

***Project S'Albufera:
monitoring for biodiversity and environmental change***
The Albufera International Biodiversity Group Annual Report 1999
Edited by Nick Riddiford

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Preface

Much has happened since Project S'Albufera began in 1989. The watershed year of 2000 seems an appropriate moment to take stock. Rather than concentrate purely on work done last year, this report summarises the structure of our multidisciplinary, international project, the site, the scientific work programme past and present, and exciting new developments for the new millennium.

Nick Riddiford, The Albufera International Biodiversity Group, February 2000

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Monitoring for biodiversity and environmental change

**Project S'Albufera
The Albufera International Biodiversity Group**

PART I

PROJECT OUTLINE

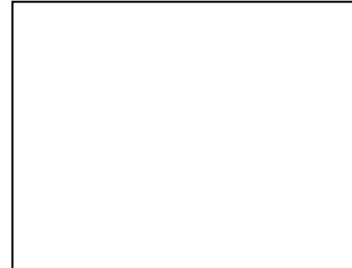
S'ALBUFERA DE MALLORCA, SPAIN

Project s'Albufera

PROJECT OUTLINE

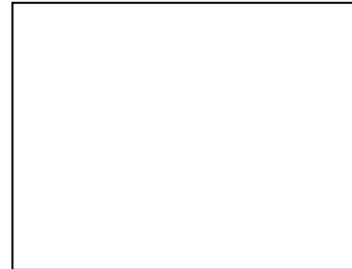
International importance of The Albufera

The Albufera wetland has been recognised as internationally important since the MAR list of 1965 (now known as the RAMSAR list of internationally important wetlands). At that time the wetland was imminently threatened by drainage and commercial development. By the 1980s the adjacent sand-dunes, along with much of Mallorca's accessible coastline, were also earmarked for tourist development.



Parc Natural de s'Albufera

- **Fortunately**, after a long struggle, the greater part of the wetland and a flora-rich length of coastal dunes were acquired and safeguarded as a 1708 ha natural reserve by the Balearic and Spanish government conservation agencies. It was named Parc Natural de s'Albufera, literally "Natural Park of *the* Albufera" in English.



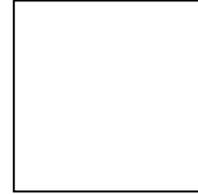
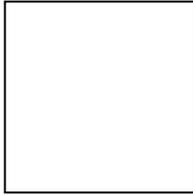
Project S'Albufera

- **In 1989**, just one year after the inauguration of the Park, prompting by International Conservationist, Max Nicholson, and with the enthusiastic support of the newly formed Earthwatch Europe, led to the establishment of this Project, known informally as Project S'Albufera.



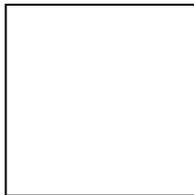
Research, management, long-term monitoring

- **The immediate goals** of the Project were to undertake an extensive survey to underpin management in order to exploit the full potential of this vital reserve without harm to still unrevealed features of scientific importance; and to set up a series of long-term monitoring studies to investigate and measure environmental change, including global change.



Interdisciplinary approach

- **This required** the participation of many specialists, and from the start one of the Project's major features and strengths has been its interdisciplinary approach involving scientists from diverse fields and specialties working together.



Applied biodiversity programme

- **The initial goals** were achieved during the first three years, 1989-91. An internal assessment of first phase results followed by scientific consultations, including an on-site peer review in April 1992 (Varley 1992), re-focused the goals.

It was realised that the information gathered during the first three years formed an unrivalled baseline for the understanding of the functions and values of wetlands and dunes throughout the Mediterranean; and that the opportunity had arisen to establish an applied biodiversity programme which could act as a model for similar sites throughout the region and beyond.

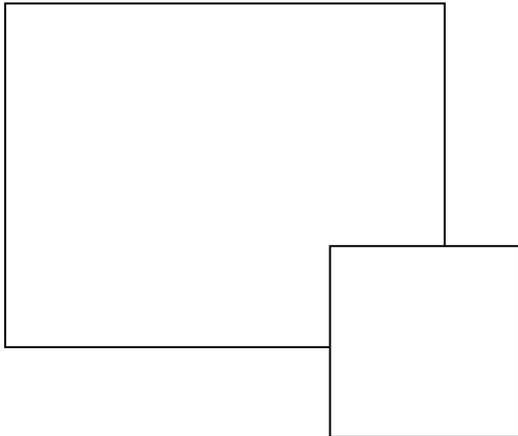
Biodiversity model

- **From 1992** the two main goals of the Project have been to establish a Biodiversity model, and to continue the development and implementation of a monitoring programme for environmental change.

S'ALBUFERA DE MALLORCA, SPAIN

Data availability

- A great deal of data has been collected regarding ecological and socio-economic values in the last 11 years by a combination of the Park authorities, Earthwatch Europe's Project S'Albufera and scientists from the University of the Balearic Islands (UIB). Monitoring measures by the Park directorate are specified in its management plan.
- The Park maintains a programme of ornithological, hydrological and meteorological monitoring throughout the year. However, it has achieved more comprehensive monitoring than its structure and funding would have allowed by cooperating with an international agency, Earthwatch Europe, to instigate a scientific research programme with biodiversity studies and monitoring for environmental change as major themes - supported by a multidisciplinary scientific team (The Albufera International Biodiversity Group), Earthwatch Europe's Project S'Albufera.
- In addition to on-site data, the Park maintains databases of publications, materials and sources for materials and data pertaining to S'Albufera.



The Park and The Albufera International Biodiversity Group

The Albufera International Biodiversity Group (TAIBG) comprises an independent team of scientists affiliated to Earthwatch Europe's Project S'Albufera, a charitable organisation which provides funds and volunteers for scientific field studies. It works very closely with and responds to the needs and requests of the Park authorities. Its large ecological database is held by the Group Leader, Nick Riddiford, individual scientists and, most importantly (as all data are shared), with copies of Project data lodged at the Park.

Objectives of Project S'Albufera

The Project defined five objectives.

1. The first was to assemble baseline information comprising full and detailed ecological data to reach an understanding of composition, functioning and dynamics of the ecosystems; and Public Use data, including visitor use and impact of visitor numbers.
2. The second was to provide standardised comparative data for evidence of environmental change, to be re-recorded at intervals of time, to provide a model for other monitoring stations.
3. The other objectives were: to afford material for application in further research and reserve management at s'Albufera and in general conservation practice;
4. to provide resources for comprehensive interpretive programmes and dissemination in all appropriate forms;
5. to serve as a focus for education of residents and visitors of all age-groups and levels and to help create environmental awareness and commitment.

The Project employs a combination of inventory, monitoring and applied research to achieve its objectives.

S'ALBUFERA DE MALLORCA, SPAIN

ORGANISATIONAL SETTING

Biodiversity training site

- **S'Albufera** is a RAMSAR site and a Europa 2000 Site as a Special Protection Area for Birds. Since 1995, s'Albufera has also been a biodiversity training site for biologists, conservationists and ecologists as part of the European Union/Darwin Initiative African Fellowship Programme, administered by Earthwatch Europe and led by The Albufera International Biodiversity Group (TAIBG).

MedWet study site

- **It was also** a pilot study site for the EU MedWet programme subproject *Inventory and Monitoring in Mediterranean Wetlands*. The study was conducted jointly by the Park and The Albufera International Biodiversity Group, whose Principal Investigator, Nick Riddiford, also acted as scientific editor to the MedWet publication *Monitoring Mediterranean Wetlands* (Tomas Vives *et al.* 1996).

Education

- **At the local level**, members of TAIBG have also collaborated in preparation of a CD-ROM for Balearic schools (cd-rom del Parc Natural S'Albufera, 1995) and a travelling Biodiversity exhibition for Balearic Island communities and schools (Biodiversitat. Les mil i una formes de la vida, 1999).

International links

- **The Park and The Albufera International Biodiversity Group** have already established

links with institutes and universities in Holland, France, Britain and Germany.

Research centre

- **To facilitate international** scientific ventures and collaborations, the Balearic and Spanish Governments completed a new research centre, the **Casa de las Universidades Europeas**, in 1998. The centre has four study bedrooms, offices, lecture room and laboratory.



Photo:

Dennis Bishop Memorial Laboratory

- **Thanks to a** generous grant from benefactors and friends of s'Albufera, money has become available to equip the laboratory to the highest standards. The laboratory will be known as the **Dennis Bishop Memorial Laboratory**.

Biological station

- **The newly elected Balearic government** has expressed an intention to build on this base and is currently preparing a proposal to establish a Biological Station, based at s'Albufera but acting as a focus and stimulus for conservation-related scientific work throughout the Balearic Islands.

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Monitoring for biodiversity and environmental change

**Project S'Albufera
The Albufera International Biodiversity Group**

PART II

***ESTACIÓN BIOLÓGICA DE S'ALBUFERA DE MALLORCA
(The Albufera de Mallorca Biological Station)***

S'ALBUFERA DE MALLORCA, SPAIN

Estación Biológica de s'Albufera de Mallorca

Base for applied environmental studies

The Balearic Government's intention to establish an international field station at s'Albufera de Mallorca will make s'Albufera and its facilities, in particular the Dennis Bishop Laboratory, the base for applied environmental studies not just at s'Albufera but for all natural areas within the Balearics.

Working together

It will be used to bring together scientists, conservationists, Universities and other institutes from the Balearic Islands and abroad to work together for education, science and the long-term benefit and care of the Balearic's rich natural values and assets.

Training and education

One of its major roles has been identified as providing opportunities for training and education of local and foreign biologists, ecologists and environmentalists, particularly in the field of biodiversity study and the understanding and development of protection measures for biodiversity conservation.

The Albufera International Biodiversity Group (TAIBG)

TAIBG already works very closely with the Park authorities and will provide scientific support for the new Biological Station. The incorporation of TAIBG into the work of the Biological Station will allow the Group to collaborate even more closely with the Balearic Environment Ministry and local conservationists.

Main Focus of Research and Development Tasks

TAIBG in collaboration with the Park authorities has interests in all Research & Development tasks but, in conjunction with Wageningen University's Environmental Systems Analysis Group, has pilot experience in *Valuation framework development*. With its ability to call upon a considerable number of experienced scientists, the group has also become heavily involved in *Training and Dissemination* activities. *Database development* is also viewed as important. TAIBG is in a position to play a useful role in all these tasks.

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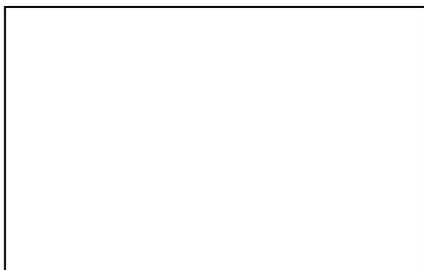
**Project S'Albufera
The Albufera International Biodiversity Group**

PART III

SCIENTIFIC RESEARCH PROGRAMME

SCIENTIFIC RESEARCH PROGRAMME

Biodiversity training



Project S'Albufera has, from the start, sponsored young Balearic and Spanish Peninsular scientists, conservationists and environmentalists to participate as volunteers in the Project.

This policy is considered a key part of the programme, acting as a training school in field techniques and ensuring local involvement, awareness and knowledge of both the Project and conservation issues generally.

A number have progressed to important and influential environmental posts (Wetlands International coordinator, MedWet sub-project on Inventory and Monitoring; two successive Heads of Eurosite, Iberia; Government biologists; teacher-naturalists; university staff; officers within wildlife and conservation groups).

Through the Project, and the substantial support of Earthwatch and Earthwatch Europe, the Park has now become a focus for education at a much wider level.

The project has always attracted volunteers from throughout the World. This has been extended to include sponsored fieldwork experience and training courses.

One such development in 1995-1997 involved British and European teachers as recipients of Glaxo Wellcome and Arco Chemical Awards, sponsored by those companies.

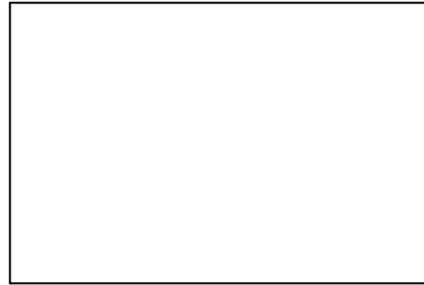
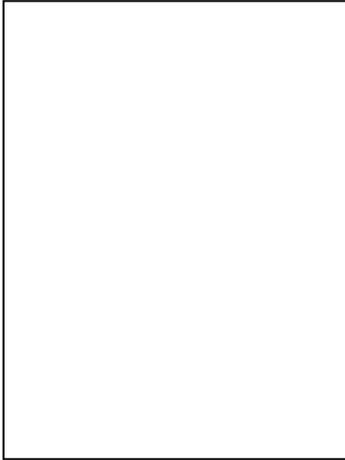
A most important development, and one which recognises the scope of the Project and the role it can play in acting as a model for other sites and areas of the World, was the introduction from 1995 of an African Fellows scheme.

The African Fellowship programme was established by Earthwatch Europe and sponsored by the European Commission and the Darwin Initiative of the UK government.

This form of volunteer participation is extremely worthwhile because it integrates the ecological research with the training and education aspects of the Project. The African Fellows are all highly motivated, skilled ecologists, who come with a desire to learn as much as they can about conservation and environment issues.



The programme has even greater benefits because of the cooperation and support of the Park directorate and Balearic government departments, which have provided additional material, seminars, organized activities and information.



Because the Project programme has been designed to use straightforward methodology which is both cost-effective and user-friendly to volunteers of all abilities, the Fellows are able to learn techniques which may be adapted to situations in their native country.

This gives the Fellows the opportunity to gain an insight into conservation and the environment in Mallorcan, Balearic and national contexts as well as allowing them to place their experience of Project S'Albufera work and activities in a wider perspective.



Course members so far have been drawn from Cameroon, Kenya, Uganda, Nigeria, Ethiopia, Equatorial Guinea and South Africa.

International co-operation and academic links

- **Consultancy to the MEDWET programme**, an action programme for Mediterranean wetlands comprising a partnership of the government conservation bodies of 5 countries, the RAMSAR convention and a number of NGO's. The Project and Park were particularly involved in the preparation and testing of the MEDWET methodology for monitoring wetlands.
- **Co-operation with Wageningen Agricultural University**, The Netherlands to establish s'Albufera as a case study in the functional analysis and valuation of ecosystems.
- **Incorporation of the project in the academic programmes of the following universities:**
 - Royal Holloway Institute for Environmental Research (RHIER), University of London, England (soil nutrient dynamics).
 - University College London Ecology and Conservation Unit, England (baseline data collection, research dissertations and field courses).
 - Centre for Remote Sensing and Mapping Science, University of Aberdeen, Scotland (remote sensing and habitat mapping).
 - University of the Balearic Isles, Palma, Mallorca (hydrology, limnology, dune studies, vegetal physiology).

- **Collaboration with the following organisations:**
 - Wilhelmina Zoological-Biological Garden, Stuttgart, Germany (pond terrapin studies)
 - Tour du Valat Biological Station, Camargue, France (heron and egret studies; reedbed ecosystem monitoring)

Biodiversity and Monitoring

- **Over 100 new species of plants, fungi, bryophytes and insects added to the Mallorcan list.** A small series of moths in May 1997 included the important find of the first ever male, the species being known previously from just 7 West African females. Other major discoveries include two previously undescribed species of fly and an undescribed fungus.
- **Presentation of the Project s'Albufera Biodiversity Model** to the World Conservation and Monitoring Centre, Cambridge, England in 1994; and collaboration in a travelling Biodiversity exhibition for Balearic Island communities and schools in 1999.
- **Major studies** of the world's highest known density of Moustached Warblers and the internationally important Prickly Juniper.
- **The application of a freshwater quality monitoring programme** for the first time in a Spanish coastal wetland. This study has already shown that it can act as an early warning system for major pollution events.

Park Management and conservation policy

- **Project s'Albufera recommendations were incorporated in the Parc's first management plans.** This is updated every 4 years, with the next plan due in 2003.
- **Studies having particular importance for the 1998 management plan are:**
 - the effect of grazing animals on key plant populations e.g. orchids.
 - distribution mapping of key bird and invertebrate species in relation to vegetation structure and management.
 - aquatic invertebrate and vegetation communities in relation to water quality.
 - the impact and recovery from major events such as drought, severe storms and fire in various vegetation communities.
 - The impact of tourist related coastal dune erosion on pioneer plant communities.
- **Active participation in the reintroduction or rehabilitation of species once native to the Parc,** eg the purple gallinule (one of Europe's rarest birds) and barn owls; and monitoring their subsequent progress.
- **Many of the one-off projects conducted each season are at the request of the Parc staff.** The Parc does not currently have the resources to conduct many scientific studies, so the input of project data is vital.
- **Nick Riddiford was scientific editor of the MEDWET methodology guide** published in 1996.
- **A major contribution to the Parc's educational CD-ROM** produced by the University of the Balearic Isles in 1995 and available in every school in the Balearic Isles.
- **Providing materials and helping to build the displays for the Parc's Visitor Centre,** including a major exhibit describing the role of Earthwatch and Project s'Albufera.
- **Provision of an ecological training programme** for young Spanish scientists, African NGO and UK teacher and Millennium Fellowships through participation in Project s'Albufera. Several have subsequently progressed to major conservation posts.
- **Papers from the project's annual reports and research** have provided major contributions to publications including the Balearic Natural History Society's monograph on s'Albufera and the first three numbers of the Parc's own scientific bulletin.
- **Publication** of Parc habitat posters and a plant guide (in preparation) available to Park visitors.

Education and Publications

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Monitoring for biodiversity and environmental change

**Project S'Albufera
The Albufera International Biodiversity Group**

PART IV

S'ALBUFERA DE MALLORCA: DESCRIPTION OF SITE

S'ALBUFERA DE MALLORCA, SPAIN

DESCRIPTION OF THE SITE

- **International importance**

Major wetlands are uncommon and declining around the Mediterranean, but are of special ecological value for their diversity of fauna and flora and as breeding areas or staging posts for migratory birds. Coastal sand-dunes throughout the Mediterranean are also under enormous pressure and a dwindling resource. S'Albufera de Mallorca wetland is by far the largest of the very few wetlands remaining in Mallorca and the Balearic Islands; its dune system is one of very few in Mallorca which have been protected and not destroyed or severely damaged by tourism and associated urbanisation.



- **Location, size, physiography**

S'Albufera de Mallorca, 39°47'N 3°6'E, is a 1,700 ha coastal wetland in northeast Mallorca, Spain. The area is flat and just above sea level. The boundaries comprise the sea, tourist urbanisation and agricultural land. An inland band of stabilised dunes partially interrupts the wetland and a further coastal belt acts as a buffer against the sea. S'Albufera is part of Sa Pobla Plain, a 30-40 m thick layer of quaternary sediments. It has a typical Mediterranean climate, though somewhat milder and with a slightly higher rainfall than the surrounding area.

- **Wetland types occurring at the site**

The Ramsar wetland types comprise: non-forested alkaline fen, permanent freshwater marshes/pools, salt marsh, coastal brackish and saline lagoons, coastal freshwater lagoons, permanent saline, brackish and alkaline marshes and pools, seasonal saline, brackish and alkaline marshes and pools, and freshwater springs .

One permanent narrow connection and two one-way connections controlled by sluices connect part of the marsh with Alcudia Bay in which three further Ramsar wetland types are represented: permanent shallow marine waters less than six metres deep; marine subtidal aquatic beds, of the sea grass *Posidonia oceanica*; sand shores, comprising 1.5 km of a 10 km shell sand beach, backed by a 0.5 km wide band of coastal dune which began to form about 10,000 years ago. A rocky marine shore habitat is simulated by stone block banks to the canalised connection between marsh and sea.

- **Dune types occurring at the site**

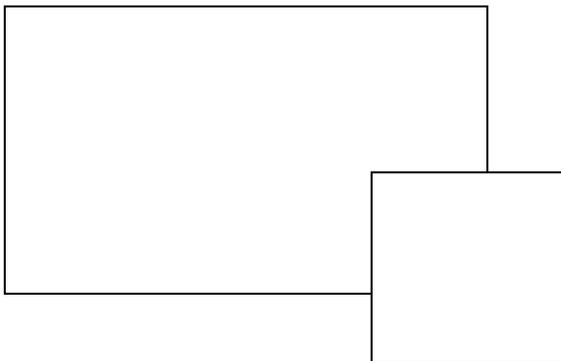
Approximately 200 ha of the Parc is sand dune, comprising an inland band of consolidated fossil dunes, difficult to age but considered to be over 100,000 years old and a 1-8 km long coastal band up to 800 m wide, up to 10,000 years old. The fossil dunes support dune grassland and woodland. The coastal dunes are a mosaic of established woodland, woodland scrub and heath. The whole area is very important botanically, and supports Balearic endemics and internationally important populations of other species.

S'ALBUFERA DE MALLORCA, SPAIN

- **Main values of the site**

Products include a traditional eel fishery; forage resources, now confined to grazing for environmental purposes; and agricultural resources, by retaining a high water table of benefit to cultivations immediately inland and by the action of plants and positive human management to improve and/or maintain water quality. The cast remains of sea grass *Posidonia*, known locally as “alga”, were formerly harvested from the beach as natural fertiliser for arable land. The beach is now heavily used in summer by tourists. The most important product is wildlife resources, which led to designation as a Natural Park in 1988. This designation recognised the biological richness of the site and its importance to conservation, including conservation education, and to “green tourism”.

The biological attributes are numerous, and occur at regional, national and international levels: they include breeding populations of a number of internationally or nationally rare vertebrate species; rare and newly discovered invertebrates; and endemic and nationally rare plant species – an inventory for the site (S’Albufera Biodiversity Catalogue, Riddiford in press), due to be published shortly, lists over 2500 taxa from over 50 faunal and floral groups. At a regional level, s’Albufera augments the rich biological diversity of Mallorca by providing habitats and species not or hardly replicated elsewhere on the island. The site has an international reputation and attracts large numbers of wildlife enthusiasts from throughout Europe.



S’Albufera has a well documented history from Roman times, when the wetland was much larger. The site has a major place in the folklore and cultural identity of the human population surrounding it, and is appreciated for its roles as a buffer against saltwater intrusion (essential for the farming community) and in its contribution to wildlife tourism which, amongst other attributes, has afforded the region an environmental “quality label” and lengthened the tourist season into the spring and autumn.

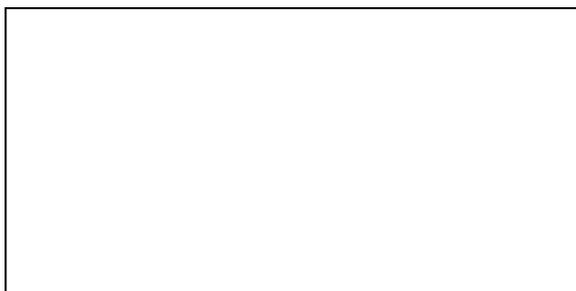
- **Land use and main threats**

Land use is restricted to activities compatible with nature conservation. These comprise a small, regulated eel fishery, licensed angling, conservation orientated grazing by livestock, regulated visitor access and scientific research. Previous activities included paper production from reed bed plants, salt production, hunting and rice growing. The last two still occur in wet areas outside the Park. Elsewhere, urbanisation has led to the disappearance of wetland, though two lagoons remain to the north and a water purification plant has been established at the park’s southern border. The declaration of a natural park has removed the threat of development within the designated area.

One serious threat is the impact on water quality of nutrient runoff from agricultural land and inputs of phosphates from the extensive tourist urbanisation on the coastal strip. Other tourist impacts include erosion damage to the seaward edge of the protected coastal dunes, litter within those dunes, and an ever-present fire risk.

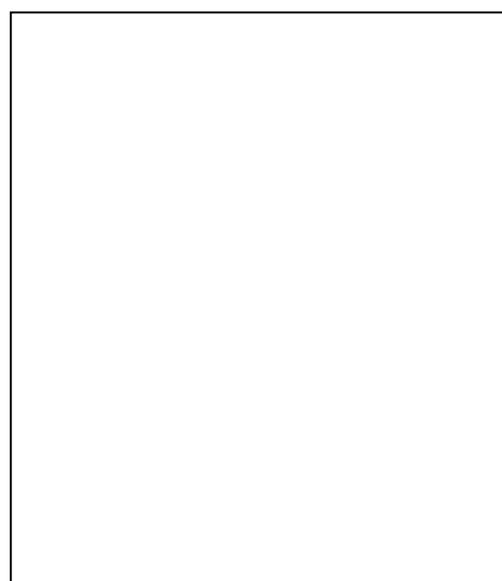
Competition for water supply is an issue, which has extended recently to extractions from the Albufera aquifer to provision for human populations elsewhere on the island. The level of pollution from a coal fired power station, situated immediately north of the Park, is unknown.

S'ALBUFERA DE MALLORCA, SPAIN



- **Ownership, legal status and management body**

A total of 1,708.75 ha, including nearly all the current wetland, became the Parc Natural de S'Albufera by Balearic government decree in 1988. Ownership is shared by the Balearic Government, the Spanish Environment Ministry, and the Municipality of Muro. There are still private landowners in a small proportion of the Park. The site was declared a Special Protection Area under the EC Birds Directive (SPA) by the European Commission in September 1987. The Park is administered by the Balearic Environment Ministry's General Directorate of Biodiversity and functions under guidelines set out in a Plan for Use and Management, drawn up by the Park directorate and approved by the Park Board (*Junta Rectora*). The *Junta* acts as an advisory body and comprises representatives of governmental and non-governmental bodies with an interest in the site. A small proportion of the wetland, as it now exists, lies outside the protected zone.



- **Other relevant aspects**

Urbanisation is prohibited on the Park's west and southwest borders, otherwise there is no strict buffer zone. The Park is constrained to balance conservation management with some local needs and requirements (e.g. to avoid flooding of adjacent agricultural land).

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Monitoring for biodiversity and environmental change

**Project S'Albufera
The Albufera International Biodiversity Group**

PART V

PROJECT S'ALBUFERA: SUMMARY OF WORK IN 1999

Summary of Work for 1999
Nick Riddiford, Principal investigator

- **Human and management impact studies**

Title: Aquatic invertebrate communities in relation to water quality.

Main objective: to use aquatic invertebrate communities as water quality indicators.

Secondary objective: to develop a replicable methodology which can be adopted in other wetlands throughout the Mediterranean basin.

Led by: Michelle Chapman.

Nature of work: systematic sampling of invertebrates using standard sweep-net methodology at representative sites throughout the Park also sampled systematically throughout the year for water quality.

Fieldwork period: April.

Note: a cost-effective technique for guiding management of wetland sites.

Publication references: Chapman (1996, 1998).

Title: Bio-indicators for monitoring water quality regulation.

Objective: to identify indicator animals and/or plants and incorporate them in a model of the dual functions of water quality regulation and biodiversity conservation which optimizes the two functions and advises the long-term management and conservation of the Park.

Led by: Jeroen Veraart (Masters study and thesis).

Nature of work: sampling for aquatic vegetation (including phytoplankton) and zooplankton populations and matching with abiotic variables (including nitrate, phosphate, chlorophyll-a & secci depth measurements).

Fieldwork period: April-August.

Note: An international collaboration with the Environmental Systems Analysis Group & Aquatic Ecology and Water Management Group, Wageningen Agricultural University, Netherlands.

Publication reference: Veraart (1999).

Title: Eutrophication and biodiversity conservation.

Objective: to formulate hypotheses for the decline in aquatic macrophyte diversity.

Led by: Jeroen Veraart (Masters study and thesis).

Fieldwork period: April-August.

Nature of work: matching data on phyto- and zooplankton populations to water quality data; and water quality data to catchment land use and other impact parameters.

Note: An international collaboration with the Environmental Systems Analysis Group & Aquatic Ecology and Water Management Group, Wageningen Agricultural University, Netherlands.

Publication reference: Veraart (1999).

Title: An assessment of the seagrass *Posidonia oceanica* habitat in the Bay of Alcudia bordering the Parc Natural de S'Albufera, Mallorca.

Objective 1: to map the extent of seagrass habitat in Alcudia Bay using aerial photography.

Objective 2: to identify areas of seagrass experiencing disturbance and establish baseline monitoring in these areas.

Objective 3: to investigate the water quality of the Gran Canal and its impact on the Bay and its seagrass ecosystem.

Led by: Emma Whittingham (Dept. Tropical Coastal Management, University of Newcastle).

Nature of work: digital analyses of aerial photographs; ground-truth fieldwork in Bay; water sampling for nutrient analysis.

Fieldwork period: May, June.

Note: Masters study and thesis in Coastal Marine Management.

Publication reference: Whittingham (1999).

Title: [Vegetation re-colonisation after fire, Es Comú.](#)

Objective: to follow the natural recovery of vegetation in order to understand the long-term implications of the impact of fire on the coastal dune ecosystem.

Led by: Nick Riddiford.

Nature of work: census of plant species, vegetation cover and proportions of bare ground using a series of 1 x 1 m quadrats positioned randomly (paired random numbers) within a 70 x 50 m zone of uniform vegetation type in an area of coastal dunes burnt out in 1994.

Fieldwork period: April.

Note: an annual study begun in 1995.

Publication reference: Riddiford & Zas (1996).

Title: [Dune regeneration in the foredunes of Es Comú.](#)

Objective: to monitor the success of works undertaken in 1999 by the Balearic Government Ministry of the Environment to protect the foredunes where they meet the beach - using pioneer vegetation as an initial indicator.

Led by: Nick Riddiford.

Nature of work: identification and recording of species cover within random quadrats along the beach/foredune interface of Es Comú – to assess recovery of pioneer vegetation following remedial works to protect dunes.

Fieldwork period: October, November.

Note: this is a new study prompted by the conservation management actions taken, which themselves were derived from recommendations made by Project S'Albufera following baseline studies in 1996-97.

- [Biodiversity studies](#)

Title: [Herbarium development and curation.](#)

Objective: to maintain as complete a reference as possible in pressed material and photos of the plants of s'Albufera, to be held at the Park as a permanent resource to assist Park staff and other scientists working in the Park.

Led by: Jo Newbould, Carolina Encinas, Rachel King.

Nature of work: changing papers in press; labelling and setting new species for press; adding prepared species to herbarium; general curating procedures to maintain herbarium.

Fieldwork period: throughout the year.

Note: begun in 1989.

Publication reference: Newbould (1993).

Title: [Fungi and habitats.](#)

Objective: to increase our knowledge of Fungi biodiversity and the ecology of this group in relation to the Albufera ecosystems.

Led by: Rachel King.

Nature of work: census work and mapping in specific habitats; collecting, identifying, describing, drawing and preparing specimens.

Note: begun in 1997; an international collaboration with leading Balearic mycologist, Pep Siquier.

Publication references: King (1998), Siquier, Lillo & Salom (1999).

Title: [Development and curation of the Albufera invertebrate collection.](#)

Objective: to maintain as complete a reference as possible in specimen material and photos of the invertebrates of s'Albufera, to be held at the Park as a permanent resource to assist Park staff and other scientists working in the Park.

Led by: Nick Riddiford.

Nature of work: preparing, identifying and labelling specimens; curating, maintaining and reorganising collections; cross-referencing material to database.

Fieldwork period: April, October, November.

Note: an international collaboration with the Natural History Museum, London.

Title: [Lepidoptera and habitats.](#)

Objective: to increase our knowledge of Lepidoptera biodiversity and the ecology of this group in relation to the Albufera ecosystems.

Led by: Martin Honey.

Nature of work: investigation of habitats and specific plants, particularly key species for s'Albufera (e.g. the Balearic endemic *Thymelea myrtifolia*), to survey Lepidoptera at all stages of development and gather more detailed information about species' ecology.

Fieldwork period: April.

Note: an international collaboration with the Natural History Museum, London.

Publication reference: Honey (1999).

Title: [Diptera reference collection.](#)

Objective: to increase our baseline knowledge of the diptera, a poorly known but important element of S'Albufera's biodiversity.

Led by: Nick Riddiford.

Nature of work: collecting, preparing specimens for later, expert identification; relating specimens to plant pabulum and/or habitat.

Fieldwork period: April, October, November.

Note: an international collaboration with Dr Martin Ebejer, an expert from Malta who specialises in flies of the Mediterranean islands.

Title: [Biodiversity catalogue – verification and extension.](#)

Objective: to improve the catalogue (currently standing at 2500 species of 52 faunal and flora groups) by targeting gaps in our knowledge, verifying unconfirmed records and investigating the current status of species known from s'Albufera.

Led by: Nick Riddiford, Rachel King.

Nature of work: targeted survey and collecting; literature searches.

Fieldwork period: throughout and particularly April and October-November.

Note: the current catalogue went to press in December 1999 for publication in 2000.

Publication references: Paul (1995), Stern (1997, 1999).

- **Ecological and monitoring studies**

Title: **Bird population studies - transects.**

Objective: to monitor bird population fluctuations as a measure of local environmental change (e.g. in habitat quality or type) or more generally (e.g. in response to climate change).

Led by: Nick Riddiford, Jane Reid.

Nature of work: two permanent transects, each of just over 7 km and sampling all major Park habitats, both divided into sections reflecting habitat types: counts of all birds seen and heard within 25 metres of the transect line.

Fieldwork period: April, October, November.

Note: annual study, begun in 1990.

Publication reference: Riddiford (1992).

Title: **Butterfly and dragonfly population studies - transects.**

Objective: to monitor butterfly and dragonfly fluctuations in a range of habitats as a measure of local environmental change (e.g. in habitat quality or type) or more generally (e.g. in response to climate change).

Led by: Charlie Rugeroni, Rob Strachan, Chris Donnelly.

Nature of work: two permanent transects, one of 2 km in the coastal dunes and a longer one of 7 km sampling all major Park habitats, both divided into sections reflecting habitat or habitat structure types: counts of all butterflies and dragonflies within 5 metres of the observers.

Fieldwork period: April, October, November.

Notes: annual study, begun in 1991.

Publication references: Riddiford & Bowey (1992), Ferragut (1994), Riddiford & Mayol (1997).

Title: **Faunal associations with habitat.**

Objective: to investigate species use of habitats in order to improve our knowledge of ecosystem functioning at s'Albufera.

Led by: Chris Donnelly.

Nature of work: collecting, sorting and identifying invertebrates in specific targeted habitats (e.g. leaf litter of riverine woodland); field observations of vertebrates in relation to habitat utilisation.

Fieldwork period: April, October, November.

Notes: this study is specifically to support development of the biodiversity demonstration programme.

Publication reference: Donnelly (1999).

Title: **Small mammal studies.**

Objective: to investigate niche partitioning by three species of mouse in s'Albufera marshland.

Led by: Rob Strachan (Wildlife Conservation Research Unit, Oxford University).

Nature of work: live trapping using 'Longworth' small mammal traps laid out in a three-dimensional grid system; identifying and marking three species of mouse for capture-recapture population density and niche partitioning information.

Fieldwork period: October, November.

Note: the situation at s'Albufera of three mouse species sharing a wetland habitat is very unusual and possibly unique in Europe.

Publication reference: Strachan (1995).

Title: [Systematic light trapping for moths.](#)

Objective: to monitor moth population fluctuations to detect changes, especially in response to climate change; e.g. there is evidence of North African moths colonising Mediterranean Europe.

Led by: Martin Honey, Nick Riddiford, Elizabeth Riddiford.

Nature of work: setting up (evening) and emptying (morning) moth trap using mercury vapour ultra-violet lamp; identifying, counting and releasing or collecting captures.

Fieldwork period: late March, April, October, November.

Notes: an annual study, begun in 1991; we have also established a collaboration with s'Albufera des Grau Natural Park, in Menorca.

Publication references: Goater (1994), Riddiford (1994), Honey (1999).

Title: [Monitoring the structural evolution of Mediterranean reedbeds: 1. Vegetation.](#)

Objective: a study to reach an understanding of the relationships between vegetation growth, reedbed structure and aspects of hydrology and water quality in Mediterranean wetlands.

Led by: Carolina Encinas (S'Albufera); André Mauchamp (overall project director for the Mediterranean-wide study).

Nature of work: description of reedbed vegetation: comprising collection of *Phragmites* ecological data (proportion of dead and live stems; maximum height; width at base; number flowering) at 2 m intervals and occurrence and cover of other plants at 4 m intervals within 25 x 25 cm and 50 x 50 cm quadrats respectively along a permanent 250 m transect live; collection of water level and conductivity information within and outside permanent piezometers.

Fieldwork period: transects and vegetation quadrats in autumn, water levels and conductivity once a fortnight.

Notes: begun in 1997. An international collaboration with Tour du Valat Biological Station in the Camargue, France. This study is being carried out in 40 reedbeds in France, two in Greece and Albania and 4 in s'Albufera (the only Spanish site participating).

Publication references: Mauchamp (1999), Riddiford, Encinas & Mauchamp (1999).

Title: [Monitoring the structural evolution of Mediterranean reedbeds: 2. Bird populations.](#)

Objective: a study to reach an understanding of the requirements and development of bird populations in relation to vegetation growth, reedbed structure and aspects of hydrology and water quality in Mediterranean wetlands.

Led by: Brigitte Poulin, Gaetan Lefebvre (Tour du Valat Biological Station).

Nature of work: standardised mist-netting for birds along two 250 m transects set parallel and 50 m apart through selected reedbeds at regular intervals during the year - mist-netting session comprising 5 hours from first light for one day at each site in each season; collection of food samples from trapped birds for later analysis; standardised sweep-netting along transects to establish invertebrate food availability for reedbed

Fieldwork period: October, November.

Notes: begun in autumn 1999. This is a new, additional facet of the Carolina Encinas vegetation study outlined above – which is an international collaboration with Tour du Valat Biological Station in the Camargue, France. This study is being carried out in 40 reedbeds in France, two in Greece and Albania and 4 in s'Albufera (the only Spanish site participating).

Publication reference: Poulin (1999).

- **Park management**

Title: Marsh orchid *Orchis palustris* census.

Objective: to conduct an annual census of the numbers and distribution of flowering *Orchis palustris*, and relate it to Park management and in particular the intensity and timing of grazing by domestic animals.

Led by: Rachel King.

Nature of work: a complete census of *Orchis palustris* based on flowering plants at all known sites within and adjacent to the Park.

Fieldwork period: late April.

Notes: A long-term study, begun in 1993. We are beginning to understand the ecology of the species. Grazing favours the species because it needs relatively open marsh, but it is very sensitive to grazing from January or February through until flowering. The best results are obtained if the flowering zones are grazed from about June until the end of January, then left ungrazed. A good example of the impact of grazing regimes is the marsh alongside camí des Polls. In 1997 grazing animals were removed in February, leading to a count of 1690 flowering *Orchis palustris* in late April-early May. In 1998 the animals were not removed and only 35 *Orchis* flowered. The change in grazing management resulted in a 98% decrease in flowering plants between years (numbers in other areas remained relatively constant).

Title: Census of the Albufera endemic fungus *Psathyrella halophila*.

Objective: to learn about the ecology and the conservation needs of this very rare fungus endemic to s'Albufera and currently only known from a very restricted area of grazed *Cladium* marsh.

Led by: Rachel King.

Nature of work: survey of suitable habitats (open marshland), mapping and census counts.

Fieldwork period: November.

Note: the study was begun in 1998.

Publication reference: Siquier, Lillo & Salom (1999).

Title: Census of migrant and breeding birds.

Objective: to record birds for the Park records and to provide information for visitors of the diversity and results of the breeding and migration seasons.

Led by: Nick Riddiford.

Nature of work: Censuses of waterfowl on specific water bodies (from bird hides); counts of starlings *Sturnus vulgaris* and other birds entering roost sites; counts of birds of prey attending roost sites and observations of their activities.

Fieldwork period: April, October, November.

Note: results of census work entered onto the Parc's ornithological daily log sheets.

Publication references: Rebassa & Vicens (1997), Vicens & Mayol (1994, 1995), Vicens Siquier (1999).

- **Programme Development**

Title: Development of s'Albufera biodiversity practical demonstration programme.

Objective: to prepare an internationally compatible biodiversity programme structure which links the various studies of the project.

Led by: Chris Donnelly.

Nature of work: Demonstration of structure and format; brain-storming sessions on improvements and streamlining of programme.

Fieldwork period: April, October, November (plus desk study work during other months away from the Park).

- **Interpretation and education**

Title: [Guide to the flowers of the Park tracks and paths.](#)

Objective: to prepare a colour guide targeted at general visitors so they can appreciate and know the plants they see in flower along s'Albufera tracks.

Led by: Jo Newbould (text) and Dinah MacLennan (artwork).

Nature of work: collection of information for guide; sketching and painting from live specimens and plants in flower.

Fieldwork period: February, March, May, June, September, October.

Note: after an intensive three or more years' work, Jo and Dinah expect to finish the guide in 2000.

Title: [Plants in flower.](#)

Objective: to obtain details on a monthly basis of the distribution and abundance of plants in flower along s'Albufera tracks, to provide information to the authors of the flower guide currently in preparation.

Led by: Carolina Encinas.

Nature of work: regular surveys of tracks to collection data on the distribution and abundance of plants in flower.

Fieldwork period: throughout the year, and particularly in summer.

Title: [Biodiversity training for African biologists.](#)

Objective: to provide training in the study of biodiversity and biodiversity conservation for African biologists and conservationists awarded Fellowships through a European Union/Darwin Initiative Programme managed by Earthwatch Europe.

Led by: Nick Riddiford.

Fieldwork period: 25th October to 8th November 1999.

Nature of work: as described in individual studies above; plus seminars and presentations on biodiversity and conservation field research.

Notes: Fellowships for autumn 1999 were awarded to biologists from Nigeria, Ethiopia, Kenya (2) and Uganda (3).

Publication references: Fondo (1998, 1999), Earthwatch Institute (2000).

- **P**articipants, 1999

There were 3 teams, two in spring and one in autumn.

Team 1 (one week: 4-11/4)

Principal Investigator: Nick Riddiford (TAIBG, UK).

Scientists: Martin Honey (Natural History Museum, London), Jeroen Veraart (Aquatic Ecology and Management Group, Wageningen, Holland); *and visiting:* Carolina Encinas Redondo, Inmaculada Mateo Salazar (TAIBG, Mallorca).

Volunteers: Barbara Aldridge, Kate Hockley, John Clark, Christine Lee (Enfield Lock Conservation Group, UK).

Team 2 (two weeks: 12-26/4)

Principal Investigator: Nick Riddiford (UK).

Scientists: Jeroen Veraart, Chris Donnelly, Rachel King, Michelle Chapman (TAIBG, UK) Diana de Palacio Sainz de Rozas, Juan Cervantes Sanchez (TAIBG, Spain), Charlie Rugeroni (Gibraltar; and Butterfly Conservation, UK); *and visiting:* Carolina Encinas Redondo, Margalida Roig Ramis (Mallorca).

Volunteers: John Clark (Enfield Lock Conservation Group, UK), Steve Cornwell, John Green, Anne Green, Tony Serjeant, Pamela Hill (Peterborough Wildlife Group, UK) Anna-Karin Lilleengen (Sweden); *and visiting:* Matthias Messner (Germany).

Team 3 (15 days: 26/10-9/11)

Principal Investigator: Nick Riddiford (UK).

Scientists: Chris Donnelly, Rachel King, Elizabeth Riddiford (TAIBG, UK), Brigitte Poulin & Gaetan Lefebvre (Canada; and Station Biologique de la Tour du Valat, France) Rob Strachan (Wildlife Conservation Research Unit, Oxford University, UK), Suzanne Marshall (Biodiversity Officer, Environment Agency, UK), Jane Reid (Department of Environmental & Evolutionary Biology, Glasgow University, Scotland); *and visiting:* Carolina Encinas Redondo. *Volunteers:* Juana M^a Garau Muntaner (Mallorca; and the Earthwatch Institute EU/Darwin Initiative African Fellows: Asimalowo A. Abdullahi (Nigeria), Kumara Wakjira (Ethiopia), Bernard Risky Agwanda, Edwin Selemo (Kenya), George Ochieng, Preventus Kanyesigye Kiiza and Rhobinah Kalwany Nanyunjala (Uganda).

• Other scientific visits

Twice a month throughout the year

Carolina Encinas (TAIBG, Mallorca): water level and quality measurements as part of a long-term Mediterranean-wide monitoring study (in collaboration with Tour du Valat Biological Station, France) of reedbed structural development.

26th February to 5th March, 24th May to 26th June, 28th September to 12th October 1999

Jo Newbould & Dinah MacLennan (TAIBG, UK): fieldwork in preparation for guide to the flora of the Park tracks

27th March to 10th April and 2nd to 16th October 1999

Martin R Honey (The Natural History Museum, London, UK): biodiversity studies in Lepidoptera at S'Albufera and Sa Dragonera in spring and at s'Albufera, S'Albufereta (Mallorca) and S'Albufereta d'es Grau, Menorca in autumn

1st April to end August 1999

Jeroen Veraart (Aquatic Ecology and Water Management Group, Wageningen, Holland): Master's study on aquatic microflora and fauna as indicators of water quality

May-June 1999

Emma Whittingham (Centre for Tropical Coastal Management, University of Newcastle-upon-Tyne, UK): Master of Science in Tropical Coastal Management; dissertation entitled "The coastal zone of Alcudia Bay, Mallorca: an assessment of change and potential anthropogenic impacts on the *Posidonia oceanica* seagrass habitat"

8th to 15th November 1999

David Hanford and ringing group (Wales): reedbed ringing studies at Es Colombar

• Additional Events

- The work of the Project and Project friends was recognised by the new government on 27th October 1999 when presentations were made to Max Nicholson (in his absence), Pat Bishop and Nick Riddiford by the Balearic Environment Minister, Margalida Rosselló in recognition of their contributions to Balearic conservation. At the same event, Margalida Rosselló accepted on behalf of the Park a donation from Pat Bishop on behalf of the Bishop family for the establishment of a Dennis Bishop Memorial Laboratory in memory of her late husband – himself a great friend and benefactor of the Park.
- A number of articles appeared in the Balearic press reporting the donation of money by the Bishop family for the Dennis Bishop Memorial Laboratory; and two features on the Earthwatch Institute European Union/Darwin Initiative African Fellows in October-November 1999.
- A short documentary featuring the Project's studies of moth populations in relation to climate change appeared on the Spanish national television channel TVE2 in December 1999.

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his excellent scientific team, Mallorcan members of the group Carolina Encinas and Inmaculada Mateo for their year-round commitment, all our volunteers, Dr Dolf de Groot and his team from the Institute for Environment and Climate Studies, Wageningen, scientists from several departments of the University of the Balearic Islands, the Balearic Institute for Advanced Studies, former Parc Director Joan Mayol, Balearic government officers Catalina Massutí, Pere Tomàs and Jordi Muntaner, and the Project's special scientific advisors, Michael Archer, Steve Brooks, Barry Goater, Chris Haes, Martin Honey, Paul Lupton, Colin Plant and Rod Stern in the UK, Martin Ebejer in Malta, and Xisco Lillo, Jaume Servera, Miquel Palmer and Guillem Pons in Mallorca. Particularly special thanks are due to Pat Bishop and Max Nicholson for committed devotion to the Parc and Project, and to Biel Perelló who, in his role as liaison officer between us, the Parc and the Balearic government, consistently provides considerable additional help, supportive advice and a smooth path without which the Project would have stumbled and fallen years ago. To everyone above, and any advisors, helpers and supporters inadvertently omitted or overlooked, I give my sincerest thanks.

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EARTHWATCH Europe



Monitoring for biodiversity and environmental change

**Project S'Albufera
The Albufera International Biodiversity Group**

PART VI

***PROJECT S'ALBUFERA: SYNOPSIS OF MAIN STUDIES,
1989-99***

Project S'Albufera

A brief synopsis of main studies, 1989-99

The following text summarises the range of work undertaken by Project S'Albufera scientists and volunteers during the eleven years of the project. It includes all the main studies and those which are current or otherwise significant to the Project's long-term aims and objectives. The synopsis takes the form of a simple statement of methodology, followed by a summary of some of the more interesting or important results pertaining to the study. Studies have been allocated to one of five fields of research: ecosystem studies; impact studies; biodiversity studies; monitoring studies; and parc management. It should be borne in mind that this is for convenience of presentation - many studies produce results of direct relevance and importance to several or all the various fields of research.

1. Ecosystem studies

Biomass and productivity of marshland vegetation
Winter, Spring, Summer, Autumn

1989-91
Professor Palmer Newbould

The above-ground biomass and productivity of the marsh vegetation were measured repeatedly during the year at 10 locations within the Albufera marsh with the objective of studying the variation in growth of the two main species, *Phragmites australis* and *Cladium mariscus*, on different parts of the marsh and over different time periods, and to see how this variation related to local conditions, time since last burn and other factors. At each sample site and date, plants from five 1 m x 1 m quadrats were harvested at ground level, sorted, the plant shoots measured and weighed and sub-samples dried to allow the results to be converted to dry weight. Leaf Area Indices were measured as the product of the dry weight of leaf material per square metre and the surface area per gram dry weight of those leaves. Four sites were sampled on four occasions (February, April, July and October), while in April six additional sites were sampled.

The study found that the morphology and seasonal growth patterns of the two species were strongly contrasting. The above-ground biomass of *Phragmites* showed greater seasonal change than that of *Cladium* reflecting the annual pattern of growth in *Phragmites* as opposed to the perennial habit of *Cladium*. The main factors influencing the structure, performance and reproductivity of the marsh vegetation were found to be:

- Site conditions related to the axes of salinity and trophic status.
- History of burning.
- Structure of underground parts, of particular import in relation to the two previous factors.
- In the case of *Phragmites*, caterpillar damage (mainly the moth caterpillar *Archanara geminipuncta*, infestations of which were found to be high in older, undisturbed reedbeds).
- Climatic variation from year to year, e.g. mild winters, cold winters.

Two important changes related to time since burning are the accumulation of standing dead material and increase in caterpillar damage. This latter not only affects the structure of growing shoots, encouraging lateral branches but also affects the structure of standing dead because stems tend to break at the point of damage, especially if the caterpillar damage is accentuated by the Reed Bunting *Emberiza schoeniclus*. These findings have management relevance as well as increasing our knowledge of ecosystem functioning.

PROJECT S'ALBUFERA

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Odonata nymph studies Spring and Autumn

**1992 and 1993
Ed Cross**

Collection, identification and counting of Odonata species by sweep netting and 400 cm quadrat sampling methods at 7 sites. Other invertebrates found were also recorded.

Odonata larvae occurred in all sampled habitats. Important food source for vertebrates in some areas where densities of up to 200/m² found. Odonata larvae appeared quick to colonise re-flooded areas at end of summer drought. Recommendations were made for further studies investigating aquatic invertebrate communities to water quality (which has led to the current M Chapman research – see below).

References

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Water quality and aquatic invertebrate communities Spring, Summer and Autumn

**1992 & 1995 onwards
Michelle Chapman**

Collection, identification and counting of aquatic invertebrate populations by sweep netting at 15 sites and comparison with water quality chemical data obtained by Parc staff. Parc hydrology and potential pollution sources were used to determine the sites sampled and checked for completeness using ANOVA. Species diversity is used to determine and monitor pollution impacts. Selected invertebrate types and the chemical data are used in computer modelling. Though the main objective is the use of aquatic invertebrate communities as water quality indicators, a secondary objective is to develop a replicable methodology which can be adopted in other wetlands throughout the Mediterranean basin.

The monitoring programme has already revealed salt water leakage into the Parc from power station cooling water and concern over the lack of recovery from a sewage pollution incident.

PROJECT S'ALBUFERA

References

- CHAPMAN, M. 1996. Aquatic invertebrates and water quality at S'Albufera. *Earthwatch Europe S'Albufera Project Rep. 7* (1995): 72-88.
- CHAPMAN, M. 1998. A Further Study of Water Quality and Aquatic Invertebrate Communities at S'Albufera, Mallorca in the Spring, Summer and Autumn of 1996. *Butlletí científic dels Parcs Naturals de les Balears* Series 2 (No. 1): 45-55.

Reedbed utilisation by small mammals
Autumn 1992, Spring 1993, Summer 1995 onwards

1992/93 & 1995 onwards
Rob Strachan

Ten days (per team) of small mammal trapping at 25 sites in the Es Colombar area to determine utilisation of habitat, population size and inter-specific relationships between three species of mouse found at S'Albufera. 1995 also included the evaluation of a number of different types of traps, with the Sherman trap selected for future trapping studies.

Current findings indicate that the three species may be partitioned in their foraging strategies with wood mice *Apodemus sylvaticus* favouring open ground and covering a larger home range, house mice *Mus musculus* tending to favour areas of dense cover and feeding on fallen fruits/seeds and terrestrial invertebrates and Algerian mice *Mus spretus* also favouring dense vegetation cover but tending to forage above the ground in branches and stems for the same types of items. Three mice species "sharing" the same reedbed habitat is a unique occurrence in Europe.

Reference

- STRACHAN, R. 1995. A short-term investigation on the Ecology of the Small Mammals at s'Albufera. *Butlletí del Parc Natural de s'Albufera de Mallorca* 2: 49-69.

PROJECT S'ALBUFERA

Habitat and feeding ecology of Moustached Warblers Summer

**1993
Roy Taylor (University College London)**

An in-depth autecological investigation targetted to inform and guide future management beneficial to the Albufera's internationally important moustached warbler *Acrocephalus melanopogon* population. The investigation focused on the habitat utilisation and feeding ecology of the moustached warbler. The effects of extensive grazing and recent anthropogenic fires within the parc's reedbeds were also investigated.

The investigation found that:

- Old, wet reedbeds containing a high proportion of dead material and complex lower strata, with tall reeds above, are favoured by moustached warblers. Common reed *Phragmites australis* is preferred to the very dense, insect-poor saw-sedge *Cladium mariscus*.
- Moustached warblers prefer to forage in the lower vegetation strata, and can be found throughout the horizontal space of a reedbed but do not venture beyond them. The species has the lowest vertical distribution of all reedbed passerines studied at s'Albufera, and feeds on the least mobile invertebrate groups, which are caught by a laborious "search, pick and probe" feeding technique.
- Invertebrate productivity is greatest along wet reedbed edges and decreases with increasing vegetation density, but is complicated by factors such as wetness and vegetation type. Therefore the moustached warbler breeding cycle appears to be linked to the opportunistic exploitation of different invertebrate groups, in both time and space.
- Burnt reedbeds, though quickly recolonised, lack the complex lower strata favoured by moustached warblers. At s'Albufera, *Phragmites australis* reedbeds require a period of growth greater than seven years in order to meet optimal habitat structure requirements.
- Extensive grazing results in a deflected succession, maintaining reedbeds at a young age structure unable to support high breeding densities of moustached warblers.

The results of the investigations formed the basis for a series of recommendations and guidelines for the management of moustached warbler at s'Albufera as an important step towards the global conservation of the species.

References

- TAYLOR, R. 1993. *Habitat and feeding ecology of Acrocephalus melanopogon and the impact of recent fires and management practices at S'Albufera de Mallorca*. M.Sc. in Conservation dissertation, University College London.
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Habitat choice by birds Spring (1994 Coots only)

**1993 and 1994
Mike Wood**

Standard feeding behaviour and time budget studies of coot *Fulica atra* and white-headed duck *Oxyura leucocephala* populations. Daily observations were made over a month-long study period in three key habitat areas.

White-headed ducks preferred open, deeper water in areas of freshwater; coots also preferred open water but were more tolerant of depth and water chemistry. However, feeding was most intense in shallow freshwater and least intense in shallow brackish water. Birds in brackish water spent more time preening.

PROJECT S'ALBUFERA

Reference

- RIDDIFORD, N. 1994. Coot *Fulica atra* habitat choice and time budgets. *Earthwatch Europe S'Albufera Project Rep. 5* (1993): 101-105.
- RIDDIFORD, N. 1994. White-headed Duck *Oxyura leucocephala* observations. *Earthwatch Europe S'Albufera Project Rep. 5* (1993): 106-109.

Habitat requirements of *Arum*/*Arisarum* species

1994

Autumn

Maria Zas

All Parc pathways were surveyed and the distribution and habitat requirements for *Arisarum vulgare* and *Arum italicum* were mapped. A third species, *Arum pictum*, was recorded for the first time.

Arum italicum grew in damp habitats with deep shade. *Arisarum* grew in damp and drier habitats, and in less shady conditions, preferring lighter vegetation (often on sandy soils). The *Arum pictum* was in very deep shade in a dry site. *Arum pictum* has a restricted World range of the Balearics, Corsica, Sardinia and adjacent parts of Italy.

Reedbed aphids

1994-96

Spring 1994, Summer 1995, Autumn 1996

Nick Riddiford

Random sampling of *Phragmites australis* and *Cladium mariscus* plants for the extent of aphid infestation.

30 sites were sampled. No infestations were found on *Cladium mariscus*. *Phragmites australis* infestation was low, but a few plants were heavily infected, particularly in spring. Results indicated large seasonal and distributional variations in frequency and abundance. Aphids are potentially an important food resource for reedbed birds, and their ecology warrants more detailed investigation.

References

- WOOD, R. & HALLIDAY, K. 1996. Aphids on *Phragmites*, August 1995. *Earthwatch Europe S'Albufera Project Rep. 7* (1995): 40-42.

Reedbed utilisation by roosting birds

1994 & 1996

Autumn

Chris Donnelly, Nick Owens

Observations of bird population size, pre-roost activity, predator-prey interactions and roost locations of key bird species on most days at dusk of the team's duration. Starling *Sturnus vulgaris* and marsh harrier *Circus aeruginosus* activity was observed in 1994 and 1996, white wagtail *Motacilla alba*, swallow *Hirundo rustica* and herons/egrets (Ardeidae) in 1994 and corn bunting *Miliaria calandra* in 1996.

The study found that by November, over 700 000 starlings, 1000+ white wagtails and swallows and several hundred corn buntings were roosting in the reedbeds nightly. The starlings roosted in the same zone each night. The other species were much more scattered and thus it was not possible to achieve a full census of roost population size. Marsh harriers and several falcon species were recorded habitually hunting and/or interacting with birds coming to roost. The Ardeidae were mainly egrets. They habitually gathered in pre-roost flocks before heading to a communal roost in the north of the Park (away from the passerine roost sites). Little egrets *Egretta garzetta* entered the roost later and left it much earlier in the morning than cattle egrets *Bubulcus ibis*.

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This behaviour is thought to relate to their prey preferences - fish for little egrets, large invertebrates such as grasshoppers (which do not become active until the sun warms them up) for cattle egrets. S'Albufera is a very important roost site for migrant and wintering birds.

References

- DONNELLY, C. & RIDDIFORD, N. 1997. Estudi de la importancia de s'Albufera per a la colgada d'auells colonials a la tardor de 1994. *Butlletí del Parc Natural de s'Albufera de Mallorca* 3: 47-55.
- OWENS, N. 1996. Observations of roosting Starlings, 22nd October to 3rd November 1995. *Earthwatch Europe S'Albufera Project Rep. 7* (1995): 59-61.
- OWENS, N. 1997. Roosting birds at S'Albufera de Mallorca, October/November 1996. *Earthwatch Europe S'Albufera Project Rep. 8* (1996): 123-125.

Vegetation re-population after fire Spring

**1995 onwards
Maria Zas & Nick Riddiford**

Monitoring the re-population of vegetation in the coastal dunes destroyed by fire in 1994. A minimum of 30 one-metre random quadrats were assessed for plant species, vegetation height and % cover and compared with the vegetation structure of an adjacent area not affected by the fire and thus most similar to the pre-fire vegetation type within the monitored area.

All living above-ground plant material was destroyed in the fire. Study from 1995 indicated that short-lived annuals were quick to colonise but by 1997 were being shaded out by perennials. Survival/re-colonisation by these was predominantly through seed (tiny, newly germinated plants). Some shrubs survived (from undamaged rootstock). However, shrub frequency was less than 5% that of the control (unburnt) area. Vegetation structure was still very different from the control site and in dynamic change, though the proportion of bare sand had decreased from a mean 95% in 1995 to less than 20% in 1997 and 5% in 1999.

Reference

- RIDDIFORD, N. & ZAS, M. 1996. Re-colonisation of an area of coastal sand dune by vegetation destroyed by fire. *Earthwatch Europe S'Albufera Project Rep. 7* (1995): 43-45.

PROJECT S'ALBUFERA

Water quality and aquatic vegetation Summer

**1996 pilot study
Paul Lupton**

An assessment of whether key plant species can be used as indicators of eutrophication. Abundance and distribution of *Enteromorpha* and *Typha* were mapped along the Gran Canal for comparison with nitrate and phosphate data obtained by the University of the Balearic Islands.

The distribution and abundance of *Enteromorpha* was clearly correlated with known recent sewage incidents (phosphate intrusion), while dense stands of *Typha* at the head of all canals and waterways entering the Park

from farmland indicated that it had a role as an indicator species for nitrate intrusion into the Park. Both species have a role in future monitoring for domestic/agricultural chemical input to the Park.

Reference

LUPTON, P. & RIDDIFORD, N. 1997. Biodiversity studies: distribution and abundance - a pilot study.

Earthwatch Europe S'Albufera Project Rep. 8 (1996): 106-107.

Egret activities Autumn

1996 pilot study Nick Owens & Mike Wood

Assessment of egret behaviour in relation to water quality, vegetation structure and habitat determined by grazing and other management activities. 629 two-minute activity observations of selected egrets were made together with estimates of egret numbers every 10 minutes in one day. In addition, a similar study was conducted at 4 key sites on another day, with observations at five minute intervals.

The pilot study concentrated mainly on little egrets *Egretta garzetta*. It showed that they preferred open, shallow water where the bird could wade. They associated when resting and preening, but were solitary when feeding. Much aggression was shown, with some individuals clearly dominant and demonstrating preferred feeding sites. Prey appeared to be mainly small fish (e.g. *Gambusia*). Fresh, clean water seemed to be preferred over more brackish, sediment-loaded water. The small amount of data gathered from cattle egrets *Bubulcus ibis* indicated they were more social even when feeding and, unsurprisingly, associated with cattle, horses and buffalo when feeding.

Reference

OWENS, N. 1997. Study of Egrets: Earthwatch S'Albufera 27/10/96-2/11/96. *Earthwatch Europe S'Albufera Project Rep. 8 (1996): 85-105.*

Environmental Function Assessment Autumn, Spring and Summer

1995 (pilot study), 1996 onwards Wageningen Center for Environment & Climate Studies

A collaboration between Project S'Albufera and Wageningen Agricultural University's Center for Environment & Climate Studies, based on Dr Rudolf de Groot's pioneering field of study: the functions and values of environmental sites.

The study grew from a pilot study into the functions and socio-economic values of natural ecosystems and protected areas, using S'Albufera as the model, into a holistic assessment including: biodiversity studies and values; a GIS study of the functions of S'Albufera's wetland ecosystem as a tool for ecosystem evaluation for land use planning; the preparation of a manual on ecosystem valuation, including assignments, based on S'Albufera - to be used as a model internationally; and selection of bio-indicators to monitor effects of agriculture and tourist developments on water quality and aquatic biodiversity – to be used as early warning devices and tools for biodiversity conservation management.

References

BORGGREVE, C. 1997. *Biodiversity conservation in S'Albufera Natural Park: an analysis of main relevant functions, (potential) land-use conflicts and related policies*. Graduate thesis, Centre for Environment and Climate Studies and Department of Terrestrial Ecology and Nature Conservation, Wageningen Agricultural University.

MATA, M. 1997. Evaluación de las funciones y valores socio-económicos de los ecosistemas

naturales y areas protegidas: Estudio piloto en el Parc Natural de s'Albufera de Mallorca. *Butlletí del Parc Natural de s'Albufera de Mallorca* 3: 97-98.

- MATA, M., HEIN, L. G. & DE GROOT, R. S. 1997. *Assessment of Functions and Socio-economic Values of Natural Ecosystems and Protected areas: Pilot Study on the Parc Natural de S'Albufera de Mallorca*. Foundation for Sustainable Development (FSD) working paper 9702. Center for Environmental Assessment and Ecosystem Health, FSD, Amsterdam and Center for Environment and Climate Studies, Wageningen Agricultural University.
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- VAN DER PERK, J. P. 1997. *Modelling the potential conflicts between Biodiversity Conservation and Water Quality Regulation in S'Albufera Natural Park, Mallorca*. M.Sc. thesis, Centre for Environment and Climate Studies, Wageningen Agricultural University.
- VERAART, J. 1999. *Selection of bio-indicators to monitor effects of agriculture and tourist developments on water quality and aquatic biodiversity in s'Albufera Natural Park, Mallorca*. MSc. thesis. Wageningen University, Earthwatch Institute and Universitat de les Illes Balears.

**Faunal associations with habitat
Spring and autumn**

**1998 onwards
Chris Donnelly**

This is a developmental study which investigates species communities and their use of habitats in order to improve our knowledge of ecosystem functioning at s'Albufera. The study currently comprises collecting, sorting and identifying invertebrates in specific targeted habitats (e.g. leaf litter of riverine woodland); and field observations of vertebrates in relation to habitat utilisation.

The purpose of this study is specifically to support development of the biodiversity demonstration programme.

Reference

Donnelly, C. 1999. Observacions sobre la distribució d'odonats i lepidoptèrs al Parc Natural de s'Albufera de Mallorca. Nota preliminar. *Butlletí científic dels Parcs Naturals de les Balears* Series 2 (No. 1): 57-59.

PROJECT S'ALBUFERA

2. Impact studies

**Reedbed infestation by internal stem-feeding larvae 1992 to 1994
Autumn 1992, Spring 1993 and 1994 Alan Radermacher**

100 to 170 samples per survey season were taken of *Phragmites australis* in five locations to ascertain reedbed condition and its infestation by various caterpillars.

Caterpillar infestation was far higher in old, undisturbed reedbeds. Colonisation of reedbeds recovering after fire was slow, and from the edge. These findings have major implications. The caterpillar, which lives inside the reed stem, is a food item for the local reed bunting *Emberiza schoeniclus witherbyi*, which has developed a much thicker bill than birds of the same species farther north. This allows it to access a food source (the caterpillar) which other birds (including the nominate race of the reed bunting) cannot obtain. The activities of the caterpillar and the reed bunting combine to weaken the reed stem, thus hastening the period of time between stem growth and stem collapse into the reedbed. S'Albufera reedbeds support the highest known density of moustached warblers *Acrocephalus melanopogon* in the World and they require undisturbed reedbeds with a lower, horizontal collapsed layer of reed in which to feed. Management for old reedbeds supports this exceptional chain of events, a form of ecosystem functioning which is of benefit to a number of special species.

References

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- RADERMACHER, A. 1995. A brief study of the growth of *Phragmites*. *Earthwatch Europe S'Albufera Project Rep.* 6 (1994): 25-32.

Coastal dune erosion Summer

Pilot study 1996; 1997 Nick Riddiford

An photographic monitoring programme was set up to record the distribution, abundance and species composition of pioneer vegetation and the extent of dieback among the coastal band of the internationally important prickly juniper *Juniperus oxycedrus macrocarpa*. A series of photographs was taken of the beach/foredune interface at 100 m intervals along a 1.8 km transect line, and width and density (% cover) of pioneer vegetation cover recorded at the same points. Juniper dieback was also assessed using a simple four point recording procedure (1 dead; 2 severely affected; 3 lightly affected; 4 apparently well) per metre depth of bush for 30 randomly selected samples along the beach.

The results indicated severe damage to the coastal foredune. The photographs showed severe erosion of the dune bank, leading to extensive exposure of juniper roots. Pioneer vegetation was absent in 50% of cases, and sparse with a narrow range of species in all others. The classic dune forming grass, marram *Ammophila arenaria*, was absent (though occurring in less damaged areas within the Bay). Sampling indicated a mean 70% dieback per juniper bush along the leading edge of the dunes. To counter the impact, recommendations for management were made to the Park authorities regarding tourist access and beach-cleaning activities.

One recommendation was the repetition of the photographic study, using the same methodology and photographic points, at 10 year intervals – provided management recommendations were enacted. Remedial measures to protect the coastal dune bank, based on Project recommendations, were enacted in the early part of 1999.

References

- PASSMAN, J. & SPURR, A. 1998. Public use of the Es Comu beach, Parc Natural de S'Albufera, August 1997. *Earthwatch Europe S'Albufera Project Rep.* 9 (1997): 56-57.
- PASSMAN, J. & SPURR, A. 1998. A preliminary survey of prickly juniper *Juniperus oxycedrus*

macrocarpa in the Parc Natural de S'Albufera coastal dunes. *Earthwatch Europe S'Albufera Project Rep. 9* (1997): 58-59.

PROJECT S'ALBUFERA

White poplar investigation Spring and Summer

**1996
Nick Riddiford**

A survey of 2141 white poplar *Populus alba* trees in the Parc to assess their condition, following observations in 1995 that some trees had far fewer leaves than normal. Four trees (one from each condition category: apparently well, lightly affected, severely affected, dead) were investigated further for possible causes using bark and tree section examination.

Insect, fungal and air pollution damage were discounted as potential causes of the damage. Recent drought and/or salt water intrusion into the water table were suggested as possible causes. To draw attention to the problem, a report was presented to the Park authorities, including recommendations for further, specialist technical investigations. The recommendations are being addressed.

Reference

RIDDIFORD, N. & CHALUPA, M. 1997. Studies of *Populus alba*. *Earthwatch Europe S'Albufera Project Rep. 8* (1996): 59-68.

Seagrass *Posidonia oceanica* studies Spring and early summer

**1999 onwards
Emma Whittingham, Suzy Marshall**

A pilot study Emma Whittingham (Dept. Tropical Coastal Management, University of Newcastle).in May-June 1999 used digital analyses of aerial photographs, ground-truth fieldwork and water sampling for nutrient analysis: to map the extent of seagrass habitat in Alcudia Bay using aerial photography; to identify areas of seagrass experiencing disturbance; and to investigate the water quality of the Gran Canal and its impact on the Bay and its seagrass ecosystem.

The study showed that the Alcudia Bay seagrass, recognised as the most intact example of this habitat remaining in Mallorca, was under stress and retreating. A baseline was established on which to construct monitoring of the ecosystem, to be developed from 2000 onwards, testing the hypothesis that continued anthropogenic stresses will result in further progressive retreat of the seagrass meadows and a reduction in the diversity of the important marine communities the habitat supports.

Reference

WHITTINGHAM, E. 1999. *The coastal zone of Alcudia Bay, Mallorca: an assessment of change and potential anthropogenic impacts on the Posidonia oceanica seagrass habitat*. MSc. Dissertation. Centre for Tropical Coastal Management, University of Newcastle-upon-Tyne.

3. Biodiversity Studies

Biodiversity demonstration programme

1996

Throughout the year**Chris Donnelly**

The objective of this key study is to prepare an internationally compatible biodiversity programme structure which links the various studies of the project. Development of this programme, and endeavours to make it practical rather than purely theoretical, is being achieved by volunteer as well as scientist participation. Work on site includes demonstrations of structure and format; and brain-storming sessions to improve and streamline the programme.

References

- DONNELLY, C. 1999. Observacions sobre la distribució d'odonats i lepidoptèrs al Parc Natural de s'Albufera de Mallorca. Nota preliminar. *Butlletí científic dels Parcs Naturals de les Balears* Series 2 (No. 1): 57-59.
- LUPTON, P. & RIDDIFORD, N. 1997. Biodiversity studies: distribution and abundance - a pilot study. *Earthwatch Europe S'Albufera Project Rep.* 8 (1996): 106-107.

Biodiversity catalogue**1989 onwards****Throughout the year****Nick Riddiford**

One of the major elements which feeds the biodiversity demonstration programme is the biodiversity catalogue. The first species inventory, for the years 1989-93, listed 1350 species of 26 plant or animal groups (Riddiford & Nicholson 1984). A catalogue, for the years 1989-1999, to be published by the Balearic Government in 2000 (Riddiford in press) lists 2500 species of 52 groups. The almost linear increase demonstrates that comprehensive knowledge of a site's biodiversity is not achieved quickly or easily. The species lists for all categories have been boosted by the participation of specialist scientists in addition to the general observation and collecting made by each team. The inventories are also supported by extensive invertebrate reference collections, herbarium and photographic archive.

Specialist contributors and identification advisors include:

Guillem Alomar, Jo Newbould (flowering plants), Sheila Wells, Francesc Lillo, Pep Siquier, Rachel King (fungi), Tom Chester (lichens), Rod Stern (bryophytes), Dr Toni Martinez (stoneworts), Barry Goater, Martin Honey (macro lepidoptera), Dr David Agassiz (micro lepidoptera), Simon McKelvey (hoverflies), Dr Miquel Palmer (beetles), Colin Plant (lacewings & ant-lions), Steve Brooks (mayflies), Chris Haes (grasshoppers, crickets and allies), Dr Martin Ebejer (flies), Dr Michael Archer, Paul Lupton (hymenoptera), Dr Chris Paul (molluscs), Emma Whittingham (marine life), Jordi de Manuel (rotifers), Damià Jaume (crustaceans), Guillem Pons (spiders), Pere Vicens, Nick Owens, Jon King (birds), Jean-François Noblet (bats), Francesc Riera, Antoni M. Grau (fish).

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PROJECT S'ALBUFERA

Herbarium development and curation
Throughout the year

1989 onwards
Jo Newbould

As a measure of plant diversity, as complete a reference as possible is maintained of pressed material and photographs of the plants of s'Albufera, to be held at the Park as a permanent resource to assist Park staff and other scientists working in the Park. The reference now comprises over 300 species and is an essential on-site tool in support of studies being undertaken.

Volunteers assist with changing papers in press; labelling and setting new species for the press; adding prepared species to herbarium; general curating procedures to maintain the herbarium; and cross-referencing to the species inventories and biodiversity model.

Fungi and habitats
Autumn and spring

1997 onwards
Rachel King, Pep Siquier

The objectives of this study are to increase knowledge of fungi biodiversity and the ecology of this group in relation to the Albufera ecosystems. The group is also acting as a pilot for ecosystem functioning and biodiversity. The study comprises census work and mapping in specific habitats; collecting, identifying, describing, drawing and preparing specimens.

The study pays particular attention to the ecology of a newly described species, *Psathyrella halophila*, which grow in areas of grazed or open *Cladium mariscus*. Distribution and numbers of fruiting bodies are mapped and

censused in autumn, and compared with abiotic and environmental factors including climate, habitat changes and Park management. Early results suggest that grazing and trampling of vegetation by domestic stock and water levels each influence the distribution and numbers of fruiting bodies. The species is still only known from s'Albufera and must, for the moment at least, be considered a s'Albufera endemic.

References

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The Albufera invertebrate collection Throughout the year

**1990 onwards
Nick Riddiford, Martin Honey**

As complete a reference as possible is maintained of specimen material and photographs of the invertebrates of s'Albufera, to be held at the Park as a permanent resource to assist Park staff and other scientists working in the Park. This resource supports the species inventories and biodiversity modelling. It also links with other studies, of particular relevance because many invertebrate species are mobile and quick to react to favourable or unfavourable climatic conditions for the species. They are thus excellent indicators of climate change. The work comprises preparing, identifying and labelling specimens; curating, maintaining and reorganising collections; cross-referencing material to the database. It is an international collaboration with scientists from the Natural History Museum, London.

Lepidoptera and habitats Spring and autumn

**1999 onwards
Martin Honey**

The objective of the study is to increase our knowledge of Lepidoptera biodiversity and the ecology of this group in relation to the Albufera ecosystems. The work comprises investigation of habitats and specific plants, particularly key species for s'Albufera (e.g. the Balearic endemic *Thymelea myrtifolia*), to survey Lepidoptera at all stages of development and gather more detailed information about the species' ecology. The study is led by Martin Honey of the Natural History Museum, London.

References

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Diptera reference collection Spring and autumn

**1999 onwards
Nick Riddiford, Martin Ebejer**

The objective is to increase our baseline knowledge of the diptera, a poorly known but important element of S'Albufera's biodiversity. The work comprises collecting, preparing specimens for later, expert identification; relating specimens to plant pabulum and/or habitat. This study is an international collaboration with Dr Martin Ebejer, an expert from Malta who specialises in flies of the Mediterranean islands.

4. Monitoring studies

Bird transects
Spring and Autumn

1989 onwards
Nick Riddiford

Two standard bird transects are walked once every ten days during the early morning of each season. The transects are designed to cover a variety of habitats and the number of sightings and calls are recorded for each species seen or heard within 25 m of the transect line as it is walked.

The only detected trend has been an increase in finch numbers (in sand-dune pine woodland) during a prolonged period of years with below average rainfall. The value of relating the transect sections to habitat was quickly demonstrated when a fire swept through a reedbed (Transect 1, Section C) in 1990. Subsequent transect studies indicate that reedbed birds were slow to recolonise the burnt area, with the moustached warbler *Acrocephalus melanopogon* (requiring very specific reedbed structure normally found only in old, undisturbed beds) the slowest - only returning to pre-1990 numbers in 1997. Since then it has maintained its numbers at or above the 1997 level.

References

RIDDIFORD, N. 1992. S'Albufera bird transects. *Earthwatch Europe S'Albufera Project Rep. 3* (1991): 135-141.

PROJECT S'ALBUFERA

Butterfly transects
Spring, Summer and Autumn

1989 onwards
Nick Riddiford

Monitoring of butterfly habitat and population variations. The two transects are walked at least once every ten days during mid morning to early afternoon in each season and the numbers of species are recorded within 5 m of the transect line walked. Since 1995 Odonata sightings are also recorded.

There has been a trend during a prolonged period of years with below average rainfall of increased numbers of migrant butterflies, considered to be from North Africa (observations include the African monarch *Danaus chrysippus* and the Moroccan orange tip *Anthocharis belia*). Marked annual and seasonal variations have been recorded for resident species. The reasons for these are not currently understood, but probably include habitat and climate change. Butterflies (and dragonflies) are quick to react to changing conditions and may be good early warning indicator species for climate change.

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Meteorology data
Every day

1989 onwards
Parc staff

Temperature, sunshine and rainfall data are collected by Parc staff every day.

These are made available as an aid to the interpretation of a number of Project studies. When more detailed or a complete suite of data are required, these are made available by the Sa Canova station, a unit of the government Meteorological Service, collecting comprehensive weather data at a site 6 km west of S'Albufera's western boundary.

References

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PROJECT S'ALBUFERA

Body condition of birds

Spring, Autumn (plus Summer 1995 & 1997)

1991 onwards

Nick Riddiford & Jon King

Weight, adipose fat and muscle condition of birds recorded from constant effort ringing studies undertaken by licensed mist netting personnel in various areas of the Parc.

Using newly developed techniques, based on an incremental scale for sub-cutaneous fat deposits and pectoral muscle thickness and profile, we are developing models for assessing the "fitness" of migrant and resident birds. Current research suggests that passage birds have low fat and muscle scores (particularly those in spring which will have crossed the Sahara, North Africa and the Mediterranean) on arrival. High fat scores indicate that S'Albufera is an important re-fuelling stop for migrants going off-passage to feed, and that the birds involved are preparing for a further substantial migration flight. Pectoral muscle scores, however, remain low. Residents tend to have low fat but relatively high muscle scores. Muscle strength is an important component of fitness, but takes longer to establish and cannot quickly be recycled as "fuel", unlike fat deposits. Thus, it is possible in many cases to differentiate between residents, newly arrived passage migrants and passage migrants about to continue their migration. Variations occurring within these tendencies are due to a series of factors not yet fully understood. However "stress", e.g. caused by breeding activities and competition for territories or mates, may be a major factor for resident birds in determining pectoral muscle quality - with inferior birds in sub-optimal areas having lower muscle scores.

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Mammal transect

Spring, Summer and Autumn

1991 & 1995 onwards

Nick Riddiford

A record is kept of the identity and numbers of mammal species seen on and alongside a route from the project base at Sa Roca to the Parc entrance at Englishman's Bridge each time this route is taken (on average twice a day). This is particularly to record the recovery, if any, of the rabbit *Oryctogalus cuniculus* population from the effects of a virus.

The 1991 mammal transect established a baseline for mammal frequencies along the transect route. No further information was recognised as valuable at the time, so the transect was suspended. However, with the arrival of a new haemorrhagic virus (which has reduced the Spanish mainland rabbit population by an estimated 80%) the usefulness of the baseline was demonstrated and the transect re-established. This demonstrated no significant change in frequency of other mammal species (e.g. the brown rat *Rattus norvegicus*) but a decrease in frequency of rabbit sightings of about 70%. Rabbits were encountered very infrequently during the late 1990s, but appear to be staging a recovery from 1999.

References

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PROJECT S'ALBUFERA

Moths and other insects attracted to light Spring, Summer and Autumn

1991 onwards David Agassiz, Barry Goater, Martin Honey

A standard insect light trap is used on most nights during each season to capture moths and other insects attracted to light.

Findings have been numerous (including over 30 species new to the Balearic Islands), but the most important include: establishing that S'Albufera supports a strong population of, and is therefore the World's most important known site for, the footman moth *Pelosia plumosa*, previously known from a handful of specimens at two sites in mainland Spain, one in Italy and one in North Africa; the capture in 1997 of the African moth *Areopteron ecphaea*, previously known from just 3 specimens in West Africa and one in Greece; and the capture with increasing regularity of a number of species traditionally considered to be North African in origin, some abundant enough to suggest an established local population. The study has also demonstrated that S'Albufera is a zone of high diversity for this and other insect groups.

Like their day-time counterpart, the butterflies, moths are quick to react to changing conditions and are ideal early warning indicator species for climate change.

References

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Remote sensing and ground truthing
Spring, Summer

1992 and 1993
University of Aberdeen

A series of studies were undertaken. Jurado Estevez (1992) studied the possibility of utilising satellite imagery to determine and monitor habitat types, investigated in conjunction with ground observations and aerial photographs; Marcus (1992) used satellite imagery to determine and map land-use in the agricultural plain surrounding the parc; McGovern (1993) used satellite imagery to measure the extent and rate of urbanisation in the zones bordering s'Albufera; and Gonzalez (1993) used satellite imagery to determine and map the proportion of woodland cover along the adjacent *Tramuntana* mountain range.

Jurado Estevez (1992) demonstrated that it was possible to determine main marshland vegetation types (*Cladium mariscus*, *Phragmites australis*, *Juncus* species) and changes in the distribution of those types over time, using remote sensing and ground truthing. The relative distribution of *Cladium* and *Phragmites* is a key issue because *Cladium* is very sensitive to water chemistry, dominating in alkaline, non-saline marshes but elsewhere replaced by the more water tolerant *Phragmites*.

Marcus (1992) presented information on agricultural land-use and crop distribution which will form a baseline for future land-use and future changes in crops, field sizes and agricultural practices.

McGovern (1993) demonstrated the rapid and extensive urbanisation along the coastal strip adjacent to s'Albufera, and provided very useful baseline information for future studies into the impacts of tourism on the Parc and its ecosystems.

Gonzalez (1993) also presented useful baseline information: on woodland cover and distribution within that part of the *Tramuntana* (two-thirds of the entire range) which forms the hydrological catchment for S'Albufera.

References

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- JURADO ESTEVEZ, J. 1992. *The usefulness of Landsat TM data for vegetation discrimination in S'Albufera de Mallorca - a marsh*. M.Sc. in Environmental Remote Sensing dissertation, Centre for Remote Sensing and Mapping Science, University of Aberdeen.
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- McGOVERN, P. 1993. *The use of Landsat Thematic Mapper Data for the detection of urban change in Mallorca (Bahía de Alcudia)*. M.Sc. in Environmental Remote Sensing dissertation, Centre for Remote Sensing and Mapping Science, University of Aberdeen.

PROJECT S'ALBUFERA

Marsh frog study
Spring

1993 and 1994
Sara Hawkswell & Nick Riddiford

Assessment of distribution and density of the marsh frog *Rana ridibunda perezii* using quadrat observation at hourly intervals over two 24-hour periods; and systematic mapping of distribution, abundance and habitat preferences.

S'Albufera is important because it supports a very large population of marsh frogs, which are important prey items for many vertebrates while being major predators themselves of fish fry and invertebrates. Despite obvious (deafening) abundance, no methodology could be constructed to achieve a realistic measure of density (other than comparative ratios between sites). Nevertheless, the study demonstrated that adults preferred open water or mud but with some emergent or floating vegetation (sparse reedbeds & canals); calling individuals were heard occasionally in dense, tall emergent vegetation; none was observed or heard in brackish zones; and that frogs were active throughout the 24 hours, but activity was greatest on calm, warm nights.

References

RIDDIFORD, N. & HAWKSWELL, S. 1994. Study of the life cycle of the Albufera Marsh Frog *Rana ridibunda perezii*. *Earthwatch Europe S'Albufera Project Rep. 5* (1993): 133-139.

Habitat mapping **Autumn**

1994, updated 1999
Sara Hawkswell, Chris Donnelly

A complete habitat map of the Parc was produced using the JNCC Phase 1 methodology.

The habitat mapping was undertaken to provide comparative material with previous Park generated and pre-Park maps (though those were done using different methodologies) and with future follow-up mapping studies to monitor vegetation distribution change. The maps are also used extensively to provide background vegetation information for biodiversity and other monitoring studies.

References

HAWKSWELL, S. 1995. Habitat mapping. *Earthwatch Europe S'Albufera Project Rep. 6* (1994): 82-88.

Water level recording **Autumn**

Pilot 1994
Sara Hawkswell

A study of water level fluctuations within the Gran Canal area was undertaken by recording the levels seen at various stageboards on a daily basis at 3-hourly intervals during daylight hours.

The pilot suggested that air pressure played a major role in determining fluctuations in sea level, with amounts of rainfall a minor contributor. There was no evidence of a regular twice-daily pattern to suggest a tidal influence.

References

HAWKSWELL, S. 1995. Water level recording in the Gran Canal. *Earthwatch Europe S'Albufera Project Rep. 6* (1994): 74-81.

PROJECT S'ALBUFERA

Hydrology and Hydrochemistry data
Every month

1994 onwards
Parc staff

Parc staff conduct a day of water sampling each month at 27 sites, collecting dissolved oxygen, conductivity, pH and temperature data. In addition, phosphate and nitrate levels are monitored by the University of the Balearic Islands.

The information is used in the interpretation of aquatic studies listed in section 1. The data are presented in the Parc's own Science Bulletin. The information is also used in management planning and in Park staff consultations with and advice to government bodies and land/water users adjacent to the Park.

References

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Purple Gallinule survey
Autumn/Spring

1995 onwards
Nick Owens

Investigation of the range of dispersal and colonisation since reintroduction five years earlier. Two censuses along the Parc's accessible tracks and boundary were conducted each year. The 1996 purple gallinule *Porphyrio porphyrio* population was estimated at 43 breeding pairs, from an original 28 individuals released in 1992.

Spring 1997 results indicate further population increases, though with distribution still radiating out from the original release zone. Pioneer breeding in the south-east of the Park (from 1997) indicates that further expansion is possible and that a population saturation point has not yet been reached.

References

- OWENS, N. 1997. Purple Gallinules *Porphyrio porphyrio* at S'Albufera de Mallorca, October/November 1996. *Earthwatch Europe S'Albufera Project Rep.* 8 (1996): 123-125.
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Reedbed structure in relation to water quality
Summer, Autumn

1997 onwards (vegetation studies)
Dr André Mauchamp,
Carolina Encinas

Autumn, Spring

1999 onwards (birds & invertebrates)
Brigitte Poulin, Gaetan Lefebvre

Vegetation studies

Measurements taken annually along 150 m transects in four reedbeds of differing type and water quality. Measurements taken of reed *Phragmites australis* structure at 2 m intervals (number of live stems per 25 cm²,

number of dead stems per 25 cm², width at base of stem and height of *Phragmites* nearest left-hand near-corner of quadrat, height of tallest *Phragmites* in quadrat) and of other plant species at 4 m intervals (including % cover where applicable) within 50 cm² quadrats. Water level and conductivity also measured from piezometer positioned at beginning of transect, these last two measurements being taken at each site at regular intervals twice every month.

This is a long-term monitoring study launched in collaboration with the Tour du Valat Biological Station, Camargue, France which is undertaking parallel studies using the same methodology in southern French reedbeds. The Albufera study is being led by local (Pollensa) post-graduate, Carolina Encinas. The four monitoring sites selected at S'Albufera comprise an old, undisturbed reedbed in freshwater (Es Colombar), an old, undisturbed reedbed in brackish/saline water (Es Cibollar), a very tall *Phragmites* reedbed at the western edge of the parc potentially exposed to chemical run-off from agricultural land (Es Forcadet) and a *Cladium/Phragmites* reedbed of diverse vegetation structure again adjacent to agricultural land near the western edge of the parc (Son Carbonell).

Birds and invertebrates

Plans to extend the monitoring to include bird and invertebrate monitoring at the same sites, following trials in France to arrive at suitable methodologies, were fulfilled in October 1999. The objective of this international study is to reach an understanding of the requirements and development of bird populations in relation to vegetation growth, reedbed structure and aspects of hydrology and water quality in Mediterranean wetlands. The work, led by Brigitte Poulin and Gaetan Lefevbre from the Tour du Valat Biological Station, comprised standardised mist-netting for birds along two 250 m transects set parallel and 50 m apart. The mist-netting session comprising 5 hours from first light for one day at each site and was conducted at three of the study sample sites – Es Colombar, Es Forcadet and Son Carbonell. Collection of food samples from trapped birds was also conducted for later analysis; and standardised sweep-netting was undertaken along transects to establish invertebrate food availability within the reedbed.

This inter-disciplinary approach to reedbed ecosystem functioning is an international collaboration with Tour du Valat Biological Station in the Camargue, France. This study is being carried out in 40 reedbeds in France, two in Greece and Albania and 4 in s'Albufera (the only Spanish site participating).

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PROJECT S'ALBUFERA

5. Parc management

Sand-dune and marshland orchid monitoring Spring

1991 onwards
Terry Wells, Rachel King

The main aims of the programme are: to establish population data on orchid species as a baseline from which change in species abundance can be measured in the future; and to provide a scientific base for formulating future management of orchid populations by studying the general biology and ecology of selected orchid species. The sand-dune orchids are the bumblebee orchid *Ophrys bombyliflora*, bee orchid *O. apifera*, mirror orchid *O. speculum*, bug orchid *Orchis coriophora* and small-flowered tongue orchid *Serapias parviflora*. Areas containing large populations of one or a mixture of the 5 species were selected for study. This led to the establishment of five, large (various sizes between 10 x 8 and 10 x 20 m) permanent quadrats as study areas. The position of each orchid within the study area was given a unique co-ordinate using two 30 m tapes attached to the permanent markers. The following data were recorded for each orchid: 1) its unique coordinate, 2) whether vegetative or flowering, 3) number of leaves in basal rosette, with notes on the state of the leaves, 4) height of the inflorescence, if present, 5) number of flowers per inflorescence, 6) notes of damage by grazing animals.

Results so far indicate that only a proportion of orchids flower each year. Populations within the study areas remain high or have increased (e.g. bumblebee orchid). Grazing damage and climate (hot, dry versus wetter years) may both influence flowering success. Population changes and survival rates require further, long-term monitoring, which is also needed to confirm or refute any short-term variations or trends.

S'Albufera is the only site in Spain which supports a population of the scarce marshland orchid *Orchis laxiflora palustris*. The population is small enough to census completely. The census is achieved by counting the orchids in temporary strips through its marshland habitat, each strip being delineated by two parallel ropes laid down by the volunteers. This ensures that no orchid is counted twice, or missed. The counts are transferred to maps and notes are also kept of grazing patterns and other management activities within each compartment of marsh.

The marshland orchid population increased annually since 1994 to a peak of over 3000 flowering spikes in 1997 but has declined since. We are still learning of its ecology, but its ability to colonise new sites and its eventual disappearance from sites with tall, dense vegetation suggests it is a relatively short-lived orchid which propagates mainly by seed, and which is activated by subsequent opening or clearance of its habitat. The expansion of the population was at least partially promoted by grazing regimes. Fine-tuning of our understanding of the impact of grazing continues, but we know that spring grazing by horses is very damaging, as is trampling by cattle and buffalo. The best grazing option may be to remove livestock from orchid zones from the end of the year until after flowering. Flowering takes place in April-May.

References

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- WELLS, T. 1993. Monitoring orchids at S'Albufera, Mallorca, 1992. *Earthwatch Europe S'Albufera Project Rep. 4* (1992): 172-182.

PROJECT S'ALBUFERA

Fossil dunes
Spring

1993 onwards
Jo Newbould

A study of the impact of grazing by horses on the dune vegetation at Turo de ses Eres, with particular reference to the distribution and development of the spurge *Euphorbia terracina*, a potential shade species. Six permanent 10 x 10 m quadrats have been established together with photographic surveys at 32 points along marked transects in the fossil dune area.

Early results from this long-term study suggest that the *Euphorbia* population fluctuates in relation with climatic conditions, with a higher level of germination occurring in wetter years. The plant exudes a distasteful sap which is unpalatable to animals. However, young plants may be grazed and some trampling of larger plants also occurs. Cattle may contribute more (through trampling and grazing of young plants) than horses in keeping the population in check, but may also contribute more erosion damage to the fragile fossil dune habitat.

References

NEWBOULD, J. 1994. Monitoring the changing population of *Euphorbia terracina* on the Turo de Ses Eres. *Earthwatch Europe S'Albufera Project Rep. 5* (1993): 42-60.

Visitor survey Spring and Autumn

**1993, 1995
Nick Riddiford & Matthias Meissner**

433 visitors to the Parc were surveyed in one day in spring 1993 together with a fuller survey in 1995 in order to assess the potential impact of visitors to the Parc, their management and the role of the Parc in extending the tourist season in Mallorca.

The fuller survey confirmed that large numbers of visitors entered the Park daily, not all calling in to the reception centre to register. About 60% were foreign nationals (Germans, followed by British being the most numerous), 30% were from Mallorca and a further 10% from other parts of Spain. Interviews with visitors indicated that they were pleased with their visit, and the facilities on offer - but a number wanted more information and in a range of languages. An overwhelming majority of foreign nationals said they were prepared to pay for such increased facilities. It was also felt that local people should pay less or nothing to enter the Park. The results of this survey have been conveyed to the Park authorities.

References

MEISSNER, M. 1997. Us public del Parc Natural de s'Albufera: Entrevistes amb visitants estrangers. *Butlletí del Parc Natural de s'Albufera de Mallorca* 3: 83-86.

Parc Visitor Centre display interpretation Spring

**1993
Hannah Bonner**

Provision and building of display materials for the new Parc Visitor Centre.

It is estimated that over 100,000 visitors enter the Park each year and the majority visit the Centre, which is open daily. In addition to Earthwatch EarthCorps involvement in setting up the exposition, there is a dedicated Earthwatch display board, conveying in pictures and text the role and activities of the Project.

References

BONNER, H. 1994. S'Albufera: display materials for the new Visitor Centre. *Earthwatch Europe S'Albufera Project Rep. 5* (1993): 150.

PROJECT S'ALBUFERA

Barn Owl boxes
Autumn

1996
Nick Owens

Construction and siting of 2 boxes to encourage the local barn owl *Tyto alba* population.

The only breeding barn owls within the Park were lost when old, unsafe buildings were demolished in 1992. In an attempt to encourage them to return, two owl boxes were constructed and placed in carefully selected sites within the Park. The boxes were not occupied by breeding birds in 1997-99, but there is no shortage of potential prey and the owls would perform a good service reducing the local rat population. Hopes remain high that the boxes will be occupied soon.

Information compiled for TAIBG by Nick Riddiford and Michelle Chapman