MONITORING FOR ENVIRONMENTAL CHANGE

THE EARTHWATCH EUROPE S'ALBUFERA PROJECT

A summary report of the ninth season's work, 1997

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Report of ninth season's work

Annex 1

MONITORING FOR ENVIRONMENTAL CHANGE

THE EARTHWATCH EUROPE S'ALBUFERA PROJECT

1. INTRODUCTION

Earthwatch Europe's Project S'Albufera is a long-term programme of research into biodiversity and environmental change at the Parc Natural de S'Albufera, Mallorca. This report summarises the ninth year of fieldwork, carried out at the Parc Natural de S'Albufera, Mallorca by teams of ecologists and volunteer fieldworkers. Fieldwork involved Earthwatch, Balearic and Spanish mainland volunteers assisting and working alongside specialist scientists for periods of two weeks at a time. In 1997, there were two spring teams and one in the autumn. A further team was put into the field in August, implemented by Earthwatch Europe using volunteers sponsored through Glaxo Wellcome Education and ARCO Chemical Teacher Fellowships. As in previous years, a number of additional monitoring tasks were carried out by Park staff and resident Mallorcan volunteers outside the designated Earthwatch Europe sponsored fieldwork periods.

Details of the establishment of the Project and choice of site were given in the first season's report (Newbould & Riddiford 1990) and its first eight years' progress in Newbould & Riddiford (1990), Riddiford & Newbould (1991), Riddiford (1991), Riddiford & Perring (1992), Riddiford (1993), Riddiford & Wells (1994), Riddiford (1995a), Riddiford (1996) and Riddiford (1997a).

The objectives of the Project were

a) To assemble full & detailed ecological data, including climate, hydrology, soils, pollution past & present land uses & cultural influences and reconstruction of past conditions to reach an understanding of composition, functioning and dynamics of major ecosystem types.
b) To provide standardised comparative data for evidence of local, regional & global change, to be reconciled with aerial photography & space sensory data and to be re-recorded at intervals of time; to provide a model for other global monitoring stations.
c) To afford material for application in further research & reserve management at S'Albufera and in general conservation practice.
d) To provide resources for comprehensive interpretive programmes & dissemination in all appropriate forms.
e) To serve as a focus for education of residents & visitors of all age-groups & levels and to help in creating environmental awareness & commitment.

The 1997 spring teams comprised 4 scientists and 6 volunteers from 12th to 26th April, and 8 scientists and 3 volunteers from 29th April to 13th May. The autumn team comprised 5 scientists and 8 volunteers from 26th October to 9th November. The August team ran from 16th to 30th August and comprised 8 scientists and 14 volunteers. The volunteer composition

by country was 11 from the United Kingdom, 4 from Kenya, 3 from France, 3 from Mallorca, 2 from mainland Spain, one from the Netherlands, one from South Africa and one from the United States. The participation of a number of volunteers was assisted by sponsorship and awards: nine UK teachers in August were recipients of Glaxo Wellcome Education Fellowships and a further 3 from France (2) and the Netherlands were recipients of ARCO Chemical Teacher Fellowship_; four of the UK volunteers in autumn were recipients of Earthwatch Europe Millennium Award Fellowships; the Kenyan volunteers were recipients of Earthwatch Europe African Fellowship Awards, a scheme made possible by European Union sponsorship; and the South African volunteer, a teacher and co-ordinator of the Green Machine Environmental Club for schoolchildren, was recipient of an Earthwatch Mitsubishi Fellowship. The Project science team was drawn mainly from the United Kingdom but included two from Mallorca and one from France (Tour du Valat Biological Station, Camargue). Visiting scientific advisors were drawn from Mallorca (Department of Earth Sciences, University of the Balearic Islands) and the Netherlands (Director of the Wageningen Institute for Environment and Climate Studies).

In March 1997, Project participants appeared and spoke of their work in a special environmental awards programme of the Thames Television holiday feature “Wish You Were Here”. The programme featured the “Environmental Tourism Awards for Tomorrow” ceremony, in which S’Albufera won the highly coveted special environmental award. The activities of the summer and autumn teams were reported at length in articles in the Mallorcan daily newspaper, El Dia del Mundo.

As in all previous years, the teams were afforded the support of, participation by or advice from: members of the Universitat de les Illes Balears (UIB, particularly its Departments of Earth Sciences and Biology) and the Institut d'Estudis Avançats de les Illes Balears; visiting scientists; members of the Park staff; and the Park's director, Sr. Joan Mayol. The overall responsibility for planning and supervision was assumed, as normal, by the Project's Principal Investigator, Nick Riddiford. Details of all participants are given in Appendix 1.

2. PROJECT S'ALBUFERA FIELDWORK IN 1997

The project was established to undertake long-term monitoring, and the monitoring work described previously (Riddiford 1994a; Riddiford 1997b) has continued. Both the monitoring work, and additional studies and programmes continued or initiated during 1997, have been in response to the original objectives set in 1989. To place each activity into its overall context, a summary of 1997 fieldwork is given below in relation to the Project objectives. A further more detailed summary, by activity, is given in section 3.

First objective: *to assemble full and detailed ecological data to reach an understanding of composition, functioning and dynamics of major ecosystem types.*

Ongoing studies included: vegetation re-colonisation of an area of coastal sand dune destroyed by fire; observations of roosting starlings *Sturnus vulgaris* in relation to habitat and

to human and raptor disturbance; reedbed utilisation by small mammals; the composition of aquatic invertebrate communities in relation to water condition and quality; egret activities; the distribution of the purple gallinule *Porphyrio porphyrio*; bird, mammal and butterfly transects; a study of butterfly and dragonfly activity and occurrence in relation to habitat and ambient conditions; and the collection of new records for flowering plants, fungi, moths and butterflies (lepidoptera), grasshoppers and crickets (orthoptera), lacewings and ant-lions (neuroptera) and a range of aquatic invertebrates. This was augmented in 1997 by a considerable suite of new records and information for microlepidoptera, hymenoptera, diptera, fungi and marine biota. Other new ecosystem studies in 1997 included a pilot study to establish a means of recording the distribution of aquatic macrophytes; a study to elucidate whether hymenoptera and diptera could be used as indicators of ecosystem condition and in particular, in the case of diptera, water quality; and a baseline study of the inter-relationship between white poplar *Populus alba* condition, larval infestation by lepidoptera and parasitic load by hymenoptera on the lepidopteran larvae.

Second objective: *to provide standardised comparative data for evidence of local, regional and global change; and to provide a model for global monitoring stations*.

The moth (lepidoptera) light trap study continued and for the first time, comparative data were also collected from the Albufera des Grau Natural Park in Menorca. Project scientists and advisors are currently engaged in setting up a reference collection for Albufera des Grau and the first specimens were available for use in the Es Grau Park by the end of the year. It is hoped that co-operative studies between the two sites may be used to assess whether future changes in species occurrence or composition are the result of local or more universal factors.

A new co-operative study was established in August between the Project and the Tour du Valat Biological Station, Camargue, France to study the vegetation structure and long-term functioning of reedbeds. This study, which incorporates a number of reedbeds throughout southern France, uses a standard methodology which will allow comparisons to be made both with local ambient conditions (physical and natural) and more widely at the regional level. Four sites were selected at S'Albufera as representatives of distinct reedbed and/or water condition types.

The Project continued to work closely with the Center for Environment and Climate Studies, Wageningen Agricultural University, Holland (now the Wageningen Institute for Environment and Climate Studies) and by the end of the year the Wageningen team, led by Director Dr Dolf de Groot, had produced five dissertations on various aspects of S'Albufera and its environment (see Annexes 1-5 of this report). The aim of this work is to establish S'Albufera as a model for the study of the functions and values of environmental sites. The dissertations not only addressed this issue but laid the foundations for further co-operative work, in the form of a programme of research and monitoring of key environmental factors. At a site meeting in November, it was resolved to take this programme forward as a co-operative venture between the Wageningen Institute, Project S'Albufera, the University of the Balearic Islands and the Park.

The Project continues to develop its Biodiversity model in order to make its data useful and accessible internationally. Description of this model (entitled *Project S'Albufera: a biodiversity model in Mallorca*) was published in the first volume of the review document

Biodiversity Assessment, A Guide to Good Practice (Jermy *et al*. 1995).

Third objective: *to afford material for application in further research and reserve management and general conservation practice.*

As stated in previous reports, much of the information gained from study of the processes at work in the ecosystem has direct relevance to conservation management at S'Albufera, and more widely. Studies particularly targeted towards assisting with the design or planning of management activities included: co-ordinate mapping of the *Euphorbia terracina* population of Turo de ses Eres to monitor vegetation structure changes in a fossil dune habitat grazed by horses and other mammals; census studies of orchid population dynamics, also to assess and advise on the impact of livestock grazing; distribution mapping of key bird species and groups in relation to vegetation structure and management; sampling of aquatic invertebrates at the Park's water chemistry monitoring sites to assess invertebrate communities in relation to water quality; study of the rate and types of vegetation re-population within a 3.5 hectare area in the southernmost part of Es Comu coastal dunes following fire in 1994; monitoring through observations and census of the purple gallinules *Porphyrio porphyrio* in order to assess their status and dispersal following re-introduction; investigation into the health of the Park's white poplar *Populus alba* population, which is showing signs of severe stress; and study of the effects of heavy erosion in the Es Comu coastal dunes on pioneer vegetation and on the internationally significant population of the prickly juniper *Juniperus oxycedrus macrocarpa*. This last study was extended in 1997 to include an investigation of juniper regeneration, which is currently very limited, and the impact of public use on the dune system and processes.

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It is hoped that the aquatic invertebrate study will not only assist Park management planning but lead to an understanding of the relationship between communities and water quality, and the development of a methodology which can be adopted at other Mediterranean wetlands where chemical data are not directly available. The study also demonstrates the importance of water quality in maintaining and enhancing biodiversity in aquatic habitats generally.

The herbarium, plant and invertebrate reference collections and photographic archive, now impressive in size and quality, have become an extraordinarily useful resource. This material is accessible not just to Project members, but to Park staff and visiting scientists who wish to avail themselves of this excellent on-site reference source.

The Project scientific team continues to respond willingly and promptly to requests for advice, comment or materials relating to management and other conservation issues and it is pleasing to note the high level of integration and interchange of views daily between Project members and Park staff.

Fourth objective: *to provide resources for comprehensive interpretive programmes and dissemination in all appropriate forms.*

The major focus of interpretive work during the year was the preparation by Dinah McLennan of the artwork and Jo Newbould of the text for a guide to the wayside flowers of

the Park. Good progress was made in 1997 in the preparation of plates and research into the flowering seasons. The project scientific team was pleased to make available materials and ideas to the Park's teacher-naturalist team which includes, once more, past Project volunteer, Mari-Angels Ferragut. Plans were made in 1997 for future additions to the interpretive programme.

Fifth objective: *to serve as a focus for education of residents and visitors of all age groups and levels and to help in creating environmental awareness.*

The Project was again active at the local and international level. As in all previous years, we were pleased to sponsor a series of young Balearic and Spanish scientists, conservationists and environmentalists to participate as a volunteers in the Project. Their participation is considered a key part of the programme. It has the dual benefits of allowing them the opportunity to obtain hands-on experience of a range of practical field techniques and ensuring local involvement, awareness and knowledge of both the Project and conservation issues generally. Environmental awareness and education are also being achieved through the interpretation initiatives described above.

The international nature of the Project continued in 1997. For the third successive year, British teachers were afforded the opportunity in August to obtain fieldwork experience and training as recipients of Glaxo Wellcome Education Awards, sponsored by Glaxo Wellcome plc. We were delighted in 1997 to expand the remit of the team to include teachers from France and the Netherlands, sponsored by ARCO Chemical. We were also delighted to welcome for the third successive year, talented biologists and conservationists from Africa as part of the African Fellowship Scheme. The African Fellowship Scheme was established by Earthwatch Europe and is sponsored by the European Commission and the Darwin initiative of the UK government. The three-year programme of participation by African Fellows has demonstrated unequivocally the immense benefits gained by all. Feedback from the Fellows indicates that they gain enormously in ideas, techniques, confidence and inspiration from the experience, while their flow of ideas and their abundant enthusiasm and commitment have brought a new dimension to the Project and to the Park. This form of volunteer participation is extremely worthwhile because it integrates the ecological research with the training and education aspects of the Project. The value and success of this integrated training programme is undoubted and sets a standard which can be recommended as a model for other sites and areas of the World.

3. FIELDS OF RESEARCH IN 1997

The following is a summary, by category, of research studies by Earthwatch Europe's Project S'Albufera in 1997 (and see Appendix 2 for more details).

Ecosystem studies

Vegetation repopulation after fire. For the third consecutive year EarthCorps teams monitored the re-population by vegetation of an area of Es Comu coastal dunes destroyed by fire in 1994. It was carried out by identifying plant species, vegetation cover and proportions of bare ground in a series of one-metre quadrats during the months of April and May. Vegetation changes have been swift and by year three little bare ground remains. Grass species currently dominate. With the notable exception of pine *Pinus halepensis*, the shrub species which dominate in the adjacent, undamaged control site surveyed in 1996 are all represented in the recovering vegetation community. The methodology and a summary of the first season's results are presented in Annex 3 of Riddiford (1996).

Water quality and aquatic invertebrate communities. EarthCorps volunteers under the leadership of Michelle Chapman continued to develop the study begun in 1995 of aquatic invertebrate communities in relation to water quality, using standard sampling techniques and combining Park water chemistry data. The study is proving a very good means of assessing variations in water quality. Examples include slow recovery of invertebrates at the seaward end of the Gran Canal following a polluting incident in 1996, and a major water quality problem in the northern part of the Park which coincides with current policy to pump sea water used as cooling water for the electricity power plant into a canal adjacent to the Park's north-east boundary. A report of 1996 fieldwork is presented in Annex 3 of Riddiford (1997a); and the methodology and first season's results are presented in Annex 9 of Riddiford (1996). Details of previous aquatic invertebrate work are given in Riddiford (1993) and Riddiford & Wells (1994).

Water quality and aquatic vegetation. As an extension of the aquatic invertebrate community studies, a start was made in August to develop a methodology for using aquatic macrophytes occurrence and distribution in relation to water chemistry to add to the suite of indicators for water quality within the Park. Previous work concentrating on the distribution of *Enteromorpha* as an indicator of phosphate load is given in Annex 5 of Riddiford (1997a).

Egret activities. Dr Nick Owens continued his study, begun in 1996 into the behaviour, activities and distribution of egrets. The study aims to assess the potential of egrets as indicators of a range of ecosystem features, including preferences in relation to water quality, vegetation structure, and habitat determined by grazing and other management activities. The methodology and results of the pilot study are described in Annex 4 of Riddiford (1997a).

Reedbed vegetation structure and water quality. This is a new long-term study introduced in August. The aim is to achieve an understanding of the relationship between reedbed structural evolution and aspects of water quality and hydrology. Four sites were chosen: a mature *Phragmites* reedbed in brackish water at Es Cibollar; a mature, long-undisturbed *Phragmites* reedbed in fresh water at Es Colombar; the reedbed of tallest *Phragmites* in the entire Park, and close to agricultural land, at Es Forcadet; and a *Cladium mariscus* bed with high plant diversity, also close to agricultural land, at Son Carbonell. A piezometer was established at each site, and a 150-m long transect set up. Water levels and conductivity are measured at fortnightly intervals within and immediately outside each piezometer, while details of vegetation structure (including species present, % cover, % live stems, *Phragmites* height and stem thickness at base) are taken once a year from quadrats at regular intervals along the transect. This is a collaborative study with the Tour du Valat Biological Station,

Camargue, France. Studies using the same methodology are being conducted in a number of reedbeds in southern France. The S'Albufera fortnightly measurements are being taken by Mallorcan members of the Project S'Albufera team, Carolina Encinas and Inmaculada Mateo.

Reedbed utilisation by small mammals. Rob Strachan continued his investigation into the utilisation of habitats, populations and inter-specific relationships for three species of mouse at S'Albufera, concentrating for the third consecutive year on their distribution, numbers and diurnal activities in August, at the end of a period of low rainfall and water levels. He discovered that the Algerian mouse *Mus spretus* was largely absent from his main study area, possibly because of the dryness of the site following a particularly dry summer. However, a transect line of traps along the Cami d'en Pujol revealed a high density of the species, suggesting that in times of drought the species sought areas of denser grounder vegetation. Results of his initial study are given in Annex 12 of Riddiford & Wells (1994).

Reedbed utilisation by roosting birds. Information was gathered once more in autumn 1997 of birds roosting in the S'Albufera reedbeds. The 1997 work again concentrated on starling *Sturnus vulgaris* activities and interactions between this species and potential predators. Notes were also gathered on roosting activities of corn bunting *Miliaria calandra* and marsh harrier *Circus aeruginosus*. The results of previous years' studies are presented in Annex 5 of Riddiford (1996), Annex 10 of Riddiford (1997a) and in Mayol & Perello (1997).

Impact studies

Coastal dune erosion. Further work was conducted into the coastal dune erosion problem, first studied in 1996 in response to concerns about the extent of erosion along the coastal fore-dune/beach-head interface, and the consequent damage to the coastal pioneer plant communities and the important prickly juniper *Juniperus oxycedrus macrocarpa* population. The 1997 work included study of public use of the beach and dunes, mapping and measuring to investigate increases in number and width of tracks through the Es Comu coastal dunes, and investigation of the distribution and level of regeneration occurring among Juniper plants throughout the Es Comu coastal dunes. There was a close negative relationship between the numbers and distribution of people using the beach and amounts of pioneer beach-head vegetation (e.g. the areas of beach closest to the hotels, north and south, had the highest public use and the least, usually nil, pioneer vegetation). Mapping and measurements indicated a strong growth in the number of tracks, and widening of main tracks, based on comparisons with previous aerial photographic evidence for that area. There is a considerable population of *Juniperus oxycedrus macrocarpa* beyond the coastal fringe. These, unlike their coastal brethren were predominantly in good condition, but regeneration was very limited. Public use of the dunes, and a consequent increase in open areas of loose sand, may be a factor in the lack of regeneration. Coastal dune specialist, Dr Jaume Severa of the UIB Department of Earth Sciences, joined the team in November to consult with us on the problem. His explanations of the natural physical evolution of the dune system, its vulnerability and responses to the effects of human activities, and the requirements for re-establishing and protecting the natural processes clarified a lot of the issues raised by our studies and will help us and the Park in planning for appropriate management measures to be enacted. The results of the public use survey are presented in Annex 7 and a description of the initial juniper regeneration study in Annex 8 of this report.

Juniper regeneration in the coastal dunes. See ***Coastal dune erosion*** above.

White poplar *Populus alba* investigation. The level of dieback among white poplars *Populus alba* did not increase markedly in 1997. Nevertheless, the problem remains and the causes are still not fully understood. In an attempt to eliminate possibilities, series of soil samples were collected in various parts of the Park, close to healthy and sick populations, by the August and autumn teams. The samples were sent for laboratory analysis. Preliminary results indicated an abnormal acidity and abnormal values of sulphur and other constituents in some samples. It is intended to send water from the Park's rain gauge for analysis, to investigate the possibility of acid rain. The results of the initial investigation are presented in Annex 2 of Riddiford (1997a).

Parasitism and larval infestation of white poplar. This new study, introduced by David Agassiz in spring 1997, looked at the inter-relationships between levels of infestation by larvae of the moth *Gypsonoma minutana*, the proportion of larvae parasitised by other invertebrates and the health of the host tree. This demonstrated how one species, the white poplar, supports an entire community thus adding to the diversity of the Park. Data from the 1997 study will act as a baseline for monitoring how this community reacts to variations in the condition of the Park's poplar population (including the community's long-term survival in a worst case scenario of poplar population loss).

Biodiversity studies

Species inventories. As in all previous years, the S'Albufera biodiversity database continued to grow. A number of additions were incidental, being gathered during routine monitoring or ecological research activities. However, five major groupings, microlepidoptera, diptera, hymenoptera, fungi and marine biota, were specifically targeted in 1997. These are detailed below. Wherever possible, inventory information was extended to include data on distribution and abundance. Development of methodologies to do this systematically was continued, including a follow up of the 1996 pilot study of the distribution and abundance of Odonata and butterflies. The results of this pilot study are presented in Annex 8 of Riddiford (1997a).

Lepidoptera. In spring, we were very fortunate to obtain the services of Dr David Agassiz, President of the Society for European Lepidoptera and a foremost specialist on micro-lepidoptera. He sampled a range of habitats and, as a result, added greatly to our knowledge of the micro-lepidopteran communities and their status in the Park. His greatest find so far was the capture of *Araeopteron ecphaea*. The species was known from just five West African specimens, all female, until one was take in Greece, also a female. There had been a doubt over the veracity of the species, because of the problems of separating these on morphological grounds from females of a very similar Asiatic species. His capture of a male, and the discovery of two further males amongst the S'Albufera collection, allowed study of genitalia which demonstrated beyond doubt that the species was indeed distinct from its Asiatic counterpart. He has also identified *Scythris mus*, not previously known from the Balearic Islands. Other exciting finds are expected as the process of identification continues, with several World specialists involved in the identifications.

Diptera and Hymenoptera. In August we were joined by Paul Lupton, who undertook a

study of the hymenoptera and diptera of the Park. Previously, very little information had been gathered for these two groups. In addition to taking steps to fill this gap, Paul undertook a pilot study to ascertain the viability of using these groups to assess habitat quality, particularly relating to water chemistry. A report of this study is given in Annex 10 of this report.

Fungi. In autumn, Rachel King, aided by local experts Pep Siquier and Xisco Lillo, sampled all the main habitats for fungi. In addition to expanding the baseline, some important finds were made. The most notable of these was probably the discovery of several fruiting bodies of *Psathyrella halophila*. This species, recently described for the first time (Esteve-Raventos & Enderle 1992) and still only known from S'Albufera, was confirmed as being associated with the reedbed plant, *Cladium mariscus*, but was found in non saline conditions, refuting the suggestion of the original authors that the species required saline conditions. The fungus *Marasmius caesioater*, discovered just two years ago by Xisco Lillo and only previously known from Argentina, was found to be relatively common and widespread at the base of dead *Phragmites* stems within the reedbeds. Further details of fieldwork, and initial results, are given in Annex 9 of this report.

Marine biota. Considerable additional information was gathered in spring and summer by Emma Whittingham (spring) and Carolina Encinas (spring and summer) of the marine biota of the shallow waters adjacent to the Park's littoral/coastal fringe. Particular attention was paid to the marine community of S'Oberta, where the Gran Canal enters the sea and within 200 m of a site where Michelle Chapman's ***aquatic invertebrates and water quality*** study (see above) had indicated slow recovery of aquatic invertebrates following a polluting incident in 1996. In autumn EarthCorps volunteers collected and identified a range of marine species washed up after a severe gale in the bay.

Odonata. A review paper, incorporating historical records as well as data from Project S'Albufera biodiversity files appeared in 1997 in the *Buttleti del Parc* (Mayol & Perello 1997). An English version of this paper is presented in Annex 7 of Riddiford (1997a).

Butterflies and dragonflies. Chris Donnelly used these two groups as subjects in further field trials of methodology designed to collect biodiversity data in relation to Biodiversity database development. Her initial field trial, conducted in 1996, is described in Annex 8 of Riddiford (1997a).

Reference materials. In keeping with previous years, the herbarium of flowering plants was maintained and further plants added. Efforts were made to cross-reference the Project's collection of flora photographs, established as an adjunct to and extension of the herbarium. Responsibility for the herbarium, botanical references and plant species list remains in the careful hands of Jo Newbould. The reference collections of insect groups also continued to grow. EarthCorps volunteers were involved in further reorganisation of the Lepidoptera collection to incorporate the volume of new microlepidoptera material accruing from the work of David Agassiz. A working reference collection of aquatic invertebrates is also held on site to assist with the aquatic invertebrates and water quality study. This collection was also added to in 1997.

Data management. Work continued to develop and use the model for biodiversity data collection and management outlined in Riddiford (1995a). In 1997, much of the work

concentrated on developing a system using the relational database *MS Access* to link the numerous individual studies into various applied aspects of the Park's ecology, and biodiversity.

For further details of the structure and other aspects of the S'Albufera biodiversity database and the development of data management systems see Annex 14 of Riddiford & Wells (1994), Annexes 4 to 7 of Riddiford (1995a) and the description of the Project's biodiversity model in the UK review document *Biodiversity Assessment, A Guide to Good Practice* (Jermy *et al*. 1995).

Monitoring studies

Birds. Two bird transects, conducted annually since 1989 and 1990 respectively, were repeated in 1997 during the spring and autumn fieldwork periods. The transects have been designed to obtain temporal and longer-term fluctuations of breeding and migrant birds in a range of habitats. For details of the bird transect methodology see Riddiford & Perring (1992).

In August, ARCO Chemical/GlaxoEducation Fellows assisted Rachel King and Nick Riddiford in gathering information on the late summer use by bird species of the old, undisturbed reedbed at Es Colombar. Information was gathered on the body condition of birds using the reedbed by collection of weight, adipose fat, muscle condition and moult data from a sample of birds trapped during a standard 25 hour period over 5 days. The August study was the prototype for a constant-effort monitoring programme, using the same methodology and parameters to collect comparable data at regular intervals during the year. The monitoring programme is being conducted by a joint UK and Mallorcan team, led by experienced ringer David Hanford.

In autumn, the distribution and numbers of purple gallinules *Porphyrio porphyrio* at S'Albufera were surveyed for the third consecutive year. The first year's survey was introduced following a storm which had flattened the reedbeds. The reedbeds have now fully recovered, making census work for purple gallinules far more difficult. Thus 1997 census counts were not strictly comparable with previous ones and could not be used to measure population growth. Nevertheless, it was clear that further substantial population growth had occurred, with a number of distributional records from areas and sites not previously occupied. For a description of the methodology and results of the initial, 1995, survey, see Annex 1 of Riddiford (1996). The results of the second year's survey are presented in Annex 9 of Riddiford (1997a).

Mammals. A mammal transect, established in 1991, and reactivated in 1995 in response to a new development, the arrival from the mainland of a virus which attacks and kills rabbits *Oryctogalus cuniculus*, was continued during all fieldwork periods in 1997. Once again, rabbits were recorded very infrequently, indicating that the S'Albufera population remains at a low ebb. Further observational data were collected for this and a range of other species. Rob Strachan's continued investigation into the utilisation of habitats, populations and inter-specific relationships for three species of mouse at S'Albufera is described in ***Ecosystem studies*** above.

Butterflies. Two transects designed to monitor butterfly habitat preferences and population variations, the first established in 1989 and the second in 1991 and both repeated annually thereafter, were conducted regularly in 1997 during all the fieldwork periods. For further details of butterfly transects, including methodologies, see Riddiford & Perring (1992).

Moths and other insects attracted to light. Standard insect light traps were used on most nights during fieldwork periods in 1997. The involvement of specialist David Agassiz in spring led to a number of additional habitats being sampled and a substantial advance in our knowledge of lepidoptera diversity and distribution, particularly for the smaller lepidoptera. Once again, new faunal records were not restricted to moths. Among the interesting species recorded in 1997, the lacewing *Sisyra iridipennis* Costa, 1884 stands out. The species is rare, other records being restricted to the Spanish peninsula, Morocco, Algeria and Sardinia. The only previous Mallorca record was a female collected in 1908 (at Pollensa).

Marine studies. In addition to collecting baseline data (see **Marine biota** above), Emma Whittingham began developing a programme for future monitoring with particular reference to the impacts of water quality and human use of the marine waters adjacent to the Park.

Hydrology and hydrochemistry. The Park continued to collect water regime and water chemistry data throughout the year from sample sites throughout the Park, maintaining the suite of information which forms such an important resource for setting against a range of Project monitoring and ecosystem studies. Water chemistry analysis is undertaken by Park staff in partnership with members of the Department of Limnology at the University of the Balearic Islands. The sampling technique and equipment used to obtain water quality measurements are described in Annex 3 of Riddiford (1995a).

Meteorology. As in all previous years, meteorological data were collected daily by Park staff and made available to the Project and its scientific team.

Park management

Orchis palustris population. Monitoring of the marshland orchid *Orchis* (*laxiflora*) *palustris*, undertaken annually by EarthCorps volunteers, again took the form of counting and mapping flowering plants in early May. The population continues to thrive, with record numbers recorded. The most important site was once again the grazed “fire-break” zone near the western perimeter of the Park. It is becoming increasingly evident that the species benefits from domestic stock grazing of its habitat prior to the flowering season, but does poorly if grazing, at least by cattle and horses, is maintained immediately prior to and during the flowering period.

Fossil dunes. Monitoring was again undertaken by EarthCorps teams under the direction of Jo Newbould in the spring. The aim of the study is to obtain information about 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 *Euphorbia terracina* population, a potential shade species apparently unpalatable to grazing animals. Details of methods used were reported in Annex 3 of Riddiford & Wells (1994).

Coastal dunes. A study of vegetation repopulation in the coastal dunes after fire is described under Ecosystem studies above. For further details of dune studies, see also Wood (1991),

Riddiford & Newbould (1991), Riddiford & Perring (1992) and Riddiford (1993).

Barn Owl boxes. The boxes erected in 1996 were monitored but remained unoccupied in 1997.

Interpretation and education

Botanical interpretation material. EarthCorps teams again assisted Dinah McLennan and Jo Newbould in collecting information with the long-term goal of providing botanical interpretation material. Jo and Dinah continued to collect information about the distribution and flowering periods of plants for their S'Albufera flower guide for Park visitors, currently in preparation, while Dinah made substantial progress in the preparation of the plates.

For further details of interpretative work, see Annex 16 and Annex 17 of Riddiford & Wells (1994).

Programme development

S'Albufera Biodiversity Database. See ***Database management*** above.

Functions and values. Further information was gathered and made available to assist students from the Center for Environment and Climate Studies, Wageningen Agricultural University, to develop their model of functions and socio-economic values of natural ecosystems and protected areas using S'Albufera as a model. This resulted in the production of five theses, all of practical value and application, by the end of the year. Summaries of these dissertations are given in Annexes 1-5 of this report. A description of the pilot study for this work is presented in Annex 7 of Riddiford (1996).

For further details of fieldwork studies undertaken by the Project, see Wood (1989, 1991), Newbould & Riddiford (1990), Riddiford & Newbould (1991), Riddiford & Perring (1992), Riddiford (1993), Riddiford & Wells (1994) and Riddiford (1995a, 1996, 1997a).

4. PROGRESS AND FUTURE PLANNING

During 1997 Project S'Albufera was invited by Earthwatch, as part of the renewal process, to submit a research proposal covering the next three years, 1998-2000, for independent scientific peer review. This review, by an international group of scientists, was successful and prompted very favourable comments on the quality and value of Project work. Unfortunately, concurrent with the scientific review, Earthwatch conducted a financial audit which concluded that recent recruitment had been insufficient to carry the costs of managing the project. As a result, Earthwatch gave notice in December 1997 that it was no longer able to support Project S'Albufera. Earthwatch Europe, on the other hand, indicated a willingness to continue support of the project. Unfortunately, it was too late to organise volunteers for the

spring and the only Earthwatch field team in 1998 will be an Earthwatch Europe one in the autumn.

Earthwatch Europe's commitment of continued support came at an important time for the project. Considerable progress had been made in 1997 in the development of a programme of international collaborations of the type the Project had been seeking since its inception. An immediate example was the launch in August 1997 of a joint study with Tour du Valat Biological Station, France, using Mallorcan members of the Project S'Albufera team to collect data in S'Albufera reedbeds as part of a wider monitoring programme being carried out in French Mediterranean wetlands. By the end of the year, a more extensive programme was being developed through the initiative of Dr Rudolf de Groot, Director of the Institute for Environment and Climate Research, Wageningen Agricultural University. Following the completion and reporting of the S'Albufera functions and values pilot study undertaken by members of his Wageningen team, Dr de Groot initiated in November 1997 the task of developing a programme which would incorporate the scientific skills and involvement of his Institute, the University of the Balearic Islands, the Park and Balearic Conservation Department in partnership with ongoing and revised Project S'Albufera work. The detail is still to be finalised, but early signs are that the venture will go ahead, with full commitment on all sides.

It is hoped that this international co-operation will attract financial support, but in the meantime efforts are being made to procure funding elsewhere and particularly to carry the Project through this difficult year. Friends and supporters are equally determined to see the Project survive and prosper, and this has led to constructive help in various ways as a short-term measure. Help has extended to a rescue of the spring fieldwork period. Though, sadly, no Earthwatch volunteers will be with us in spring 1998, there will be a strong presence of Project S'Albufera scientists throughout the spring period, culminating in a group in the second half of April supported by volunteers from Mallorca, Spain and the Peterborough Conservation Volunteers and Peterborough Wildlife Group, UK. This will enable several essential ongoing studies to be maintained.

Despite the withdrawal of Earthwatch support, the research proposal for 1998-2000 still forms the basis for future planning (though liable to amendments currently under discussion with our planned International partners), and for this reason the scientific element of the proposal is repeated in Annex 6 of this report.

Details of the revised 1998 Project S'Albufera programme are given in Appendix 3.

5. ACKNOWLEDGEMENTS

I would like to thank the Balearic Ministry of the Environment's Conservation department for granting permission to operate, Earthwatch Europe for its support, the parc staff for their friendship and help and our many friends for their encouragement and commitment. They include: Joan Mayol, Conservation Director of the Balearic Conselleria de Medi Ambient, Ordenació del Territori i Litoral; the Conselleria's Minister, Director General and administration; Biel Perelló and all the staff of P.N. S'Albufera; Pat Bishop and her late, much missed, husband Dennis; Max Nicholson, still beavering away behind the scenes in

support of the Project; Pere Tomàs-Vives; all members of the Project S'Albufera scientific team; Mallorcan members of that team, Inmaculada Mateo and Carolina Encinas for their year-round fieldwork commitment and help; Earthwatch and Earthwatch Europe staff; the sponsoring organisations of Glaxo Wellcome plc, ARCO Chemical, the European Union and the Darwin Initiative; Dr Dolf de Groot and his team from the Center (now Institute) for Environment and Climate Studies, Wageningen; scientists from several departments of the University of the Balearic Islands; the Balearic Institute for Advanced Studies; our Mallorcan supporters, including the Friends of S'Albufera, Nicole Smith, Marga Roig and many other individuals; and the Project's special scientific advisors, Barry Goater, Rod Stern, Chris Haes, Colin Plant and Martin Honey in the UK, Xisco Lillo, Pep Siquier and Jaume Servera in Mallorca. They all deserve a huge vote of thanks for their help in so many ways. But, as always, my final and biggest thanks go to the wonderful band of EarthCorps volunteers, whose quality and enthusiasm has been such an enrichment to the Project.

To everyone above, and advisors, helpers and supporters inadvertently omitted or overlooked, I give my sincerest thanks; which are extended to all participants in, and visitors to, the Project detailed in Appendix 1 below.

APPENDIX 1 - List of Participants, 1997

Principal Investigator
Nick Riddiford

Parc Natural de S'Albufera Advisor to Project
Joan Mayol (Director of Balearic Natural Areas)

Parc Natural de S'Albufera Liaison Officer to Project
Biel Perelló (Conselleria de Medi Ambient, Ordenació del Territori i Litoral)

Cook
Margalida Moranta

Team I (12th-26th April)

Scientists
Nick Riddiford (PI), Jo Newbould (botanical studies), Dinah McLennan (botanical illustrations and studies), Mike Wood (ecological studies; logistics)

Volunteers
Jennie Voisin (Jersey, Channel Islands), Brian Lavercombe (UK), Stéphanie Boissel (France), Inmaculada Mateo (Mallorca) and the Earthwatch European Union sponsored African Fellows: James Makau Nzioka and Thuita Thenya (Kenya)

Team II (29th April-13th May)

Scientists
Nick Riddiford (PI), Dinah McLennan (botanical illustrations and interpretation), Emma Whittingham (marine ecology) David Agassiz (lepidoptera), Rob Strachan (small mammals), Chris Donnelly (biodiversity studies), Michelle Chapman (aquatic invertebrates), Inmaculada Mateo (logistics)

Volunteers
Carolina Encinas Redondo (Mallorca) and the Earthwatch European Union sponsored African Fellows: Francis Karanja Kamau and Esther Fondo (Kenya)

Team III (26th October-9th November)

Scientists
Nick Riddiford (PI), Chris Donnelly (dune erosion, juniper regeneration studies), Rachel King (fungi), Nick Owens (ornithology), Mike Wood (logistics, ornithology)

and the visiting scientific collaborators:
Jaume Servera Nicolau and José Angel Martin Prieto, Dept. of Geography, University of the Balearic Islands (dune erosion); Xisco Lillo and Pep Siquier (fungi); Carolina Encinas and Inmaculada Mateo (reedbed monitoring); Rudolf de Groot, Wageningen Center for Climate and Environment Research (functions and values of natural areas); David Hanford, Heather Coats, Bob Rigdon and Rhian Evans (constant effort ringing for reedbed monitoring)

Volunteers

DeRon Freeman (USA), Jennie Voisin (Jersey, Channel Islands), Michael Spies (South Africa - recepient of Mitsubishi Fellowship), Julie Brewer, Sam Hillcox, Val Tunwell, Jim Wild (Earthwatch Europe Millennium Fellows, UK), Juana Maria Soler Brunet (Mallorca)

Glaxo-Wellcome Education/ARCO Chemical Teacher Team (16th-30th August)

Scientists
Nick Riddiford (PI), Inmaculada Mateo (logistics), Rob Strachan (small mammals, butterflies, dragonflies), Paul Lupton (Diptera, Hymenoptera), Michelle Chapman (aquatic invertebrates), Carolina Encinas (reedbed monitoring, marine studies), Rachel King (reedbed bird ecology)

and the visiting scientific advisor:
André Mauchamp, Tour du Valat Biological Station, France (reedbed monitoring)

Volunteers
Meryl Bevington-Bird, Paula Cornish, Andrea Gillon, Len Harding, Julia Passman, Liz Piercy, Amanda Spurr, Kate Wheeler, Catherine Lyons (UK), Ineke Kuijs (Netherlands), Anik Brunet, Régine Mulet (France), Belén Fervenza Couñago, Cristina Real Morchón (Spain)

Additional scientist and volunteer contributions
Carolina Encinas and Inmaculada Mateo (fortnightly water height and salinity measurements for reedbed monitoring study)

Identification advisors in UK
Steve Brooks, Natural History Museum, London (Ephemeroptera & Odonata)
Barry Goater (Lepidoptera)
E. C. M. (Chris) Haes (Orthoptera/Dictyoptera/Dermaptera)
Martin Honey, Natural History Museum, London (Lepidoptera: moths)
Colin Plant (Neuroptera: lacewings)
Rod Stern (Bryophytes)

Visitors to the Project

Team I
Jennifer Batty, Napier University, Edinburgh
Martin Honey, Natural History Museum, London
Team II
Max Nicholson (Founder, Project S'Albufera)
Pat Bishop (Founder supporter of Project S'Albufera)
David Wellings, Chief Executive, retired - Cadbury Schweppes
Team III
Rudolf de Groot, Institute of Environment and Climate Studies, Wageningen Agricultural University
Toni Martinez, Department of Limnology, University of the Balearic Islands

Maurici Ruiz, Department of Earth Sciences, University of the Balearic Islands
David Hanford, Heather Coats, Bob Rigdon, Rhian Evans, UK
Pat Bishop, Claire O'Donald, Professor Donald Trelford, Sally, Paul, Richard & Nicky Grey (Friends and Supporters of Project S'Albufera)
Glaxo/ARCO Education Team
Abdelghani BELOUAD, Directeur de la Protection de la Faune et de la Flore, Direction Generale des Forets, Ministere de l'Agriculture, and Directeur General par Interim de l'Agence Nationale de la Conservation de la Nature, Algeria.
Ammar BOUMEZBEUR, Sous Directeur des Parcs Nationaux et des Groupements Vegetaux Naturels, Direction Generale des Forets, Ministere de l'Agriculture, Algeria.
and, regularly
Representatives of Friends of S'Albufera and the Grupo ornitologico Balears
Pere Tomàs Vives (MedWet Project-Wetlands International, Mallorca)

Staff, Parc Natural de S'Albufera
Joan Mayol - Director of Conservation
Gabriel J. Perelló - Technical Assistant
Francesc Lillo - Chief Warden
Alexandre Forteza - Reception Centre
Pilar Lacalle - Reception Centre
Pere Viçens - Ornithologist
Jaume Gamundí - Guard
Martí Solivelles - Guard
Manuel Coello - Maintenance
Viçens Lillo - Maintenance
Carlos Martínez - Monitor
Gabriel Payeras - Monitor
Mari-Angels Ferragut - Monitor
Javier Tebar - Monitor
Margalida Moranta - Cook

Seconded to Park on non-military national service
Torrens, M
Gelabert, J
Corró, A

APPENDIX 2 - 1997 Fields of Research

The following is a catalogue of information collected in 1997. This information, along with 1989-96 material, has been deposited at Earthwatch Europe's Oxford (UK) headquarters. A second set of the material is held at S'Albufera Natural Park. Details of published material are given in Appendix 4.

Category: Ecosystem studies
Title of Work Done:
Vegetation repopulation after fire.
Catalogue Reference Number: 97/6

Category: Ecosystem studies
Title of Work Done:

Water quality and aquatic invertebrate communities.
Catalogue Reference Number: 97/12

Category: Ecosystem studies
Title of Work Done:
Water quality and aquatic vegetation - aquatic macrophyte survey.
Catalogue Reference Number: 97/13

Category: Ecosystem studies
Title of Work Done:
Egret activities.
Catalogue Reference Number: 97/7

Category: Ecosystem studies
Title of Work Done:
Reedbed vegetation structure and water quality.
Reedbed bird studies.
Catalogue Reference Number: 97/16

Category: Ecosystem studies
Title of Work Done:
Reedbed utilisation by small mammals.
Catalogue Reference Number: 97/17

Category: Ecosystem studies
Title of Work Done:
Reedbed utilisation by roosting birds.
Catalogue Reference Number: Not allocated - raw data with scientist (Nick Owens)

Category: Impact studies
Title of Work Done:
Coastal dune erosion.
Juniper regeneration studies.
Catalogue Reference Number: 97/14

Category: Impact studies
Title of Work Done:
White poplar *Populus alba* investigation; soil sampling.
Catalogue Reference Number: 97/15

Category: Impact studies
Title of Work Done:
Parasitism and larval infestation of White poplar *Populus alba*.
Catalogue Reference Number: 97/C (raw data with scientist David Agassiz)

Category: Biodiversity studies
Title of Work Done:
Species inventories.
Faunal records.

Catalogue Reference Number: 97/3

Category: Biodiversity studies
Title of Work Done:
Diptera and Hymenoptera.
Catalogue Reference Number: 97/10

Category: Biodiversity studies
Title of Work Done:
Butterflies and dragonflies.
Catalogue Reference Number: 97/19

Category: Biodiversity studies
Title of Work Done:
Botanical list and plant photos library references.
Catalogue Reference Number: 97/18

Category: Biodiversity studies
Title of Work Done:
Herbarium.
Catalogue Reference Number: 97/B

Category: Biodiversity studies
Title of Work Done:
Marine studies.
Catalogue Reference Number: 97/11

Category: Monitoring studies
Title of Work Done:
Bird population surveys: transects 1 and 2.
Catalogue Reference Number: 97/5

Category: Monitoring studies
Title of Work Done:
Mammal studies: mammal observations.
Mammal studies: mammal transect.
Catalogue Reference Number: 97/2

Category: Monitoring studies
Title of Work Done:
Butterfly transects.
Catalogue Reference Number: 97/1

Category: Monitoring studies
Title of Work Done:
Moth and other insects attracted to light.
Catalogue Reference Number: 97/4

Category: Monitoring studies

Title of Work Done:
Hydrochemistry - monitoring water quality.
Catalogue Reference Number: Computerised files on site (Park database)

Category: Monitoring studies
Title of Work Done:
Park meteorological data.
Catalogue Reference Number: Computerised files on site (Park database)

Category: Park management
Title of Work Done:
Orchis (*laxiflora*) *palustris* survey.
Catalogue Reference Number: 97/8

Category: Park management
Title of Work Done:
The impact of grazing: distribution of *Euphorbia terracina* at Turo de Ses Eres.
Catalogue Reference Number: 97/9

Category: Programme development
Title of Work Done:
S'Albufera Biodiversity Database.
Catalogue Reference Number: 97/D (on disk)

Category: Interpretation
Title of Work Done:
Botanical illustrations/text.
Catalogue Reference Number: 97/A (sketches & data with Jo Newbould & Dinah McLennan)

APPENDIX 3 - 1998 programme details

Project Title
Monitoring for biodiversity and environmental change at S'Albufera, Mallorca.

Research Site
Parc Natural de S'Albufera, Mallorca, Spain.

Principal Investigator
Nick Riddiford

Team Dates in Field

TEAM I (scientific team)	March 28-April 17, 1998
TEAM II (scientists & volunteer team)	April 18-May 2, 1998
TEAM III (Earthwatch Europe team)	October 25-November 8, 1998

Team Composition: integrated teams of Scientists, Spanish and Peterborough Conservation

Volunteers in spring; and of Scientists, Earthwatch Europe and Mallorcan/Spanish Volunteers in autumn.

Fields of Research

Human and Management Impact studies

1. Aquatic invertebrate communities in relation to water quality (Michelle Chapman).
2. Coastal dune studies (Chris Donnelly; Nick Riddiford).
3. The impact of agricultural practices on the Park environment (Macarena Mata).

Biodiversity studies

1. Arachnid [spider] studies (Tony Sargeant).
2. Taxonomy of *Ischnura* damselflies (Rachel King).
3. Herbarium development and curation (Jo Newbould).
4. Insect reference collection (Nick Riddiford; Barry Goater).
5. Marine biota baseline (Emma Whittingham).

Monitoring studies

1. Bird population studies - transects (Nick Riddiford).
2. Butterfly and dragonfly transects (Nick Riddiford; Mike Wood).
3. Mammal transects (Nick Riddiford).
4. Reedbed vegetation monitoring (André Mauchamp; Carolina Encinas; Inmaculada Mateo).
5. Reedbed bird monitoring (David Hanson).
6. Systematic light trapping for moths (Nick Riddiford).

Park management

1. Abundance and distribution of *Orchis palustris* (Rachel King).

Interpretation and education

1. Plant Illustrations/Preparation of botanical interpretation material (Dinah

McLennan and Jo Newbould).

2. Bird Illustrations/Preparation of ornithological interpretation material (Mike Wood , Nick Owens and Pere Vicens).

Programme development

1. Biodiversity program development for standardised data processing and storage (Nick Riddiford; Chris Donnelly).

APPENDIX 4 - LIST OF PUBLICATIONS

Details of Project S'Albufera-generated publications are given below. Note that a single asterisk (*) prefixes publications which have appeared since the last Project S'Albufera report.

ALOMAR, G. 1995. Anotacions al Catàleg de la Flora del Parc Natural de s'Albufera de Mallorca. *Buttletí del Parc Natural de s'Albufera de Mallorca* 2: 109-110.

ALOMAR, G. 1995. Apunts sobre la flora del Parc Natural de S'Albufera de Mallorca. *S'Albufera de Mallorca: Monografies de la Soc. Hist. Nat. Balears* 4: 79-88.

*ALOMAR, G. 1997. Noves anotacions al Catàleg de la Flora del Parc Natural de s'Albufera de Mallorca (II). *Buttletí del Parc Natural de s'Albufera de Mallorca* 3: 95-96.

ANON. 1994. Conclusions de la Primera Reunió nacional sobre la Cel.la marbrenca, *Anas angustirostris*. *Buttletí del Parc Natural de s'Albufera de Mallorca* 1: 79-80.

ASSOCIACIÓ BALEAR D'AMICS DELS PARCS (ed.). 1990a. *Seguiment de l'avifauna del Parc, agost 1989-juliol 1990.* Palma.

ASSOCIACIÓ BALEAR D'AMICS DELS PARCS (ed.). 1990b. *Parc Natural de S'Albufera de Mallorca: ornithological overview, August 1989-July 1990*. Palma.

ASSOCIACIÓ BALEAR D'AMICS DELS PARCS (ed.). 1991. *Seguiment de l'avifauna del*

Parc, agost 1990-juliol 1991. Palma.
ASSOCIACIÓ BALEAR D'AMICS DELS PARCS (ed.). 1992. *Seguiment de l'avifauna del Parc, agost 1991-juliol 1992*. Palma.
BARRINGTON, R. 1993. Mediterranean secret. *Country* 94 (August 1993): 21.
*BENNASSAR TORRENDELL, P., MAS CIFRE, J. & MAS REINDERS, R. 1997. Seguiment i control de la qualitat de les aigues de s'Albufera de Mallorca. Primers resultats. *Butlletí del Parc Natural de s'Albufera de Mallorca* 3: 69-78.
BONNER, H. 1994. S'Albufera: display materials for the new Visitor Centre. *Earthwatch Europe S'Albufera Project Rep.* 5 (1993): 150.
BORDOY, M. & PERELLÓ, G. 1995. Parc Natural de s'Albufera. Base de dades bibliogràfica. *Buttletí del Parc Natural de s'Albufera de Mallorca* 2: 93-106.
*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.
BOWEY, K. 1993. Mammal Studies at the Parc Natural de S'Albufera, October 1992. *Earthwatch Europe S'Albufera Project Rep.* 4 (1992): 146-155.
BOWEY, K. 1995. Apparent female Moustached Warbler singing. *British Birds* 88: 113.
BOWEY, K. & RIDDIFORD, N. 1992. Mammal studies, 1991. *Earthwatch Europe S'Albufera Project Rep.* 3 (1991): 142-143.
CHAPMAN, M. 1996. Aquatic invertebrates and water quality at S'Albufera. *Earthwatch Europe S'Albufera Project Rep.* 7 (1995): 72-88.
*CHAPMAN, M. 1997. A Further Study of Water Quality and Aquatic Invertebrate Communities at S'Albufera, Mallorca in the Spring, Summer and Autumn of 1996. *Earthwatch Europe S'Albufera Project Rep.* 8 (1996): 69-84.
CROSS, E. 1993. Sampling of Odonata larvae and other aquatic fauna. *Earthwatch Europe S'Albufera Project Rep.* 4 (1992): 104-135.
CROSS, E. 1994. Sampling of Odonata larvae and other aquatic fauna at S'Albufera, Mallorca in October 1992. *Earthwatch Europe S'Albufera Project Rep.* 5 (1993): 76-87.
DE MANUEL, J. 1995. Aportació de la fauna de rotífers de les aigües de S'Albufera de Mallorca. *S'Albufera de Mallorca: Monografies de la Soc. Hist. Nat. Balears* 4: 113-118.
DIRECCIÓ GENERAL D'ESTRUCTURES AGRARIES I MEDI NATURAL. 1994. *Butlletí del Parc Natural de s'Albufera de Mallorca* 1. Govern Balear Consellería d'Agricultura i Pesca, Palma.
*DONNELLY, C. 1997. Further studies of the distribution of Odonata and Lepidoptera: S'Albufera 1996. *Earthwatch Europe S'Albufera Project Rep.* 8 (1996): 119-122.
DONNELLY, C. & RIDDIFORD, N. 1995. A study of roosting birds at the Parc Natural de S'Albufera, autumn 1994. *Earthwatch Europe S'Albufera Project Rep.* 6 (1994): 60-73.
*DONNELLY, C. & RIDDIFORD, N. 1997. Estudi de la importancia de s'Albufera per a la colgada d'aucells colonials a la tardor de 1994. *Butlletí del Parc Natural de s'Albufera de Mallorca* 3: 47-55.
ESTEVE-RAVENTOS, F. & ENDERLE, M. 1992. *Psathyrella halophila* spec. nov., eine neue Art aus der Sektion Spintrigerae (Fr.) Konrad & Maublanc vom Meeresstrand der Insel Mallorca (Spanien). *Zietschrift für Mykologie* 58: 205-209.
EQUIP D'EDUCACIÓ AMBIENTAL. (ed.). 1993. *Programació Didactica: Coneguem el Parc Natural de S'Albufera*. Consellería d'Agricultura i Pesca, Serveis Forestals de Balears, Palma.
FERRAGUT, M. A. 1994. L'estudi de papallones diurnes a s'Albufera. *Butlletí del Parc Natural de s'Albufera de Mallorca* 1: 49-50.

FORNOS, J. J. 1995. Enquadrament geològic, evolució estructural i sedimentologia de S'Albufera de Mallorca [Geological setting, structural evolution and sedimentology of the S'Albufera of Mallorca]. *S'Albufera de Mallorca: Monografies de la Soc. Hist. Nat. Balears* 4: 47-58.

FORTEZA, A. & PERELLÓ, G. 1995. Seguiment meteorològic al Parc Natural de s'Albufera. Estació B-605. *Butlletí del Parc Natural de s'Albufera de Mallorca* 2: 91-92.

FOX, R. J. P. 1992. *Monitoring Environmental Change at S'Albufera Parc Natural: the role of aquatic invertebrates*. M.Sc. in Conservation dissertation, University College London.

*FRITZ, U. P., LENK, J., MAYOL, J., PIEH, A. & SATTELE, B. 1997. Dades sobre l'origen de la població mallorquina de Tortuga d'aigua, *Emys orbicularis*. *Butlletí del Parc Natural de s'Albufera de Mallorca* 3: 92.

FRONTERA I SERRA, M. & FORTEZA I PONS, V. 1991. Seguiment dels efectes de la paustura al parc natural de S'Albufera de Mallorca, 1990. *Documents tecnics de Conservació* 4. SECONA, Palma de Mallorca.

*GARGALLO, G. 1997. Ageing Cetti's Warbler *Cettia cetti* by means of plumage characteristics. *Ringing & Migration* 18: 14-17.

GOATER, B. 1993. *Archanara geminipuncta*, *Phragmites australis* and Reed Buntings. *Earthwatch Europe S'Albufera Project Rep.* 4 (1992): 66-71.

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HAFNER, H. & HOFFMANN, L. 1990. *The Albufera de Alcudia (Mallorca): an assessment of the importance of this wetland for colonially nesting Ardeidae*. Station Biologique de la Tour du Valat cyclostyled report.

HAWKSWELL, S. 1992. Seminar on the computerisation of data for the management of natural areas. *Earthwatch Europe S'Albufera Project Rep.* 3 (1991): 145-146.

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

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JERMY, A. C., LONG, D., SANDS, M. J. S., STORK, N. E. & WINDSER, S. (Eds.). 1995. *Biodiversity Assessment: a guide to good practice*. Volume 1. Department of the Environment/HMSO, London, UK. [page 176]

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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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*KING, J.R. 1994. Initiation of remige moult by first-year Great Reed Warbler *Acrocephalus arundinaceus* in Europe. *Ringing & Migration* 15: 123-126.

LILLO, F. 1995. Noves aportacions a la toponimia de S'Albufera. *S'Albufera de Mallorca: Monografies de la Soc. Hist. Nat. Balears* 4: 19-38.

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Annex 1: Assessment of Functions and Socio-economic Values of Natural Ecosystems and Protected areas: Pilot Study on the Parc Natural de S'Albufera de Mallorca - Conclusions by M. Mata[1], L.G. Hein[1] and R.S. De Groot[2]

FSD working paper 9702, September 1997; Foundation for Sustainable Development, P.O. Box 570, 6700 AN, Wageningen.

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[2]Center for Environment and Climate Studies, Wageningen Agricultural University

*[**Editor's Note**: This and the following four Annexes comprise summaries or conclusions from theses and reports produced by the Wageningen Center for Environment and Climate Studies team undertaking a pilot study of the functions and values of natural ecosystems and protected areas, using the Parc Natural de S'Albufera as its model and working in close collaboration with Project S'Albufera]*

Conclusion/Discussion

1) Data-availability

One of the purposes of this pilot study was to identify the data needed to make a socio-economic valuation of the functions of protected areas, with S'Albufera NP as case study. Although it was possible to make a qualitative overview of the main functions of the study area within a relatively short period of time, the study showed that much quantitative information on environmental functions, and their socio-economic importance, is still lacking. Only for the function tourism, a first estimation of the economic value was made.

For the other functions, extrapolations from literature were made, and it is indicated what data is needed to carry out future socio-economic valuations.

These recommendations were used as input into the outline for a Handbook of Function Evaluation (Hein & de Groot 1997), and to advise the Park management and EARTHWATCH to improve future data-collection and environmental monitoring in the Park. It is also intended to use this report for the development of a proposal for more detailed research on the functions and socio-economic values of S'Albufera NP.

2) Handbook on Function Evaluation of natural areas

A second aim of this study was to use S'Albufera as case study to contribute to the development of a practical handbook for the ecological and socio-economic evaluation of natural ecosystems/protected areas. The study provided much useful information, also because of the involvement of several students. Based on these experiences, a first draft for such a handbook is described in a separate report (Hein & de Groot). Important elements or steps in such an evaluation procedure are:

a. description of the main environmental characteristics (state variables) that are relevant to the function-performance
b. description of the main functions and maximum sustainable use levels (sustainability indicators)
c. description of the socio-economic value of each function, including a list of socio-economic indicators and methods for their monetary valuation.

For each of these steps, guidelines are given below how to collect the relevant information.

3) Participation of EARTHWARCH Volunteers

An important aspect of data-collection for function-analysis is the need for long-term time-series on various environmental aspects. EARTHWATCH is active in S'Albufera for many years already, and based on the experiences of this pilot study, a protocol could be written how Volunteers could be involved in the data-collection and monitoring of the main environmental functions of the S'Albufera ecosystems.

4) Conflict analysis

As a "spin-off" of an integrated analysis of the functions and socio-economic benefits of a given natural/protected area, it is possible to obtain insight in the main (potential) conflicts relating to the use of these functions. These conflicts may relate to the overuse of a certain function, or to the incompatibility of the simultaneous use of several functions at the same time or place (or both). Some of these (potential) conflicts are briefly listed in Appendix IV; they are not discussed in detail because that was not the main purpose of this study. It should be seen as a checklist of issues that could (and maybe should) be addressed by further studies.

Reference

Hein, L. G. and de Groot, R. S. 1997. *Outline of a Handbook to Evaluate the Functions and Socio-economic Benefits of Natural Ecosystems*. FSD report No. 9702.

Annex 2: Towards a manual for the practical application of the environmental function assessment: a case study of Natural Park S'Albufera de Mallorca - final comments by Sas Terpstra

Wageningen Center for Environment & Climate Studies, Wageningen Agricultural University

*[**Editor's Note**: single chapter extract from full report - see Editor's note at head of Annex 1; for references in this Annex, see Appendix 4 of this report]*

Chapter 7: Final Comments

7.1 Introduction

A manual as referred to in the title of this report ("Towards a manual for the practical application of the environmental function assessment") has not been accomplished. The gap between the theory of EFA and the use of available information is too big. Therefore "towards" in the title should be emphasised. At this stage the practical use of the environmental function assessment is strongly dependent on the availability of information that is available for implementation.

However, the report contains some more information which will help to finally realise this manual. I will finish the report by discussing the objectives that were mentioned in the introduction (chapter 1).

7.2 Environmental Function Assessment

I think the environmental function assessment could be a good framework for more research in S'Albufera. The approach to assess environmental functions can be used to analyse and monitor the ecosystem functioning of S'Albufera de Mallorca. Once functions have been

described and their representative characteristics in the field have been distinguished, the approach can support quantitative studies on the qualities of the ecosystem. The functions as described in the methodology are easily understandable and describe qualities of an ecosystem in a quantitative way. The condition of an ecosystem (its functioning) should be predictable from the status of the state of variables and processes connecting them. The holistic approach is required to be able to understand the relationships between social demands and the capacity of the ecosystem to satisfy them.

7.3 Digital data

During my stay at Mallorca it became clear that digital data for implementation in a Geographical Information System was hardly available. At SECONA, the department of the Balearic Government, there is an employee digitizing the information of all Mallorca. Data on S'Albufera are scarce and not the kind that can directly be used for implementation in the environmental function assessment. Digital maps like figure 3.6 in this report are produced by the department. However, the data available provides for a basis (there is a digital map of S'Albufera) and could be useful for further work-out. The GIS-department of the Balearic University in Palma de Mallorca was very friendly and seemed to be enthusiastic to focus on S'Albufera. Contacts with the department should be maintained by the Wageningen Center for Environment and Climate Studies, by the research group of Earthwatch Europe and the Natural Park S'Albufera de Mallorca.

7.4 Research

Intentionally the S'Albufera project was proposed as an example for monitoring changes in ecosystems, also in relation to climatic and environmental changes. The data that have been gathered over the last five years can be used to deepen knowledge of the monitoring for climatic and environmental change. More international and interscientific collaboration can support a better understanding of ecological processes in wetland ecosystems like S'Albufera. I think collaboration with the university in Palma is very important. Working together could mean a greater insight in research to be done and of course more expertise in different fields. Those GIS can help to analyse the functioning of the ecosystem and its relationship with the surroundings. Once the ecosystem is known better the conservation and management of Natural Parc S'Albufera de Mallorca can be supported.

I did not succeed in developing a programme to measure and monitor variables in the field for assessing the environmental functions of S'Albufera. The habitat survey as reported by Hawkswell (1994) is very useful. In a preliminary research I tried to make a further division in the habitats present in S'Albufera. Especially the swamp areas should be worked out more fully. Interesting differences between the reedbeds *(Phragmites),* the vegetation types with *Cladium* and the other habitat types in the swamp areas could make more clear about ecosystem functions. Suggestions for this research have been done in this report (paragraph 6.2.2). Based on the preliminary results and observations in the field, there is good hope for further division in habitats. Data derived from aerial photographs and/or remote sensing images of recent years would be of great advantage for this type of research. This is also a reason for enlarging the collaboration with universities and other organisations; the knowledge of the functioning of the ecosystem increases with accumulated data, studies and materials.

Within the framework of the environment function assessment I would recommend to focus more on the direct characteristics of the different habitats in S'Albufera. Biophysical characteristics represent in a way the qualities of an ecosystem (see also my thesis report: Terpstra, 1996). Especially hydrology is of extreme importance to S'Albufera. Most ecological processes in the wetland are directly depending on the characteristics of the area. Not only water quantity but also water quality influence the rate and extent in which processes perform and set limits to the presence of different species. The measurements of the water quantity (stream velocity and water depth) and water quality (both chemical and biological) are very useful. Additional measurement of nutrient concentrations throughout the ecosystem could help to understand more of the ecosystem functioning and the effects of external land uses. The suggestion to measure the concentration of phosphates and nitrates is also done in the MedWet report (Tomas, 1996), so I think it may be really necessary. Also other recommendations done by Riddiford & Mayol in the MedWet report (Tomas, 1996), are very interesting and can directly be related to the methodology as proposed in the environmental function assessment. The manual for practical application of the environmental function assessment could be illustrated by using practical measurement methods as proposed in the MedWet report.

Annex 3: Towards the operationalization of the environmental function assessment in a GIS-application: a case study of Natural Park S'Albufera de Mallorca - summary by Sas Terpstra

Wageningen Center for Environment & Climate Studies; Wageningen Center for Geographical Information Systems and Remote Sensing, Wageningen Agricultural University

*[**Editor's Note**: summary from full report - see Editor's note at head of Annex 1]*

Summary

This report aims at the operationalization of a methodology to analyse functions and values of the natural environment. This methodology is described by Dr. R. S. De Groot in his book "Functions of Nature" (1990). In this report the methodology will be referred to as the Environmental Function Assessment (EFA).

The environmental function assessment is developed to analyse functions and values of the natural environment. To identify - and possibly quantify - the most important environmental characteristics and processes that link change in the ecosystem-structure to change in its functioning and vice versa, is the main aim of this thesis.

Environmental functions of the studied ecosystem can be described, but the translation into measurable variables that can be observed in the field is more difficult and time consuming. Therefore the most obvious variables have been worked out for some regulation functions. The available data have been used to distract information on the performance of environmental functions in the study area.

After the functions and their characteristics have been distinguished, a Geographical Information System could be helpful in storing and handling the data. However, the complexity and scale of environmental processes are too huge to define a metaphysical model

of the ecosystem. Therefore implementation in a GIS-model to analyse environmental functions of the studies ecosystem has not been realised. The modelling of the approach in its current form is not feasible.

Therefore further completion of the theory of environmental function assessment by studying more areas - or the same area more intensively - is recommended. As a result of various studies a basis could be accomplished to develop a manual for the practical application of the environmental function assessment.

Eventually the method may lead to a quick and nearly complete analysis of the ecosystem and its functioning. To consider an ecosystem as a gathering of functional relationships, will create a framework by which land-use planners and decision-makers can easily define their goals and analyse the ecosystem in its different aspects. Therefore the environmental function assessment is an important tool for research and decision-making.

Annex 4: Modelling the potential conflicts between Biodiversity Conservation and Water Quality Regulation in S'Albufera Natural Park, Mallorca - summary by J. P. Van der Perk

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*[**Editor's Note**: summary from full report - see Editor's note at head of Annex 1]*

Summary

This research focuses on the potential conflicts between two main environmental functions of the coastal wetland S'Albufera Natural Park, Mallorca. These functions are 'Maintenance of the Park's biodiversity' and 'Regulation of water dynamics (quantitative: freshwater conservation, as well as qualitative: nutrient recycling)'.

In the S'Albufera wetland, an interesting cycle is occurring related to a vegetation growth pattern and changing flora composition (*Phragmites* and *Cladium*). This cycle provides a vegetation mosaic in the landscape with *Phragmites, Cladium* and open water areas, resulting in high habitat diversity and biodiversity.

Intensive and polluting land-use in the catchment area, around the wetland, might disturb the wetland ecosystem by eutrophication (nitrates mainly from agriculture and phosphates mainly from domestic effluents) and salinization (fresh groundwater extraction lowering the fresh groundwater table, enabling brackish/salt water to enter the surface and sub-surface of S'Albufera.

Based on the functions-of-nature approach, the potential conflicts are analysed. The main potential conflicts between the desired environmental conditions for maximum freshwater conservation, optimal nutrient recycling versus a high biodiversity are identified. The maintenance of the dynamic vegetation growth cycle, with a diversity of habitats (including older structured reedbeds, open waters, flora diversity, minimal salinization and

eutrophication) is in conflict with an eutrophic helophytes mono-vegetation, with a maximum groundcover, high stem density, maximum storage of freshwater and maximum nutrient uptake capacity.

These potential conflicts between both functions can be monitored in the field by means of bio-indicators. These should be bio-indicators indicating both functions. Such a species should respond to a change in biodiversity (as an important food resource in the food chain) and react (population dynamics) to eutrophication and salinization in its natural habitat. It seems to be that the amphibian *Rana perezi* and a number of aquatic invertebrates can be used as function-integrating bio-indicators.

An increasing nutrient load in the surface water and groundwater, in combination with the effect of salinization, might change the structure and density of the *Phragmites-Cladium* vegetation, to the benefit of *Phragmites*. This species will probably dominate the vegetation and expand in ground cover, height and stem density, resulting in less open water and a uniform vegetation with less habitats for the corresponding fauna-species.

Little quantitative modelling is done, because of the lack of accurate data concerning the water balance of S'Albufera, the hydrology of the catchment area and nutrients entering, passing and accumulating in the wetland. An indication of the theoretical nutrient load from the catchment area entering S'Albufera varies for nitrogen between 230 and 850 (mean value 540) tons/year and for phosphorus between 20 and 60 (mean value 40) tons/year. The recycling of nitrogen in the wetland takes place by helophytes and denitrification. Phosphorus is only partly recycled by helophytes, sedimentation and absorption. The actual nutrients recycling capacity of S'Albufera is not known.

For future management it should become clear whether the environmental functions in this research can be combined (integrated) in the Park itself without the loss of biodiversity, nutrient recycling capacity and freshwater supply, or whether functions should be separated. In the second case, the size of a helophytes buffering zone should be between 120 and 340 ha (that is 7 to 20% of the present area of S'Albufera). This zone also increases the storage capacity of freshwater.

For future research in the Park it is recommended to monitor the nutrient dynamics and bio-indicators representing both functions. Transects across the Park, according to the gradients of nitrate-, phosphate-, chloride-content and vegetation composition, can be used to combine research on changing biodiversity due to eutrophication and salinization.

Annex 5: Biodiversity conservation in S'Albufera Natural Park: an analysis of main relevant functions, (potential) land-use conflicts and related policies - summary by Carolien Borggreve

Wageningen Agricultural University

*[**Editor's Note**: summary from full report - see Editor's note at head of Annex 1]*

Summary

The aim of this study was to analyse the importance of the biodiversity conservation at S'Albufera Natural Park, Mallorca (Spain), to analyse the main associated environmental conditions and to analyse (potential) land-use conflicts. Information was obtained from literature and from some interviews.

S'Albufera Natural Park is a coastal wetland of 1708.75 hectares in northeast Mallorca. The area is surrounded by the sea, tourist urbanisation and agricultural land. The area is under protection since 1988.

The research questions are:

- What is the importance of the park for biodiversity conservation?
- Which conditions in the park are of importance for biodiversity conservation?
- Which environmental conditions around the park influence biodiversity conservation in the park?
- What are the policies for biodiversity conservation at regional (Balearic Islands), national (Spain) and international (Europe) level?

The site is important for many species. The importance of biodiversity was identified by investigating a number of species which are dependent on S'Albufera Natural Park. Species numbers of *Acrocephalus melanopogon* (Moustached Warbler), *Ardea purpurea* (Purple Heron), *Circus aeruginosus* (Marsh Harrier) and *Ixobrychus minutus* (Little Bittern) exceed criteria by the EEC or Ramsar for the assignment of an internationally important area. Apart from these bird species this research focuses on the birds *Oxyura leucocephala* (White-headed Duck) and *Porphyrio porphyrio* (Purple Gallinule), on the bats *Barbastella*

barbastellus (Barbastelle), *Rhinolophus hipposideros* (Lesser Horseshoe Bat) and on *Orchis laxiflora* (Loose-flowered Orchid). Some important conditions that influence the presence of these species in the park were investigated. Most species use reedbeds as habitat. Many of the species are favoured by high stem density of the vegetation, a certain amount of open water and by fresh water.

A great part of the area around the park is being used by agriculture. Run-off of nutrients into the park influences water quality. Nothing is known about the amount of fertilisers used in agriculture, and also the amount of nutrients entering the park is not known. At this time it cannot be said if the amounts exceed the maximum level that can be taken up by reedbeds. So nothing can be said about the influence of nutrients flowing from agricultural land on the vegetation.

Although there were no quantitative data available on the influence of agriculture on species inside the park, conflicts between farmers and park authorities exist. These are caused by different view-points about for instance acceptable water table levels and the control of run-off into the park of fertilisers and toxic chemicals.

A lot of the Spanish wetland area has already been lost. The functional types that can be found in Spanish wetlands are unique among the West European water bodies. These wetlands should be conserved because they house many rare or endangered plant and animal species. There was no information found on policy on biodiversity conservation of the Balearic government. Probably some kind of policy on this subject exists.

Europe does not have a wetland policy as such, but some of the environmental Directives imply objectives which aim to stimulate wetland conservation.

Annex 6: Project S'Albufera research proposal for 1998-2000 by Nick Riddiford and Michelle Chapman

Project Title: Mediterranean Biodiversity; the S'Albufera, Mallorca, Model
Research Site: S'Albufera Natural Park, Mallorca, Spain

Abstract of Proposal

S'Albufera de Mallorca is a large area of wetland and coastal dunes and a high quality, protected representative of two of the Mediterranean Basin's most endangered and dwindling ecosystems. These ecosystems at S'Albufera not only contain their own biological interest but host many rare and endemic animals and plants, while the wetland serves as a wintering site for many waterfowl from further north in Europe and as staging posts for birds migrating between Europe and Africa. S'Albufera is internationally famous, attracting large numbers of birdwatchers, naturalists and other visitors from throughout Europe and beyond. Yet local conservation organizations only managed to save the site from development as recently as 1988, when S'Albufera was declared a Natural Park and special interpretive facilities established to forward conservation education. The Earthwatch S'Albufera project began in 1989 to provide a scientific base for interpretation and education while using the site to set up an international programme for the study of Environmental Change and Biodiversity.

The goals of the project are to survey and evaluate the biodiversity, functions and values of S'Albufera ecosystems in order to:

1. obtain detailed ecological data to reach an understanding of composition, functioning and dynamics of the ecosystems;
2. develop monitoring programmes which detect types and rates of environmental change;
3. afford material for application in further research and reserve management at S'Albufera and in general conservation practice;
4. provide information and resources for interpretive programmes;
5. serve as a focus for education of residents and visitors of all age-groups and levels and to help in creating environmental awareness and commitment;
6. provide information and advice to other programmes or sites, to include the development of models and databases.

Fieldwork comprises monitoring, survey and research into aspects of the physical environment, water regime, plant species distribution, invertebrate diversity, vertebrate populations, socio-economic impacts, management activities and results, and visitor use of the Park. Great store is placed on developing cost- effective field methodologies which can be applied elsewhere in the Mediterranean.

Volunteers take part in all the survey tasks, and contribute to seminars. Without the volunteer input this interdisciplinary research programme would not be feasible nor carried out.

Research Plan

1. The Project

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 and staging posts for migratory birds. Throughout the Mediterranean, coastal sand-dunes are also under enormous pressure. The Albufera wetland has been recognised as internationally important since the MAR list of 1965. 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. 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 1700 ha natural reserve by the Balearic and Spanish government conservation agencies.

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. 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. 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.

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 unrivaled 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 to act as a model for similar sites throughout the region and beyond.

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. We have already achieved a great deal but there is much still to be done and these remain the major focus and goals of our Project.

2. Research Objectives

The research objectives fall into three categories:

1. Biodiversity

- Objective: to establish a Biodiversity Model which includes detailed ecological data to reach an understanding of composition, functioning and dynamics of the ecosystems.

2. Environmental Change

- Objective: to develop and activate a programme to provide standardised comparative data for evidence of environmental change.

3. Spin-off

It was realised from the start that the considerable information amassed by scientists from different disciplines and EarthCorps volunteers working together had a number of additional applications and uses. Thus, the following additional objectives were identified:

- Objective: to afford material for application in further research and reserve management at S'Albufera and in general conservation practice.
- Objective: to provide resources for comprehensive interpretive programmes and dissemination in all appropriate forms.
- Objective: to serve as a focus for education of residents and visitors of all age-groups and levels and to help in creating environmental awareness and commitment.

The research objectives are based on a series of steps which have already been taken, but are constantly changing and in need of amplification and review. These are:

i) establishment of a baseline from which to achieve the Project goals;
ii) use of that baseline to identify impacts on the Park and its ecosystems;
iii) extend Biodiversity knowledge towards an understanding of the role of species, communities, habitats and impacts in relation to ecosystem functioning;
iv) evaluate and set priorities for the achievement of Project goals;
v) undertake research based on these priorities;
vi) disseminate results in all appropriate forms.

Following baseline studies, mainly completed in 1989-91, we were able to establish the main problems or issues. Impacts which required monitoring included alterations to the water regime, physical/biological alterations affecting the ecosystem, and the impact of tourist and agricultural developments and activities adjacent to the Park. Other issues of unknown but potential impact were the effect of climate change on sea levels, and the potential for pollution from a coal-fired power station adjacent to the Park. Public use within the Park and management activities were also identified as issues, whose impacts could be as much beneficial as negative or neutral. To tackle these issues, a series of priority steps were identified and introduced. They were devised to target information about Biodiversity as well as to assess impacts related to environmental change. The steps were:

1. multi-disciplinary study of processes affecting or dependent on -
    i) the *Phragmites* and *Cladium* dominated wetland ecosystem,
    ii) the hydrological system,
    iii) the dune systems,
    iv) the whole catchment of the Park and adjoining coastal waters;
2. the impact of management and related studies;
3. environmental and socio-economic studies;
4. data-processing and development of the database potential and methodology, including in the light of its wider applicability;
5. long-term monitoring aimed at assessing and advising on environmental change;
6. extension of Biodiversity information, including to groups and areas not fully studied or understood.

These steps have been taken and research over the next three years will concentrate on maintaining the on-going monitoring programme, amplifying our knowledge of elements of the study of processes, and further development of the Biodiversity database and model. The key aim in all this work continues to be that the results, full and interim, are disseminated quickly - particularly to the Park Directorate and Balearic Government conservation agency which put such store on the information. This is achieved by a series of detailed annual reports, numerous publications, cooperation with and integration of Park staff in project activities and each-way feedback between Park staff, scientists and organisers of other programmes during frequent formal and informal consultations.

Some of the spin-offs from the research have been:

i) discovery of what is there, i.e. detailed taxonomic studies;
ii) increased understanding of the interrelationships between species;
iii) identification of species which form links with other wetlands or dunes in the Mediterranean;
iv) understanding the effects of management on the wetland;
v) provision of a range of materials and information for use in educational and interpretive programmes developed for local people, schools and the large number of tourists who visit the island;
vi) training programmes for Spanish and African ecologists;

vii) dissemination of knowledge and advice to other Mediterranean sites, particularly wetlands.

3. Methods

In eight years, the project has undertaken a plethora of studies, employing a diverse suite of methods. When more sophisticated data collection techniques are used, these are done under close supervision of the scientists involved. However, wherever possible, and particularly in our monitoring work, we largely use simple, cost-effective recording techniques. Simple methods can be among the most effective: as Darwin showed, careful observation is often more useful than modern electron microscopy. Cost-effectiveness is a key issue in the Mediterranean where field conservation and research is often hampered by financial deprivations. Some of the most regular used methods, and ones we shall be employing in 1998, are outlined below.

1. Vegetation and Flora studies:
    i) dune transects - identifying and measuring height of plants at 10 cm intervals along fixed transect lines set perpendicular to beach;
    ii) vegetation repopulation after fire - identifying and recording percentage cover for all plant species within a series of random one-metre quadrats with an area of recent fire (1994) and within an unaffected "control" area.
    iii) the survival and mortality of plants - recording the location of individual orchid and other plant species within permanent quadrats by running tapes from two fixed points (corners of the quadrat). Each plant is located by a set of "coordinates" corresponding to its distance from the two corners as measured by the tapes.
    iv) a collection of named, pressed plants (herbarium) has been established for reference, and further specimens will be added to make it as comprehensive as possible.

2. Hydrology and Water Quality: every fortnight the Park staff visit specific sites to take measurements of surface water levels, as well as the conductivity, oxygen content, temperature and pH of the water; and further information is collected by the University of the Balearic Islands' limnology department regarding pollutants and nutrient run-off from agricultural land. Volunteers will assist with these collections or collect additional information, e.g. by recording fluctuations in sea levels or aquatic plant distributions in relation to water quality.

3. Aquatic invertebrates and water quality: samples of invertebrates will be obtained, using simple, standard, repeatable techniques, from those sites sampled for water quality; to identify species and/or species communities which may be useful indicators of water quality range.

4. Land invertebrates: population dynamics of butterflies and dragonflies will be assessed by walking fixed routes through well-defined habitat types and identifying and counting all individuals within 5 metres of the route. Sampling of other invertebrates, particularly moths, will be done using ultra violet light traps; and other trapping techniques, including "water traps" for Diptera and Hymenoptera and netting by hand, will be employed to increase our knowledge of biodiversity, relate abundance and distribution to habitat and add to our growing on-site reference of named specimens, begun in 1990.

5. Birds: population dynamics of birds will be assessed by walking fixed routes through well-defined habitat types and identifying and counting all individuals within 25 metres of the route. The "fitness" of migrant and resident bird species will be measured by recording fat deposition levels and pectoral muscle size of birds mist-netted for banding.

6. Mammals: reedbed utilisation and niche partitioning by small mammals will be assessed by baiting live traps set in a grid pattern, at ground level and in the higher vegetation of the reedbed.

7. Visitor impacts: assessment of the level and rates of erosion occurring along the forward edge of the coastal dunes will be made using a combination of photographic recording from a series of fixed points and field measurements of beach width and erosion profile.

8. Data management: the project database will be continuously updated by the addition of newly gathered and historical data to the computer's database and spreadsheet programs.

4. Application of results

Project results have already contributed to a number of issues and developments in the fields of biodiversity studies, international collaborations, Park management, Balearic conservation policy, education, provision of materials, ecological training and green tourism.

Biodiversity studies

Biodiversity studies have revealed the importance of S'Albufera for taxa from a wide range of groups. Discoveries include two previously unknown species of fly (Raffone 1994 and in prep.), an undescribed fungus (Esteve-Raventos & Enderle 1992) and a wealth of threatened or undangered species [examples: the rare dragonfly *Selysiothemis nigra* (Riddiford & Mayol 1997); the moth *Pelosia plumosa* previously known from a handful of specimens at localities in Spain, Italy and North Africa but abundant at S'Albufera (Goater 1994); the West African moth *Areopteron ecphaea* only known in Europe from one in Greece in 1990 until the May 1997 discovery in the Park (D. Agassiz, in litt.) ; Petalwort, *Petalophyllum ralfsii*, listed in Appendix I of the Berne Convention and Annex II of the European Commission Habitats Directive as a threatened species (Stern 1997); a raft of threatened bird species, including a strong colony of purple heron and the highest known density of moustached warblers in the World (Taylor 1993)]. Whenever a specialist is invited to participate in the Project, exciting

discoveries are made in that person's particular field of expertise. Studies have already been conducted on the ecological and management requirements of some these special species (e.g. Taylor 1993, 1994).

In 1994 a review was made of all the faunal and floral information for the Park and the result was presented to the World Conservation Monitoring Centre (Cambridge, England) as a first step towards establishing S'Albufera as a World Biodiversity Model site. Description of this model has recently been published in the first volume of the UK Government's review document Biodiversity Assessment, a Guide to Good Practice (Riddiford 1995 in Jermy et al. 1995). Application of the model has led to a number of research studies to investigate the composition, functioning and dynamics of the ecosystems, by addressing the relationships between species, species communities and physical aspects of their immediate environment (e.g. Newbould, P. 1994, 1995; Strachan 1995; Chapman 1996; Donnelly & Riddiford 1997; Owens & Vicens 1997).

International collaborations

At the international level, partnerships have been forged with the Royal Holloway Institute for Environmental Research (RHIER), University of London, UK, with the University of Aberdeen's Centre for Remote Sensing and Mapping Science, Scotland and with the Center for Environment and Climate Studies, Wageningen Agricultural University, Holland. Director of RHIER, Professor Ed Maltby, sent one of his team to undertake a pilot study into soil nutrient dynamics with the view of extending it to a full-scale research study. Aberdeen's Centre for Remote Sensing and Mapping Science have undertaken a series of remote sensing studies (Jurado Estevez 1992; Marcus 1992; Gonzalez 1993; McGovern 1993). Dr Dolf de Groot, director of the Center for Environment and Climate Studies, was persuaded by the information and facilities available to use S'Albufera as a model for his own field of study - the functions and values of environmental sites (De Groot 1992). This began in October 1995 as a pilot study into the functions and socio-economic values of natural ecosystems and protected areas, using S'Albufera as the model (Mata 1996, 1997). It was subsequently expanded to include biodiversity studies (Borggreve 1997), a GIS study of the functions of S'Albufera's wetland ecosystem as a tool for ecosystem evaluation for land use planning (Terpstra 1996a & 1996c), and the preparation of a manual on ecosystem valuation, including assignments, based on S'Albufera - to be used as a model internationally (Mata, Hein & De Groot 1997; Terpstra 1996b; Van der Perk 1997).

Whenever limits on time or resources prevented the Project from delving more deeply into research issues which nevertheless needed investigation, efforts were made to locate Universities or Institutes with expertise in those fields. This has led to a number of ventures and a number of useful reference works, particularly with University College London Ecology and Conservation Unit, in the form of research dissertations (Howe 1989, Fox 1992, Taylor 1993). Close links have been forged too, with the University of the Balearic Islands, particularly the Departments of Geography (hydrology; dune studies) and Biology (sub-departments of limnology and vegetal physiology). Other collaborations have been with the Balearic Institute of Advanced Studies and Balearic Invertebrate Group (entomology, e.g. Palmer & Vives 1993; Pons 1993), Wilhelma Zoological-Botanical Garden, Stuttgart, Germany (pond terrapin studies, Fritz *et al*. 1997), Tour du Valat Biological Station,

Camargue, France (herons & egrets, Hafner & Hoffmann 1990; reedbed monitoring) and, of course, closely with the Park directorate and staff. Project scientists also collaborated with members of the Balearic Natural History Society in the preparation of the publication "S'Albufera", making contributions to several chapters of this Society Monograph (Martinez Taberner & Mayol Serra 1995).

To complete the list of cooperative ventures, Project scientists and Park staff worked closely with MedWet in both 1995 and 1996, in the preparation of a methodological guide to monitoring Mediterreanean wetland,s which appeared in June 1996 (Tomas Vives 1996). MedWet is a coordinated action programme for Mediterranean wetlands undertaken by a partnership comprising the government conservation bodies of five Mediterranean member countries of the European Union, the Ramsar Convention and a number of non-governmental organisations. The guide was part of the work of the MedWet sub-project on Inventory and Monitoring in the Mediterranean, under the auspices of Wetlands International and the Portuguese government nature conservation institute, Instituto da Conservacao da Natureza (ICN). The guide advises on and demonstrates the steps to be taken in preparing and applying a well-planned monitoring programme. S'Albufera input included a paper outlining monitoring priorities at S'Albufera (Riddiford & Mayol 1996) and substantial advice and consultation for the entire guide, particularly regarding practical matters. The participation of Project Principal Investigator, Nick Riddiford, extended to the role of scientific editor for the guide, which was planned and produced by Pere Tomas Vives of MedWet (formerly a Project participant and Park staff member).

EarthCorps volunteers have played an active part in developing programs and collecting data for these researchers, including working with and alongside them in the field.

Park Management and Balearic Conservation Policy

Much of the information gained from study of the processes at work in the ecosystem has direct relevance to conservation management at S'Albufera, and more widely. Typical examples of Project studies which have been established to monitor the success of management, or to provide the information required by Park staff to assist or refine current management planning, are those designed to monitor the impact of grazing by the domestic animals used as a management tool. Studies include coordinate mapping, permanent quadrat and census studies of orchids and other key plant populations (Wells 1992, 1993; Newbould, J. 1994); and distribution mapping of key bird and invertebrate species and groups in relation to vegetation structure and management (Owens 1997; Owens & Vicens 1997; Donnelly 1997; Donnelly & Riddiford 1997). In addition, studies have been developed in parallel with the Park's water chemistry monitoring programme to assess aquatic invertebrate communities in relation to water quality (Fox 1992; Chapman 1996 & in prep.); and the role of dominant reedbed plants as primary producers in zones of disparate salinity (Newbould, P. 1994, 1995). These studies are already assisting Park management planning and leading to a greater understanding of the relationship between communities and water quality. From the start, a major objective of these studies has been to develop cost-effective methodologies which can be adopted at other Mediterranean wetlands where chemical data are not directly available. The studies also demonstrate the importance of water quality in maintaining and enhancing biodiversity in aquatic habitats generally.

Other studies, which have the dual purpose of monitoring change and collecting information for use in management planning, have been in response to "impacts" having a marked effect on the Park environment. These include studies of sand-dune vegetation recovery after fire (Riddiford & Zas 1996); the impact on vegetation structure following an exceptional hailstorm which uprooted trees and flattened much of the reedbed (Wood in prep.); a survey and investigation into the health of the Park's white poplar *Populus alba* population, which showed severe signs of stress after two exceptionally dry years (Riddiford & Chalupa 1997); and the impact of tourist-related coastal erosion on pioneer vegetation and the internationally important Prickly Juniper *Juniperus oxycedrus macrocarpa* population - which is a major force in consolidating the first line of dune (Riddiford in prep.).

Results are presented quickly, both verbally and in report form, to the Balearic government conservation agency and Park directorate. Results are presented in a non-contentious manner. Results are always accompanied by recommendations or guidelines but the Project does not take a political view and relies on the Balearic conservation bodies to act on the scientifically-based recommendations.

The most important recent development has been the participation of Project S'Albufera in the consultation process for the Park's second management plan, covering the years 1998-2002. This was at the invitation of the Balearic government's Director of Conservation, Joan Mayol. The consultation process involved the entire Project scientific team and we were able to submit a series of comments and recommendations based on our observations, studies and results. These issues have been heavily incorporated into the draft plan.

Education, provision of materials, ecological training

As the Project information base has grown, it has increasingly become involved in interpretation initiatives. In 1993 it contributed substantially to the new Park information centre, scientists provided information, text and photographs while several EarthCorps volunteers assisted with the preparation of models and other display materials (cf. Bonner 1994). More recently (1995), the Project was heavily involved in the preparation of a CD-ROM disk, produced by the University of the Balearic Islands and funded by the Balearic Education Department. The object of the work was to produce a CD-ROM which would interpret all aspects of the Park for Balearic schoolchildren through a combination of sound, pictures and text. Project involvement included preparation of texts for common or notable plants and invertebrates and provision of photographs to illustrate the chosen taxa. Copies of the CD-ROM have been distributed to every school in the Balearic Islands, and is also available in the Park reception centre for use by visitors to the Park. The next major project is a guide to the Park's common and important wayside plants. The aim is to produce a small book which will help all visitors (tourists, schools and the local community) to understand and appreciate the flowers they see as they walk round the Park. The guide is being prepared by the Project's botanical team of Jo Newbould and Dinah McLennan. Artist/Illustrator, Dr McLennan is also producing a series of posters of Park habitats, the first of which (freshwater marsh) was so popular that it is already out of print!

The Project has, from the start, sponsored young Balearic and Spanish 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; Government teacher-naturalists; University tutors; 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 from 1995 involves British and European teachers who are recipients of Glaxo Wellcome and ARCO Chemical Awards, sponsored by those companies. One of the most important developments, 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, who have provided additional material, seminars, organized activities and information. This gives the Fellows the opportunity to gain an insight into conservation and the environment in the 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. 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. Course members so far have been drawn from Cameroon (6), Kenya (5), Uganda and Ecuatorial Guinea.

Green Tourism

S'Albufera is adjacent to a rapidly growing tourist zone, and large numbers (over 100,000 per annum) visit the Park. In 1993, the European Union commissioned a report, based on the expertise gained by the Project team, for the European Community Model of Sustainable Tourism (ECOMOST Project, DGXXIII) entitled Ecotourism in Mallorca (Nicholson & Riddiford 1993). The document, published and guided by Earthwatch Europe, encompassed aspects of ecotourism for the whole of Mallorca. Information about the perceptions and aspirations of visitors to the Park has been gathered through a series of Public Use interview and census studies (e.g. Meissner 1997), which were made possible by the considerable participation of EarthCorps volunteers.

5. Concluding Summary

Project S'Albufera continues to address its goals and disseminate its results in a practical manner. The invitation to provide practical advice for MedWet's methodological guide to monitoring Mediterranean wetlands was seen as recognition of the endeavours and experience of the Project's first six years and it was gratifying that Project scientists were able to work together with the Park directorate and staff to prepare that advice. The Parc Natural de S'Albufera has become an international focus in the fields of monitoring and biodiversity studies. This is amply demonstrated by cooperative ventures with European research institutes, and by the application of Project research to training programmes, both locally and at the international level. The work of Project S'Albufera, its role as a resource for the wise management of a rich natural area, and the cooperation and support received by the Balearic Conservation Service and Park staff have created a model for protected sites world-wide. This was summed up by an African Fellow who wrote "It was noteworthy that S'Albufera staff carries out ecological research on a regular basis, results of which Earthwatch Project S'Albufera uses to complement her more methodic and standard but periodic researches. I greatly appreciated the harmonious working of this system and I think I should investigate into ways we can adapt it to our own purposes here in Cameroon" (Monya 1995).

*[**Editor's note**: For **References** cited in Annex 6, see Appendix 4 of this report]*

Annex 7: Public use of the Es Comu beach, Parc Natural de S'Albufera, August 1997 by Julia Passman and Amanda Spurr

Introduction

In August 1997, as part of an ongoing study of erosion along the interface between the Es Comu coastal dunes and beach, we organised an all-day survey of public use. The objective was to investigate the relationship between human density on the beach and distance from hotels and Es Comu picnic area car park.

Method

A beach survey was completed every two hours from 0800 to 2000 hours on Saturday 23rd August and Wednesday 27th August 1997. The beach was divided into sections of approximately 100 m (based on distances of 100 paces) and counts made in each of people sitting/stationary on the beach, walking on the beach and in the sea. The start point for the survey was the final (northernmost) hotel at the Ca'n Picafort end of Bahia de Alcudia and the finish point the northern (Playa de Muro) end of the Es Comu section of beach (i.e. northern end of the Parc Natural section). In addition, people and cars were counted during the same two hour periods in the designated picnic area within the Es Comu dunes.

Result

The survey showed that population pressure was highest nearest to the hotels at either end of the beach and most adjacent to the car park. The "busiest" period was between 1200 and 1400 hours with numbers increasing dramatically at the beach and in the car park.

The 2000 hours survey showed a large decrease in density on the beach and in the car park. Lower numbers were recorded in the mid-week survey than in the Saturday survey.

Conclusion

The highest human densities were at each end of the beach (and closest to the hotels) and that part of the beach immediately accessible from the picnic car park. Numbers declined markedly with distance from those areas. This is illustrated graphically in Figure 1.

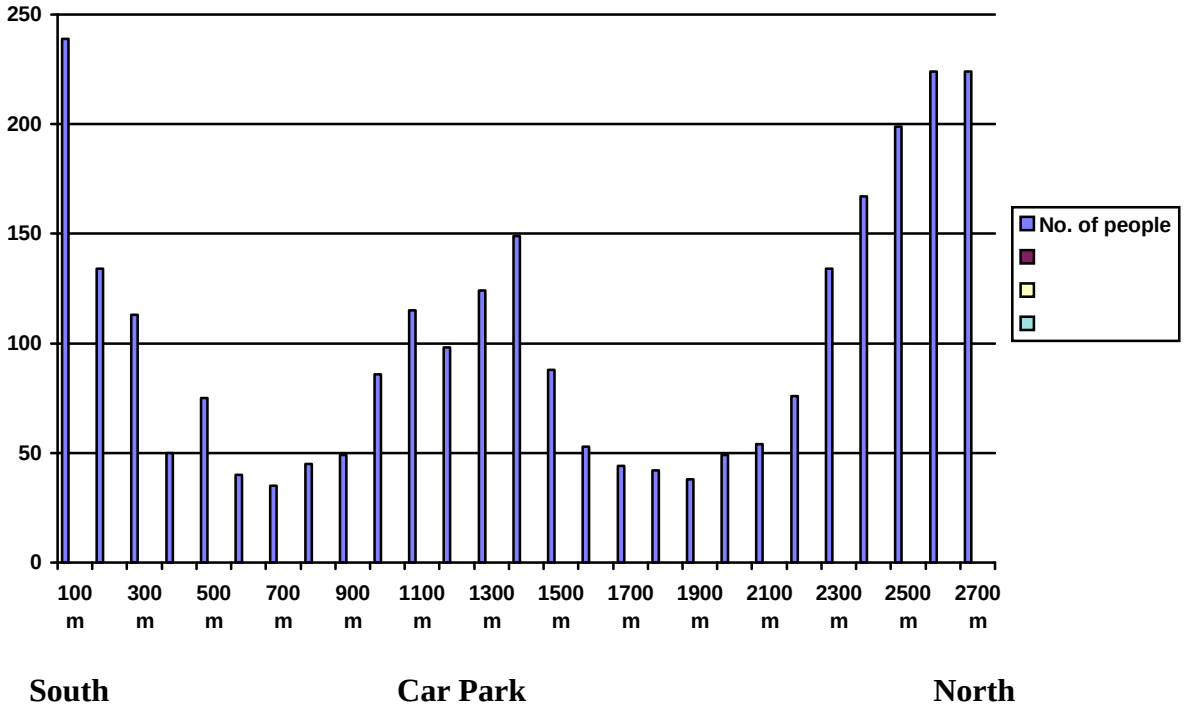
The Saturday population comprised considerable numbers of Mallorcans as well as tourists whereas the mid-week survey encountered a primarily tourist population. The survey showed that the Mallorcans/Spanish were more likely to utilise the picnic area, the car park and the dunes. The heaviest densities of tourists were concentrated on the beach nearest the hotels (at each end). There was a marked reduction in numbers between these areas. This may have been due to people's unwillingness to walk a long distance. Tourists may use the beach

closest to the hotels simply for convenience.

Summary

An initial survey was conducted of public use of the Es Comu beach. Two twelve-hour surveys were completed, one at the weekend and one in mid-week. The results were compared and a frequency calculated for sections of one hundred paces. The number of cars and people using the car park and picnic area was also recorded.

***Figure 1**: Public use of Parc Natural beach; distribution of people at 100 m intervals, south to north.*



Annex 8: A preliminary survey of prickly juniper *Juniperus oxycedrus macrocarpa* regeneration in the Parc Natural de S'Albufera coastal dunes by Julia Passman and Amanda Spurr

Introduction

In response to a request from Park warden, Xisco Lillo, a survey was initiated with the objective of determining whether regeneration was occurring among the prickly juniper of the Es Comu coastal dunes.

Method

A survey was undertaken alongside the main track from the picnic area car park with the intention of locating juniper seedlings independent from parent plants. Two transects from the beach area to the picnic car park were completed. Observations and records were made in sections of twenty paces for a distance of two hundred paces. Parent plant densities were assessed and recorded on an index of 0-10, the scale rising from 0 for no plants in the section to 10 for complete cover. The number of seedling numbers per section were recorded up to a distance of ten metres from the track.

Results

	Main track from beach		**Minor track from beach**	
Paces from beach	No. of seedlings	Parent density Scale 0-10(high)	No. of seedlings	Parent density Scale 0-10(high)
20	0	8	0	8
40	2	10	0	7
60	2	7	0	6
80	1	2	0	7
100	0	1	0	8
120	7	1	0	9
140	4	4	2	7
160	1	2	2	5
180	0	1	1	4
200	0	1	0	6

Conclusion

The survey revealed that regeneration was very limited, at least within the zone chosen for study. The dune area nearest to the beach had fewest seedlings. Further away from the beach there was an increase in parent plant density and seedling number. Closer to the picnic area parent plant density decreased slightly, probably because shaded out by tall pine trees.

The dune area nearest the beach is heavily used and juniper roots are exposed. Trampling and human pressure on this area may have a direct result on seedling survival. Further away from the beach the parent plant density may allow for greater protection of seedlings and smaller plants rooted to the parent plant. The decrease in human pressure may also id seedling survival. Closer to the picnic area immature pines may offer extra protection and lessen human pressure in the dunes - though this protection may end as the pines mature.

Summary

This was a preliminary survey to investigate the level of regeneration of prickly juniper *Juniperus oxycedrus macrocarpa* occurring in Parc Natural de S'Albufera coastal dunes. Two transects were completed using simple search and locate methods to gain an understanding of parent plant density and seedling number. The survey suggested that seedling survival is best in areas of least public use.

Even in areas of least public use, few seedlings were found and regeneration along the transects was very limited. Further studies will be needed to investigate levels of regeneration more widely within the coastal dunes, and the impact of public use on the juniper population.

Annex 9: Los Hongos del parque natural de S'Albufera, Mallorca by Rachel King

Este estudio estaba realizado con el propósito de ampliar nuestro conocimiento de las especies de hongo presentes en el parque y de su distribución en relación con la vegetación.

El Parque Natural de s'Albufera consiste en una vegetación variada, que en su major parte se consta de una zona muy húmeda de carrizales. Dentro de una zona tan húmeda no se espera una gran diversidad de hongos pero, como en todos los biotopos extremos, se encuentran especies interesantes. Otros biotopos importantes son: los bosques de *Pinus halepensis* (Es Comú, Es Comú "bosque de Ca'n Picafort" y Ses Puntes) sobre dunas costeras y dunas fosiles; los caminos del parque donde se encuentran arboles como *Populus alba*, *Ulmus* x *hollandica* y *Crataegus monogyna*; y las praderas de caballos y vacas. Cada comunidad de vegetación tendra sus especies de hongos particulares y la variedad de biotopos que existe presenta mas posibilidades de encontrar especies de hongos diferentes.

No ha sido posible estudiar intensivamente el parque entero. Entonces, este estudio piloto trataba de tomar al menos una muestra en cada habitat reconocido para establecer una lista mínima de las especies y donde se encuentran. La lista que sigue representa sólamente un porcentaje de las especies que existe en el parque pero nos da un base sobre el cual podremos ampliar nuestro conocimiento de los hongos de s'Albufera y de su ecología.

Es Comú, dunas costeras (28 especies)

Especie	**Habitat**
Suillus collinitus	Debajo de *Pinus*, *Pistacia*, *Erica* y *Juniperus*.
Suillus bovenoides	Debajo de *Erica*, *Rosmarinus* y *Pinus*.
Xerocomus rubellus	Debajo de *Pinus*, mas común cerca de la carretera.
Xerocomus chrysenteron?	Debajo de *Pinus*.
Inocybe heimii	En los caminos arenosos.
Inocybe arenaria	En los caminos arenosos.
Polyporus meridionalis	Sobre *Rosmarinus* y *Erica*.
Limacella subfurnacea	Debajo de *Pinus*.
Tramites versicolor	Sobre un ejemplar de *Pinus*.
Lycogala epidendron	Sobre un ejemplar de *Pinus*
Hygrocybe conicoides	En arena cerca de la playa.
Hygrocybe aurantiolutescens	Debajo de *Pinus* en musgo.
Psilocybe coprophila	Sobre excremento de caballo.
Panaeolus rickenii	Suelos arenosos con *Teucrium*.
Phaeolus schweinitzii	
Coprinus comatus	Sobre excremento.
Coprinus plicatilis	En hierba corta.
Coprinus fimetarius	
Amanita ovoidea ovoidea	Debajo de *Pinus*
Amanita graciolor	Debajo de *Pinus*.
Volvariella taylori	Debajo de *Pinus* en hierba corta.
Clavulina cinerea	Debajo de *Pinus*.

Sarcosphaera crassa	Debajo de *Pinus* en musgo.
Clitocybe cerussata	Debajo de *Pinus*.
Clitocybe dealbata	Debajo de *Pinus*.
Hemimycena delicatella	Sobre hojas de un ejemplar de *Pinus*.
Mycena seynii	Sobre piñas.
Agaricus devoniensis	En arena al lado de la carretera.

Secados.
2 *Suillus collinitus*?
3 *Xerocomus*?

Es Comú, bosque Ca'n Picafort (22 especies)

Especie	**Habitat**
Suillus collinitus	Debajo de *Pinus*.
Xerocomus rubellus	Debajo de *Pinus*.
Inocybe heimii	En caminos arenosos.
Inocybe rimosa	Debajo de *Pinus*
Mycena seynii	Sobre piñas
Mycena capillaripes	Sobre hojas de un ejemplar de *Pinus*.
Mycena flavipes	Sobre madera de un ejemplar de *Pinus*.
Polyporus meridionalis	Sobre *Erica*.
Pseudohiatula tenacella (*collybia* o *Marasmius*)	
Coprinus micaceus	Debajo de *Pinus*
Limacella subfurnacea	Debajo de un ejemplar de *Pinus*.
Lepiota josserandii	
Clavulina cinerea	En musgo.
Ramaria abietina	
Leptoglossum rickenii	En musgo.
Amanita ovoidea ovoidea	Debajo de *Pinus*.
Lactarius sanguifluus	Debajo de *Pinus*.
Arrhenia spathulata	En musgo.
Paxillus panuoides	Sobre un ejemplar de *Pinus*.

Secado

9 *Agaricus* ?	Debajo de *Pistacia* y de un *Pinus*.
10 *Tulostoma brumale* ?	En musgo y hierba corta.
11 *Inocybe* ?	Debajo de *Pinus*, en hierba corta y musgo.

El Camino a Bishop Hide (15 especies)

Especie	**Habitat**
Agrocybe aegerita	Sobre troncos de *Ulmus* y *Populus*.
Panaeolus sphinctrinus	Sobre excremento
Marasmius candidus	Sobre *Rubus*.
Crinipellis stipitaria	Sobre ramitas de ?
Marasmiellus Trbuti	Sobre *Ulmus*.
Auriculariopsis ample	Sobre *Ulmus*.
Coprinus plicatilis	Debajo de *Ulmus* y *Populus*.
Coprinus xanthothrix	Sobre troncos muertos de *Ulmus*.
Coprinus disseminatus	Sobre el base de *Ulmus*.
Auricularia auricula-judae	Sobre *Populus*.
Mycena clavularis	Sobre ramitas de *Crataegus monogyna*.
Tubaria autochthona	Debajo de *Crataegus monogyna*..
Crepiodotus sp. - Congelado	

Secado

1 *Coprinus*?	Sobre *Ulmus* muerto y en el suelo sobre ramitas.
4 *Tubaria autochthona*	Debajo de *Crataegus monogyna*
6 *Pluteus* ?	Sobre *Ulmus*.

<u>Cami d'Enmig (4 especies)</u>

Especie	**Habitat**
Limacella subfurnacea	Debajo de *Ulmus*.
Clathrus ruber	Debajo de *Ulmus* y *Phragmites*.
Auricularia auricula-judae	Sobre *Populus*
Peziza vesiculosa	

<u>Ses Puntes (7 especies)</u>

Especie	**Habitat**
Suillus collinitus	Debajo de *Pinus*.
Limacella subfurnacea	Debajo de *Pinus*.
Volvariella taylori	Debajo de *Pinus*.
Leptoglossum rickenii	En suelos arenosos en musgo debajo de un P*inus*.
Agrocybe aegerita	Sobre *Populus*.

Secado

7 P*anaeolus* ?	Sobre excremento de caballo.
8 L*imacella* ?	Debajo de *Pinus*.

<u>Cami des Senyals (2 especies)</u>

Especie	Habitat
Mycena flavipes	Tronco muerto de un ejemplar de ?*Pinus.*
Pluteus ? (Pep Siquier lo tiene)	Sobre *Phragmites*.

Los carrizales de Prat de Son Serra y Son Carbonell (2 especies)

Especie	Habitat
Marasmiellus caesioater	Sobre *Phragmites* y *Juncus* cerca del nivel de agua.
Cordyceps militaris	Sobre restos muertos de *Phragmites*.

Cami des Polls (3 especies)

Especie	Habitat
Psathyrella candolleana	Sobre *Ulmus* en grupos.
Psathyrella halophila	En zonas muy húmedas sobre *Cladium*.
Agrocybe aegerita	Sobre *Populus*.

Ca'n Etxut (4 especies)

Especie	Habitat
Coprinus comatus	
Paxillus panuoides	Sobre troncos muertos de un *Pinus*.
Suillus collinitus	Debajo de *Pinus*.
Leucoargaricus? (Pep Siquier lo tiene)	

Los ejemplos secados

1 *Coprinus*?

Sombrero	2cm por 2, campanula, estriada desde bastante arriba. Beige palido casi blanco pero mas oscuro por el centro.
Carne	Blanco a crema palido.
Pie	3 a 4 cm por 0.2 a 0.5 cm, mas delgado en el apice cada vez (ligeramente) mas ancho hacia el base. Sin anillo y volva. Base mazudo. Pie blanco, liso, sedoso (fibras pequeñas) y hueco. Con el tacto pierde el blanqueza y vuelve translucido.
Olor	No distintivo.
Laminas	Adnato, gris de joven con el borde mas palido, los ejemplares adultos con laminas marron oscuro con el borde mas palido.
Sobre	Troncos de *Ulmus* y ramitas.

2 *Suillus*?

Sombrero	De 6 a 10 cm, marron caramelo vivo, pegajoso cuando húmedo, se pelar facilmente.

	Colora los dedos un poco marron.
Tubos	De joven amarillo palido cambiando a amarillo verdoso mas oscuro con la edad. No cambia de color con el presión del dedo. Compuestos angulosos.
Pie	6 por 1 a 1.5 cm. Color amarillo vivo naranja, con puntitos/rallitas de rojo/marron mas concentrado cerca del sombrero. Hueco por estar comido por gusanos.
Carne	Color limon palido en sombrero, con tonos de rojo encima del sombrero donde lo han comido los gusanos. Algo rosa abajo el cuticula.
Sabor	Suave, dulce a fruta.
Olor	Agradable.

3 *Xerocomus*?

Sombrero	5 a 13 cm rojo color de sangre o mas oscuro, agreatado rojo en las agreatas. Azulia lentamente despues del corte luego voliendo a su color original.
Tubos	Bastante grande y angular, amarillo verdoso en adultos.
Pie	8 por 1.5 cm. Amarillo, y rojo en el base.

5 *Hygrocybe*?

Sombreo	2.5 cm. Conico a convexo a mas abierto casi plano con mamelon. Amarillo, rojo o naranja, ennegreciendose con la edad. Viscoso.
Laminas	Libres. Blanco algo colorado del mismo color que el sombrero. Ennegreciendose despues de tocar. Mas anchos que el carne del sombrero.
Pie	Amarillo vivo un poco anaranjada ennegreciendose en el base. Fibroso, hueco y viscoso. Antes de ennegrecerse el base esta blanco.
Carne	Igual que la cuticula.
Habitat	En grupos sobre musgo debajo de pinos.

6 *Pluteus*?

Sombrero	3 cm un poco convexo con umbo, casi plano cuando adulto, color beige. Con escamas pequeñas de color marron oscuro como pelos concentrados en el centro produciendo un disco central. El margen un poco estriado.
Pie	Blanco. 5 por 0.4 cm. Con fibras (como pelos) oscuras mas largas y llamativas cerca del base. El apice cubierto de escamas blancas muy pequeñas. El pie es un poco mas ancho hacia el base. Pie hueco.
Laminas	Adnata, apretada de color café con leche.
Carne	Blanco/crema delgado, mas grueso en el centro con zona hidrofilica encima de las laminas.
Olor	Suave, poco fragante a avillanac.
Sabor	No distinctivo.
Esporos	Beige oscuro.

7 *Panaeolus*?

Sombrero	4.5 cm. Campanulato a convexo a1 final casi piano. Beige dorado, liso a veces con escamas de marron mas oscuro.
Laminas	Gris palido con zonas mas oscuras pero el borden quedando mas palido. Bastante apretadas, adnata.
Pie	9 por 0.6 cm. Estriate +o- del mismo color del sombrero. Mas blanco en el base por el micelio.
Carne	Bastante delgado, beige palido.
Olor	Fungica.
Habitat	Sobre excremento de caballo.

8 *Limacella*?

Sombrero	3 cm blanco, muy poco cremoso, un poco viscoso, con arrugas cuando mas seco y se pela facilmente. Convexo a plano mas tarde.
Laminas	Cremosa palida, libres y apretadas.
Pie	Blanco y liso. Delgazando un poco hacia el base. Hueco por estar comido por gusanos.

9 *Agaricus*?

Sombrero	11 cm, plano liso y gris sin escamas. Un color ocracio desde el centro hacia fuera. Un poco depilado desde el margen.
Laminas	Muy apretadas, marron muy oscuro. Mas negro por el borde con zonas mas palidas. Libres igual de ancho que la carne del sombrero.
Pie	9.5 por 1.4 cm. Blanco, fibroso un poco curvado en el base. Cilindrico con restos de micelio blanco. Anillo descendente pero doblado hacia arriba de color ocraceo amarillo persistente.abajo el anillo (que esta en el parte inferior del medio) el pie es de un color amarillo ocraceo palido con escamas muy pequeñas cerca del base. Tiene una zona pequeña hueca.
Carne	Blanca, algo grisacea en el sombrero, marron gris obscuro en el apice del pie cerca de las laminas no por motivo del corte que no provoca cambios.
Olor	Fungica suave.
Sabor	Ligera, algo picante?

10 *Tulostoma brumale*?

Sombrero?	1.2 por 0.5 cm. Marron rojizo mas beige palido cuando se seca. Poro apical 1 mm o mas pequeño.
Esporas	Color ocraceo.
Pie	4 por 0.4 cm. Cilindrico, carne blanca con una zona delgada hueca y de

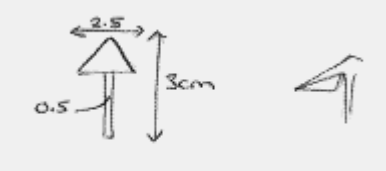
	color marron palido por fuera con escamas mas oscuras dando aspecto rugoso. El base es algo bulbiforme por el micelio como raices finas blancas.
Habitat	En musgo debajo de pinos en suelos arenosos.

11 *Inocybe*?

Sombrero	1.5 a 3 cm. Campulado a convexo un poco umbonado. Marron oscuro fibroso. De gris palido adnata, no demasiado apretadas con los margenes mas blancas.
Pie	1.5 a 3 cm. En general mas largo que el sombrero. Blanco, fibroso, con escamas pequeñas flucosas. Un poco mas grueso en el base. Algunos ejemplares algo hueco por gusanos.
Carne	Blanco, tanto en el pie como en el sombrero con zonas hygrofilicas encima de las laminas. Algunos con tonos rosados en el pie despues de tocar.
Olor	Espermatico fuerte.

Diagrams.

Number 5



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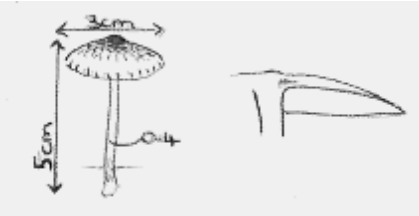

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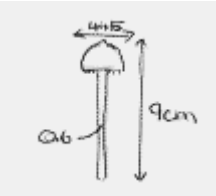

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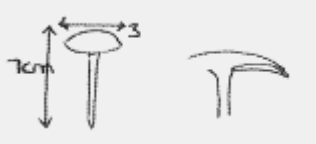

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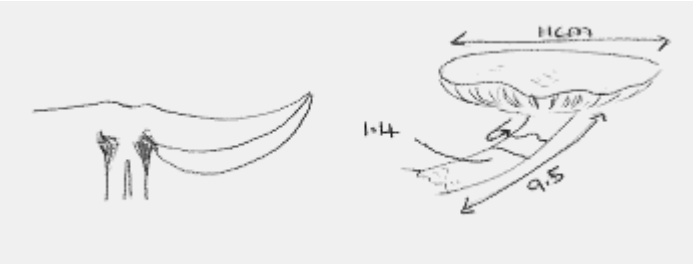

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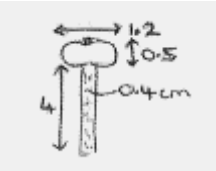

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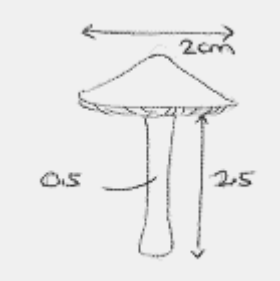

Annex 10: Project S'Albufera, invertebrate survey and evaluation by Paul Lupton

Aim

a) To investigate the invertebrate fauna of the marshes with particular reference to the larger Brachycera and Hymenoptera.
b) To evaluate the major canals through a systematic water trap survey.
c) To produce baseline data with which future comparisons can be made using a repeatable systematic methodology.

Methods

The sampling procedure was carried out in accordance with the JNCC 'Guidelines for invertebrate sampling' (Brooks 1993). Both sites were initially walked to familiarise the sampling team with the area, and to identify those areas of most likely invertebrate interest. A number of different sampling methods must be employed in order to adequately sample the intended range of taxonomic groups.

The survey took the form of a systematic water trapping exercise over a three day period (19th-21st August 1997). White traps were used. These were approximately 20cm x 50cm and were about 8cm deep. Ten sites were selected (Figure 1) and a single trap placed at each site as close to the water as possible (where there was standing water at the site). The traps were filled to a depth of about 4cm with water, and a few drops of detergent added to break the surface tension of the water.

The traps were set early in the morning and emptied and reset 24hrs later. This process was repeated over the three day study period.

At the end of each 24hr period the traps were emptied through a tea-strainer and all organisms were sorted then preserved for later examination in a 30% ethanol solution in appropriately labelled specimen bottles.

As well as the water trapping, ‘netting’ of larger more conspicuous species also took place. This generated the majority of the species in the species list (Appendix 1).

Figure 1. Location of water trap sample sites.

FIGURE 1 TO APPEAR ON THIS PAGE

Taxonomic coverage

The following taxonomic groups were identified to species:

Diptera

Larger Brachycera -	Stratiomyidae
	Tabanidae
	Dolichopodidae
Aschiza -	Syrphidae

Aculeate Hymenoptera

All other species were counted in order to give an indication of species richness and other easily identified groups were identified to species level if time permitted. The main limitation on taxonomic coverage was the lack of availability of local keys and the shortcomings imposed by the use of English distribution data and keys. This problem was particularly acute for the Bees, especially *Andrena* and *Helictus* species.

Results

The water traps were dominated by smaller diptera mostly belonging to the Acalypterata. Due to the absence of effective keys it was not possible to identify them to species though the families represented are listed in Appendix 2.

As shown in Figure 2 and Table 1, in terms of the larger target groups sites 4 and 5 were the most species rich and sites 2 and 10 the poorest.

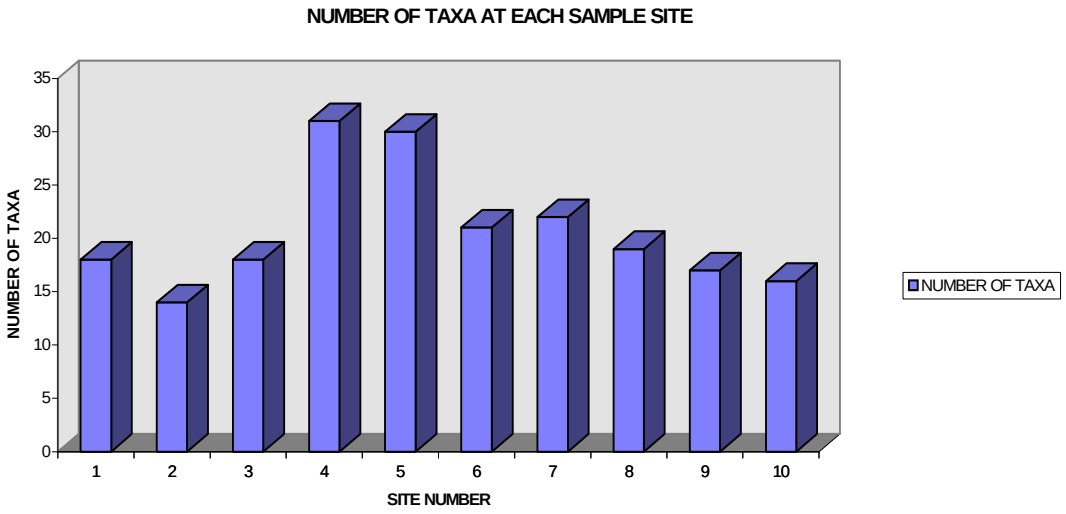

Figure 2*. Number of taxa at each sample site.*

These data produced a value for Chi 2 of 17.8 ($P<0.05$) and consequently the differences between the sites can be regarded as significant. The only major problem was at site 2 which only yielded two results due to the 'loss' of a water trap. The rather poor overall total for this site must be considered within this context.

The species list generated by the water trapping and by active netting of diptera and hymenoptera is presented in Appendix 1. The hymenoptera were well represented in the water traps though it must be said that the majority of species were caught as a result of active hunting rather than through the rather passive technique of water trapping. Weather conditions during the study period were not conducive to a high trap rate, it being very wet

for periods of all three sample days. This would reduce the flight time of the insects and consequently the trap rate.

Discussion

The presence of hymenoptera and diptera on a site is linked very closely with habitat quality and in particular heterogeneity. The site descriptions are presented in Table 1.

Table 1. *Site number and description.*

SITE NUMBER	DESCRIPTION
1	Well developed marginal vegetation, next to weir on Gran canal.
2	In poor quality ruderal vegetation and rough grasses, next to large saline pools.
3	In scrub vegetation near small freshwater pool.
4	On sandy bank near to one of the main bird feeding areas (Es Colombar).
5	Deep in *Phragmites* next to Canal Loco.
6	At western edge of park in trees 5m away from edge of canal.
7	Near narrow ditch along path. Trap placed in ruderal vegetation.
8	Very close to the water edge on rocks.
9	Trap placed in conifer plantation. No other vegetation or water feature.
10	Salt pan site. Trap placed among halophytes at the edge of the pan.

Site 4 was the area with the highest number of taxa in the traps. It is an area heterogeneous in nature with a mixture of reedbed, open water, scrub and mature trees. It is likely to be this mixed character that encourages the high species richness. Also high was site 5 which was close to both Canal Loco and Sa Siurana.

The majority of the insects caught by active hunting were at Sa Roca. This was due to the disturbed nature of much of the ground with large numbers of flowering ruderals. The insects netted were easier to see on the flower and consequently were caught. It is also probable that as a number of the wasps are Spider hunters (Pompilidae) or Digger wasps (Specidae) the large areas of open sandy ground offer good hunting and burrowing opportunities.

In the absence of distribution data it is very difficult to evaluate the species found in this survey. It is clear that many of them are southern European species with restricted distribution in Britain. It is impossible to comment on them in a local context due to lack of current information. The results do, however, set a baseline for further research and evaluation.

<u>Management implications</u>

In the majority of water bodies the margins are the most important for invertebrates and a varied margin can provide a habitat for many species. Ideally a water margin should consist of a range of successional stages which in the case of reedbeds can only be maintained by either cutting on a long rotation with the removal of accumulated litter or by scrub removal with limited reed cutting (Kirby 1992).

A gradient of vegetation height away from the edge of the water body is more valuable to invertebrates than an 'edge'. It is, I believe, significant that the richest site is site 4 which is a mixture of open ground, good quality water, and a varied vegetation structure. A gradual transition between two habitat types is better than an abrupt change; clearing the edges of the rides on site will not assist in maintaining such a gradual transition. In many ways poorly defined paths can provide more interest due to floral height restriction caused by trampling.

The greater the complexity of the habitat structure and the wider the range of growth forms the better; so areas of scrub encroachment and the effects of cattle grazing are not necessarily a bad thing. It has been said that conservation for one species can be damaging to another. On this site the best opportunities for habitat enhancement for invertebrates also provide the opportunity to increase floral diversity and interest.

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Appendix 1. *Species Lists, S'Albufera, August 1997*

HYMENOPTERA	**FAMILY/SUPER FAMILY**	**IN WATER TRAP**
Ammophila sabulosa	Sphecidae	No
Ancistrocerus gazella	Eumenidae	No
Ancistrocerus nigricornis	Eumenidae	No
Bembix oculaxa		No
Crabro 6-cinctus	Sphecidae	No
Cryptocheilus notatus	Pompilidae	Yes; site 4
Denteragenia variegata		No
Dolichovespula adulterina	Vespidae	Yes; site 10
Dufourea species	Bee	No
Ectemnius rubicola	Sphecidae	No
Episyron rufripes	Pompilidae	No
Eumenes coarctatus	Eumenidae	No
Hylaeus species	Bee	No
Lasioglossum species	Bee	Yes; site 4
Leucospris gigas	Leucospidae (Chalcidae)	No

Megachile species	Bee	No
Ophion luteus	Ichneumonidae	No
Polistes gallicus	Vespidae	No
Pompilus cinereus	Pompilidae	No
Priocnemis propinquus	Pompilidae	No
Sphecodes species	Bee	No
Tiphia morio	Tiphiidae	No
Trypoxylon figulus	Sphecidae	Yes; sites 10 & 2
DIPTERA		
Tabanus quatuoronotatus	Tabanoidea	No
Tabanus bovinus	Tabanoidea	No
Neoascia podagrica	Syrphidae	No
Eristalinus sepulchralis	Syrphidae	No
Eristalinus aeneus	Syrphidae	No
Syritta pipiens	Syrphidae	No
Thrypticus pollinosus	Dolichopodidae	Yes; site 10
Sciapus heteropygus	Dolichopodidae	Yes; site 9
Stratiomys furcata	Stratiomyidae	No

Appendix 2*. Diptera families represented in water samples*

FAMILIES	SITES
Agromyzidae	5
Calliphoridae	4,6
Chironomidae	8,6
Conopidae	9
Dolichopodidae	9,10,4
Mycetophilidae	5,8
Phoridae	1,8,6,5,2
Simuliidae	5
Sphaeroceridae	5,9,6
Tachinidae	4