoromorpha) or leafhoppers (Hemiptera, Cicadomorpha), were trapped in both habitats over a one year sampling period. For Fulgoromorpha, 28 species and 8 families were recorded but only 18 species, with more than 10 individuals collected, representing 7 families, were retained for analysis. These 18 species, including 15 taxa common to both habitats, are represented by 3851 specimens of which 2248 (58 %) belong to the prevalent species *Achaemenes quinquespinosus* Synave, 1959. Specific richness is almost similar in intact (18 taxa) and disturbed (17 taxa) habitats. Exotic Delphacidae and Flatidae, infeodated to the secondary vegetation of the island, were not trapped in Mare-Longue forest. Among Cicadomorpha, 12 morphospecies were recorded, *Xestocephalus* sp. (Xestocephalinae) appeared to be the dominant taxa with 5598 individuals over 5771, representing 97 % of the cicadomorph fauna of this area. Eight species of Typhlocybinae and Deltocephalinae collected in this forest formation are newly recorded for Reunion Island.

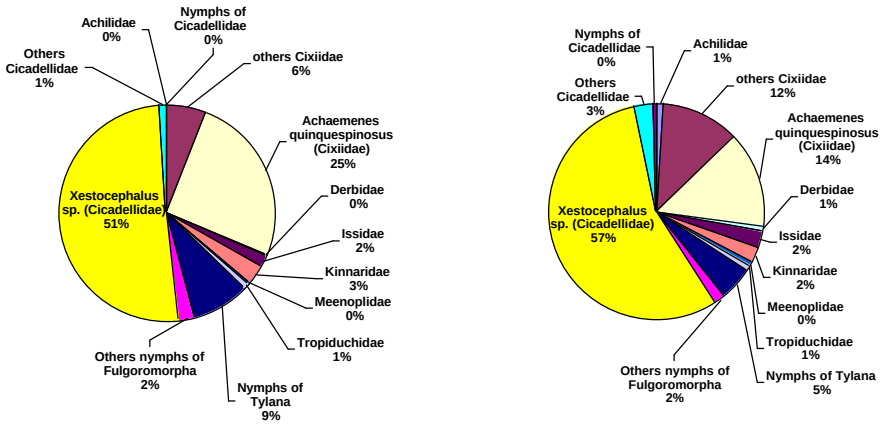

Fig. 1 Percentage of Auchenorrhynchous taxa in disturbed and intact habitats

From a quantitative analysis (Fig. 1), Fulgoromorpha and Cicadomorpha share almost equally the phytophagous resources in Mare-Longue in both disturbed and intact habitats, with a small predominance of leafhoppers in the latter. The leafhopper *Xestocephalus* appears to be the dominant auchenorrhynchous taxa in the whole area: respectively 51 % and 57 % in disturbed and undisturbed habitats. It is followed by the planthopper *A. quinquespinosus* representing

respectively 25 % and 14 % in the same habitats. Cixiidae appears to be the most diversified and dominant family. A high percentage of nymphs of the Issid *Tylana* is noticeable in both habitats.

Effects on communities

Correspondence analysis (dudi.coa function from ade4 R-package) (Thioulouse et al. 1997), http://pbil.univlyon1.fr/ADE-4/) depicts a clear gradient in the temporal distribution of Fulgoromorpha species between intact and disturbed habitats (Fig. 2). Particularly for Cixiidae, intact habitats are privileged by *Brixia belouvensis aurata*, *Brixia insularis*, *Brixia belouvensis belouvensis* Synave, 1959, *Brixia costalis* Synave, 1959 (Cixiidae), *Insulisia* sp. 1 (Meenoplidae), *Idiomyctus nigrostriatus* (Synave, 1961), *I. notatulus* (Stål, 1866), *Clardea unicolor* Signoret, 1862 (Tropiduchidae), *Muirileguatia borbonica* Williams, 1976 (Derbidae) and *Paraphypia macabeana* (Achilidae), while disturbed habitats are characterized by the presence of *Insulisia* sp. 2 (Meenoplidae), *Oliarus sanctiphilippi* Synave, 1959 (Cixiidae) and *Cuneoceps insularis* Williams, 1981 (Tropiduchidae). These species appear as useful indicators of Reunion forest disturbance, particularly *I. nigrostriatus*, *I. notatulus* and *C. unicolor* which are strictly infeodated to the intact forest whereas *Insulisia* sp. 2 and *C. insularis* are closely related to disturbed sites.

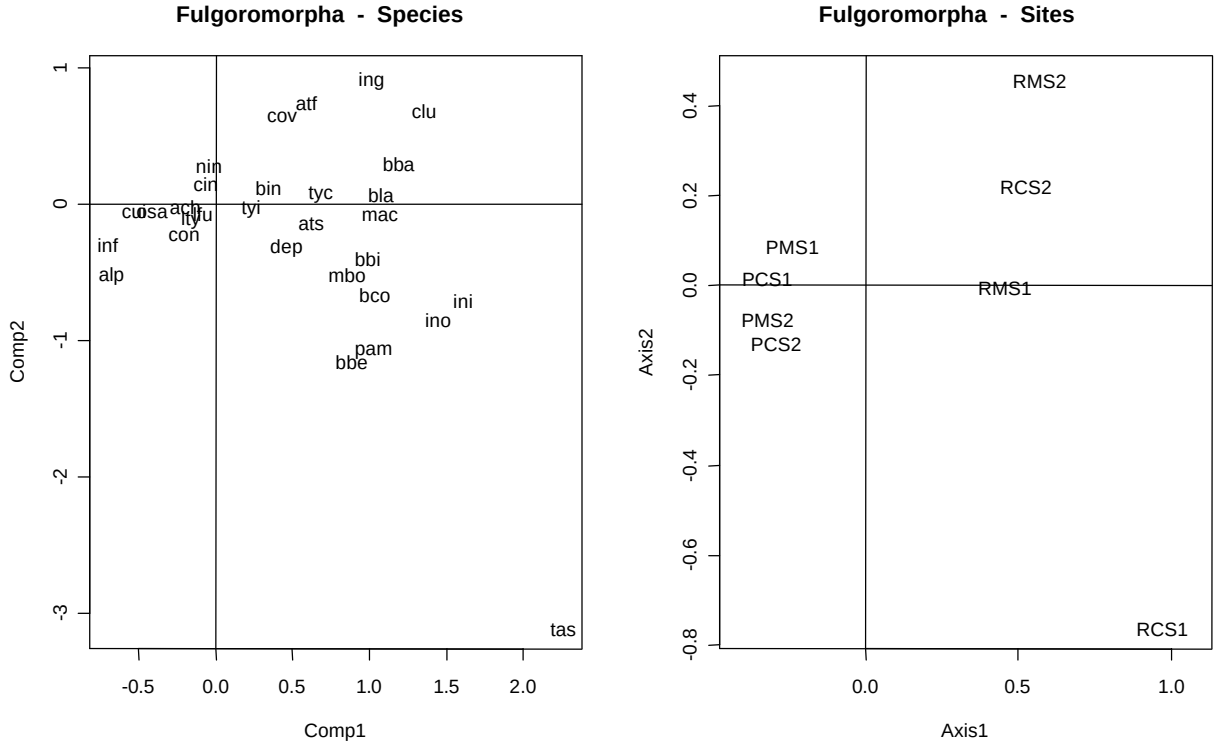

Fig. 2 Factorial Component Analysis for Fulgoromorpha species according to habitats (P: disturbed and R: intact), insect trap types (M: Malaise and C: aerial Malaise) and sites (S)

Conclusions

In the lowland rain forest, Fulgoromorpha diversity depends primarily on botanical variables due to their high diet specialization in a number of host plants (Attié 1999; Attié et al. in prep.). Host pattern analysis of Mascareinian planthoppers contributes to explain their food use in the botanical and ecological context of these islands. Hoppers species distribution is directly linked to their host plants distribution but also to the latter's abundance. *Oliarus sanctiphilippi* is for example supported in disturbed habitat by land ferns. In this intact biotope, the presence of *I. nigrostriatus* and *I. notatulus* is related to that of the Ericaceae *Agauria salicifolia*, a tree quasi absent in this disturbed habitat.

According to McGeoch (2000), species indicators should be considered as ecological indicators if they readily reflect the state of environment, if they represent the response of other taxa to

environmental state and are temporally and spatially robust within the context of the bioindication objective. If Cicadomorpha do not appear to be good candidates as such indicators in Reunion Island, Fulgoromorpha in return show several potential taxa. Cixiidae particularly, the most diversified family in the forest vegetation of the Mascarenes (Attié et al. 2002), have several taxa that should be tested in that sense. In other insular areas such as the Hawaiian archipelago and Polynesia, Delphacidae are characterized by a preponderance of dicot records (Wilson et al. 1994). They should have been a potential taxa for such a project. However it is also noticeable that Delphacidae feed principally on herbaceous monocots (Bonfils et al. 1994; Attié 1999) in Reunion Island as in continental areas and appear to be totally absent from the survey.
A first application of these observations should be to include some "disturbed" areas in conservation and management planning because of their high entomofauna diversity.

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MOLECULAR PHYLOGENY OF THE LARGE AFRO-MALAGASY SUBTRIBE ANGRAECINAE (ORCHIDACEAE).

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The subtribe Angraecinae is belonging with the Aeridinae and the Aerangidinae to the tribe Vandeae and contains about 400 species distributed into 18 genera, 14 are African: *Aeranthes*, *Ambrella*, *Angraecum*, *Bonniera* (endemic from La Réunion), *Calyptrochylum*, *Cryptopus*, *Jumellea*, *Lemurella*, *Neobathiera*, *Oeonia*, *Oeoniella*, *Ossiculum*, *Perrierella* and *Sobenikoffia* and 4 are South American: *Campylocentrum*, *Dendrophylax*, *Harrisella* and *Polyradicion*. Species are represented by epiphytic monopodial orchids having white or green nectariferous flowers with generally a prominent spur associated with moth-pollination syndrome. Around 60 species are occurring in the Mascarene archipelago.

Into the subtribe Angrecinae, the main genus, *Angraecum*, contains more than 200 species, divided up 19 sections, occurring in tropical Africa (50 spp), Comoros (10 spp), Madagascar (140 spp) and Mascarene islands (40 spp, of which 20 endemics). Concerning plant-pollinator coevolution, the genus *Angraecum* had become famous, because of *A. sesquipedale*, for which Darwin (1862) predicted (according to the spur length around 30 cm) an unknown giant hawkmoth as pollinator, found 41 years later in Madagascar. If hawkmoth pollination syndrome is predominate in the genus, the morphology of the flowers is nevertheless very diverse, suggesting different kind of pollinators. The Angraecoides, Nana and Gomphocentrum sections group actually species with little-green flowers and the Hadrangis one (*A. striatum*, *A. bracteosum* and *A. cadetii*), endemic from La Reunion, is particularly interesting, because of the shape of the spur (wide and short), very uncommon for white flowers in the genus. The high morphologic diversity of the flowers involves a high variety of pollinators (unknown for most of the species), what makes the *Angraecum* genus a good pattern for studying the plant-pollinators evolution process in the Indian Ocean zone.

With both endemic genus and endemic section of *Angraecum*, the Angraecinae species from Reunion Island represent an ideal pattern for resolving phylogenetic question about orchid origin and diversification in an oceanic island. The purpose of the molecular phylogeny of the Angraecineae subtribe was (1) to clarify the phylogenetic relationships of the genera into the subtribe, especially the sister-group of the endemic genus *Bonniera*, (2) to test the monophyly of the genus *Angraecum* and its different sections, especially the endemic Hadrangis one, with the very particularly spur shape, (3) to draw an evolutionary scheme of the pollination syndrome and the spur length among the subtribe, according to the floral biology and the known pollinators.

BRYOPHYTES IN FOREST ECOSYSTEMS OF RÉUNION ISLAND

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Bryophytes are mainly composed of tiny chlorophyllous plants that possess neither roots nor real conductive tissues. Generally, as photo-autotrophous organisms, they colonize terrestrial and aquatic sites. Even though bryophytes reproduce according to a haplo-diplophasic cycle, they also multiply abundantly in a vegetative way. On a taxonomic level, as Embryophytes, they can be divided into 6 classes *Hepatopsida, Anthocerotopsida, Andreaopsida, Sphagnopsida, Takakiopsida* and *Bryopsida* (Crum 2001).

Bryophytes are present in all the regions of the earth, from the Equator to the arctic grounds, and from the littoral zone to mountains. Due to their tiny size and their capacity to occupy and to exploit innumerable micro-sites , their distribution is less precise and pertinent than that of tracheophytes. In contrast, they are very useful in underlining local edaphic and climatic conditions. Consequently, they are more sensitive than phanerogams by reacting to low variations of the specifications of a given site.

Bryophytes, according to the ecological groups they belong to, are specialized enough to occur in diverse biotopes. Numerous species are subservient to particular ecological environments. According to colonization stage, they can play the role of pioneer, post-pioneer, nomadic or climax species. As a consequence, they are considered as good indicators of the intrinsic evolution of ecosystems. In tropical areas, due to the high diversity of plants and the confinement of bryophytes, they have been less frequently investigated than vascular plants. Moreover the number of experts is low and bibliography is incomplete (Frahm 2003).

In fact, the first bryological inventory concerning Réunion Island dates to the end of the 19th century. Bescherelle wrote the first synthesis (Bescherelle 1878; Bescherelle 1880) followed by the works of Renauld, 1897). Then, other researchers came and collected bryophytes in the 20th century (Onraedt 1977; Jovet-Ast 1958; Jovet-Ast 1993; Bischler 1990; Arts & Yamada 1998)…and in the 21st century (Müller 2002).

Presently, bibliographies do not give a precise assessment of the bryological richness of the island. Nevertheless, Frahm (2003) estimated that for Réunion Island at least 376 Musci and 227 Hepaticae were present. Consequently, it becomes necessary to update these data and make some new inventories in a more systematic and coordinated manner.

Moreover, compared to other islands in the occidental Indian Ocean area, Reunion Island is characterized by the presence of well-preserved native ecosystem. Presently, 30 % of the surface is still covered by natural forests. A good knowledge of the specific and functional diversity is required for the conservation of primary vegetation.

The rôle of bryophytes in ecosystems is extremely variable. This is essentially related to the importance of the relative biomass in ecosystems. The relative biomass of bryophytes can be extremely low in open and dry environments, whereas it can be very significant in humid environments. However, in forest areas, they can play an important role in the circulation of water and dissolved nutrients, particularly due to their retention and storage abilities (Pócs 1982).

The general aim of this three years project is first to evaluate the bryological diversity in tropical insular forest ecosystems, responding to a lack of knowledge on dynamics and diversity of the species living in indigenous habitats. This project also aims at evaluating the impact of fragmentation, habitat degradation and introduction of allochtonous species on bryophyte communities. Comparative studies will be carried out between indigenous primary habitats and their diverse stages of disturbance (natural or human).

Further, this project aims at putting the bryophyte flora of Reunion Island in a biogeographical context, by comparing bryophyte diversity of Réunion Island with that of neighbouring islands in the Mascarene area.

Another objective of this work concerns the estimation of the bryological richness associated to diverse cormophytic communities, which are structuring the major vegetation of the island. In this case, particular attention should be paid to the organization and the spatial distribution of bryophyte communities in the studied ecosystems, in order to define and to specify the behaviour of species (auto- ecology).
This research program is integrated into national issues on conservation of natural biological resources. On the long term, this work can be integrated into a broader program, in order to obtain a better knowledge on bryological diversity and ecology of species in the West Indian Ocean area (Réunion, Comores, Seychelles, Mauritius, Madagascar).

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SOPHORA DENUDATA TREES: MAJOR CENTRES OF BIODIVERSITY WITHIN THE MOUNTAIN THICKET VEGETATION AT LA FOURNAISE HIGHLANDS?

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The ecological importance of *Sophora denudata* is poorly known. Many biological features are studied since the observations suggested that this endemic species is under threats that can compromise its regeneration. The hypothesis of a recent and extensible colonization at La Fournaise highlands is proposed for areas over 2 150 m asl that are well conserved and not disturbed by human presence. *Sophora* stands are still in progress and spread through the ericaceous bushes. It is equally argued that *Sophora denudata* is a host-plant and a major source of food for two bird species (main pollinators?), two specialized moths and caterpillars, and several coleopterans. Another property of *S. denudata* is the fog droplet-catching process that provides water benefits to ecosystem. This biogeographical study aims at proposing, first, additional knowledge, and finally a multi criteria tool for decision aiding and analysis for both national forestry service and national park management plan.

Key words. *Sophora denudat*a, *Cydi*a, *Zosterop*s, reproductive biology, seed bank, germination, fog, subalpine cloud forest, biodiversity, decision analysis, management, Piton de La Fournaise.

Session 2: BIOLOGICAL INVASIONS AND CONSERVATION PLANNING

PLANT INVASION ECOLOGY IN 2004 ~ ADVANCES AND CHALLENGES

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Substantial progress has been made over the past two decades in the field of plant invasion ecology – the study of plants introduced to regions outside their natural ranges due to human activity. Studies have addressed all aspects relating to the introduction of plant species, their ability to establish, naturalize and invade in the target region, their interactions with resident organisms in the new region, and the consideration of costs and benefits of their presence and abundance with reference to human value systems. How far have we really come in the half century since Charles Elton's pioneering book on "*The ecology of invasions by animals and plants*" set the scene for what is now known as invasion ecology? And, how much of what we have learnt about invasions is really useful for managing the problem?

Fundamental issues at the forefront of plant invasion ecology recently have been: (1) What kind of ecosystems are more (or less) likely invaded by alien plants?; (2) What kind of plants are the most successful invaders and under what circumstances?; (3) What is the impact of the plant invaders?; and (4) How to use our improved understanding of the above issues to manage plant invasions.

This presentation reviews some key developments in the field, including:

- The greatly improved availability of lists of alien species for many regions, in some cases with the application of objective criteria for defining the status of species within the new region;
- Appreciation of the varied and complex roles of a wide range of biotic interactions in facilitating or limiting invasions;
- The development of several far-reaching conceptual models describing the interaction of the many factors that influence invasiveness and invasibility;
- Considerable advances in spatially-explicit modelling, facilitating improved understanding of key processes, including the role of long-distance dispersal and the importance of propagule pressure;
- The explosion of detailed experimentation to unravel fundamental aspects of invasiveness and invasibility;
- The provision of objective criteria for assessing the impacts of alien species;
- The careful delimitation of the pathways for introduction and dissemination of species associated with certain spheres of human activity, e.g. forestry and agroforestry, and horticulture;
- The application of formal cost-benefit analyses and related techniques in resource economics to plant invasions;
- Emerging understanding of the implications of global change, including climate change and elevated CO_2 for alien plant invasions.

DETERMINANTS OF INVASIVE ALIEN PLANT DISTRIBUTION AND ABUNDANCE IN SOUTH AFRICA: THE ROLE OF ENVIRONMENT, HUMAN ACTIVITIES AND PROPAGULE PRESSURE

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A large number of alien plant species have been introduced to South Africa, some with huge ecological and economic impacts on natural habitats. We reviewed the role of human activities, propagule pressure and environment in structuring spatial patterns of invasive alien plant distribution and abundance in South Africa. The South African Plant Invaders Atlas database has nearly 50,000 records (mostly collected at a quarter-degree-square scale) for 572 introduced plant taxa. We used these data to quantify the spatial pattern of plant invasion. Nearly 300 species are confined to a few locations, mostly in human-disturbed areas. The 126 species that are clearly invasive in natural and semi-natural ecosystems were the focus of our study. We developed predictive models of species distribution and abundance for five major invasive plants. Climatic factors explained relatively well the spatial pattern of species distribution, but not abundance. Abundance was better explained by the extent of habitat transformation and human-induced disturbances. The spatial pattern of *Acacia mearnsii* distribution in natural areas was strongly auto-correlated with its spatial pattern in disturbed areas, suggesting that for some invasive species, populations might build up in disturbed areas before invading natural areas. We discuss the implications for management.

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SPATIAL ANALYSIS OF THE MAIN INVASIVE PLANT INVASIONS ON LA RÉUNION ISLAND

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Introduction

The Malagasy region including the Mascarene Islands (La Réunion, Mauritius, and Rodrigues) is recognised as a biodiversity hotspot (Myers et al. 2000). La Réunion conserves by far the largest area of relatively intact habitats in this archipelago. Around 30 % of the original vegetation of La Réunion is considered as intact (Strasberg et al. 2005), compared with less than 5% for Mauritius and none for Rodrigues (Lorence & Sussman 1988). This intact remaining vegetation is very important in terms of biodiversity conservation because it includes an important rate of endemic flora (~70 of indigenous plant species are endemic of Mascarene), but also an important fauna diversity. Therefore, this intact vegetation will be soon 'protected' (creation of a national park, scheduled for proclamation in 2005). But, even if human impact will become less important, La Réunion faces many threats, including severe and rapidly escalating impacts due to invasive alien species, especially plants (Macdonald et al. 1991; Lavergne et al. 1999; Baret et al. 2004). Thus, biological invasions will become the primary threat to biodiversity in the intact habitats of La Réunion (those not already transformed by agriculture and urbanization). Since European colonization in the 17th century, more than 2000 plant species have been introduced to the island. Of these, some 628 species are naturalized, and 62 are highly invasive (Macdonald et al. 1991). Therefore, conservation authorities have called for criteria on which to base spatial priorities for conservation, including requirements for the effective management of alien plant invasions. However, no spatial analyses have been done for invasive alien plants across the island, and current priority setting is simply based on checklists that are available for some areas. Our study aimed at identifying areas to prioritise in managing invasive alien plants for biodiversity conservation. Thus, we firstly determined spatial distribution of the most problematic invasive alien plants. Secondly, we predicted the potential extent of some of them. Finally, specific guidelines were formulated for use by decision makers and nature reserve managers.

Material and Methods

We used extensive surveys of 238 distinct untransformed areas (called ZNIEFF in French system) on La Réunion to define the current distribution of all introduced plants (Dupont 1985-2001). Using expert knowledge, we compiled maps of the current distribution of the most invasive plants at the habitat scale. Data from 440 botanical relevés across the island (Lavergne, unpublished data) and a variant of climatic envelope models (Mahalanobis model, see Farber & Kadmon 2003, Rouget et al. 2004) were used to derive climatic suitability surfaces (altitude, precipitation and slope). This approach generates predictive maps of species distribution using data on the climatic characteristics of the site where the species were recorded.

Results-discussion

At the wide scale of the island, our results identified lowland and leeward coast as the most degraded habitats. As in our study, we focussed on remnants of intact native habitats, we highlight the importance to act rapidly against alien invasive plants within these areas. However, in a goal to limit future problems, appropriate methods will be necessary to be better scientifically studied (see Lavergne in this fascicule for an example against *Hedychium*

gardnerianum). Moreover, invasive plant eradication will be different if the alien plant is present in large patches than if its only represent by some individuals. Thus, attention should be given to preventing increasing density within their current range and to surveying potentially suitable areas to eradicate new invasion foci.

Our study is a first stage in conservation planning. Other important parameters in term of conservation biodiversity as birds nesting site, rare plant species localisation, insects distribution… will be important to include in a future global conservation planning at La Réunion.

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THE CONSERVATION FARMING PROJECT – AN ANALYSIS OF CONSERVATION FARMING PRACTICES IN FOUR REGIONS OF SOUTH AFRICA THAT HAVE GLOBALLY SIGNIFICANT LEVELS OF BIODIVERSITY.

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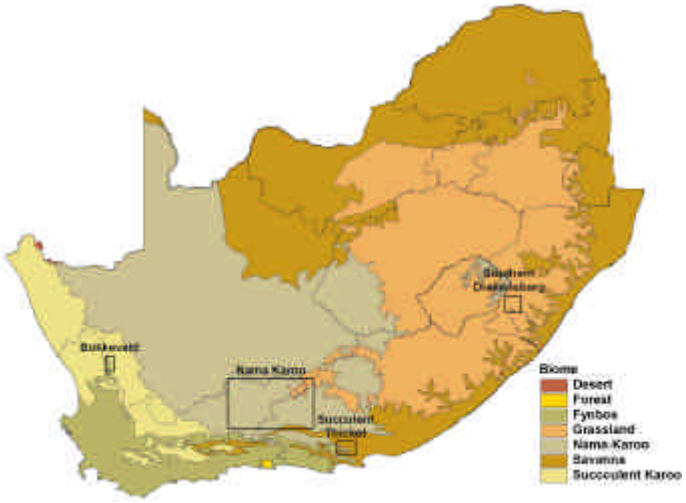
South Africa has an exceptionally rich natural diversity of plants and animals. Although the country represents only about 0,8% of the Earth's land surface area, more than 8% of all plants grow in South Africa. It is also home to between 2% and 7% of the world's amphibians, reptiles, birds and mammals. Only 6% of South Africa's land surface area is formally conserved, far less than the figure of 10% recommended by the World Conservation Union (IUCN). In South Africa, wild animals enjoy greater protection than plants, with about 90% of amphibians, reptiles, birds and mammals being found in nature reserves. However, there are different natural vegetation types and some are very poorly conserved. Depending on the vegetation type, only 34% to 74% of plant species occur in nature reserves. Farmers manage about 80% of the land in South Africa. Although many farmers have developed land use practices that conserve biodiversity, agriculture can also damage the environment and threaten biodiversity. Because our network of nature reserves is inadequate, any national conservation assessment or strategy must take account of the role of farmers in conservation.

The South African National Biodiversity Institute received a grant from the Global Environment Facility to evaluate conservation farming practices in four regions of South Africa that have globally significant levels of biodiversity so that these practices can be more widely applied as part of an overall conservation strategy, and promote land use practices that conserve biodiversity and provide sustainable livelihoods for farmers and rural communities. In this study we assessed the possible benefits of biodiversity and carbon sequestration to farmers and then evaluated the economics of different farming practices and the social costs and benefits of different options. Finally we used the information to develop an ecological-social-economic model for each region that can be used to assess the extent of win-win scenarios for conservation farming and guide land use planning in the area. Due to inherent differences in the data, two methods were used – in two of the regions models were based on different land use scenarios (using EXCEL spreadsheets) whereas dynamic systems models were constructed for the other two regions using STELLA software.

The main achievement of the Conservation Farming Project was to provide a sound basis for evaluating the role of conservation farming in strategies to conserve biological diversity. Other projects funded by the Global Environment Facility and the Critical Ecosystem Partnership Fund in South Africa have already established that conservation on private land is an essential component of national and regional conservation strategies. This project showed how and where conservation farming can make a contribution.

The broad outcomes of the study are discussed below under each of the four regions.

Map of South Africa indicating the four study sites.



Bokkeveld Plateau

The Bokkeveld Plateau is a semiarid region that straddles the margins of the Cape Floristic Region and the Succulent Karoo. Both the Cape Floristic Region and the Succulent Karoo are recognised biodiversity hotspots, and the Bokkeveld Plateau has remarkably high plant diversity (ca. 1350 species) and endemism (6.5%). Our studies show that on the Bokkeveld Plateau there is a definite biodiversity benefit associated with practices that retain existing vegetation remnants, and where the veld is periodically rested from grazing. However, these farming practices result in a financial loss for farmers unless they are able to increase revenue from ecotourism. Conservation strategies in this region therefore need to find ways of compensating farmers for lost income or increasing farmers' access to revenue from ecotourism.

Nama Karoo

The Nama Karoo occupies 607 235 km2 and is the largest biome in South Africa. The entire biome is characterized by low (ca. 200 mm) and variable annual rainfall, which results in highly variable grass and shrub biomass production. The area is suitable only for extensive livestock pastoralism, but the frequency of disaster-magnitude droughts presents a huge challenge to farmers trying to make a sustainable living in this area. We were unable to discern any clear benefit associated with different grazing systems. However, because of the aridity Karoo ecosystems are known to take up to 40 years to respond to changes and part of the strategy for this area should be to monitor the status of biodiversity under different grazing systems.

Southern Drakensberg

Much of the area has been used for extensive grazing of cattle or dairy herds on commercial farms, or rough grazing on communal land areas. Grazing has been regarded as a biodiversity-friendly landuse although poor pasture management has resulted in sheet and gulley erosion and a loss of biodiversity. Harvesting of firewood and collection of medicinal plants is also common practice on communal land. Recent changes in the economics of farming have resulted in dramatic conversions to plantation forestry, high-yield crops (potatoes, maize), ecotourism and game farming. Although conservation farming provides benefits in terms of biodiversity, water provision, and carbon sequestration, there are limited benefits for farmers. Security problems, the high value of land, and the expansion of forestry have created a dynamic situation where land use and conservation planning are far more important for effective conservation strategies than the implementation of conservation farming practices.

Succulent Thicket

The Thicket Biome has high levels of endemism. Extensive pastoralism, mainly with angora goats, has been the predominant landuse but frequent droughts and poor stock management have resulted in degradation, erosion and loss of biodiversity. Several farmers have switched to game farming as an alternative to stock farming and this has a clear biodiversity benefit that is also more financially viable than goat farming, as well as having a substantial carbon benefit. This win-win outcome suggests that conservation farming practices can play and important role in conservation strategies in this area.

The regions differed substantially in terms of biodiversity, sociology and economics, but a number of cross cutting lessons can be learnt from the outcomes:

- All farming systems have an impact on biodiversity, but some are better than others. However, it is important to develop objective criteria for assessments because factors such as land use history and the location of the farm (e.g. heterogeneity) can obscure the impacts of current land use.
- Farmers generally care about the environment and most view themselves as conservation farmers. This is partly due to confusion regarding what they are trying to conserve (soil, agricultural resources, or biodiversity) and it is important to make the case for biodiversity conservation more explicit.
- The social component of the study showed that land use decision-making is a complex process that is influenced by a variety of needs and satisfiers. In addition to financial reasons, farmers may pursue certain practices because of support networks (extension services, social networks), quality of life decisions, or security needs. The mainstreaming of biodiversity in the agricultural sector needs to take this into consideration when developing enabling mechanisms.
- A review of past successes in conservation farming showed that enabling mechanisms (subsidies, extension services, research) were more effective at achieving a change in behaviour than legal instruments, which were seldom applied. The challenge is to provide enabling mechanisms that focus on biodiversity.
- Farmers identified three relatively simple needs that would enable them to accommodate biodiversity in their farming practices.
  - Information on WHAT biodiversity occurs on their farms
  - Information on the IMPACT of farming practices on biodiversity
  - Information on ALTERNATIVES. Most farmers articulate this as a need for further RESEARCH on sustainable land use practices
- At present farmers do not derive any benefit from the downstream value of ecosystem services (water provision, carbon sequestration). Land use decisions in places like the Drakensberg may be quite different if water provision and carbon sequestration provided financial benefits to farmers.
- The benefits to farmers from local (on farm) use of ecosystem services (pest control, soil health) is often too obscure to elicit a change in behaviour. This may be possible for services such as pollination, but is hard to demonstrate for many other services, especially services that may have different values at local and regional scales (e.g. water infiltration).
- Conservation farming practices are often linked to charismatic individuals with a good understanding of the ecology of their farms. Unless their insights and ideas are more widely adopted in the community, the conservation value of the land will decline when the land passes on to new owners.

- Farmers are inherently experimental, but often do not properly assess the outcomes of their experiments, either on farm production or the environment. Many farmers expressed interest in a research format that links scientists with farmers to test their ideas more rigorously.

Acknowledgements
The outcomes of the project discussed here were derived from studies by a large team of researchers whose results are appearing in numerous scientific publications. The project was funded by the GEF through the World Bank and coordinated by the South African National Biodiversity Institute. Mazda Wildlife Fund generously supported the project with two courtesy vehicles. The project would not have been possible without the cooperation of the many farmers and land-users who warmly welcomed us into their homes and onto their farms, and gave freely of their time, expertise and information. Collecting permits were obtained from the various Nature Conservation organizations. Thanks are extended to all of them.

Please visit the project website at www.nbi.ac.za - go to Research and then Conservation Farming Project.

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ERADICATION OF INVASIVE ALIEN PLANTS HAS CONSEQUENCES ON BIODIVERSITY: THE CASE STUDY OF *HEDYCHIUM GARDNERIANUM* IN LA RÉUNION ISLAND.

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Introduction

In La Réunion island, the invasion of indigenous ecosystems by invasive alien plants (IAP) may have important impact on community composition, structure and function.
Active control started in the 1980's and is carried out by the Office National des Forêts (ONF). However, a better understanding of the impact of control is needed. Several hurried eradications have been carried out without monitoring before and after control. Then positive or negative impacts on native communities and ecosystems are unknown. Control measures focus only on eighteen target species and few data are available regarding the impacts of eradication.
Control carried out by ONF in native ecosystems generated a timely study within the framework of the national research programme INVABIO on biological invasions. An experimental site was chosen in a native forest (réserve biologique de Bon Accueil, Les Makes) where ONF is controlling the wild ginger *Hedychium gardnerianum* (Zingiberaceae).
In this study we examined whether the weeding ("severe eradication treatment") or cutting the stems ("light treatment") of *H. gardnerianum* have changed the abundance and diversity of the woody seedlings, herbaceous and molluscs into a native forest ecosystem.
In early 2003 an experiment was set up and four different treatments are applied in April 2003 by ONF: (1) total weeding; (2) stems cutting only; (3) total weeding + shade induced by shade houses; (4) control (3 replicates per treatment; 200 m^2 plots; 12 plots). Measures of the abundance and richness of woody seedlings, herbaceous and molluscs species were conducted before and after treatments in sampling units of 1 sq-m-quadrat.

Results

The less efficient method of control is when the IAP is totally removed (weeding). The abundance of *H. gardnerianum* seedlings became significantly higher from the 11^{th} month after weeding and the same as in the initial state (7-8 seedlings / m^2) (Fig. 1).
A total of 67 plants species have been identified in the 120 experimental 1 sq-m-quadrats. The total richness was significantly greater when *H. gardnerianum* was totally removed and its stems were cut. The average abundance and richness beneath the *H. gardnerianum* cover for all sampling dates are relatively high.
The patterns of abundance are very variable according to the species. The abundance of 11 species increased after the treatments and the abundance of 2 species decreased after light increased.
A total of 22 snails and slugs species were collected in 180 experimental 1 sq-m-quadrats. The total abundance and richness of molluscs showed a treatment and a date effect. The total abundance and the diversity of the native species decreased significantly after total removal of *H. gardnerianum.* The abundance of 11 species did not differ significantly between treatments and by sampling date.

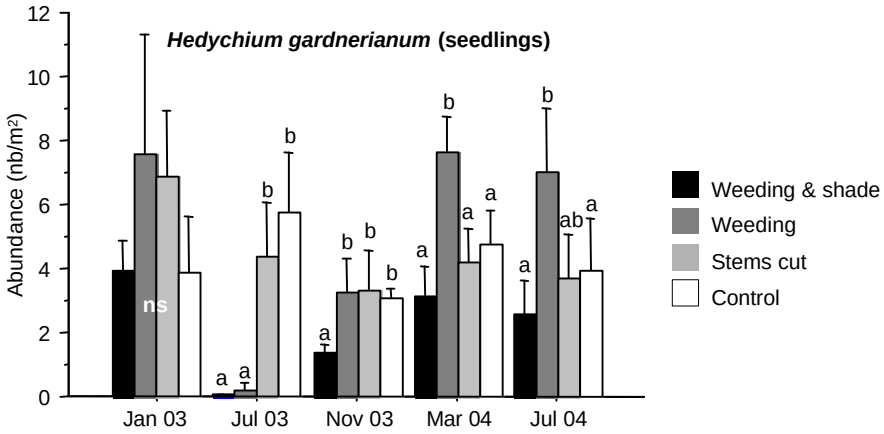

Fig. 1. Abundance (mean no. / m^2 ± SD) of *H. gardnerianum* seedlings in forest plots submitted to four different controls of *H. gardnerianum* (weeding & shade; weeding; stems cut; control) before treatments (January 2003) and 3 months (July 2003), 7 (November 2003), 11 (March 2004) and 15 months (July 2004) after treatments; 30 $1m^2$ quadrats were used per treatment. The values of a characteristic followed of the same letters do not differ significantly (SNK test, $P<0.05$); ns = non significant difference.

Perspectives and implications

This three-year study is among the first to combine conservation biology's focus on abundance and diversity changes, with experimental scrutiny of the control effects.

The incorporation of realistic management need into our experimental design made it possible to answer scientific and practical questions. The patterns of biological responses following the removal of a species within an ecosystem constitute a theoretical contribution for ecology of communities.

The results have implications for understanding the biodiversity changes following the eradication of an IAP.

The results of that work define a new direction for the managers (ONF), decision makers and conservationists. The local policy of control against the IAP should be directed more toward prevention actions.

This project induced many exchanges and partnerships not only in La Réunion, but also between the western Indian Ocean islands, in order to ensure coordination and organisation of the strategies of control of biological invasions.

INVASIVE ALIEN SPECIES: RESEARCH AND MANAGEMENT IN THE KRUGER NATIONAL PARK

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Abstract
This paper presents a synthesis of the evolution and current status of management in the Kruger National Park, as well as recent research developments. Management has evolved over the past 25 years, from crude, untested methods to a large, well organized programme. Unfortunately, research initiatives were not similarly developed and have only gained momentum in the past five years.

Introduction
The Kruger National Park (KNP) covers an area of 20,000km, measuring 360km north-south and 60-90km east-west (Foxcroft & Richardson 2003). The KNP is managed principally for biodiversity conservation and as such, the invasion of alien organisms threatens the natural processes and fluxes of the ecosystem (Freitag-Ronaldson & Foxcroft 2003). Depending on classification methodology, the KNP is divided into 35 landscapes (Gertenbach 1983) or 55 land types (Venter 1990), the units of which form the basis for management zones. In order to manage growing tourism demands, a "recreational use" zonation plan provides for appropriate development across the landscape (Kruger National park 1997a).
The KNP has had a long history of wildlife management, with early conservationists focusing on a "common sense" appraisal of the situation at hand and good biological observation (Foxcroft in press). Early efforts included anti-poaching measures, fire management, large mammal population control, water provision and other traditionally recognized aspects of conservation management. During this time, alien plants were a low priority and many invasive species problems today were as a result of intentional cultivation (Foxcroft et al. 2003).
Due to a growing demand externally for more transparent management actions and internally for a new ecological management paradigm, a review of the KNP objectives and management plan was launched in 1997. The emerging concept was of acceptance of "natural fluxes of nature", as oppose to the previous, strictly applied "balance of nature" paradigm (Foxcroft in press; Rogers & Biggs 2003).

Discussion
Management: a synthesis
The KNP has been actively managing alien plant invasions for the past 25 years. Control operations have developed from small scale, low resourced efforts, into substantially funded, co-ordinated programmes. However, it was still not until during the management review workshops in 1997 that the seriousness of alien plant invasions in the KNP was recognized. It was during this workshop that invasive alien species were rated as "the greatest threat to the biodiversity of the KNP" (Kruger National Park 1997b).
Although the KNP is a large conservation area, it is essentially an island surrounded by a multitude of different land uses and conservation values. The major rivers, all of which arise in the higher lying areas to the west of the KNP, are invaded to varying extents and supply a continuous source of propagules into the rivers (Foxcroft & Richardson 2003). To date, the alien plant list for the KNP includes approximately 370 taxa, from the less-invasive ornamental garden plants to serious transformer weeds (Foxcroft et al. 2003).
During the current review process (2004-05) of the 1997 objectives, the Invasive species objectives (Appendix 1) were re-aligned, and focused on a comprehensive approach to management. The main focus areas include strategy and support, prevention, control and research and aim at developing a long-term, holistic management approach.

Research questions: a co-ordinated approach

Due to the serious concerns surrounding current plant invasions, much emphasis was placed on correcting the disproportionately lower status of alien plant management and associated resources. During 2000, with the establishment of an invasive species research programme manager post, this highlighted the need for management orientated, applied ecological research. Using the KNP objectives hierarchy, research projects were solicited, with the aim of answering some of the main questions occupying management's agenda (Foxcroft & Freitag-Ronaldson in press).

To date, ten research projects have been officially registered with the KNP, with a further five projects and broader programmes being developed. These projects, covering aspects of impacts and ecology of invasions and management, all aim at understanding the ecosystem, its responses and management options in the long-term. As such, the KNP is interested in research partners, who are keen to explore the many questions, within the framework of objectives (Kruger National Park in prep).

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TACKLING INVASIVE ALIEN PLANT SPECIES IN RÉUNION ISLAND

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Introduction

La Réunion has a long history of concern about the problem of invasive alien plant. By the beginning of the nineteenth century till now, many botanists has mentioned the threat due to weeds. For example, the Giant bramble *R. alceifolius* should have been introduced in the 1840th and was already cited as an invasive at the end of the 19th-century. Early in the 1980th, the problem of forestry weed control is officially mentioned; and the forestry service ONF[5], begins in chemical and mechanical control. Because of the high cost of the control and since it has been impossible to control chemically or mechanically at a large scale, at the end of the 80th, the idea to set up biological control emerge. In 1991, Macdonald *et al.* did the first prioritisation of the invasive plant problem for the island (Macdonald *et al.*, 1991). From this study, the two first biological control research programmes began in 1997 on *R. alceifolius* (Amsellem, 2000; Baret, 2002; Baret *et al.*, 2003) and *Ligustrum robustum* var. *walkeri* (Lavergne, 1999; 2000). Other species, such as *Acacia mearnsii* (Tassin, 2002) or *Hedychium* spp. (Radjassegarane, 1999) have been also studied during the last years.

At the moment the capability to predict the invasive risk for a not yet introduced species or for a non naturalised exotic species is became a major stake. (Smith *et al.*, 1999). That is why new actions are on going:

- Invasion spatialization and modelling to help environmental management
- Adaptation of an invasion risk analysis protocol to improve the regulation of plant international exchange.

In Réunion Island, several stakeholders are in concern with invasive alien species. Research has been done by the Joint Research Unit Cirad-University of La Réunion with contribution of the CBNM[6]. Control implementation and landscape management mainly belongs to the ONF and partly to the CBNM and the CG[7]. Regulation is responsible to the DIREN[8] and the SPV[9].

1 Invasion process analysis

The Giant Bramble (*Rubus alceifolius* Poir.) is an invasive species coming from South-East Asia. We studied it as a plant model to analyse the different aspects of the biological invasion process. Genetically we evaluated the level of diversity of the population within La Réunion, then we compared this population to other populations from the area of introduction and from the native area. We compared ecological and biological characteristics in Réunion to the native area, to understand patterns responsible to its invasiveness.

The Giant Bramble population is clonal within La Réunion and genetically close to those from Mauritius, Queensland, Mayotte and Madagascar. But it is very different to those from the native area, so we could not find the exact original place of this weed. We hypothesized that after an introduction in Madagascar the Asiatic Bramble has hybridised with an indigenous one (mentioned in some literature). Then the hybride has spread in Madagascar and the islands around. Growth is higher in la Reunion.. We showed that seed production is apomyctic in the area of introduction instead of allogamy in the native area. Multiplication can be done by seeds, cuttings or layers Growing from sea level to 1600 m of elevation, seed production occurs only from 0 to 1100 m. Seeds are locally spread by streaming or on long distance by birds. Seed germination needs light, thus all vegetation gap promotes germination and growth of the plant.

[5] ONF : Office National des Forêts
[6] CBNM : Conservatoire Botanique National de Mascarin
[7] CG : Conseil Général de la Réunion
[8] DIREN : Direction Régionale de l'Environnement
[9] SPV : Service de la Protection des Végétaux

This plant invades lightly areas, such as fallows, forest side, field side, tracks and forest cuttings. We did not find any specific natural enemy in the area of introduction. Surveys in the native area showed about 27 insects et 3 pathogens. The most susceptible to become biological control agents where *Cibdela janthana* (Sawfly), *Phaedon fulvescens* and *Cleorina modiglianii* (Chrysomelids), *Gerwasia rubi* and *Hamaspora acutissima* (rusts). Rusts where too specific to attack the Reunionese Bramble. The sawfly seemed to be the best agent and is now in quarantine in La Réunion for more specificity tests.

3 Setting up an integrated control

Integrating results from biological and ecological studies has enabled us to set up integrated management at the island level. Biological control with *C. janthina* is expected for all shiny places at low elevation where Rubus is fruiting a lot. Inside the forest, it is necessary to reduce gaps as possible and to favour the fast closing of the canopy. Mechanical control has to be done in winter to minimise cuttings and when possible with uprooting. Areas still not contaminated, i.e. Cilaos circus, need to be regularly surveyed with systematic eradication when a plant appears

4 Mapping and modelling biological invasions

The University of La Réunion and the Institute for Plant Conservation (Cap Town University) went to a research cooperation (2001-2002) on biodiversity and habitat transformation on La Réunion. After a first step of identification and mapping of the main 19 ecosystems of La Réunion (1:50000), the second step was to establish the potential spatial distribution of invasive alien species using models developed in Australia (Climex) or in South Africa. Distribution maps has been produced for 10 species at the level of ZNIEFF (national zones with ecological, flora and fauna interest)

This kind of information is essential to follow the spread of species and to set up control planning of invasive species.

5 Regulation and introduction prevention

Phytosanitary regulation at the border has to respect SPS and WTO agreements. Policies has to be based on scientific principles and must be compatible to international rules. All introduction of plant or part of plant in La Réunion, is inspected at the border by the Plant Protection Service. But, until now, the phytosanitary regulation does not include natural landscape invasive plants and very little about agricultural invasive plants. It is now under revision. So, following the Australian Weed Risk Assessment, Plant Protection Service has adapted the Phytosanitary Risk Assessment protocol from EPPO[10] to invasive plant species.

This protocol has been tested on *Chromolaena odorata* and is now under recognition to EPPO. A 611 species list of potential invasive plants has been prepared that have to be evaluated threw this protocol.

Discussion and conclusion

This work is in keeping with a global approach of biological invasions and biodiversity conservation on La Réunion and more over on tropical islands.

At the same time of the research into and control of weeds, we are trying to set up a global strategy for invasive alien plant management at the scale of the island. This process is based on international works from GISP[11], CBD[12], IUCN[13], Australia and South Africa (CRCAWM, 2001; Glowka *et al.*, 1996; Macdonald, 2004; McNeely, 2001; McNeely *et al.*, 2001; Mooney, 1999; Nel *et al.*, 2004; Randall, 2002; Richardson & van Wilgen, 2004; SCBD, 2001a; b; 2002; van Wilgen, 2004; Virtue *et al.*, 2004; Wittenberg & Cock, 2001).

[10] EPPO : European Plant Protection Organization
[11] GISP : Global Invasive Species Programme
[12] CDB : Convention sur la Diversité Biologique
[13] UICN : Union Internationale pour la Conservation de la Nature

The objective is to organize and coordinate actions at the different steps of the invasion process, i.e. introduction prevention, regulation, public awareness, networks for surveys for early detection and early warning, control methods…as it is done in South Africa or in Australia.
But the most important is to help decision makers, scientists and stakeholders in prioritising the actions.
Do we first have to work on a full spread species, for a long time recognized as an invader (i.e. *Rubus alceifolius*) or do we have to focus on a localized species recently introduced but known to be highly invasive (i.e. *Clidemia hirta*). Do we have to control a species everywhere on la Réunion or do we have to prioritise actions on some specific part having a high stake of conservation. Do we have to work on cleaning areas likely to face the greatest pressure from invasive species or do we have to focus on preservation of threaten areas but still free of pests?
According to Nel and collaborators (Nel *et al.*, 2004), classification is a necessary means of prioritizing species at a national level, or at an island level, because it circumvents the problem across multiple spatial scales, which make it difficult to compare the importance of species that occupy different ranges and habitats, with different levels of impact and abundance. But, in the same time we need to improve our understanding in how prioritizing conservation stakes of the main ecosystems of the island. The combination of both approaches should enable us to elaborate conservation and weed control planning for La Réunion Island.

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TROPICAL FOREST STRUCTURE AND DYNAMICS FOR CONSERVATION

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Introduction

Numerous ways of controlling invasive introduced plants exist on La Réunion. A synthesis of technical control used by forestry service against these plants has been recently published in a grey report (Hivert 2003). Other case by case studies have also been realised (Lavergne et al. 1999 on *Ligustrum robustum* subsp. *walkeri*, Baret et al. 2004 on *Rubus alceifolius*) or nowadays on going (see Lavergne et al. in this fascicule on *Hedychium gardnerianum*). These studies are very interesting in terms of controlling specific species, but unfortunately insufficient in terms of controlling all invasive plants within a forest. Therefore, a recent review has focused on the possibility to consider invasive species in a whole-ecosystem context and not only case by case (Zavaleta et al. 2001).
Thus, we highlight the importance of studying forest structure and dynamics as a basis for a global restoration program. Therefore, we would like to distinguish successive stage of a forest from pioneer to mature and to regroup indigenous plant species within the different stages obtained.

Methods

We tested life history traits observed during the establishment stage of 71 woody indigenous plants distributed within all terrestrial natural habitats on La Réunion. Twelve life history traits were identified (see fig. 1). Data were analysed using R-stat software. In order to regroup species based on homogenous life history traits, we used a multiple correspondence analysis (using only qualitative data) conjointly with a hierarchic ascending classification (AGNES - AGglomerative NESting-).

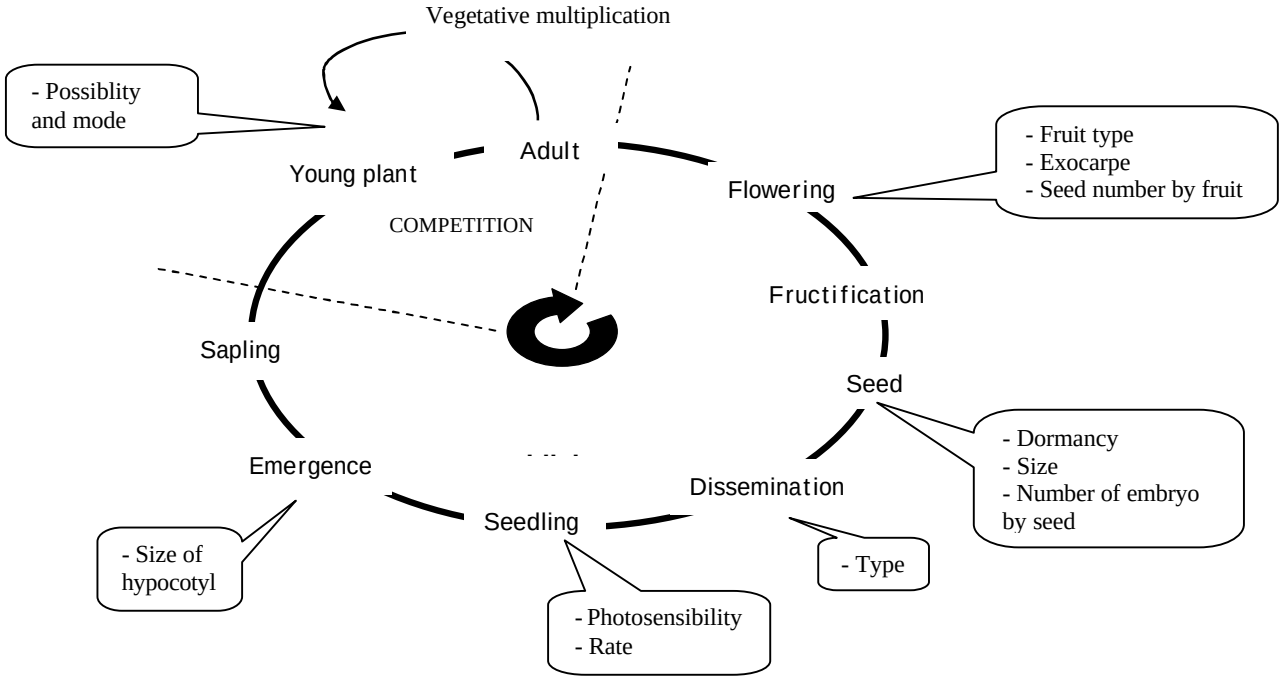

Figure 1. Cycle of natural stage regeneration of indigenous species. The 12 life history traits used in our analysis are framed.

Results and discussion

Seven homogenous groups were distinguished. Using life history traits and expert knowledge, these groups were classified from pioneer to mature stage as following:

- pioneer having a short life span (ex.: *Faujasia salicifolia*, Asteraceae);
- pioneer having a long life span (ex.: *Agauria salicifolia*, Ericaceae);
- post-pioneer species (ex.: *Sideroxylon borbonicum*, Sapotaceae);
- pioneer nomad (ex.: *Dombeya* spp., Sterculiaceae);
- canopy trees (ex.: *Mimusops maxima*, Sapotaceae);
- understorey nomad (ex.: *Antirhea borbonica*, Rubiaceae);
- understorey (ex.: *Chassalia corallioides*, Rubiaceae).

Each group can be characterised by the life history traits studied. As an example, pioneer species correspond to heliophyllous and anemochorous species, while post-pioneer species correspond to zoochorous or hydrochorous species and canopy trees group corresponds to barochorous species. The nomad group includes opportunistic species corresponding to species having a large ecological niche (shade or light tolerant) which are anemochorous or zoochorous (mainly by birds) species.

Based on these results, the following questions can be asked:

- Does disturbance (natural or anthropogenic) play a role in the dynamics of the forest?
- Do invasive plant species appear at a specific stage of succession or belong to a specific group?
- Which indigenous species could be used in possible restoration programs? After eradication of the invasive plant species, can indigenous species belonging to one of the successional group defined in this study, be used to close up of the canopy? Can the same species be used for different habitats present on La Réunion?
- Is there specific group of species that needs absolute priority? Understorey species are known as indicator of the forest state, will it be interesting to focus on this species group?
- Could other plant types such as ferns be studied within the forest and could they reveal us interesting informations on forest dynamics?

Thus, our results can be used as a basis for conservation planning through an adapted restoration program which will be different in relation to the different habitat of La Réunion. Nevertheless, numerous other studies will be necessary to better understand ecosystem functioning and they need to be set up at the short term.

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FROM IMAGE TO DECISION MAKING… CONTRIBUTION OF REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS TO MANAGEMENT OF TERRESTRIAL BIODIVERSITY: CASE STUDY OF INVASIVE PLANTS MANAGEMENT

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La Réunion is a French tropical island located in the Indian Ocean. This island is confronted with strong threats on terrestrial biodiversity: invasive plants, extension of urban fringes, habitat fragmentation, extension of agriculture areas (mainly pasturage and sugar cane).
Good governance of biodiversity rests with collective decision making of stakeholders on a territory. In this framework, it's necessary to gather scales of ecological/geographical phenomena and organisation levels in an encapsulated management policy (from global to local). Ideally, an integrated management of biodiversity should be based on a systematic approach of biodiversity described in a social and economical environment (i. e. geodiversity).
Through both geographical and ecological approaches, this work affiliated to research institutes (Cirad, IRD, CNES) tries to understand the interactions between invasive alien plants and other geographical components. The main objective of this work is to provide a helpful tool for decision makers in order to adapt conservation planning policy. How to integrate spatial complexity of the geodiversity within a conservation planning? How to target conservation effort? How to link data and knowledge bases in relation with invasive plants, landscapes and land uses? Which methods and wich tools must be improved in order to mine and to update the informations provided by spatial imagery? How to optimize connectivity between GIS and remote sensing technologies?
Firstly, biodiversity conservation and invasive plants managing involve to identify needs of decision makers. Then, the design of a decision making tool based on a Geographic Information System feeded by informations extracted from satellite imagery can be done. At least, our objective is to integrate this tool for decision making in a Systematic Conservation Planning.
High improvements of GIS and remote sensing technologies provide Very High Spatial Resolution data (for exemple, Spot 5: 2.5 m). This remote sensing datas intails new geo-statistical approaches based on object's shapes, texture and structure of these images: o*bject oriented classification, data mining (mining of informations from numerous and complex datasets), expert classification.*
Our aim is to analyse the relationship among scales and geographical components of the environment (biogeography, urbanization, landuse dynamic, etc…) focusing on invasive plants management. Then, we will estimate the interest of each type of spatial image (Spot 5, Quick Bird, etc.) in relation with the component studied and the classification algorithms used. In a second way, we will try to define an evaluation matrix in order to prioritize conservation areas. The matrix will include parameters such as: invasive plants, landuse, landscape… This matrix is the base of the implementation of a spatialized model feeding by internal and external geographic informations. The final goal is to target the conservation effort on sensible areas. Our modelling will focus on sensible areas threatened by invasive plants.

Remote sensing datas from BD_Isle - CNES (http://medias.obs-mip.fr/isle_reunion/).

Key words: Biodiversity, Remote sensing, Invasives alien plants, GIS, Land use, Landscape, Supervised classification, Spot satellite, Spatial dynamics, Decision analysis, Territorial management, Systematic Conservation Planning, Réunion island

INVASIVE ANTS IN LA REUNION ISLAND: DISTRIBUTION AND IMPACT.

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Most of our current knowledge on the invasion success comes from studies that compare behavioral and ecological attributes of invasive species with the native ones they displace. However, invasion success is probably more influenced by community structure rather than invaders properties, especially when community is composed by several invasive species. The ant fauna of La Reunion Island, which is composed of four of the most widespread and damaging invasive ants, constitute a good place to test how, in a given region, differences in competitive abilities become a determinant factor to explain differences in invader success rate. To document the distribution and illustrate the occurrence of competition among invasive ants, tuna baiting experiments have been carried out in several sites representative of the major habitat types, spread out over the island. Results indicate that, between the four invasive species that occur at La Reunion, two have a dominant status, having a mutually exclusive distribution whereas the two others, when present in baits, are systematically displaced by the dominants. Differences in interference competitive abilities seem to play an important role in determining abundance and distribution of these ants and must be interpreted at light of abiotic factors, especially temperature and resource availability. This apparent hierarchical order of competition among invasive species is an important point to keep in mind in the development of management strategies aiming the control of these species.

LIFE HISTORY TRAITS AS PREDICTORS OF BIOLOGICAL INVADERS?

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Invasive species have often been said to display *r*-selected traits. However, when ecologically similar species are already established, interspecific competition rather than the ability to colonize or rapidly grow in numbers at low density could be the limiting factor of invasion, favouring *K* rather than *r* traits.
We tested this idea using the "invasive series" approach. We define an invasive series as a suite of ecologically and/or taxonomically similar taxa invading the same region, characterised by hierarchical invasive ranks, in terms of ability to competitively displace each other and become numerically dominant in the invaded area. Three species of polyphagous fruit flies (Diptera: Tephritidae) that successively invaded the Reunion Island (initially occupied by a fourth, endemic species) together provide an example of such a series.
We characterized life-history traits of these four species in optimal laboratory conditions, at all stages from egg to death in order to test whether invasive ranks were dependent on positions along an *r-K* gradient.
Our results suggest an interspecific trade-off between *K* and *r* traits, and that the *K* lifestyle is associated with higher ranks in the invasive series. The resident endemic species is an exception, as it has low values for both *r* and *K* traits. Its competitive exclusion by the three invasive species is therefore explained by some form of maladaptation rather than by a strategy along an *r-K* trade-off.

Key words: Biological invasions, competitive displacement, interspecific competition, life-history traits, *r-K* trade-off, Tephritidae.

SESSION 3: CURRENT ACTIVITIES ON BIODIVERSITY CONSERVATION IN LA REUNION

THE INSECTARIUM OF REUNION ISLAND

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The Insectarium of Reunion Island is a not for profit organisation that studies, makes known, promotes and protects terrestrial arthropods and their habitats by the means of a small museum with living arthropods, educational trainings and scientific studies in the field and the lab. Although strongly focussed on the systematic of Lepidoptera, Coleoptera, ants and spiders, and the ecology of ants and Lepidoptera, all groups of arthropods are studied.
During the five last years, in addition to extensive light trapping, several medium to large scale intensive surveys have been realised, including rainforest, highland heath, marshes and rivers, but also secondary habitats and caves. Sampling schemes follow habitats, plants and substrates in order to capture the ecology of the encountered species and to seek for ecological and interspecific interactions and possible bioindicators. Regarding the number of recorded species (850 sp. of Coleoptera, 450-500 sp. of Lepidoptera), the arthropod fauna present in Reunion Island is estimated at about 4-5000 species of insects and 1000 species of spiders, with 35% of endemic species in average. However, this rate that can go up to 90% in altitude varies strongly among taxa and habitats. Furthermore, the number of new (for Reunion or for the world) recorded species is important (e.g. ~ 10 new species of Coleoptera every year).
The Insectarium will propose soon several publications concerning Lepidoptera and Coleoptera of Reunion Island and an extension of the list of protected endemic species. For the next years, the Insectarium will keep developing its knowledge of the ecology of the arthropod fauna of Reunion Island and wish increase its collaborations in entomology and ecology, in Reunion and in the Indian Ocean area.

A NATIONAL PARK IN REUNION ISLAND…in 2006 - A WAY OF SUSTAINABLE DEVELOPMENT

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A big challenge for Reunion Island: managing its space and its development according to an important demographic growth (the population will increase by 300 000 inhabitants and reach the number of one million in the next twenty years). The conservation of the "green heart", and of the cultural identity, still present in the small towns called "îlets", offers a great contrast with the urbanisation of the coast.
The main cities form a crown around the island. But year after year, towns are growing on the slopes and are reducing lands and natural areas. Population is attached to a certain art of living ; the one of the Bottoms rediscovers it with pleasure for its moments of leisure and relaxation. And for the tourists, if the welcome of the inhabitants of the Tops is renowned as warm, the access to hand-crafted products, to a cultural organization and to a discovered nature is still too rare.
Creating a National Park is an ambitious answer including these conservation issues and sustainable development.

Original natural characteristics which exist only here!

Reunion Island: one of the three islands of the Mascarene Archipelago

The top of the Indian Ocean: the "Piton des Neiges" (3070 m)
2512 km^2, hab (a "melting pot" from the five continents)

Reunion Island consists of very original natural characteristics.

We must protect: the persistence of native ecosystems... A wide tropical oceanic rain forest, with endemic species (plants and animals which live only in Reunion Island), wonderful landscapes and mountains, and one of the more active volcanoes in the world ("La Fournaise").

Step by step, the Park is built

2000 – 2003	Collective Definition of the principles of the creation of the National Park and consultation of the local partners
March 29 2004	The Prime Minister officially announces the creation project of the National Park of Reunion Island
2004 – 2005	Elaboration of the detailed project (limits, decree project, discussions for a sustainable Development Charter)
2006	Decree of the National Park's creation

Changes expected with the National Park of Reunion Island

• A better knowledge of the natural heritage: completing the inventory of our ecosystems and landscapes, studying ecology.
• Effective conservation: a better management of the primary ecosystems (fight against the alien plants and animals, conservation of the landscapes and of native vegetation, fight against poaching...)
• Welcome and education: the park will increase information in the field, the scientific and cultural organization, thanks to guides, a network of thematic houses and of "écomusées", equipments...
• Promotion of quality in rural development: architectural integration, promotion of hand-crafted, agro tourism...
• An active partnership, a better coordination between public and private institutions: the Park's Council of Administration and its commissions that will be created to encourage participation and a better representation of the citizens.
• A label: the national park will strongly contribute to a world-wide fame of Reunion Island.

One Park… Two Areas…

THE HEART OF THE PARK

Vocation : Protecting and sharing nature, organizing its discovery, communication, information...

Regulation and monitoring : will be defined by the Council of Administration

A SPACE OF FREE AGREEMENT

Vocation : Supporting an agricultural development, respectful of cultural resources and natural spaces

Priorities and method for action : a charter is proposed to the partners for discussion

A UNIQUE STRUCTURE TO MANAGE TWO ZONES CONSISTING OF

- Men (board of directors, specialized commissions, scientific committee, equips),
- A budget,
- An installation program, a sustainable development charter and partnership contracts.

Crédit photos : Jean Philippe - Lucien Tron

CONSERVATION PLANNING IN SOUTH AFRICA – EXAMPLE FROM THE SUBTROPICAL THICKET

Mathieu ROUGET[1], Richard COWLING[2], Shirley PIERCE[2], Mandy LOMBARD[2] & Andrew KNIGHT[2]

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Systematic conservation planning is a branch of conservation biology that seeks to identify and implement priorities for conservation. It is divided into three components: (i) conservation assessment, where priority areas are identified by achieving explicit targets for biodiversity patterns (e.g. species or vegetation types) and the environmental process that will sustain these into the future (e.g. migration corridors for plants and animals); (ii) planning, which, with the involvement of stakeholders, conservation strategies are developed to achieve conservation action required to meet the biodiversity targets; and (iii) implementation, which involves on-the-ground action as guided by the conservation strategies. Note that the implementation component involves activities to promote conservation both within and without formal protected areas. All of these components are interlinked in often complex ways and there is no blueprint for the planning and implementation ones. The involvement of stakeholders, especially those that will inherit the plan for implementation, in all three components is crucial to the success of any planning initiative.
We are currently experiencing an "implementation crisis" as many conservation plans have been produced without considering implementation from the outset and involving stakeholders.

What is STEP?
The Subtropical Thicket Ecosystem Planning (STEP) Project was initiated in July 2000, in order to provide a plan and strategy for conserving the biodiversity of the Subtropical Thicket Biome. Based on lessons learned in previous conservation plans, we needed to produce maps that stakeholders – in our case primarily land use planners but also conservation officials – would find useful. Consequently, structures (steering committees, focus groups and so on) have been established to enable stakeholders to participate in the planning process in order to accommodate their expectations in the products.

Developing the products
We identified in our assessment seven conservation corridors (Map 1). These are extensive environmental gradients that would enable the persistence of the thicket fauna and flora but also considered in their location implementation opportunities (e.g. the location of existing conservancies and protected areas) and constraints (habitat that was transformed irreversibly or under severe pressure of further transformation). While these corridors provided the framework for a living thicket landscape, they did not achieve all of the biodiversity targets that we set in the STEP assessment. What to do with the remaining land?
We therefore identified a way of ensuring that the priority habitat outside of the corridors was retained by mainstreaming the planning outcomes into land use planning, especially at the municipal level. We provided the municipalities in our planning region with user-useful and user-friendly products to use when preparing their spatial development frameworks. We agreed with our stakeholders that we needed to produce maps that clearly identify categories of habitat ranked according to their priority status, and explicit guidelines of what should and should not be permitted in these.
So next we defined the conservation status categories, using two variables: the area of each habitat or vegetation type required to achieve its biodiversity target, and the remaining area of that vegetation type, both expressed as a percentage of the original (pre-transformation) extent. We thus identified four categories, listed next in order of descending priority status: critically

endangered, endangered, vulnerable and currently not vulnerable. These categories accord with the National Environmental Management: Biodiversity Act 10 of 2004, where this is provision for the listing of ecosystems that are threatened and in need of protection.

Developing a conservation strategy

Together with stakeholders, we developed a conservation strategy that had proactive and reactive components. In other words, a strategy to prevent the further loss of priority habitat by ensuring that land use planners locate developments outside of the high-priority areas, and a strategy to encourage sustainable, biodiversity-friendly land use (including – in some places - the expansion of protected areas) in the conservation corridors.

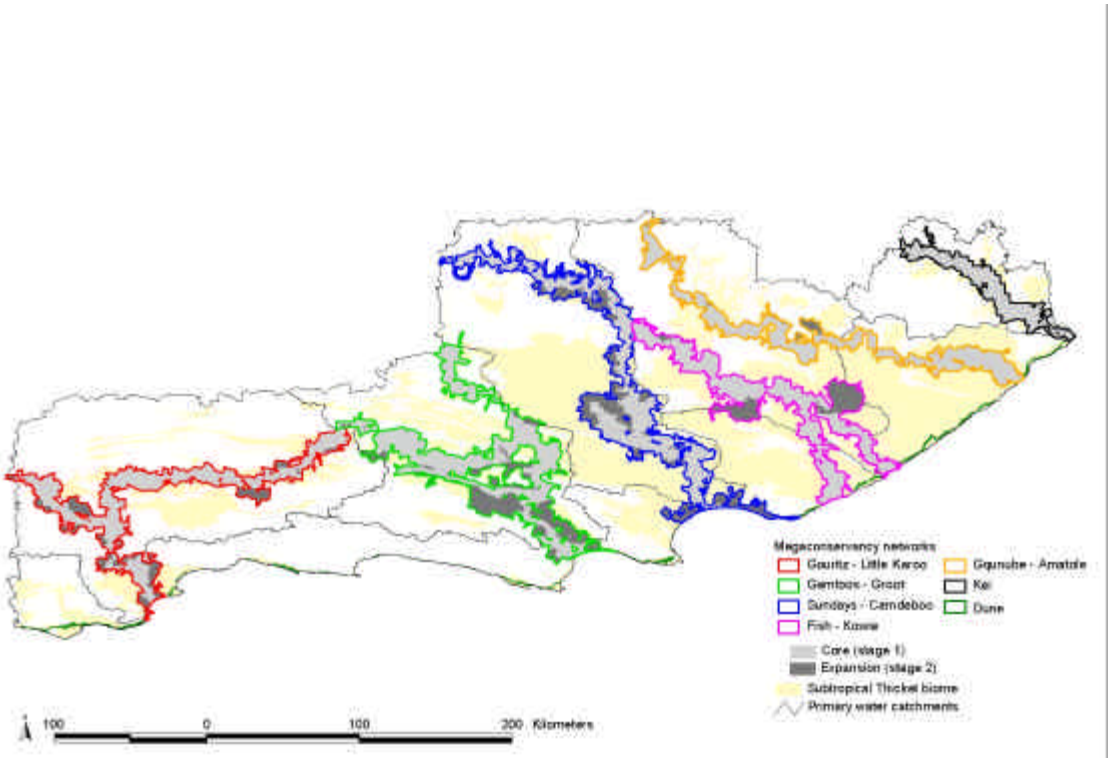
For the corridors, we identified a conservation mechanism termed a megaconservancy network (MCN). These would require a dedicated and collaborative effort for their implementation. In terms of the endangerment categories, we allocated MCNs to the critically endangered one. The MCNs formed the spatial component of our proactive strategy.

We developed the reactive strategy by producing a Handbook and a mapbook. The former is a kind of text book - dealing with issues such as the value of biodiversity, environmental legislation, description of the STEP vegetation types, and so on – that would assist municipal land-use planning officials and their consultants in fulfilling their obligations to safeguard the environment. The Mapbook (one for each municipality) comprised a conservation priority map (see Map 2) and a set of guidelines for land- use decision-making. The latter are to detailed to reproduce here but can be downloaded at http://cpu.uwc.ac.za. These were delivered to each of the municipalities.

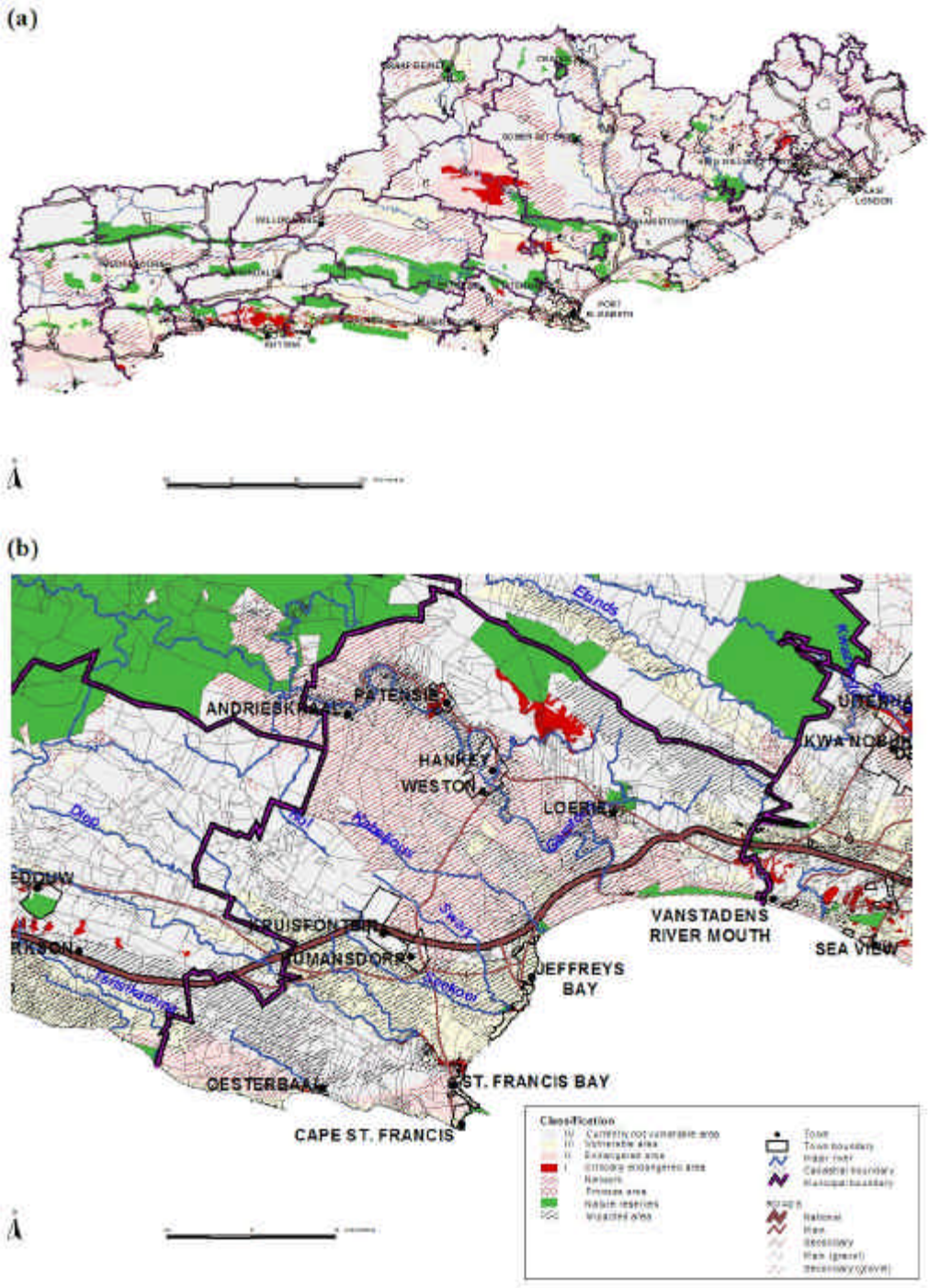
Has STEP been effective?

Just over one year since the publication and dissemination of the STEP products, we can say: yes, on balance, STEP has been effective. The MCNs have greatly assisted with the ongoing expansion of the Gouritz, Baviaanskloof and Addo conservation areas. The Mapbook has been widely used by consultants for Environmental Assessment and spatial planning at the provincial and district municipal levels. However, STEP has been less effectively mainstreamed into municipal-level decision-making due to lack of capacity. Consequently, a two-year project has just been initiated – implemented by the Biodiversity Conservation Unit of WESSA – and jointly funded by the South African National Biodiversity Institute and the Development Bank of South Africa.

Plate 1. Fish Thicket on the banks of the Kap River, east of Grahamstown. *Euphorbia triangularis* is emergent (photo: Sharon Wilson).



Map 1. Location of conservation corridors - (Megaconservancy Networks) – in the STEP planning region. Each corridor represents the most suitable route for capturing upland-lowland and macroclimatic gradients within each major drainage basin, and along the dune coast. Corridors integrate biodiversity patterns and processes and incorporate protected areas, but also avoid land-use pressures.



Map 2. Conservation priority maps of a) the entire STEP planning region and b) the Kouga Municipality.

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SESSION PLENIERE DU 3 DECEMBRE 2004

La dernière session de l'atelier de travail s'est déroulée à La Région Réunion. Le but de cette session était de présenter aux décideurs politiques et à l'ensemble des organismes réunionnais impliqués dans l'étude et la gestion de la biodiversité, les travaux effectués au cours de la semaine. Nous avons également souligné l'importance d'agir ensemble et proposer des collaborations entre les chercheurs des 2 pays et des gestionnaires locaux.

The last session of the workshop took place at the Region Reunion. The objectives of this session were to present a synthesis of our work to stakeholder and all Reunionnese organisms which are implicated in Biodiversity studies and management. We also highlighted the importance to act rapidly together and propose some collaboration between researchers of both countries and also local organisms.

ALLOCUTION D'OUVERTURE / OPENING OF THE SESSION BY PHILIPPE BERNE

Français-

Après avoir félicité l'initiative de cet atelier sur la biodiversité en collaboration avec l'Afrique du Sud et après avoir remercié la délégation sud africaine pour sa participation à ce travail, Philippe berne a rappelé un certain nombre d'éléments sur les enjeux de la biodiversité à la Réunion.

La première collaboration entre l'Afrique du Sud et la Réunion dans le domaine de la biodiversité remonte à l'année 1989 lorsque le Conseil Régional a fait appel à IAW Macdonald pour une mission d'expertise sur les plantes envahissantes.

La conservation de la biodiversité à la Réunion est un élément important du développement du tourisme. Le chiffre d'affaire du tourisme est supérieur à celui de la canne à sucre.

La biodiversité à la Réunion ne porte pas uniquement sur le domaine terrestre mais aussi sur le domaine marin de haute mer (pêche) et récifal (réserve marine) avec des enjeux très importants quant à l'urbanisation le long des côtes et la gestion des effluents.

Un gros effort est fait pour la sensibilisation de la population, et la mise en place d'outils de protection des milieux

A une échelle planétaire, la mondialisation du commerce se traduit par un flux de plus en plus important d'organismes vivants qui représentent des espèces potentiellement envahissantes pour les milieux insulaires, qu'il faut donc pouvoir surveiller et gérer. Dans le même temps, le changement climatique induit des modifications de l'environnement qui peut d'une part faire disparaître certaines espèces et d'autre part favoriser d'autres espèces, notamment des espèces exotiques qui jusque là étaient demeurées peu importantes.

L'Afrique du sud, pays continental très ancien fait l'objet d'une diversité géographique et biologique très importante avec un fort niveau d'endémisme lié à une évolution très longue, tandis que la Réunion, île isolée et récente, de petite taille mais très diversifiée présente également un endémisme important. La comparaison de ces deux situations est très intéressante.

English-

Philippe Berne was delighted by this workshop and it initiative. He thanked the visit of the South African delegation and their contribution to this work.

He summarised few element on biodiversity issues on La Réunion. The first collaboration between South Africa and La Réunion started in 1989 when Region Reunion asked to Macdonald IAW to come on La Réunion to evaluate the impacts of invasive alien plants.

Indeed, the protection of the environment is an important part of the tourism development. Tourism yields more money than sugar cane. Philippe Berne reminded us that Biodiversity is not only terrestrial but also marine with important issues linked to coastal urbanisation and the management of water catchments.

An important on-going effort is to sensitive population and to set up tools in order to protect environment. At the world scale, commerce globalisation facilitates alive organisms dispersion which can become invasive particularly in islands. It is therefore necessary to survey and to manage these species. Moreover, global change involves environmental modification which could favour species disappearance but also could facilitate exotic species.

South Africa is a mainland country which is geographically and biologically very diverse, having a high rate of endemism. La Réunion is a recent and isolated small island but which is also very diversified and possessing also a high level of endemism. Comparing these two localities can be very interesting.

L'ATELIER BIODIVERSITÉ / BIODIVERSITY SHOP BY BERNARD REYNAUD

Français-

La végétation naturelle de la Réunion a considérablement régressé depuis l'installation des hommes il y a 300 ans et certaines formations végétales, notamment la forêt sèche de basse altitude ont presque totalement disparu. Cependant près de 30% de la surface de l'île restent encore couverts d'une végétation indigène bien conservée, ce qui est exceptionnel dans les îles océaniques et pour les Mascareignes. La majorité de ces milieux est actuellement en forêt domaniales gérée par l'ONF (100 000 ha) avec déjà des zones en réserves naturelles et réserves biologiques. Le futur proche devrait voir la mise en place du Parc National des Hauts de la Réunion, comprenant une zone centrale de forte conservation et une zone périphérique dont le but est un développement économique et social respectueux de la conservation de la biodiversité et servant de protection à la zone centrale contre la dégradation de la biodiversité et l'invasion par les espèces exotiques envahissantes. La Réunion avec actuellement 700 000 habitants et bientôt 1 000 000 d'habitants va devoir conjuguer développement urbain, développement agricole et économique et protection de son environnement naturel et de sa biodiversité. Elle devra également faire face aux espèces exotiques envahissantes qui menacent l'ensemble des milieux.

L'Afrique du Sud est confrontée aux même problèmes de protection et de conservation des milieux indigènes, et des espèces rares, de développement économique et social et des gestion des espèces envahissantes. Depuis plusieurs années les chercheurs et gestionnaires de milieu ont développé une démarche de planification et d'organisation des enjeux de conservation permettant de prioriser les zones d'intervention et les actions. Un important travail est fait avec les populations pour trouver l'adéquation entre agriculture et conservation.

L'atelier sur la biodiversité qui s'est déroulé du 29 novembre au 3 décembre 2004 a porté principalement sur deux domaines : 1) la connaissance de la biodiversité terrestre (taxonomie, phylogénie, fonctionnement des écosystèmes naturels, 2) les invasions biologiques (espèces envahissantes, dynamiques des invasions, lutte contre les invasions, prévention et réglementation).

Cet atelier a rassemblé 9 chercheurs sud africains entomologistes, écologues, 9 chercheurs réunionnais et 6 étudiants en thèse, et 4 représentants d'organismes partenaires engagés dans la gestion de la biodiversité (ONF, CBNM, Mission Parc, Insectarium).

English-

Since human settlement in the 17th century, native vegetation of La Réunion has been highly reduced. Some particular habitats (mainly lowland dry forest) have almost entirely disappeared. Fortunately, 30% of the native vegetation remains nowadays. It is exceptional compared to other oceanic islands. The majority of this vegetation (100 000 ha) is currently managed by the forestry service (ONF), with some areas included in natural and biological reserves. In a near future, a national park of highlands will be set up. This park will include a central area with a high level of conservation and a buffer area which will allow a social and an economical development in respect with biodiversity conservation. This area will provide a buffer against biodiversity degradation and

alien invasive species threat to the central area.
With 700 000 habitants (and nearly 1 million in 2010), it will be necessary to La Réunion to conjugate urban, agricultural and economical development with natural environmental protection and it associated biodiversity.
South Africa is also confronted to similar problems. Therefore, since many years, researchers and habitat managers have planned and organized conservation issues in order to highlight priorities and actions which are necessary to preserve native habitats. An important work is already on going to found compromise between farming and conservation. The workshop on biodiversity dynamics (29 Nov. to 3 Dec. 2004) has focused mainly on two topics: 1) Knowledge of Terrestrial biodiversity (taxonomy, phylogeny, and natural ecosystems functioning), and 2) Biological invasions (invasive species, dynamic of invasion, control, prevention and regulation) and conservation planning.
This workshop gathered 9 entomological and ecologist researchers from South Africa, 9 reunionnese searchers, 6 phd students and 4 representative persons of local institutions working in biodiversity management and conservation (Forestry service –ONF-, the National botanical garden –CBNM-, Mission Park and the Insectarium of La Réunion).

SYNTHESE DE LA SESSION 1 – ECOLOGIE, EVOLUTION ET SYSTEMATIQUE : SERGE QUILICI

Français-
L'analyse des inventaires faunistiques et floristiques et de la systématique montre un manque notoire de connaissance dans certains groupes (Plantes : orchidées, bryophytes, fougères…, invertébrés : diptères, hyménoptères et arthropodes autres que les insectes).
Les communautés végétales sont bien décrites et les processus successionnels relativement bien connus. En revanche les relations plantes/insectes nécessitent d'être approfondies.
Des travaux de cartographie de taxa endémiques commencent pour les insectes et pour les plantes. Mais il existe peu d'information sur le fonctionnement des communautés d'invertébrés dans les habitats naturels.
De nouveaux travaux portent sur les processus d'interaction et de coévolution plantes/insectes pour la pollinisation ainsi que sur les phénomènes d'évolution et de radiations spécifique en milieu insulaire.

D'un point de vue méthodologique, les techniques bio-moléculaires, maintenant disponibles, permettent d'analyser différents aspects de la biodiversité : 1) Diversité génétique, notamment pour les espèces en danger de disparition, 2) classification systématique, et 3) approche phylogénétique. Les méthodes morphométriques demeurent très utiles et complémentaires.

Différents travaux ont été présentés
Certains portent sur des aspects taxonomiques et phylogénétiques :

- Phylogénie des groupes de base en botanique (RSA)
- Phylogénie de la sous-tribu des Angraecinae (RUN)
- Taxonomie des Bryophytes (RUN)
- Etat de connaissance sur l'Acarofaune de la Réunion (RSA-RUN)
- Connaissance variable sur différents groupes d'insectes (RUN)
- Hémiptères fulguromorphes (RUN)

Certains portent sur des aspects méthodologiques de collecte, de collection et de représentation de l'information.
D'autres portent sur des études de fonctionnement écologiques comme les insectes du Karoo ou du Fynbos en Afrique du Sud ou la forêt de Mare Longue à la Réunion, ou encore sur l'impact des activités humaines sur le fonctionnement des écosystèmes.
Les phénomènes d'évolution sont étudiés au travers de l'analyse des interactions entre plantes et pollinisateurs et la comparaison de ces processus entre zone continentale et zone insulaire.

English-
Analysis of fauna and plant inventories show a lack of knowledge in different groups: plant (orchids, bryophytes,…),

invertebrates (diptera, hymenoptera, arthropods other than insecta). Plant communities are well described (plant & habitat distribution), some ecological patterns such as primary succession are well known, other have to be investigated. We have an increasing dataset on insect plant interactions.
Mapping works on endemic taxa of insects and plants are already done. However, little information exists on functioning of invertebrate communities within natural habitats. Recent works exist on plant pollinator interactions and evolution of plant breeding systems in Islands. Evolution approach and specific radiation in insular environment are already initiated.
New available molecular techniques allow the analysis of various aspect of biodiversity: 1) to reveal the genetic diversity of plant (critically endangered), 2) to classify organisms and 3) to date taxa diversification. Morphometric techniques are also useful complements for taxonomists.
During this session, different syntheses have been presented:
Firstly on taxonomical and phylogenical orientation:

Plants
- Phylogeny of basal groups (South Africa)
- Phylogeny of the Angraecinae sub tribe in the orchid familly (Réunion)
- Taxonomical aspects of bryophytes (Réunion)

Invertebrates
- State of knowledge on acarofauna of La Réunion Island (South Africa-Réunion)
- Variable level of knowledge for the different insect orders (Réunion)
- Increasing knowledge of Hemiptera Fulguromorpha in Réunion (Réunion)

Secondly on collection methods and on information representation (e.g. GIS tools)
Other studies talk about ecological functioning such as Karoo or Fynbos insects in South Africa and insects associated to the lowland tropical rainforest (Mare Longue) on La Réunion. Human impacts on ecosystem functioning have also been presented.
Evolution phenomena are also studied through plant pollinator interactions analysis and their comparison processes between mainland and island.

SYNTHESE DE LA SESSION 2 - INVASIONS BIOLOGIQUES : MATHIEU ROUGET

Les invasions biologiques représentent l'un des principaux facteurs de perte de biodiversité après la destruction des habitats. A la Réunion, on compte plus de 2000 espèces végétales introduites en 3 siècles d'occupation par l'homme, dont plus de 1000 se sont naturalisées et une centaine sont considérées comme envahissantes. La flore indigène de la Réunion compte 900 espèces. A titre comparatif, en Afrique du Sud, la flore indigène compte 24 000 espèces, près de 9000 espèces auraient été introduites et 161 sont considérées comme envahissantes. Le coût annuel de la lutte contre les plantes envahissantes à la Réunion est évalué à 300 – 500 k€.
L'étude des phénomènes d'invasions par les plantes est abordée à différentes échelles de perception.
D'un point de vue général, une plante exotique doit franchir différentes barrières avant de devenir envahissante (géographique, environnementale, reproduction, dispersion, habitats perturbés, habitats indigènes) nécessitant un certain nombre de caractéristiques propres à la plante. Inversement un milieu est plus ou moins susceptible aux phénomènes d'invasions en fonction de ses propres caractéristiques. La combinaison des caractères de la plante et des caractères du milieu permettra ou non le processus d'invasion.
Différents cas de processus d'invasions ont été présentés, concernant des plantes comme *Rubus alceifolius* ou des insectes comme les mouches des fruits ou les fourmis, avec notamment l'étude de processus de compétitions entre espèces envahissantes.
Parallèlement, l'analyse de l'invasibilité des milieux indigènes permet d'évaluer la sensibilité des différentes étapes successionnelles aux invasions et de mesurer la capacité de régénération des milieux indigènes en fonction des méthodes

de lutte employées contre des plantes comme *Hedychium gardnerianum*.
Les principales plantes envahissantes ont fait l'objet d'une cartographie de l'état actuel de distribution spatiale et d'une modélisation de la distribution potentielle. Ce travail a été réalisé en collaboration avec le SANBI en Afrique du Sud.
L'utilisation de la télédétection à haute résolution, des images aériennes combinées aux outils de modélisation par SIG doit nous permettre de développer des outils de planification de la conservation et de gestion des invasions. Une thèse vient d'être engagée sur ce sujet.
L'Afrique du Sud a déjà une grande expérience dans ce domaine ainsi que dans l'analyse des processus déterminants des invasions. Le projet « Working for Water » allie à l'échelle du pays et au niveau des parcs nationaux comme le Kruger une approche d'analyse spatiale des enjeux et des actions et une réalisation pratique d'éradication des plantes envahissantes.
La Réunion doit renforcer ses actions au travers de procédures de prévention des introductions, de planification des recherches et des actions basée sur une analyse des priorités de conservation et de lutte. Pour cela, Les collaborations avec l'Afrique du Sud sont essentielles.

English-
Biological invasions are a major threat to indigenous ecosystems and biodiversity following habitat destruction. More than 2000 introduced plant species have been introduced on La Réunion since human settlement (in the 17th century). Among them, more than 1000 are naturalised and around 100 are invasive. Indigenous flora of La Réunion include around 900 species. Comparatively, indigenous flora in South Africa include 24 000 species. Among them, around 9000 have been introduced and 161 are considered as invasive.
The cost of controlling invasive plant on La Réunion is evaluated at 300 – 500 K€.
Plant invasions need to be studied at different spatial scales.
For an exotic plant, it is necessary to cross different barriers (geographic, environmental -local-, reproductive, dispersal, disturbed or/and natural habitats). For that, diverse plant characteristics are necessary. In parallel, depending to their own characteristics, the invasibility of the habitats can vary. Thus, the combination between exotic plant and the habitat will determine or not the success of the invasion.
Different case studies on plant (*Rubus alceifolius*) or insects (fly fruits, ants) have been reported. In parallel, we saw the importance to consider each successive stages of colonisation to better understand habitat invasibility. Regeneration efficiency of indigenous plant species has also been tested in relation to various control methods used against alien plants such as *Hedychium gardnerianum*.
The current distribution of the main alien invasive plant has been mapped and their potential distribution has been modelled. This work has been done in collaboration with the SANBI and the IPC in South Africa. Remote sensing and modelling tools under a Geographic Information system, conjointly with satellite pictures, will allow us necessary tools in a systematic conservation planning and invasive management. A PhD study is just starting in this area.
South Africa has already a high experience in this area and also in spatial analysis of the invasion processes. The "Working for Water" program (done at the large scale of the country and integrated national park) is a very useful method of invasive plant eradication.
La Réunion needs to reinforce its actions on prevention of new introduction, research planning and spatial priorities for conservation, including requirements for the effective management of alien plant invasions. Collaboration with South Africa on this area is therefore very important to share expertise.

ANALYSE DE LA DELEGATION SUD AFRICAINE : INGRID NÄNNI

Français-
La Réunion est un lieu très original:
- C'est un centre de ressources biologiques pour l'Océan Indien du fait de sa conformation géographique et un bon degré de conservation des milieux.
- C'est un laboratoire naturel en vrai grandeur où l'on peut étudier les phénomènes d'évolution et de spéciation qui ont eu lieu en peu de temps.
- C'est un lieu à haut niveau d'expertise scientifique.
- Les infrastructures scientifiques et techniques sont excellentes
- Le niveau de biodiversité est très important mais la menace des invasions est également très forte et ne fera que s'accroître.

Des collaboration locales importantes existent déjà entre centres de recherche et structures de gestion de l'environnement. De plus amples collaborations entre scientifiques de la Réunion et d'Afrique du Sud seraient d'un grand bénéfice mutuel.
Les objectifs de l'ONF et leurs besoins en appui scientifique et outils décisionnels sont très clairement exprimés. La vision du futur Parc National est excellente. Mais il est urgent de mettre en œuvre ces actions de conservation.
Deux enjeux importants sont la conservation des forêts de basse altitude dont il ne reste plus grand chose et la gestion de la zone périphérique du Parc qui est vitale.
Cette démarche de conservation de la biodiversité à la Réunion est une grande opportunité de faire reconnaître l'île au niveau mondial au travers de la promotion de la recherche locale et au travers de la promotion de l'écotourisme.
Différents aspects peuvent être développés : a) utiliser à bon escient la connaissance des écosystèmes, b) de nombreuses opportunités de restauration de milieux, c) prendre en compte le domaine privé.
Les scientifiques sud africains sont enchantés de cette visite à la Réunion, de la découverte de cette biodiversité et des rencontres faites. Ils souhaitent que cet atelier se concrétise dans un futur proche par des collaborations scientifiques entre les différentes institutions et équipes. Ils tiennent à remercier les organisateurs de cet atelier et les instances qui en ont permis le bon déroulement.

English-
La Réunion is a very special place
- Western Indian Ocean resource
- Natural laboratory and important evolutionary questions
- High level of scientific expertise
- Excellent facilities
- Impressive level of biodiversity, but serious threats (getting worse fast)

Local collaborations already exist. We are impressed with the collaboration between ONF, Parc, University, Conservatoire Botanique de Mascarin, CIRAD. More collaboration between South African scientists and La Réunion scientists would be mutually beneficial. We are very impressed with the objectives of ONF. The vision of National Park is also excellent. However, it is urgent to set up immediate implementation. Thus, we highlight the importance to conserve lowland habitats (too few at this moment) and well organized the buffer zones managing that we consider as vital.
This demarche of biodiversity conservation on La Réunion is a high opportunity to put Réunion Island on the world map through local research and ecotourism advancements.
The following local opportunities are also possible: a) capitalize ecosystem services, b) many opportunities for restoration, c) involve the private sector.
The South African researchers are enjoyed by the visit, the Reunionnese biodiversity discovery and the different meetings. They hope that this workshop will be concretize in a near future through scientific collaboration between institutes and research teams. They thank the workshop organizers and the authorities for their availability and this good week.

DISCUSSION

Serge Svizzero-

Français- Rappel du Memorendum of general agreement entre l'Université de la Réunion et l'Université de Durban depuis 1998 dans le domaine de la physique de l'atmosphère.

Présentation de l'Université de la Réunion avec 15000 étudiants dont 448 étudiants étrangers.

Il est important de développer les échanges entre universités dans le domaine de la recherche, de l'enseignement et de l'encadrement d'étudiants.

Rappel de quelques dates :

Juin 2003 : assises de la recherche dans l'Océan Indien

Juillet 2003 : une délégation réunionnaise s'est rendu en Afrique du Sud et a notamment rencontré Monique Rivier (MAE) Conseillère scientifique de l'Ambassade de France à Pretoria.

Nov 2003 : Visite à la Réunion de Monique Rivier qui à cette occasion a proposé de soutenir une action collaboration entre les chercheurs des deux pays dans le domaine de la biodiversité.

Janv. 2004 : Participation de Dominique Strasberg et Stéphane Baret au colloque Southern Connections à Cape Town et première proposition d'atelier de travail sur la biodiversité à la Réunion avec les chercheurs sud africains

La mise en place d'un Parc national dans les hauts de la Réunion est issue d'une demande locale du Conseil Régional puis du Département.

English- He referred to the Memorendum of general agreement between La Réunion and Durban Universities which exist since 1998 in the atmospheres physic field. He also presented the University of La Réunion which include 448 overseas students among 15 000 in all.

He highlighted the importance of developing exchanges between universities of both countries in the research and teaching fields and also in student training.

He referred to some important dates:

June 2003: meeting for the advancement of research in the Indian Ocean Region (http://www.regionreunion.com/fr/assises/index.htm)

July 2003: Meeting of Monique Rivier, diplomatic adviser at French Embassy in Pretoria

November 2003: Visit of Monique Rivier to La Réunion when she proposed to fund and supports a workshop on Biodiversity issues to develop sustainable collaborations between La Réunion and South African searchers.

January 2004: Participation of Dominique Strasberg and Stéphane Baret to Southern Connections conference at Cape Town and first workshop proposition on Biodiversity dynamics at La Réunion with South African and Reunionnese searchers. The set up of a National Park in highlands of La Réunion has been initiated respectively by Region Réunion and Department councils.

Philippe Berne-

Français- Le Parc des Hauts doit jouer un rôle de zone de développement économique, ciblé sur la valorisation de la biodiversité. La zone périphérique du parc doit devenir une zone de production respectueuse de l'environnement servant à la fois de pôle d'activité sociale et de protection de la zone centrale contre les perturbations liées à l'urbanisme, à l'agriculture et aux invasions biologiques.

English- The future Highlands National Park needs to play a role in economical development, focus on biodiversity valorisation. The buffer zones of the park need to become a productive area respectful of the environment by combining social activities and area of protection (of the central zone) against urban, agricultural and biological invasions disturbances.

Jocelyne Lauret

Français- L'écotourisme est un enjeu majeur de développement économique de l'île. Les prévisions portent sur la capacité d'accueil de 1 Million de touristes par an.

Pour cela il faut mettre en place une démarche de développement alliant la protection environnement, le développement économique et le développement social

English- The ecotourism is an important stake of economical development of the island. Previsions proclaim that we will rapidly arrive to 1 Million of tourisms by year. Therefore it is necessary to set up a developmental approach including the protection of the environment, the economical and the social developments.

Philippe Berne

Français- Le Conseil Régional depuis plusieurs années a une politique de protection de l'environnement ciblée. L'étude des pestes végétales a fait l'objet de financement spécifiques pour des programmes de recherche (*Rubus alceifolius* et *Ligustrum robustum*). Différentes bourses d'allocation de recherche ont été allouées à des étudiants sur cette thématique.
Parallèlement au financement de la recherche, des contrats sont passés avec l'ONF pour développer des actions de lutte contre des plantes envahissantes. Le milieu marin fait également l'objet d'une attention particulière, de programmes d'éducation et de sensibilisation à la protection. La mise en place du parc marin est en cours. Ce processus doit aboutir à la création d'une structure associative chargée de la gestion du parc marin et à l'allocation de financements pour des programmes de recherche. Ces programmes portent sur la connaissance de l'écosystème dans sa globalité pour identifier des bioindicateurs faciles à gérer et sur l'étude du phénomène de blanchiment des coraux.
La validation du Schéma d'Aménagement Régional précisera les grandes orientations de développement de l'île. Il doit prendre en compte a) l'augmentation de la population prévue à 1 Million d'habitants en 2010, b) les conflits d'usages de l'espace (urbanisation, agriculture et zones naturelles), c) la pression anthropique de plus en plus forte (circulation des eaux pluviales, des eaux épuration, piétinements, chasse, pêche, cueillette…).
Ainsi la volonté de protection de l'environnement doit prendre en compte les aspects économiques (hôtels touristiques, club de plongée..), les aspects sociaux, et les aspects culturels (que représente la forêt pour les réunionnais).
Il est donc important de définir les bons indicateurs de développement durable qui tiennent compte de tous ces paramètres.

English- The Regional Council has a well-developed politic of environmental protection since many years. We have financed specific research program on invasive plant studies (*Rubus alceifolius* and *Ligustrum robustum*). We also financed many students on this field research.
Parallel to these funding, we also financed projects with forestry service ("ONF") on control actions against alien invasive plants. The marine environment is also included in our actions with educative and sensitive programs. The set up of a Marine park is on going. We will eventually reach the creation of a partnership to supervise management of the park and research programs. These programs carry on the whole ecosystem knowledge in order to identify easy to manage bioindicators and on coral whitening studies.
The validation of the regional development scheme will indicate the large direction of the island development. It needs to consider a) the population growth estimated to 1 Million in 2010, b) the conflicts of space use, c) the more and more important anthropogenic pressures (water transfers, water purification, trampling, hunting, fishing, picking…). Thus, the desire to protect environment need to take in consideration the economical (tourist hostel, submarine club…), social and cultural (how local population consider the forest?) aspects. It is very important to define good sustainable development indicators which consider all these parameters.

Bernard Bonnet

Français- Il y a un enjeu très important de sensibilisation et d'information de la population à la protection de l'environnement.

English- He thinks that there is an important stake of sensitisation and information of the population on environmental protection.

David M. Richardson

Français- Une priorité pour la conservation de la biodiversité de la Réunion réside dans la prévention et la gestion des espèces envahissantes.

English- A priority for biodiversity conservation of La Réunion require appropriate prevention and management of invasive species.

Alain Brondeau

Français- Il demeure très peu d'habitats naturels de basse altitude à la Réunion. Est-il opportun et envisageable de faire de la reconstitution écologique de ses milieux ou faut-il se concentrer sur la préservation des quelques lambeaux qui restent ?

English- Very few natural lowland habitats remain nowadays on La Réunion. Is it realistic to restore these habitats or is it preferable to focus and preserve only some of remaining of intact of it?

David M. Richardson

Français- Il est très important de prendre les décisions de restauration et de conservation en prenant en compte les enjeux au niveau des Mascareignes et pas uniquement au niveau de la Réunion.

English- It is very important to take decision on restoration and conservation by considering opportunities at the Mascarene level and not only at the Réunion level.

PERSPECTIVES DE L'ATELIER – PERSPECTIVES OF THE WORKSHOP

Dominique Strasberg

French- La Réunion a la responsabilité locale et régionale de conserver une biodiversité unique. En effet, nombre d'écosystèmes naturels des Mascareignes, ne sont plus présents qu'à la Réunion.
Au niveau de la zone sud-ouest de l'Océan Indien, l'Afrique du Sud et la Réunion sont deux pays confrontés aux problèmes de la conservation de la biodiversité mais présentent deux situations très différentes. L'un est un pays continental, vaste, d'origine géologique très ancienne, tandis que l'autre est une île océanique de petite surface, d'origine géologique très récente. L'analyse comparée des données obtenues dans des problématiques communes dans ces deux situations très différentes doit nous apporter beaucoup d'information et d'éléments de compréhension sur les processus d'évolution et de construction de la biodiversité ainsi que sur la dynamique des menaces qui portent sur cette biodiversité (enjeux d'utilisation de l'espace, invasions biologiques…). Les équipes de recherche sud africaines sont beaucoup plus nombreuses et travaillent sur ces sujets depuis beaucoup plus longtemps que les équipes de la Réunion. Il apparaît donc très intéressant d'associer nos efforts et d'adapter les méthodologies qui ont été mises au point en Afrique du Sud aux besoins de la Réunion.
Ces collaborations pourront être renforcées par la mise en place de cursus de formation communs : Master, Doctorat, Post Doctorat et au travers de l'échange d'étudiants.

Les perspectives de collaborations portent sur les domaines suivants :
- Combler le déficit en connaissances sur certains groupes taxonomiques (orchidées, bryophytes, acariens, invertébrés autres qu'insectes…)
- Comprendre les processus évolutifs des écosystèmes tropicaux
- Comprendre les relations entre agriculture et biodiversité
- Intégrer tous les acteurs : SIG, modélisation spatiale, télédétection

- Mettre à la disposition des acteurs les données et l'information (SGBD, Web, …)
- Définir des indicateurs de biodiversité dans les différents écosystèmes
- Etudier les phénomènes de coévolution insectes/plantes
- Utiliser l'ensemble des informations disponibles et développer des outils d'aide à la décision permettant d'aboutir à une programmation de la conservation des milieux, et des espèces

A court terme, cette collaboration peut s'envisager sous la forme d'échanges de doctorants, post doctorants et de chercheurs dans le cadre de projets de recherche communs.
A plus long terme, cette collaboration doit permettre la création de cursus de formation et d'enseignement communs ainsi que la mise en place de réseaux de connaissance et d'expertise à l'échelle régionale.
Le développement de ces activités et de cette collaboration, s'inscrit parfaitement dans la démarche actuelle de connaissance et de conservation de la biodiversité à l'échelle européenne et notamment au niveau des RUP.

English- La Réunion has the responsibility to conserve locally and regionally a unique biodiversity. Indeed, numerous natural ecosystems of Mascarene Islands remain nowadays only at La Réunion. In the south-western Indian Ocean area, South Africa and La Réunion are both confronted to the biodiversity conservation problems but differently. The first one is a mainland with large areas and geologically old. The second one is a small oceanic island which is very young geologically. A data comparative analysis obtained in similar ways between these both contrasted countries will carry us important information and elements in order to better understand evolution processes, biodiversity and threats dynamic on biodiversity (land use issues, biological invasions…). South African researcher teams are more important and work on these areas since a long time compare to Reunionnese researcher teams. It looks very interesting to associate our effort and to use and to adapt South African methods to La Réunion.
These collaborations could be reinforced by common training programmes such as Master, PhD, Post doctorate and through students exchanges.

The future collaborations are based on the following fields:
- to complete taxonomic groups having a deficient knowledge (orchids, bryophytes, mites –acari-, invertebrate other than insects…);
- to understand evolutive processes of tropical ecosystems;
- to understand relation between agriculture and biodiversity;
- to integrate stakeholder knowledge with GIS, spatial modelling, and remote sensing information;
- to transfer the data and the information to politicians and decision-makers (SGBD, Web…)
- to study insect-plant coevolution
- to use all of the available information and develop decision making tools which permit us to finalize a program of environmental and species conservation.

At short term, this collaboration can be envisaged through PhD, Post-Doctorate and scientist exchanges in similar research projects.
At long term, this collaboration needs to develop similar training and teaching programmes and the installation of expert and knowledge networks at the regional scale.
These activities and collaboration projects fit perfectly within the current programme of knowledge and biodiversity conservation at the European scale and particularly in the ultra periphery region (RUP).

DISCUSSION FINALE – FINAL DISCUSSION

Philippe Berne

Français- Il est important de renforcer la coopération pour arriver à faire du co-développement avec nos voisins. C'est aussi très important pour nos étudiants.

Il y a un processus fantastique à mettre en marche au niveau régional autour du thème de la biodiversité. Il existe déjà une coopération Nord / Sud (Danemark, Belgique...), il faut maintenant développer une coopération Sud / Sud.

English- It is important to reinforce the cooperation in order to make co-development with our neighbours. It is also very important for our students. There is a fantastic process to set up on the biodiversity topic at the regional scale. It already exists a North/South cooperation (Denmark, Belgium…). It is now necessary to develop a South/South cooperation.

Llewellyn Foxcroft

Français- L'enjeux du développement touristique à la Réunion apparaît très important. Il faut étudier l'impact du tourisme à différentes échelles (économique, sociale, écologique…).

English- The tourism development looks to be very important on La Réunion. It is necessary to study the tourism impact at different scale (economical, social, ecological…).

Bernard Bonnet

Français- La mise en œuvre d'une gestion intégrée relève d'un choix politique.

English- The installation of an integrated management depends of the politic choice.

Ingrid Nanni

Français- Il faut absolument conserver les zones naturelles. Dans les zones de développement il faut absolument engager une démarche de développement durable d'un point de vue économique et environnemental. Le principal enjeu du Parc se trouve à ce niveau et a été très bien perçu.

English- It is essential to conserve natural areas. In development areas, it is very important to consider a sustainable development with an economical and environmental view. This is the major issue of the park.

Mathieu Rouget

Français- Le SAR existe en Afrique du Sud. Il intègre directement une nouvelle loi sur la biodiversité qui prend en compte de façon encore plus importante la protection de l'environnement. Les communautés locales, mais aussi les propriétaires sont obligés de tenir compte de cette loi. Protéger la biodiversité ne relève pas que des réserves et des parcs nationaux mais aussi des propriétaires privés.

English- There is also a regional development scheme in South Africa. It integrates a new law on biodiversity which consider more efficiently the protection of the environment. The local communities and land owners are obliged to consider this law. Protect biodiversity is not only the role of the reserve and national parks but also the role of private land owners.

Serge Quilici

Français- Réaliser un guide pratique de reconnaissance faune, flore pour le parc, permettrait à la fois de valoriser la connaissance sur la biodiversité locale et de sensibiliser aussi bien celui qui vit en permanence sur place que le public de passage.

English- A practical guide on identifying local fauna and flora will valorise local biodiversity knowledge but also will sensitive local public and tourist.

CONCLUSION

Université de la Réunion – Michel Watin

Français- Différents points d'intérêt majeur apparaissent au travers de cette discussion :
- Les conflits d'usage de l'espace ;
- L'enjeu de conservation et l'enjeu social du Parc national ;
- Les problèmes d'invasions biologiques ;
- L'impact des activités humaines sur la biodiversité.

L'Université de la Réunion vient de créer un pôle de télédétection et d'analyse d'images qui peut jouer un rôle important dans l'approche globale de la gestion des espaces.
Un Observatoire sur la biodiversité pourrait être un outil très intéressant pour la Réunion.
La vulgarisation et la diffusion des connaissances doivent être développées.

English- Several topics of interest to both South Africa and La Reunion appear through the global discussion:
- The conflicts of land use space;
- The issues of conservation and the social aspect of the future national park;
- Biological invasions;
- The human activity impacts on biodiversity.

The University of La Réunion has recently created a unit on remote sensing and image analysis which can play an important role in the global approach of the land use management. A biodiversity observatory could be an interesting tool for La Réunion.
Information and knowledge diffusion need to be developed.

CIRAD - Gabriel de Taffin

Français- Il existe un enjeu de recherche scientifique important dans le domaine de la conservation de la biodiversité à la Réunion. La biodiversité c'est l'affaire de tous, chercheurs, gestionnaires (CBNM, ONF, mission parc…), agriculteurs, politiques qui ont un rôle important en matière de planification et de politique d'ensemble. La proposition d'échanges d'étudiants entre les deux pays est très bonne.

English- An important scientific research issue on the Biodiversity conservation exists on La Réunion. The Biodiversity is the problem of all, researchers, managers (Mascarene National Botanical Institute, Forestry service, future national park…), farmers, politicians which have an important role in term of planning and global politic. The students exchange proposition between both countries looks very promising.

Conseil Régional - Patrick Hervé

Français- Il faut qu'au travers des travaux sur la biodiversité on ait le souci d'acquérir des connaissances et de les diffuser. Les conflits d'usages dans notre île ne peuvent que s'accentuer avec l'augmentation de la population. Les outils SIG et image satellite sont à développer pour la planification de l'utilisation de l'espace. L'étude de la biodiversité doit se traduire par la mise en place d'équipes trans-disciplinaires, afin d'aborder cette thématique dans sa globalité et pas uniquement par la biologie. Le Conseil Régional et ses partenaires doivent travailler main dans la main pour que le bénéfice ne soit pas que pour les chercheurs mais pour l'ensemble de la Réunion.

English- Through work on biodiversity, we can obtain knowledge and to disseminate it. The land use conflicts in our island will become more important with the increasing population. The GIS tools and the satellite images need to be developed for land use planning. The biodiversity studies need to integrate various teams (trans-disciplinarily) and not just focus on biology in order to capture its complexity. The Regional Council and its partners need to work together for having a mutual benefice important for the island development.

Conseil Régional - Wilfrid Bertile

Français- Il y a un an, un atelier régional sur la conservation de la biodiversité et les invasions biologiques se tenait aux Seychelles. Il est important de travailler dans un cadre régional.

English- One year ago, a regional workshop on biological invasions and biodiversity conservation has been organized in Seychelles. This highlighted the importance to work at the regional scale.

South African National Biodiversity Institute - Ingrid Nanni

Français- Aucune protection de l'environnement ne sera possible si les populations qui vivent, travaillent et font partie de ces zones ne sont pas tenus au courant des démarches et s'ils ne sont pas en accord avec ces démarches. Le travail serait inefficace. Il faut donc intégrer l'information et l'interrogation de la population très tôt dans les processus d'analyse et de prise de décision concertée.

English- No environmental protection will be possible if populations living and working on these areas did not know the different approaches and if they do not agree with these approaches. The work will be inefficient. You need to integrate the information and the concerns of the population as soon as possible in the analysis processes and in decision making.

Conseil Régional - Philippe Berne

Français- Remercie l'ensemble des chercheurs pour leurs travaux sur la conservation de la biodiversité. Les données qui seront apportées aideront les politiques dans leurs choix.

Cette semaine les personnes de l'atelier ont travaillé essentiellement sur des problèmes de biodiversité terrestre. Mais il existe aussi la biodiversité des eaux douces. La faune des eaux douce est arrivée de la mer il y a peu de temps. Les processus d'évolution et d'adaptation sont donc très intéressants à étudier dans cet écosystème. Il ne faut donc pas l'oublier.

Le problème de la biodiversité marine s'inscrit également dans le cadre des changements globaux au niveau planétaire. Des coopérations avec l'Afrique du Sud peuvent aussi être envisagées dans ce domaine.

Globalement on peut dire que la principale menace à laquelle la biodiversité doit faire face c'est l'Homme. Dans l'étude de la biodiversité il ne faut donc pas oublier les dimensions économiques, sociologiques et juridiques. Le schéma touristique de La Réunion va bientôt être signé et le Schéma d'Aménagement Régional va être révisé. Il convient d'y intégrer fortement les aspects de conservation de la biodiversité. Depuis 3 ans La Réunion met en place un agenda 21 dont la biodiversité est un élément clé.

English- He thanked all the researchers for their works on Biodiversity conservation. The present and future data will help politicians in their choice. This week, the workshop participants have mainly worked on terrestrial Biodiversity. However, there is also the fresh water and marine biodiversity. The marine fauna has recently arrived. Evolution and adaptation processes are thus very interesting to study in this ecosystem type. Don't forget it!

The marine Biodiversity problems also is part of the global change programs at the worldwide level. Cooperation on this field could also be organised with South Africa.

Globally, we can affirm that the main threat for Biodiversity is the Human being. Therefore, in Biodiversity studies it is necessary to consider economical, social and juridical aspects. The tourist scheme of La Réunion will be signed soon and the regional development scheme will be revised. It is important to integrate the Biodiversity conservation aspects. Since 3 years, La Réunion set up the 21 agenda ("the 21 diary") within it, biodiversity is a key component.

PROPOSITIONS DE COLLABORATIONS SCIENTIFIQUES AFRIQUE DU SUD / REUNION – POSSIBLE COLLABORATIONS

Français- Au cours de cet atelier, des projets de collaboration ont été élaborés entre différents partenaires. L'ensemble de ces projets fera l'objet de la préparation d'un projet global dans le cadre d'InterRég qui sera présenté début 2005 aux bailleurs de fonds.

English- During this workshop, future collaborations have been proposed between the partners. All of the following projects will be regrouped and submitted to potential funders.

TAXONOMY, ECOLOGY AND EVOLUTION

1. Co-evolution of *Agrius convulvuli* and nectar plant in the Afro madagascan region

- Does *Agrius convulvuli* can be considered as a Keystone species at the regional scale?
- South Africa / Madagascar / Réunion comparison
- **Partners**: PhD/Post-doctorate students
  S. Johnson KZN University - T. Pailler UMR PVBMT
- **Products**: Scientist & student exchange, PhD thesis; publications.

2. Reproductive assurance in invasive plants on Island versus Mainland

- Is reproductive assurance more important on island than in mainland?
- South Africa versus Réunion comparison
- **Partners**: PhD/Post-doctorat students
  S. Johnson KZN University - T. Pailler UMR PVBMT
- **Products**: Scientist & student exchange, PhD thesis; publications.

3. Bryophyte flora of la Réunion

- Undertake systematic inventory of flora.
- Collect material as part of surveys for targeted molecular analyses - particularly to look at relationships of endemics and to explore population-level variation.
- Molecular analyses to be undertaken at UCT and Reunion.
- Tropical Bryology Group workshop/field study on Reunion (10-12 people to assist with survey) 2006/07.
- **Partners**: C. Ah-Peng Phd UMR PVBMT - T. Hedderson UCT
  Tah UCT to return 2005 and spend part of sabbatical (2 months) in 2006.
- **Products**: publications; Atlas of Reunion bryophytes; Floras - traditional and interactive-; Good reference collections; On-line data for a wide variety of users (e.g. planners, legislators).
- Calendar: 2005-2008

4. Filling gaps in the knowledge of entomofauna biodiversity:

- Completion of on-going inventories: predatory mites
- Study of poorly known major groups : soil mites
- **Partners:** E.A. Ueckermann PPRI - L. Coetzee PPRI - S. Quilici UMR PVBMT
- **Products**: Complete knowledge of the acarofauna
- **Calendar:** 2005-2008

5. Insect-plant relationships and conservation in groups with high endemism:

- Knowledge of insect-plant relations, ecological niches and distribution of endemics
- Cratopus spp. (Coleo. Curculionidae)
- Derbidae (Hemiptera: Fulgoromorpha)

• **Partners:** M. Samways University of Stellenbosch - S. Quilici, B. Reynaud, M. Attié UMR PVBMT
• **Products**: Publications
• Calendar: 2006-2008

6. Phylogeny and evolution of Derbidae / Cixiidae in the Western Indian Ocean

• Evolution of Fulgoromorpha in relation with their host-plants in the Western Indian Ocean
• **Partners:** M. Samways University of Stellenbosch - M. Picker University of Cape Town - M. Attié UMR PVBMT
• **Products**: Publications
• Calendar: 2006-2008

7. Integrating multiple arthropod database

• Integrating multiple arthropod databases for mapping arthropod fauna and for observation planning (in connection with PRPV)
• **Partners:** M. Picker University of Cape Town - S. Quilici, B. Reynaud UMR PVBMT - J. Rochat Insectarium de la Réunion - S. Ribes Museum d'Histoire Naturelle
• **Products**: Global database on arthropod biodiversity
• Calendar: 2005-2007

8. Red list of arthropods of La Réunion

• Establishing red lists of threatened artrhopods (linked with IUCN/SSC = Species Survival Commission):
• Completion of on-going inventories: predatory mites (PPRI)
• Study of poorly known major groups: soil mites (PPRI)
• **Partners:** M. Samways Univ. Stellenbosch
S. Quilici, B. Reynaud UMR PVBMT
J. Rochat Insectarium de la Réunion
S. Ribes Museum d'Histoire Naturelle
• **Products**: Red list established
• **Calendar:** 2005-2006

9. Preparation of a large research project on the importance of insect biodiversity for definition and management of protected areas

• **Partners:** M. Samways University of Stellenbosch - M. Picker UCT - E.A. Ueckermann PPRI - S. Quilici, B. Reynaud UMR PVBMT
• **Products**: Use of insect biodiversity data for protected areas in the Western Indian Ocean countries
• Calendar: 2007-2010

BIOLOGICAL INVASIONS

1. Land use and conservation planning

• Remote sensing, GIS and modelling to develop conservation planning methodology
• Specific comparison between national Reunion park and Kruger National Park
• **Partners**: E. Lagabrielle Phd UMR PVBMT - T. Le Bourgeois, S. Baret UMR PVBMT - M. Rouget SANBI - L. Tron Mission Parc National Réunion - L. Foxcroft Kruger National Park
• **Products**: 2 PhD thesis; publications; decision making tools, Exchange of expertise and training
• Calendar: 2005-2007

2. Inventories of invasive species and prioritization of actions

• Listing and prioritising invasive species
• Comparison between South Africa and Reunion situation (patterns)
• **Partners:** S. Baret, T. Le Bourgeois UMR PVBMT - C. Lavergne CBNM - D. Richardson Center for Invasion Biology, Stellenbosch University
• **Products**: Updated databases on invasive species; Hierarchy of priorities
• Calendar: 2005-2007

3. Invasive species and mutualisms

• Do invasive species use native pollinators and seed dispersors (and vice versa)?
• Do the activities of native fauna on IAS disrupt naturally occurring mutualisms?
• Mainland versus Island comparison
• **Partners** : PhD/Post-doctorat students - S. Johnson KZN University - D. Richardson University of Stellenbosh - T. Pailler, S. Quilici UMR PVBMT
• **Products**: PhD thesis; publications; improved management
• Calendar: 2006-2008

4. Invasive species model the case of *Zantedeschia aethiopica*

• Comparative studies of *Zantedeschia aethiopica* invasive in La Réunion and native to South Africa
• Analysis of habitat, life history, entomofauna and pathogens links
• Partners: PhD student - D. Richardson University of Stellenbosh - S. Johnson KZN University - T. Le Bourgeois, D. Strasberg, S. Quilici, T. Pailler, S. Baret UMR PVBMT
• **Products**: PhD thesis, publications; improved management, training courses.
• **Calendar**: 2006-2008

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