

MONITORING FOR ENVIRONMENTAL CHANGE

THE EARTHWATCH EUROPE S'ALBUFERA PROJECT

A summary report of the seventh season's work, 1995

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1. INTRODUCTION

This report summarises the seventh year of fieldwork for Earthwatch Europe's Project S'Albufera, carried out at S'Albufera Natural Park, Mallorca by teams of ecologists and volunteer fieldworkers. Fieldwork involved Earthwatch and Balearic volunteers assisting and working alongside specialist scientists for periods of two weeks at a time. In 1995, there were three spring teams and one in the autumn. For the first time, a further team was put into the field in August, implemented through Earthwatch Europe and sponsored by Glaxo Holdings p.l.c. Outwith the designated Earthwatch Europe sponsored fieldwork periods, a number of monitoring tasks were carried out by resident Mallorcan volunteers and Park staff.

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 six years' progress in Newbould & Riddiford (1990), Riddiford & Newbould (1991), Riddiford (1991), Riddiford & Perring (1992), Riddiford (1993), Riddiford & Wells (1994) and Riddiford (1995a).

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.

Spring fieldwork in 1995 was undertaken by a team of 6 scientists and 4 volunteers from 9th to 23rd April, a team of 5 scientists and 2 volunteers from 27th April to 11th May, and a team of 7 scientists and 3 volunteers from 13th to 27th May. A two-week period of fieldwork in the autumn, from 22nd October to 5th November, was led by 4 scientists assisted by 7 volunteers. The August team comprised 8 volunteers and 7 scientists. The volunteer composition by country comprised 11 from the United Kingdom, 6 from the United States, 3 from Cameroon, 2 from mainland Spain, one from Mallorca and from New Zealand. The participation of a number of volunteers was assisted by sponsorship and awards, including nine who were recipients of Glaxo Education Fellowships, 2 recipients of J&B Whisky (Spain) Scholarships and one recipient of a

Guinness Earth Science Award. The participation of 3 volunteers from Cameroon was made possible by European Union sponsorship through the very worthwhile Earthwatch European Union Fellowship scheme. The Project science team was drawn mainly from the United Kingdom but included two from Spain (one attached to a Dutch University) and two from Germany.

Additionally, we were again able to call upon the support of, participation by or advice from: several members of the Universitat de les Illes Balears (UIB) and the Institut d'Estudis Avançats de les Illes Balears; participating scientists; members of the Park staff; and the Park's director, Sr. Joan Mayol. The overall responsibility for planning and supervision, however, remained with the Project's Principal Investigators, who were Nick Riddiford throughout the year and Terry Wells until his retirement in May. Details of all participants are given in Appendix 1.

2. PROJECT S'ALBUFERA FIELDWORK IN 1995

Fieldwork research in 1995 followed the now well established format of development and application of the long-term monitoring programme, including the study of the processes at work in the ecosystem. We also continued to expand our baseline knowledge in areas where information was lacking or insufficient.

Established monitoring studies included regular transects to monitor butterfly numbers and distribution in relation to habitat; transects to monitor bird population dynamics; mammal transects; permanent quadrat and census studies of orchid population dynamics; and 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.

Study of the processes at work in the ecosystem again comprised a combination of ongoing studies and new lines of research. Further study was made of reedbed utilisation by small mammals, of body condition of migrant and resident breeding birds and of aquatic invertebrate communities. In each case, however, there were new developments. All three studies were extended to August for the first time, to assess the situation at the period of driest conditions and lowest water tables. In addition, the aquatic invertebrate studies took advantage of Park water chemistry monitoring data to begin assessment of invertebrate communities in relation to water quality. Roost studies were again done in autumn, but these were badly hampered by an absence of roost sites. This was the direct result of damage caused by a freak hailstorm six weeks earlier which had flattened the reedbeds normally used. It was necessary, therefore, to shelve plans for further research into population sizes, roost locations, impact on the vegetation and behaviour (including interactions with raptors and other bird species), though observations were made of behaviour and location of displaced birds. In August, methodology was improved and further survey undertaken of aphid infestation of reedbed plants, concentrating initially on *Phragmites*. New lines of research were begun in response to two separate events. The first event was a fire which, in April 1994, completely eliminated above ground vegetation within a 3.5 hectare area in the southernmost part of Es Comú coastal dunes. Study of the rate and types of vegetation re-population was done by recording plant species and cover in a series of randomly selected one-metre quadrats. The second event was an exceptional hailstorm in September 1995 which

uprooted trees and flattened much of the reedbed. This gave unparalleled views across much of the marsh, and the opportunity was taken to census the Purple Gallinules *Porphyrio porphyrio* in order to assess their current status and dispersal following the successful re-introduction four years previously. The opportunity was also taken to make a full assessment of the impact of the storm on vegetation structure.

A start was made to tackle a number of key issues in 1995. This was achieved by co-operative partnership between the Project and other bodies and individuals. Thus, the Royal Holloway Institute for Environmental Research (Royal Holloway College, University of London) became involved, sending research scientist Dr Chris Baker in May to undertake a pilot study into soil nutrient dynamics; and Macarena Mata, research associate at the Center for Environment and Climate Studies (Wageningen Agricultural University, Holland), undertook a pilot study in October-November of the natural functions and socio-economic values of the site using techniques developed internationally by the Center. In spring, the Project also worked alongside Alexander Pieh and Bettina Sättele from the Wilhelma Zoological-Botanical Garden, Stuttgart who spent three weeks measuring and obtaining samples from Pond Terrapins *Emys orbicularis* as part of a genetic study. Another partnership was formed with Wetlands International (formerly IWRB) as part of their MedWet sub-project on inventories and monitoring in the Mediterranean. This took the form of a field test for MedWet's monitoring methodology developed for Mediterranean wetlands. The field test was carried out during the year and was conducted jointly by Park staff and Project scientists, under the direction of Nick Riddiford and Joan Mayol.

Once again efforts were made to fill gaps in and expand our baseline knowledge. This was particularly the case in August, because low water table and dry conditions make it a time of maximum stress for many S'Albufera plants and animals. The Project had not undertaken August fieldwork before so new information was collected on a number of topics, including distribution and abundance of plants flowering in summer, and faunal records. One particular invertebrate goal was to record Odonata activity and occurrence, and in particular to confirm the continued presence of the rare dragonfly *Selysiothemis nigra*, a threatened species for which S'Albufera has an international responsibility. It was pleasing to confirm its presence in suitable habitats. During the year new records were gathered for flowering plants, fungi, moths and butterflies (Lepidoptera), grasshoppers and crickets (Orthoptera), beetles (Coleoptera), hoverflies (Diptera Syrphidae), lacewings and ant-lions (Neuroptera) and a range of aquatic invertebrates. The herbarium and insect reference collections are an increasingly useful resource, which grows with each period of fieldwork. This reference base was extended in 1995 by the establishment of an aquatic invertebrate collection. Photographic reference is also used, and was boosted in 1995 by a series of Odonata photographs donated by dragonfly specialist, Paul Holliday, who also supplied records for early August, thus extending our Odonata baseline to that period; and by Ione Rice, a volunteer with Team 2, who donated photographs of a collection of beetles and bugs gathered by herself. After six years of trapping, new moth species are still being discovered. More importantly, the temporal occurrences and species composition trends are now becoming known. This information is useful and has the potential to reveal change. However, it is difficult to come to any conclusions regarding the nature of this change without having control sites for comparison. A first step was made to put this right in November 1995 when a visit was made and a portable battery operated trap loaned to the Albufera des Grau Natural Park in Menorca. The visit demonstrated that the wetland part of this site currently has a similar moth fauna to that at S'Albufera, Mallorca. It is hope that co-operative studies between the two sites may be used to assess whether future changes in species occurrence or composition is the result of local or more

universal factors.

The Project took part in a number of interpretation initiatives in 1995. The most important was the participation in the preparation of a CD-Rom disk, undertaken 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 S'Albufera involvement included preparation of texts for common or notable plants and invertebrates and provision of photographs to illustrate the chosen taxa. In addition, Dinah McLennan continued with her preparation of thematic illustrations of major Park habitats and Jo Newbould collected further material for botanical interpretation.

3. FIELDS OF RESEARCH

The following is a summary, by category, of research studies by Earthwatch Europe's Project S'Albufera in 1995 (and see Appendix 2 for more details).

Marshes

The main 1995 study in the Marsh category was a full landscape assessment of the damage caused by the severe September 1995 hailstorm on vegetation structure.

Other studies of S'Albufera marshes were reported in Wood (1989, 1991), Riddiford & Newbould (1991), Riddiford & Perring (1992), Riddiford (1993), Riddiford & Wells (1994) and Riddiford (1995a).

Dunes

Fossil dunes. Monitoring was continued of the impact of grazing by horses on the dune vegetation at Turo de Ses Eres, with particular reference to the distribution and development of the *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 below. For further details of dune studies, see also Wood (1991), Riddiford & Newbould (1991), Riddiford & Perring (1992) and Riddiford (1993).

Ecosystem studies

Vegetation repopulation after fire. This comprised an assessment of re-population by vegetation in an area of Es Comú 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. The methodology and a summary of the first

season's results are presented in Annex 3 of this report.

Water quality and aquatic invertebrate communities. Taking advantage of the Park's water quality monitoring programme, Michelle Chapman and Gillian Bourn extended and enhanced our studies of aquatic invertebrates, undertaking an intensive pilot study of the relationship between communities of aquatic invertebrates and water conditions using standard sampling techniques at locations already sampled for water quality. The methodology and first season's results are presented in Annex 9 of this report.

Reedbed aphids. Further work was done in August to develop a methodology for assessing temporal and spatial variations in aphid populations. The results of this work are described in Annex 2 of this report.

Reedbed utilisation by small mammals. Rob Strachan expanded his investigation into the utilisation of habitats, populations and inter-specific relationships for three species of mouse at S'Albufera by studying their distribution, numbers and diurnal activities in August, a period of drought and low water levels. Results of his previous study are given in Annex 12 of Riddiford & Wells (1994).

Soil nutrient dynamics. Dr Chris Baker of the Royal Holloway Institute for Environmental Research collected a series of samples for analysis as part of a pilot study into soil nutrient dynamics and their role in ecosystem functioning.

Flora and Vegetation

Species populations. British orchid population specialist, Terry Wells, continued his study of long-term recruitment and survival rates of orchids, begun in 1991. His technique comprises locating and mapping the exact position of orchid plants within large permanent quadrats. Further monitoring was also done of the distribution of the marshland orchid *Orchis (laxiflora) palustris*.

Total list. More work was done to add to the inventory of flowering plants within the park and to provide additions to the Park herbarium. Advantage was taken of the August visit to assess the numbers of plants flowering in August. This was done by recording all plants in flower in each one kilometre square, to obtain a measure of distribution and abundance.

Bryophytes. No additional fieldwork was done in 1995, but Bryophyte specialist, Rod Stern, continued to add to our knowledge through his study of material collected previously.

Fungi. Further taxa were added to the inventory of known species. Specimens were collected mainly by volunteers and identified by S'Albufera warden, Francesc Lillo, a specialist in this group.

For further details of flora and vegetation studies see also Wood (1991), Newbould & Riddiford

(1990), Riddiford & Newbould (1991), Riddiford & Perring (1992), Riddiford (1993), Riddiford & Wells (1994) and Riddiford (1995a).

Vertebrates

Birds. Data were again obtained of temporal and longer-term fluctuations of breeding and migrant birds from two well established bird transects, conducted annually since 1989 and 1990 respectively. Both were repeated in 1995 during the spring and autumn fieldwork periods. For details of the bird transect methodology see Riddiford & Perring (1992).

Further information was gathered in August on the body condition of birds using S'Albufera when weight, adipose fat and muscle condition data were collected from a sample of birds trapped for ringing conducted at a site at the north-east corner of Es Colombar. Trapping also provided an insight into use by marshland birds of the reedbed during a period of low water levels.

In autumn, methodology was developed to survey the distribution and numbers of Purple Gallinules *Porphyrio porphyrio* at S'Albufera. The main objective was to investigate the range of dispersal and colonisation from the points of reintroduction four years earlier. The study was only possible because of the exceptional circumstances of unimpeded views over much of the marsh following the devastating hailstorm which had flattened the reedbed just over a month earlier. The results of the survey are presented in Annex 1 of this report.

The destruction of the reedbed structure by the September hailstorm disrupted plans to develop the roosting bird studies, begun in October 1994. However, some behavioural information was collected and this is presented in Annex 5 of this report.

Mammals. A mammal transect, established in 1991, was reactivated in response to a new development, the arrival from the mainland of a virus which attacks and kills rabbits *Oryctogalus cuniculus*. A run of data, including data collected prior to this development, may provide evidence of population changes in the wake of this virus. Observational data were also collected for this and a range of other species. Rob Strachan's investigation into the utilisation of habitats, populations and inter-specific relationships for three species of mouse at S'Albufera is described under Ecosystem studies above.

Reptiles. A study undertaken in spring 1995 by researchers from the Wilhelma Zoological-Botanical Garden, Stuttgart, investigated the genetic status of the European Pond Terrapin *Emys orbicularis* at S'Albufera. A sample of terrapins was trapped using baited traps. A series of biometrics and other data were also collected and terrapins marked with a number before release, for future individual identification.

For further details of vertebrate studies see also Wood (1991), Newbould & Riddiford (1990), Riddiford & Newbould (1991), Riddiford & Perring (1992), Riddiford (1993), Riddiford & Wells (1994) and Riddiford (1995a).

Invertebrates

Butterfly transects. 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 again conducted regularly in spring and autumn. To assess late summer activity and for comparative reasons, both transects were also conducted in August for the first time. For further details of butterfly transects, including methodologies, see Riddiford & Perring (1992).

Invertebrate database. Standard insect light traps were again used regularly and continued to add to our knowledge of invertebrates, and particularly moths (Lepidoptera), active at night. New species were again recorded, and the opportunity to trap in August added to our knowledge of phenology for a range of moth species. Species from a number of other insect groups were also trapped at light and by other methods. This led to additions to the invertebrate database and on-site reference collection of a number of moths and butterflies (Lepidoptera), lacewings and ant-lions (Neuroptera), grasshoppers and crickets (Orthoptera), beetles (Coleoptera), dragonflies (Odonata) and hoverflies (Diptera: Syrphidae). Identifications of moth (Lepidoptera) specimens were undertaken by British moth authority, Barry Goater. Other insect identifications were provided by specialists, Colin Plant (Neuroptera and Syrphidae) and Chris Haes (Orthoptera). The photographic collection benefited from reference material for beetles and bugs from a collection made in May by volunteer, Ione Rice, and a series of Odonata prints (plus observations) from visiting entomologist, Paul Holliday. Members of the Catalonia Natural History Society visiting in May assisted with identifications of a range of beetle and moth species.

Aquatic invertebrate studies. This research has now developed into an applied study related to water quality, which is described in Ecosystem studies above; and results of 1995 work in Annex 9 of this report. Details of previous aquatic invertebrate work are given in Riddiford (1993) and Riddiford & Wells (1994).

Aphid studies. Further development of study in this field is described in Ecosystem studies above; and results of 1995 work in Annex 2 of this report.

For further details of invertebrate studies see Newbould & Riddiford (1990), Riddiford & Newbould (1991), Riddiford & Perring (1992), Riddiford (1993) and Riddiford & Wells (1994).

Hydrology and hydrochemistry

The Project continued to benefit from the quality of data relating to the water regime and water chemistry obtained by Park staff during regular (fortnightly) readings of water levels from stageboards throughout the marsh and of conductivity, pH, temperature and dissolved oxygen of the water at strategic sample sites. Analysis of this information is undertaken by the Park staff and members of the Department of Limnology at the University of the Balearic Islands (UIB). The UIB team, led by Antoni Martínez, has collected data on other facets of water chemistry. This suite of information is already proving enormously useful to the Park directorate and Project alike in the assessment of impacts and aspects of ecosystem functioning pertaining to S'Albufera.

The sampling technique and equipment used to obtain water quality measurements are described in Annex 3 of Riddiford (1995a).

Meteorology

Meteorological data were collected daily by Park staff.

Park management

The Park was the subject in 1995 of a pilot study whose objective was an assessment of functions and socio-economic values of natural ecosystems and protected areas. The study was initiated by the Center for Environment and Climate Studies, Wageningen Agricultural University, and the pilot study was undertaken by research scientist Macarena Mata in October-November, using methodology developed by the Centre. An abstract of her work is presented in Annex 7 of this report.

The period covered by the first Park management plan ended in 1995, and a set of written comments was submitted by Project scientists to assist the Park directorate evaluate it and formulating a new plan for the next five years. Details of the comments submitted are presented in Annex 4 of this report.

Data management and biodiversity studies

Species inventories were once again up-dated and expanded on the S'Albufera biodiversity database as more faunal and floral records were obtained; and work was continued to cross-reference data to precise co-ordinates or to 1 kilometre squares within a mapping grid based on the UTM system of co-ordinates. The arrival of a dedicated Project computer in August accelerated the input of data, with long-term Project monitoring studies being given first priority.

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) and Annexes 4 to 7 of Riddiford (1995a).

Interpretation and education

CD-Rom. Project participation in the preparation of a S'Albufera CD-Rom for schools involved supplying text and photographic material to describe and illustrate a selection of the Park's plants and invertebrates. The selection was determined at two levels: species for which the Park was notable, particularly for conservation or as key members of the ecosystem; and those which were likely to be noticed or catch the imagination of children, e.g. because they were spectacular, demonstrated unusual or special behaviour, or played a role in local culture or folklore. The primary objective was to provide an educational resource to enhance knowledge and encourage pride in a local wildlife area of international importance. The CD-Rom has been issued to all

Balearic schools and thus will also have a role in promoting a positive conservation attitude by the next generation's decision-makers. It is in Catalan, but is highly pictorial and thus potentially of wider scope.

Botanical interpretation material. Dinah McLennan and Jo Newbould continued to collect information with the long-term goal of providing botanical interpretation material. Dinah is currently preparing the second in her series of water-colour representations of major habitats, saltmarsh, which will be produced as a poster. Her poster of the freshwater marsh habitat, is available from the Park's Information Centre shop. Jo and Dinah also continued to do fieldwork in preparation for a S'Albufera flower guide for Park visitors.

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

Programme development

Monitoring at the international level. At the invitation of the International Waterfowl and Wetlands Research Bureau (now Wetlands International), the Project in partnership with the Park directorate and staff undertook a pilot study during the year of a wetlands monitoring methodology developed by the MedWet sub-project on Inventory and Monitoring in the Mediterranean. MedWet is a coordinated action programme for Mediterranean wetlands in collaboration with the five Mediterranean member countries of the European Union, the Ramsar Convention and a number of non-governmental organisations. The sub-project on Inventory and Monitoring has been working to formulate an inventory and monitoring programme which can be applied to wetlands throughout the Mediterranean. Project S'Albufera was invited to carry out field tests of MedWet's proposed monitoring methodology - much of which corresponds with work already in progress. The results will be incorporated into a Mediterranean Wetlands Monitoring Guide which will advise on and demonstrate the steps to be taken in preparing and applying a well-planned monitoring programme.

4. ADDITIONAL STUDIES

Park staff once again collected data throughout the year in a number of fields, most notably ornithological, meteorological, hydrological and in aspects of Park management. Members of the University of the Balearic Islands and Balearic Institute of Advanced Studies were again involved with a range of studies, particularly in the spheres of hydrology, limnology and entomology. Park staff undertook monitoring of the Park's management throughout the year. The results of Park management monitoring in 1994 were presented in Perelló, Mayol, Capellà & Lillo (1995) and 1995 results are in preparation.

Research studies and monitoring carried out by Park staff and independent institutes in partnership with, or assisted by, Project S'Albufera teams are detailed in section 2 above.

5. PROGRESS AND FUTURE PLANNING

The Project is still grossly underfunded. However, there were a number of positive developments. The most encouraging was the interest and support given by the Royal Holloway Institute for Environmental Research, and particularly their director Professor Ed Maltby. It was on his initiative and with the logistic support of his Institute that Dr Chris Baker was able to undertake his pilot study into soil nutrient dynamics in May. Also encouraging was the involvement of the Wageningen Center for Environment and Climate Studies. Its Director, Dr Dolf de Groot, had been planning for some time to develop a line of research at S'Albufera and this became possible in 1995 when a research scientist, Spanish ecologist Macarena Mata, was found with the right credentials to undertake a pilot study into functioning of the natural environment at S'Albufera. The Center will continue to commit research time to S'Albufera in 1996, beginning with a GIS application case study of the functions of the wetland ecosystem as a tool for ecosystem valuation for land use planning. Dr de Groot is also planning to use the information to develop a short course on ecosystem valuation, including assignments, which may be used at S'Albufera and more widely. To complete the list of co-operative ventures, Project S'Albufera will continue to work closely with MedWet in 1996, particularly in the preparation and production of the MedWet Mediterranean Wetland Monitoring Guide, due for publication in May. Details of the GIS application case study are given in Annex 8 of this report.

Another welcome development was the sponsorship by Glaxo Holdings p.l.c., announced in the 1994 report (Riddiford 1995a). This took the form of awards to teachers, under the Glaxo Education scheme, ensuring a steady flow of volunteers and the introduction of a further period of fieldwork, by a "Glaxo Teachers team", in August. The additional funding this brought benefited the Project in a number of ways and most importantly in providing the resources to purchase a dedicated Project computer, which had been a long overdue equipment need. The purchase of a portable was identified as the most appropriate and has already made an enormous contribution to the processing and storage of records as well as giving Project scientists immediate access to a computer. The Glaxo sponsorship was arranged through Earthwatch Europe, which continued to provide sponsorship through its volunteer scheme. Earthwatch Europe and Earthwatch Spain were also instrumental in drawing together other volunteer sponsorship through the Guinness Earth Science Award, J&B Whisky (Spain) Scholarship and Earthwatch European Union Fellowship schemes, and there is every indication that this type of support will continue in 1996. We have already learned that volunteers in 1996 will include a number of Fellows from East and West Africa under the African Fellowship programme sponsored by the European Commission and the Darwin Initiative of the UK government. This form of volunteer participation is very valuable and puts into effect the training and education aspects of Project S'Albufera. The way in which this works is explained by one of the 1995 Fellows in Annex 6 of this report.

Terry Wells retired in the summer, after two and half years as joint Principal Investigator. It is pleasing to report that Terry will remain involved with the Project, specialising in his study of orchid population dynamics. Continuity is assured as Nick Riddiford takes sole responsibility, for the moment at least, for the Project. To strengthen links with the Royal Holloway Institute for Environmental Research its Director, Professor Maltby, has offered the Project Principal

Investigator research associate status - an offer which has been gratefully accepted.

Despite continued slender means, a full programme of fieldwork is again planned for 1996, including another Earthwatch Europe Glaxo Teachers team in August. Once again I pay tribute to the unstinting loyalty and assistance of the scientists and supporters who make up the Project S'Albufera scientific team. Earthwatch Europe has agreed to maintain its support through the provision of volunteers and associated sponsorship.

Details of the 1996 Project S'Albufera programme are given in Appendix 3.

6. ACKNOWLEDGEMENTS

Seven years into this Project, the list of people and organisations to thank gets ever longer. It is noteworthy, however, that many of the names appear each year, demonstrating loyal and enthusiastic long-term support which has meant so much both to the Project and to the author personally, and has been the catalyst in keeping the Project going through a difficult period. In particular I owe an enormous debt of thanks to friends who have eased my own situation with practical help and assistance in a number of ways: Joan Mayol and Biel Perelló (P.N. S'Albufera), Hilary Barrett-Brown, Pat and Dennis Bishop (local friends and supporters), Pere Tomàs-Vives (MedWet), Park staff and all members of the Project S'Albufera scientific team. Pat Bishop's care and love for S'Albufera and her contribution to conservation generally in Mallorca, over many years, was recognised in 1995 when she was made a *miembro de honor de la junta rectora de S'Albufera* (Member of Honour of S'Albufera's managing body). The honour was presented by the Balearic Minister for Agriculture at a ceremony in Palma, and I was delighted to have had the opportunity to attend.

I would also like to pay tribute to Earthwatch Europe staff, who have been so supportive. I would particularly like to mention Maureen O'Neill. The Project, and its survival into a seventh year, owes much to her. Following her recent marriage she has retired from her position as Education officer with Earthwatch Europe and she will be sorely missed, especially by this Project.

Project funding came from Earthwatch, Earthwatch Europe and Earthwatch Spain, often through sponsoring partnerships with other organisations. I thank them and their staff, and the sponsoring organisations: Glaxo Holdings p.l.c., Guinness, J&B Whisky and the European Union. I am also extremely grateful for the co-operation, assistance and support received from Professor Ed Maltby and the Royal Holloway Institute for Environmental Research, Dr Dolf de Groot and the Center for Environment and Climate Studies, Wageningen, and Wetlands International through Pere Tomàs and the MedWet project. Scientists from several departments of the University of the Balearic Islands, especially Toni Martínez and Hipólito Medrano, and the Balearic Institute for Advanced Studies, especially Enrique Descals, willingly assisted us practically and with aspects of research. Help and support within Mallorca was also received from the Bonner family, the Friends of S'Albufera, Bernat Bergas, Nicole Smith, Marga Roig and many other individuals. I offer special thanks to all the Project scientific staff and the UK based panel (Chris Haes, Colin Plant, Barry Goater and Rod Stern) which gives specialist advice on identifications. I particularly thank Terry Wells for his encouragement and good sense during over two years as joint Principal

Investigator. I also thank logistics co-ordinators, Chris Donnelly, Mike Wood, Michelle Chapman and Gill Barker. That the fieldwork ran with such smoothness in 1995 speaks volumes for their efficiency and hard work. Of course we cannot forget that an equal contributor in time, interest and guidance to that smooth running was the Project's great friend, the Park's technical assistant and liaison officer to the Project, Biel Perelló. I would also like to thank Conservation Director, Sr. Joan Mayol Serra, whose role in ensuring the success of our Project cannot be underestimated. Joan also proposed and put into action the comparative study of moths at S'Albufera de Mallorca and S'Albufera des Grau, in Menorca. I am grateful to him and to the S'Albufera des Grau Park staff for setting this study in motion and for their hospitality and help during my visit there. All those involved with both Parks are to be thanked for making us welcome, from the Director General and administration of the Estructures Agraries i Medi Ambient section of the Balearic Conselleria d'Agricultura i Pesca, who continued to support the Project through the consent to operate and a high-level of co-operation, to the S'Albufera de Mallorca cook, Margalida Moranta, who continues to delight with a series of magnificent Mallorcan cuisine lunches.

I cannot end this list of thanks without mentioning the volunteers. The Project would not exist and progress would not be made without their input, and their quality in 1995 was once again first-class. All contributed in effort and enthusiasm. I gratefully thank them for this and, in a number of cases, for extra donations and other tangible contributions of long-term benefit to the Project.

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

APPENDIX 1 - List of Participants, 1995

Principal Investigators

Nick Riddiford and Dr Terry Wells

Parc Natural de S'Albufera Advisor to Project

Joan Mayol (Director of Balearic Natural Areas, Mallorca)

Parc Natural de S'Albufera Liaison Officer to Project

Biel Perelló (Conselleria d'Agricultura i Pesca, Estructures Agraries i Medi Natural)

Cook

Margalida Moranta

Team I (9th-23rd April)

Scientists

Terry Wells (PI), Nick Riddiford (PI), Jo Newbould (plant studies, botanical interpretation), Dinah McLennan (plant studies, botanical interpretation/illustrations), Sheila Wells (orchid studies, fungi), Christine Donnelly (logistics; ecological studies)

Volunteers

Marta Tudel i Villega, Olga Freixa i Bódalo (Catalonia, Spain), Julie Constantino, Jerry McCormick (USA)

Team II (27th April-11th May)

Scientists

Nick Riddiford (PI), Jo Newbould (plant studies, botanical interpretation), Dinah McLennan (plant studies, botanical interpretation/illustrations), Michael Wood (logistics; ecological studies), Michelle Chapman (logistics; aquatic invertebrates and water quality)

Volunteers

Victoria Barr, Ione Rice (USA)

Team III (13th-27th May)

Scientists

Nick Riddiford (PI), Michelle Chapman (logistics; aquatic invertebrates and water quality), Maria Zas Arregui (vegetation studies and herbarium), Gillian Bourn (aquatic invertebrates and water quality), Chris Baker (Royal Holloway Institute for Environmental Research - hydrochemistry and soil/sediment nutrient dynamics), Alexander Pieh and Bettina Sättele (Wilhelma Zoological-Botanical Garden, Stuttgart, Germany - Pond Terrapin studies).

Volunteers

Metu'Muabe William, Jacob Towe Sichui, O'Kah Ebwekoh Monya (Earthwatch European Union Fellows, Cameroon)

Team IV (22nd October-5th November)

Scientists

Nick Riddiford (PI), Chris Donnelly (logistics; ecological studies), Mike Wood (logistics;

landscape ecology), Macarena Mata-Porrás (Wageningen Center for Environment and Climate Studies - natural functions and values studies)

Volunteers

Marilyn Geninatti, Betty Kalliney (USA), Helen Dewberry, Nick Owens, Paul Smith (UK), Tony McNaughton (New Zealand), Margalida Roig Ramis (Mallorca)

Education Team (15th-29th August)

Scientists

Nick Riddiford (PI), Gill Barker (logistics), Maria Zas Arregui (flora), Michelle Chapman (aquatic invertebrates), Rob Strachan (small mammals), Nick Ward (ringing/bird studies), Jackie Counter (assistant, logistics)

Volunteers

Ian Hadwin, Ken Halliday, James McManners, Jenny Minors, Lynda Parker, Aleksandar Stankovic, Roger Wood (Glaxo Education Fellowships), Tom Irvine (Guinness Earth Science Award)

Additional scientist and volunteer contributions

Paul Holliday (Odonata - 7th to 18th August)

Identification advisors in U.K.

Barry Goater (Lepidoptera: moths)

E. C. M. (Chris) Haes (Orthoptera/Dictyoptera/Dermaptera: crickets & grasshoppers/mantids & cockroaches/earwigs)

Colin Plant (Neuroptera: lacewings)

Rod Stern (Bryophytes)

Visitors to the Project

Antoni Martínez Taberner, (Dept. Biologia, Univ. Illes Balears)

Pat & Dennis Bishop (Friends of S'Albufera)

Juan Carlos Muntaner Cerda (Treasurer, Friends of the Albufera)

Jordi Sargatal (Director of Aiguamolls Natural Park, Catalonia and Editor of the Handbook of the Birds of the World)

Catalonia Natural History Society group, including José J. Pérez de-Gregorio (Lepidoptera specialist), Josep Muñoz Batet (Coleoptera specialist), Francesc Vallhonrat (Lepidoptera Geometridae specialist), Albert Orozco Sanchis (Lepidoptera specialist)

José L. Siquier Virgos (visiting mycology specialist, Mallorca)

Thony Martins (visiting student studying conservation management, France)
Matthias Meissner (visiting student studying conservation management, Germany)
Representatives of Friends of S'Albufera and the Grupo ornitologico Balears

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
Jaume Cantallops - Maintenance
M'Angels Ferragut - Monitor
Antoni Verd - Monitor
Jeronia A. Bonnin - Monitor
Margalida Moranta - Cook

Seconded to Park on non-military national service

Pere Bennassar
M Coll
Jose Maria Jordan
Jaume Mas
Ramón Mas

APPENDIX 2 - 1995 Fields of Research

The following is a catalogue of information collected in 1995. This information, along with 1989-94 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: Marshes

Title of Work Done:

The impact of the September 1995 hailstorm on vegetation structure.

Catalogue Reference Number: 95/15

Category: Dunes

Title of Work Done:

The impact of grazing: distribution of *Euphorbia terracina* at Turo de Ses Eres.

Catalogue Reference Number: Not allocated - raw data with scientist (Jo Newbould)

Category: Ecosystem studies

Title of Work Done:

Vegetation re-population after fire.

Catalogue Reference Number: 95/4

Category: Ecosystem studies

Title of Work Done:

Water quality and aquatic invertebrate communities.

Catalogue Reference Number: 95/9

Category: Ecosystem studies

Title of Work Done:

Aphids on *Phragmites*.

Catalogue Reference Number: 95/13

Category: Ecosystem studies

Title of Work Done:

Reedbed utilisation by small mammals.

Catalogue Reference Number: Not allocated - raw data with scientist (Rob Strachan)

Category: Ecosystem studies

Title of Work Done:

Soil nutrient dynamics.

Catalogue Reference Number: Not allocated - raw data with scientist (Chris Baker)

Category: Flora and Vegetation

Title of Work Done:

Orchid population studies.

Orchis (laxiflora) palustris survey.

Catalogue Reference Number: 95/7

Category: Flora and Vegetation

Title of Work Done:

Plants flowering in August.

Catalogue Reference Number: 95/11

Category: Flora and Vegetation

Title of Work Done:

Fungi recording.
Catalogue Reference Number: 95/16

Category: Vertebrates
Title of Work Done:
Bird population surveys: transects 1 and 2.
Catalogue Reference Number: 95/3

Category: Vertebrates
Title of Work Done:
Ringing studies: condition of migrant birds.
Catalogue Reference Number: 95/12

Category: Vertebrates
Title of Work Done:
Purple Gallinule distribution survey.
Catalogue Reference Number: 95/14

Category: Vertebrates
Title of Work Done:
Mammal studies: mammal observations.
Mammal studies: mammal transect.
Catalogue Reference Number: RA00; 95/8

Category: Vertebrates
Title of Work Done:
Biometric and genetic studies of the European Pond Terrapin *Emys orbicularis*.
Catalogue Reference Number: Not allocated - raw data with scientists (A. Pieh & B. Sättele)

Category: Invertebrates
Title of Work Done:
Butterfly transects.
Catalogue Reference Number: 95/1

Category: Invertebrates
Title of Work Done:
Moth trapping.
Catalogue Reference Number: 95/2

Category: Invertebrates
Title of Work Done:
Invertebrate collection: moths, hoverflies and beetles.
S'Albufera moth list (up-dated).
Odonata records.
Catalogue Reference Number: 95/5

Category: Hydrology and Hydrochemistry
Title of Work Done:

Monitoring water quality.

Catalogue Reference Number: Computerised files on site (Park database)

Category: Meteorology

Title of Work Done:

Park meteorological data.

Catalogue Reference Number: RP00

Category: Park Management

Title of Work Done:

Functions of the natural environment.

Catalogue Reference Number: Not allocated - raw data with scientist (Macarena Mata)

Category: Data Management and Biodiversity Studies

Title of Work Done:

Faunal records - species lists.

Catalogue Reference Number: 95/5

Category: Data Management and Biodiversity Studies

Title of Work Done:

Biodiversity data base (up-dated).

Catalogue Reference Number: Computer Disk "Project S'Albufera Biodiversity Inventory"

Category: Interpretation and Education

Title of Work Done:

Preparation of S'Albufera CD-Rom for schools.

Catalogue Reference Number: 95/6

Category: Interpretation and Education

Title of Work Done:

Interpretation material on the plants of S'Albufera: habitat posters.

Catalogue Reference Number: Not allocated - raw material with artist (Dinah McLennan)

Category: Interpretation and Education

Title of Work Done:

Interpretation material on the plants of S'Albufera: plant guide.

Catalogue Reference Number: Not allocated - raw data with scientist (Jo Newbould)

Category: Programme development

Title of Work Done:

MedWet monitoring methodology: S'Albufera pilot study.

Catalogue Reference Number: 95/10

APPENDIX 3 - 1996 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

April 11-April 25, 1996

TEAM II
TEAM III

April 28-May 12, 1996
October 26-November 9, 1996

Team Composition: integrated teams of Scientists, Earthwatch Volunteers and Mallorcan Students.

SPECIAL GLAXO EDUCATION TEAM

August 15-August 29, 1996

Team Composition: integrated teams of Scientists, Earthwatch Europe Glaxo Education Fellows and Mallorcan Students.

Fields of Research

Human and Management Impact studies

1. Assessment of erosion at the interface of beach and Es Comú coastal dunes (Mike Wood; Nick Riddiford).
2. The impact of grazing on *Euphorbia terracina* distribution, fossil dunes (Jo Newbould).
3. Coastal dune re-population after damage by fire (Maria Zas; Nick Riddiford).
4. Aquatic invertebrate communities in relation to water quality (Michelle Chapman).

Ecosystem studies

1. Functions of the natural environment (Macarena Mata, Wageningen Center for Environment and Climate Studies).
2. GIS application to ecosystem valuation for land use planning (Sas Terpstra, Wageningen Center for Environment and Climate Studies).

Botanical

1. Monitoring of vegetation communities by dune transects (Jo Newbould; Maria Zas).
2. Herbarium development and curation (Jo Newbould; Dinah McLennan).
3. Plant Illustrations/Preparation of botanical interpretation material (Dinah McLennan).
4. Bryophyte distribution and diversity (Rod Stern).

Vertebrates

1. Bird population studies - transects, body condition of migrants (Nick Riddiford; Nick Ward).
2. Bird migration studies - Mediterranean small islands bird migration project (Matias Rabassa).
3. Mammal population studies (Rob Strachan: Wildlife Research Conservation Unit, University of Oxford).

Invertebrates

1. Entomology:

- a) insect reference collection (Riddiford; Barry Goater);
- b) studies of Diptera, Syrphidae (Riddiford);
- c) butterfly and dragonfly transects (Riddiford);
- d) Systematic light trapping for moths (Riddiford; Dr David Agassiz).

Data Management

1. Program development for standardised data processing and storage (Sarah Hawkswell; Riddiford).
2. Biodiversity studies (Riddiford; Hawkswell).

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. As co-operation with other scientists and bodies has increased so too has the number of S'Albufera research publications which have come to light and which contribute to the baseline reference and/or to current Project S'Albufera research. These additional publications are prefixed by a double asterisk (**). This document comprises the seventh annual report. From 1991, fieldwork descriptions and results have been published as Annexes to each report. For completeness, and to guide new readers to past results, these papers have been included for the first time in the list of publications. These papers are prefixed by a hash sign (#).

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

ANON. 1994. Conclusions de la Primera Reunió nacional sobre la Cel.la marbreca, *Anas*

- angustirostris*. *Butlletí del Parc Natural de s'Albufera de Mallorca* 1: 79-80.
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- ASSOCIACIÓ BALEAR D'AMICS DELS PARCS (ed.). 1990. *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.
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- *BORDOY, M. & PERELLÓ, G. 1995. Parc Natural de s'Albufera. Base de dades bibliogràfica. *Butlletí del Parc Natural de s'Albufera de Mallorca* 2: 93-106.
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- #BOWEY, K. & RIDDIFORD, N. 1992. Mammal studies, 1991. *Earthwatch Europe S'Albufera Project Rep.* 3: 142-143.
- #CROSS, E. 1993. Sampling of Odonata larvae and other aquatic fauna. *Earthwatch Europe S'Albufera Project Rep.* 4: 104-135.
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ANNEX 1

Purple Gallinules (Gall d'aigua) *Porphyrio porphyrio* at S'Albufera de Mallorca by Nick Owens (Earthwatch Europe Glaxo Education Award Fellow) and Pere Viçens (Ornithologist, Parc Natural de S'Albufera)

Introduction

Purple gallinules were hunted to extinction in S'Albufera earlier this century. This was the last remaining population in the Balearic Islands. According to Pliny, gallinules were once common in the Balearics, and were hunted for Roman feasts (Mayol 1990). Mayol also quotes Hernandez Ponseti who described Purple Gallinules as being common in Menorca at the beginning of the 20th century, where they were domesticated and kept in chicken coops.

Persecution of gallinules around S'Albufera was probably largely to secure birds for the pot. However, gallinules are known to be partial to rice (Cramp *et al.* 1980), so it is possible that damage to rice fields provided an added incentive for hunting the birds.

With the establishment of S'Albufera as a National Park, the opportunity arose to reintroduce the species. Twenty-eight birds were obtained from Coto Doñana and released in 1992. Each was provided with a plastic identification ring. This report reviews the progress of the released birds up to autumn 1995, with some notes on breeding success and habitat choice. It is based on counts of breeding birds made by Park staff, and on surveys by Earthwatch volunteers in a two week period in October-November 1995. It is hoped that it will provide a baseline for further studies.

Methods

A violent hailstorm in September 1995, which had a destructive effect on the height of reedbed vegetation, led to unimpeded views across much of the marsh during the autumn Earthwatch visit. Gallinules were mapped in two ways:

A. All birds seen or heard by Earthwatch volunteers during the period 21 October to 3 November were mapped. These were birds encountered whilst volunteers were out and about in the park, but not necessarily looking for gallinules. A different symbol was used for each day's observations. This allowed account to be taken of birds repeatedly seen at the same place on different days. A final map was drawn showing the distribution of sightings, with one symbol for each gallinule site. At some sites, gallinules were seen on several days, and at others only once or twice.

B. On 31 October a synchronised count of the whole park was attempted. Observers started at 07.00, and continued for up to three hours. All tracks and paths in and around the park were covered. Gallinules seen or heard were recorded and their positions later pooled on to one map. Volunteers varied in their ability to find gallinules and not all could recognise their calls, so inevitably some were missed.

Notes were made of behaviour, presence of young birds, and any rings seen. Age ratios of moorhens *Gallinula chloropus* were also recorded to compare with the gallinules.

Results

Numbers

Method A indicated a total of 39 birds, and method B 32 birds. In the synchronised census (method B), 3 birds were found at sites not recorded by method A. The minimum population size must be taken as 32 birds. However, if the birds were essentially sedentary and there was little movement between sites during the study (which observations seemed to suggest - see maps), the minimum population size may have been closer to 42.

Calls could not be heard farther than about 100 metres away, so some birds in the centre of large blocks of marsh could have been missed in the autumn census.

Distribution and habitat

Concentrations occurred in the Canal des Sol where reed cutting was in progress. Up to 5 birds gathered on the bank-side piles of cut material. In the census, 16 birds were counted in a short stretch of canal (about 300 metres) in the early morning. Despite this gregarious behaviour, gallinules were often seen in pairs. Also, sites where gallinules were seen away from the Gran Canal/Canal des Sol area often coincided with breeding sites. It seems that most birds made only local movements away from breeding sites, probably by walking. No bird was seen flying any distance over the reeds.

Gallinule sites all had some open water. Many were along canals, and birds were absent from canals totally blocked with reeds. Gallinules also occurred in reedbeds away from canals where there was open water or pools between the reeds. Birds in such sites appeared to be more vocal than those along canals, perhaps because they were more often hidden from each other. There may be individual recognition of calls (Cramp *et al.* 1980).

The former rice paddies in the centre of Es Columbar may have held birds that were not recorded. The aerial map shows open pools far from any paths. None was seen in that area from Tower Hide however.

Birds were seen close to the park boundary at Pont de Ferro, including one at the other side of the road. A gallinule was killed by a car in that area earlier in the year.

The presence of gallinules at Es Cibollar suggested a tolerance for saline conditions. However, these birds were associated with *Phragmites*, not saltmarsh halophytes.

Ringed birds

Only one ringed bird was seen - number X14, on the left leg. The right leg bore an alloy ring. The bird concerned was seen halfway between the Tower hide and the Gran Canal bridge, in the most northerly of the three parallel canals. Good views were obtained of the majority of the other birds recorded, so it seems that most of the 28 original birds have now died (or emigrated).

Reproduction

Records of young birds seen since the reintroduction are

1992	14 August	1 pullus at Watkinson hide
	1 September	1 juvenile at Bishop 1
1993	7 June	3 pulli
	23 September	2 pulli, Canal des Sol
1994	1 June	2 pulli, Es Ras
1995	3 April	3 pulli, Gran Canal

The above is not a complete list, as nests were not systematically looked for. Gallinules were thought to be single brooded up to 1994, but some may have been double brooded in 1995. Territorial behaviour was first seen on March 14th in 1994, but as early as 20th February in 1995.

The number of breeding pairs since the reintroduction were:-

1992	1993	1994	1995
3	9	15	23

Nesting sites were in similar habitats (reedbeds near open water) to those frequented by birds in October/November, with the exception that one pair bred in the saltmarsh, close to Bishop 1, in 1992, 1994 and 1995.

Only one juvenile gallinule was seen during the Earthwatch visit in October/November 1995, close to the bridge over Canal des Sol. It was seen on only one occasion, so may have been a mobile bird. Its plumage was much browner than the adults, but it was similar in size. The legs were pink but not so vivid as those of adults, and the bill had some red in the centre of the shield. By October some juveniles, perhaps from early broods, are largely indistinguishable from adults in plumage tone. However, at close quarters the underparts, especially the vent and undertail-coverts, continue to be brown in tone often with some paler flecking; and the bill and legs though

pink still lack the brightness shown by adults. It is possible, therefore, that some advanced juveniles in near adult plumage were overlooked, if at a distance.

Moorhen ages were noted wherever the species was encountered. This allowed a comparison to be made between gallinule breeding success and that of its nearest relative in the park. Juvenile moorhens could easily be distinguished by their brown plumage and lack of red and yellow colour on the bill. At some sites up to three counts were made. A maximum of one count was made on any one day. The overall age ratio was calculated by taking the maximum number of juveniles and adults seen at each site.

Overall age ratio of Moorhens

Juveniles	Adults
-----------	--------

16 (37%)	27 (63%)
----------	----------

Discussion

This preliminary survey of Purple Gallinules showed that the population has steadily expanded since the reintroduction in 1992.

Of the 28 birds released, only three pairs bred in 1992, suggesting high early mortality. Thereafter, breeding success was good up to 1995. Initial observations suggest that recruitment was poor in 1995. The October/November counts found a putative minimum of 42 gallinules. Although the result is affected by a possible overestimate if birds were more mobile than thought and the possibility that a few birds may have been missed, this total is comparable to the 23 breeding pairs (46 birds) counted earlier in the season. It is possible that some juveniles attaining plumage similar to the adults were overlooked. However, the lack of any clear increase in numbers after the breeding season, and the observation of only one certain juvenile, suggests that the population has stabilised, at least temporarily.

The weather was very dry in the summer of 1995, so it is possible that this led to poor food supplies and/or increased predation of gallinule young. If this were the case, it is likely to have had

an adverse effect on other ground nesting birds. In order to test this, counts were made of age ratios in moorhens at several sites in the park. The results show that moorhens had reasonably good breeding success, with a ratio of 27 adults to 16 juveniles. If the conclusion about poor gallinule breeding is correct, the causes seem to have affected gallinules more severely than moorhens.

The September hailstorm which did so much damage to the vegetation also killed large numbers of birds (over 200 birds of a number of species found dead). It is also possible, therefore, that any gallinule population increase was held in check by increased mortality caused by the hailstorm.

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.....MAP ON THIS PAGE.....

Purple Gallinules Survey Method A

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Purple Gallinules Survey Method B

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Purple Gallinules: Breeding Sites

.....SKETCH ON THIS PAGE.....

Juv. Purple Gallinule S' Albufera 29 Oct 95

ANNEX 2

Aphids on *Phragmites*, August 1995 by Roger Wood and Ken Halliday (Earthwatch Europe Glaxo Education Award Fellows)

Introduction

Stands of *Phragmites australis* act as microhabitats for green and black aphids (Aphoidea). Reedbed aphids are a potentially important food source, particularly at certain times of the year, for many reed-dwelling warblers resident within the S'Albufera marshes. Examples of species which may exploit this food source include *Cisticola juncidis* (Fan-tailed Warbler), *Cettia cetti* (Cetti's Warbler), *Acrocephalus melanopogon* (Moustached Warbler), *Acrocephalus scirpaceus* (Reed Warbler) and *Acrocephalus arundinaceus* (Great Reed Warbler). This is by no means an exhaustive list as careful observation would need to take place in order to develop a more definitive list of bird species exploiting aphids as a food source.

The aim of this study was to develop a methodology for the random sampling of aphids on *Phragmites australis*, and to recommend procedures for further research.

Methodology

To sample aphid populations in a specific locality, a transect was set up of at least 125 metres in length. Two people were used, one as recorder and the other as sampler/investigator. From the starting point, the sampler walked 5 m forwards along the transect line before taking a 1 m step either to the left or the right according to which side of the path was chosen (during the development stage of the methodology, sampling was restricted to reed-bed edges). Selection of the plant to be sampled was done by the sampler swinging his arm outwards, at shoulder height, with the first *Phragmites* stem to be touched becoming the plant selected.

The following information was collected.

1. The number of Aphids infesting
 - a) the stem;
 - b) the upper epidermal surface of the leaf, for each leaf separately;
 - c) the lower epidermal surface of the leaf, for each leaf separately.
2. The height of the plant.
3. The number of leaves on the plant.
4. The inclination of infested leaves, comprising
 - a) the angle, from the stem, of the upper surface;
 - b) the compass position towards which the leaf faced (e.g. N, S, E or W).

The number of aphids was recorded using letter notation derived from a key representing orders of abundance. This key is repeated in Table 1 below.

Table 1. Letter notation key to represent number of aphids according to order of abundance.

Letter	A	B	C	D	E
Number of Aphids	0	1-9	10-99	100-999	1000+

A minimum of 25 plants were sampled along each transect.

Summary of results

- 1) Over 90% of all aphids were found on the highest leaves, where there is greatest exposure to UVA and UVB sunlight.
- 2) The aphids, in all cases, were being “herded” by accompanying ants, and the presence of large numbers of ants was a reliable indicator of aphid presence.
- 3) The aphids encountered were predominantly green but black specimens were also observed.
- 4) Numbers were greater on the upper epidermis.
- 5) No aphids were found feeding on the stems of sampled *Phragmites* plants.

Discussion and suggestions for further study

The higher, younger leaves may be utilised for a number of the following reasons:

- a) The thinner epidermal layers may allow more effective/easier penetration by aphid stylets/piercing mouthparts in order to extract nutrients/carbohydrates from palisade and mesophyll layers.
- b) Younger leaves may have an optimum photosynthetic and metabolic process which corresponds to the needs of the aphids, and the accompanying ants.

The upper epidermis may have been favoured because it is the layer of leaf containing chloroplasts and thus the most direct route for the aphids to nutrients.

The stem tissue may have been too woody and compact in August to be an appropriate feeding station.

As the position of the leaves, their height on the stem and the amount of exposure to UVA/UVB light may affect population levels on individual plants, the following issues could be investigated:

- a) Will aphid numbers/population levels fluctuate according to the time of day? What is the effect of leaf shading as the sun moves across the sky, i.e. will levels be highest when the leaf receives 100% exposure to UVA and UVB? (optimum photosynthetic productivity?).
- b) Do aphids migrate vertically according to temperature fluctuations? (Levels highest at sunrise or at noon when sun at azimuth?).
- c) Does the inclination and position of the individual leaf make a difference to numbers, i.e. angle of inclination from stem; does the leaf face N, S, E or W?
- d) The two transects undertaken were on the shaded side of the path. It would be necessary to undertake surveys on the exposed side in order to determine differences in exposure on population levels.

In terms of the ecology of each *Phragmites* microhabitat it will be necessary to determine the following:

- i) the reed-dwelling birds which utilise aphids as a food source.
- ii) the requirements/survival needs and limiting factors of aphid population dynamics.

Appendix 1. Aphid characteristics

Classification: Insecta, Homoptera

Particular physical characteristics: cornicles exude honeydew; wingless/winged forms in most species

Phenology:

Winter - egg/dormancy stage - winter

Spring - generally all wingless and all female, parthenogenic and births mostly live rather than through egg laying

Late spring/summer - winged adults

Appendix 2. Recommendations for studying bird foraging/feeding strategies in relation to aphids

In order to determine the main foraging sites for reed-dwelling birds, and the feeding strategies involved it is necessary to determine the following:

- the choice of site by aphids;
- the height of the leaves with large/optimum micropopulations;
- the optimum environmental conditions for the growth of aphid populations and individuals.

In order to understand the predator it is more important, initially, to understand the prey, including:

- its population dynamics
- limiting factors impacting on population dynamics.

Following our increasing understanding and knowledge of the prey, it is possible to undertake

informed observations of bird foraging activities in relation to known aphid availability, location and densities.

ANNEX 3

Re-colonisation of an area of coastal sand dune by vegetation destroyed by fire; a random quadrat sampling study in Es Comú dunes, southernmost sector by Nick Riddiford and Maria Zas

Objective

To monitor the re-colonisation of vegetation completely destroyed by fire on 4th April 1994 in a 3.5 hectare area of the coastal dunes.

Location

The southernmost sector of the Es Comú coastal dunes, centred on map reference 120 033. The part surveyed was 70 m x 50 m area selected as relatively uniform in topography and drainage. It was also the farthest part of the burn from the sea and thus least likely to be affected by vegetation zonation due to maritime influences. See Figure 1 for greater detail.

Methods

Two ropes were set out at right angles, one running N-S for 70 m and the other E-W for 50 m, to delineate the largest rectangular area of complete burn. Vegetation information was collected from a series of one-metre quadrats placed at random within the delineated area. Quadrat sites were chosen from a table of random numbers. The vegetation information collected was: % cover for each species present; % bare ground; height of tallest vegetation; approximate mean height of vegetation.

Results

Thirty quadrats were surveyed in 1995, eleven on 14th April, five on 8th May, three on 18th and eleven on 20th May. The proportion of bare ground was high, averaging 75.1% (range 40 to 95%). A total of 50 species was recorded. The mean number of species per quadrat was 13 (range 6-20). Only eight species occurred in more than 50 % and only three, *Cistus salvifolius*, *Smilax aspera* and *Desmazeria rigida*, in more than 75% of quadrats. *Cistus salvifolius* was the commonest, occurring in all but one quadrat and, though no counts of individual plants were done, was certainly the commonest in number of individuals. Despite this, it was not the most significant in terms of vegetation cover, not exceeding 10% in any quadrat and generally much lower. This was because the species was represented by large numbers of very small seedlings. In the few quadrats where single species cover exceeded 10%, the plants involved were more robust or shrubby species. This was typified by *Pistacia lentiscus* which was only recorded in 9 (30%) of quadrats yet in one quadrat produced the highest recorded cover for one species of 30% - all contributed by a single robust plant. Vegetation height was low, too, with mean height per quadrats averaging 9.7 cm, and a maximum recorded height for any vegetation of 65 cm. *Pinus halepensis*, generally considered to be the main component of climax vegetation in that part of the dunes, was recorded in only three quadrats, on each occasion represented by a solitary

seedling.

Furthering monitoring of re-colonisation is planned for spring 1996.

Notes:

The extent of the burn was 3.5 hectares.

The area was checked by NR at the end of April 1994 when no living (green) vegetation was found in the sampling zone, nor in much of the 3.5 hectares burnt area.

Teams of workmen completely cleared the charred bush vegetation and humus in May 1994 using a bulldozer, which reduced the area to almost uniform bare sand.

The fire was not a planned management act but started accidentally or deliberately by persons unknown.

All species within the quadrats were identified, mainly to species but some to genus, or given a reference name as a precursor to subsequent identification or confirmation from specimens taken.

.....FIGURE 1 TO APPEAR HERE.....
(Map of burnt area)

ANNEX 4

Parc Natural de S'Albufera Management Plan, 1995-98. Consultation comments by members of the Project S'Albufera team.

In 1995 Conservation Director, Joan Mayol, invited the Project S'Albufera scientific team to assist him in his preparation of a new four-year Park management plan, by submitting a series of comments and recommendations based on our observations, studies and results. We were already involved at an informal level, but we were very pleased to extend the level of integration and interchange of views by putting our comments on paper. To achieve this, Project scientists were invited to submit succinct comments which were specific to their area of study and/or expertise, or more general. As part of our ongoing programme of feedback, some management suggestions had already been made, either verbally or included within published results. These were incorporated along with new comments in the consultation submission. The comments, which covered a range of subjects, are repeated below. Sr Mayol and the Park staff do an excellent job and we hope that our comments will be a help and a support to their work. We recognise, however, that they may not have the funding or staff time facilities to implement all our comments and recommendations (Editor).

MANAGEMENT PLAN FEEDBACK - FAUNA

Herpetological (transcription of verbal comments from Alexander Pieh)

I. Pond Terrapin *Emys orbicularis* breeding areas

1. *Emys* nest in soft sandy areas of low, relatively sparse vegetation. So Alex recommends
 - a) fence off known breeding areas to keep grazing animals off during the breeding season to prevent nest sites being trampled.
 - b) let in grazing animals during the non-breeding season (October to February?) to graze vegetation so that it does not get too dense.
2. *Emys* may be discouraged from entering areas which throw a shadow (for instance standard type fences). So Alex recommends
 - a) use single-strand electric fences rather than standard permanent fences to exclude grazing animals.

II Marsh Frog *Rana perezi* and Green Toad *Bufo viridis*

It is the opinion of Alexander Pieh that the *Bufo viridis* population may be in trouble (and possibly extinct or nearly so) because of predation of eggs and young by *Gambusia affinis* - an event which is known to have occurred in some other Mediterranean wetlands where *Gambusia* has been introduced. Alexander also expressed concern that there appeared to be an imbalance in the age classes of *Rana ridibunda*, suggesting that this population could also be under pressure for the same reason.

Alex could not recommend any management action which would alleviate the problem (once *Gambusia* is established there is no known way to eradicate it) but felt that this problem should be made known and considered.

Mammals (transcription of verbal comments from Rob Strachan)

1. Pine Marten *Martes martes*. The Park undoubtedly has a population of Pine Martens. This is unusual, because the species is normally more associated with upland habitats. The Mallorcan Pine Marten is also a distinct subspecies.

The management plan should certainly mention this (as of ecological interest), even if there are few specific measures which could be employed to enhance or maintain the population. One measure which could be employed would be to provide artificial nest-sites, such as piles of large stones - which would need of course to be placed discretely (both to reduce disturbance and for landscape/scenic reasons).

2. Bats. S'Albufera is a very important site for bats. With the removal and/or restoration of the old buildings at Sa Roca and with increased disturbance probably occurring at nearby nesting or roosting caves, the bat populations are probably under some pressure to maintain their numbers. A programme of providing artificial sites would undoubtedly alleviate this problem, as there is no shortage in food available at s'Albufera.

S'Albufera bats have important roosting and nesting sites outside the Park. One of these is the Cova de Sant Marti. If it is at all possible under the management plan, plans should be included to increase protection of this and any other known local cave sites, against undue disturbance - obviously in partnership with authorities or land-owners directly responsible for these caves.

3. Small mammals. Rob's work indicates that, at certain times of year at least, three mice *Apodemus sylvaticus*, *Mus musculus* and *Mus spretus* co-exist within the reedbed, probably by avoiding competition spatially (by living in the reeds or at ground level) and temporally (by day or night activity). This is of great ecological interest and could be mentioned in the plan.

Rob Strachan indicated his willingness to advise on any aspect of these recommendations or other matters relating to the mammals of s'Albufera.

Bats (Jean-François Noblet, from recommendations in his report, The Bats of the Albufera Natural Park, Mallorca)

He writes "... It would be useful to put up nest boxes for Barn Owls in order to obtain food pellets regularly. It would be possible to construct one in the building which serves as a workshop, in the ruins at Ses Puntetes, and in the signal towers by the sea. Nest boxes could also be installed in large trees."

His report also contains detailed practical management proposals aimed at increasing roost and breeding sites for bats within the Park.

Barn Owls (comment by Nick Riddiford)

It would be useful to put up nest boxes for Barn Owls *Tyto alba* not merely to obtain food pellets regularly for bat studies, but also to replenish potential nest sites within the Park which may have disappeared after the renovation or removal of various old buildings.

Management of *Acrocephalus melanopogon* at S'Albufera de Mallorca (from Roy Taylor's MSc. Dissertation, University College London)

"Actions

- i) Maintain high water levels in the reedbeds during early spring and summer.
- ii) Maintain (or enhance if possible) the current system of fire prevention.
- iii) In terms of area, any increase in livestock grazing should be of limited extent only and be concentrated around currently grazed areas.
- iv) Large areas of Es Colombar, Es Rotlos, Son Carbonell and S'Amarador to remain as non-intervention management zones, thus ensuring the presence of old age structured reedbeds favoured by the species.
- v) Sluicing of overgrown canals in order to maximise canal length within the reedbeds.
- vi) Creation of a series of small pools within the driest reedbed regions, i.e. Es Rotlos.

Points v) and vi) help to increase the area of highly productive 'wet edge' available for foraging."

Roy Taylor also points that "in terms of breeding density, S'Albufera appears to be the most important site for the global conservation of the species yet described", and he recommends the following monitoring tasks:

- "i) Establish mark-recapture studies in all reedbeds to determine the true population figure.
- ii) Conduct research into the winter distribution and ecology of the species at S'Albufera.

The initiation of long term studies will be needed to achieve the above."

Odonata (transcription of verbal comments from Ed Cross)

The dragonfly *Selysiothemis nigra* is rare in Europe and one of the species reputed to occur in the Park. We have not found it there. However, this does not mean it is absent or extinct, because we may not be there during its flight periods. Knowledge is needed of its current status, and measures taken to at least ensure that it is mentioned as a rare species protected by the Park - with a long-term aim of learning more of its population size, distribution, ecology and needs.

[Editor's note: *Selysiothemis nigra* was confirmed by the Project as still present in August 1995, but the comment regarding its rarity and the need to know more about it still applies.]

MANAGEMENT PLAN FEEDBACK - FLORA

Turo de ses Eres (transcription of verbal comments by Dinah McLennan)

To ascertain fully the threat of *Euphorbia terracina* to the vegetation structure of Turo de ses Eres, Dinah and Jo Newbould require a three-year period of planned grazing. They suggest that the area should be grazed from 1st June to October or November, then the animals taken off for the winter (this corresponds with the thoughts of Terry Wells who told Xisco Lillo verbally that the earliest time to put grazing animals on without damaging the orchids there was the very end of May).

Dinah also emphasised that a fixed grazing plan was important generally, with pre-defined dates for putting on and removal of grazing animals to benefit the various conservation objectives (whether plants or birds) as it is much easier to assess the impact of grazing if a regular pattern of grazing time is established. She emphasised, however, that flexibility should be built into the plan so that, if pre-defined periods of grazing are demonstrated to damage the conservation interest, these periods can be adjusted to take that into account.

Track sides. Dinah pointed out that track sides walked regularly by visitors, most notably the track-side leading to the Tower Hide (camí d'enmig) were not as floristically rich in 1995. This may partly be due to the dry weather, but she felt that it also reflected a denser ground vegetation against which flowers could not compete. She recommends that short stretches of vegetation immediately alongside the track could be cleared on a regular basis in winter (e.g. once every three years, with different stretches being cleared each year) so that flowering plants could be given the opportunity to come through. Clearing should be confined to the immediate track-sides and should not involve any clearance of trees or taller vegetation which act as screens for the wildlife on the canals beyond. The increased floristic diversity which would result from clearing stretches has no huge conservation value but enhances the Park's interest for visitors - particular in spring.

Mosses (Rod Stern, Conservation Officer of the British Bryophyte Society)

The following extract from the 1994 Project S'Albufera Report comprises the conservation recommendations and conclusions made by Rod Stern following his visit in November 1994:

"Conservation

The total of over 50 species recorded in 1993 and 1994 is relatively high for a Mediterranean lowland locality with limited habitat diversity. The general management of the Parc must be regarded as beneficial for bryophytes. There are, however, two aspects which need to be considered.

The first is the importance of retaining trees by the canal, even the dead and diseased elms. The woodland habitat, although it is very limited in the main part of the Parc, is an important one for bryophytes (as well as for lichens), both for the moist conditions under the trees and for the

epiphytes which grow on the trees themselves. The general lack of epiphytes is partly because of the relatively small size of most of the trees, as well as the unsuitability for epiphytes of *Populus alba* as the commonest tree, the generally dry climate and possibly some air pollution from the Es Murterar Power Station. It is therefore important that the trees are retained, in particularly the elms, not all of which in any case appear to be affected by the disease.

The second aspect relates to water quality. The aquatic liverwort *Riccia fluitans* was recorded by Rosselló in 1981 (Rosselló 1994). It was noted by N. Riddiford in more than one site until about 1990 but could not be found in a search with him in 1994. It seems likely that this species has disappeared as a result of pollution of the water from agricultural chemicals used on the arable land near the Parc on the west side. The moss *Octodiceras fontanum* which was also recorded by J. Rosselló in 1981, was refound in 1994 in a search with N. Riddiford; however, this species is known to be pollution tolerant, unlike the *Riccia*. It is to be hoped, therefore, that measures will be taken to reduce the level of pollution, which has of course undesirable effects on other wildlife as well.

Finally, it should be noted that the southernmost part of the Parc is a location for the hepatic *Petalophyllum ralfsii*. This is an Annex II species in the European Habitats Directive as well as being listed in Appendix I of the Berne Convention as a species threatened because of the destruction of its habitat. At S'Albufera, it occurs on damp stony ground on the inland part of Es Comú (an area known to the project as "Ca'n Picafort woods").

Conclusion

Bearing in mind the unsuitability of much of the Parc, the brio flora is by no means without interest. It should be monitored from time to time and there is more scope for further examination of the sites listed above as well as surveying of other sites. The author hopes himself to spend more days in the Parc in the next few years.... At least one specimen of most of the species will be kept for reference in the herbarium at the Parc headquarters."

MANAGEMENT PLAN FEEDBACK - GENERAL

(written comments from Keith Bowey)

"Broad Principles: obviously the most important principle with any management plan is to decide on the priorities for which the reserve is being managed, to define the aims and objectives and to stick to these. This stage of the process should be carefully considered and under no circumstance should it be hurried. I feel very firmly that the reserve should be managed on strong ecological principles, i.e. that the ecological imperatives drive the preparation of the management plan, and subsequently of the site, and not resource allocation or political considerations. Obviously public access and commercial considerations influence decisions but they must not drive them! Such factors which might limit the extent to which the ideal aims and objectives can be achieved should be identified in the plan, for all to see.

Each compartment of the reserve needs to be carefully identified and de-lined, which involves much mapping, as do any sub-compartments. This is an important discipline as it makes the site

managers, who are already familiar with the site, go back to first principles and look for the factors, ecological and physical, which make one area of habitat definably different from another. After the definition of the broad "reserve-wide" objectives every single compartment should then have identified its own ideal objectives, at which the managers want to arrive over the life of the management plan. Only by going through this process can there be any way of quantifying the degree of success, or failure, of the plan at the end of the defined period of its use.

Only after these procedures have been undertaken should prescriptive statements, for each compartment and sub-compartment, be decided upon and drawn up. There is a grave danger that certain people (particular if changes in personnel occur) might reverse this sequence and attempt to make the objectives tally with the adopted management prescriptions, for whatever personal or political agenda; that way leads to ecological confusion and potential disaster!

I feel very strongly that s'Albufera should be managed for what it undoubtedly is, one of Europe's most important wetlands. This requires an holistic approach, the managers should never lose sight of the qualities which make the site special in the first place; the water, its quality and the reliability of its flowing into the reserve. Ultimately water management dictates what will happen over the whole of the site so a sensible and consistent hydrological approach must be decided upon. There should be no reactive decisions, to raise or lower the levels, for short lived conditions or gains (emergencies always excepted). Water management within the reserve should be proactive and planned only after careful enquiry of the whole hydrological system of which the reserve forms a part."

MANAGEMENT PLAN FEEDBACK - VISITORS/INTERPRETATION

(written comments from Keith Bowey)

1. Interpretation

The new facilities in the centre are superb but perhaps a series of interpretive panels discretely placed at or near the road could give the basic information about the site, without a need for a visit to the visitor centre - thus taking pressure off the current single focal point for visitors, while informing more people about the Park.

2) Zonation and Channelled Access

Although the hides provide relatively good channelled access to some areas of the reserve, maximum use is not made of some of them. One feature which would be good both from the point of view of reedbed management and for allowing people to "enter" (at least visually) a reedbed would be to have a series of ditches/small canals radiating out from the central point of an arc (the hide), so that people can see along them. This would provide a very large area of reedbed edge for feeding herons, bitterns and other species, excellent bird-watching and it would also provide an interpretive opportunity. The ditches/canals could be cleared on a rolling programme over a period of years, so that each one was at a slightly different stage of

vegetational succession. Hence all stages of reed re-invasion could be represented in front of one hide. This would allow some interpretation of the development of a reedbed and the importance of the different age classes of reeds to different organisms. Watkinson hide would be an obviously locality to choose for such a programme of works.

Visitors and facilities (comments by Nick Riddiford)

Visitors are important to the Park, not least in demonstrating to political policy and decision-makers the overwhelming interest and prestige of S'Albufera at an international level and, increasingly, at a local level - it has become a recognised refuge of interest and benefit to the Mallorcan people.

Unfortunately, because of the wetland nature of the area, visitors are heavily concentrated in a very small space. This is perfectly acceptable for the wildlife, which have large areas of undisturbed space, but puts enormous pressure on the facilities, particularly at the point of largest concentration (which is at Sa Roca). At certain times, the hides also become sites of heavy concentration.

These factors can undermine or negate the atmosphere of "wilderness" which the Park has the capacity to generate (for instance in the evenings when visitors have departed). Visitors are drawn to the Park for many reasons. But two major "types" can be recognised 1) the birdwatcher/nature-lover, and 2) the tourist drawn into the Park on a dull day when the beach is not an attractive option and there is "nothing to do". The two types are very different, but both expect to gain from visiting the Park.

The naturalist types tend to prefer space, quiet and wilderness. They do not need much tuition for what they are seeing, just the opportunity to see it. Most are prepared to walk some distance to see nature. They can be disappointed if the car park is full, they cannot move for joggers and noisy tourists, and the hides are so full that they cannot get in.

The "tourist-off-the-beach" types expect to see something but they do not know what. They are often disappointed because they feel that what is on offer does not compensate them for the long, dusty walk.

Facilities have improved enormously and continuously since it was designated a Park. However, there is scope for further improvements (some of which I know are already planned) which could offer something positive to each type of visitor. My recommendations would be:

For the avid birdwatcher/naturalist: more hides.

For the "casual" tourist: more active interpretation. The audio-visual presentation and exhibition are both excellent. However, active interpretation, perhaps through guided walks or demonstrations would be of benefit from a public relations point of view; and, importantly, these casual visitors are a "captive market" of people many of whom perhaps have little knowledge or care for the environment - the conservation benefits of pro-active activities with such a group

could be enormous.

I would also recommend that considerable thought is given to developing other interpretation/reception areas nearer the road. This would spread the "load" of visitors more widely and evenly.

Problems of Implementation

My ideas are fraught with difficulties. For instance the coast road is now so busy and the cars so fast that a reception centre near the road could be a traffic hazard (though no more so than the current dangerous entry/exit point at Pont dels Inglesos). There is also the danger, if interpretation facilities are established (e.g. by putting up a series of detailed information boards at the entrance), that the Park will lose the opportunity to monitor the number of people recorded visiting the Park with a consequent decline in published figures (which could damage the Park in the eyes of the decision-makers or lead them to force a change of management in a counter-productive way).

The biggest problem is of course finding the money needed to implement further improvements. The Park staff are already fully committed and stretched in their current roles and could only take on more to the detriment of work they are already doing.

One solution would be to make a charge. I know that it is not policy to charge visitors to Spanish parks, and I approve of this. But many international visitors express surprise at not having to pay, and they often express to me a desire to make some sort of contribution, particularly if they feel that they will benefit from it in the long term (by improving the facilities on offer).

To afford my recommendations above I suggest the following:

that new hides and other visitor amenities which have been identified and for which funding is not available should be paid for by visitor contributions. Contributions should be sought actively: by collecting containers placed prominently and accompanied by a display explaining the use to which the contribution would be put; and by reception centre staff informing visitors who ask about contributions.

that guides are employed at peak times to interpret aspects of the Park. The guides would need to have language ability as well as knowledge of the local environment, but there must surely be competent Balearic students who would be happy to do it during their vacation periods (for instance). There would be a charge for this service, which would pay for the guides.

It strikes me that the local hotels and tourist industry should be party to any such developments. It is very much in their interests and I would like to see them recognise this fact by providing some funding towards developments (such as information boards in the Park, and perhaps in the hotels, hide facilities, guide services etc.). They could also be instrumental in arranging groups to take advantage of the "guided walks" service - thus underwriting the employment expense by ensuring regular customers.

Seeing the numbers of people flocking into the Park clearly demonstrates to me the overwhelming interest and demand for such environmental sites and facilities. Eventually this

demand should be met by increasing the number of conservation sites in the area, rather than concentrating more and more people in just one site but this is a long-term thought and probably not within the remit of the current plan.

Exhibition/Audio-visual (comments by Nick Riddiford)

These are super ventures which are very much appreciated by all who see them. It is a great achievement that the money was found to set them up, but funding should also be budgeted annually for the care and up-keep of the displays, and perhaps to up-date them or alternate and introduce new themes from time to time (to keep them fresh for both first-time and returning visitors).

Horse-riding and jogging (comments by Nick Riddiford)

I am sure there are policies regarding these two activities within the Park and they may do no harm. However, the following factors should be taken into account in any future planning and permissions:

Horse-riding:

1. horses galloping through the Es Comú sand dunes loosen the sand on the tracks to such an extent that it impedes walking. Visitors to this area, therefore, tend to avoid these areas of soft sand and walk alongside the edge of the track, thus widening the track and causing erosion and vegetation damage to the sides of the track. As the track becomes wider, more track is available for the horses to churn up, forcing pedestrians wider still. The ultimate result could be "highways" rather than tracks.
2. I have witnessed horses being galloped very fast indeed, particularly along the camí de ses Punes, and it is only a matter of time before there is a serious accident between a horse and visitors to the Park.

I recommend that horse-riding policy be reviewed, and if it is to be allowed at all it should be done on a *permiso* basis with owners and hirers of horses agreeing to a code of practice - which would include a map delineating which paths were permissible for horse-riding and a limit on the speed horse-riders were allowed to ride.

Joggers:

I recommend that a policy should be put into place for "joggers", which would certainly prohibit groups from jogging (I have been passed by groups of up to 100 on occasions - which has disrupted bird and butterfly transect work). If joggers are to be allowed at all, they should be restricted to certain tracks (and certainly not on the narrow paths leading to the hides, where I have encountered joggers in the past).

MANAGEMENT PLAN FEEDBACK - MANAGEMENT PLANNING

Ses Salines (comment by Nick Riddiford)

As soon as this area is brought into full ownership and control, I recommend that remedial works are set in place to re-establish a salt-pan environment (which may require restoring the salinity input from the sea). Consideration should also be given to the feasibility of establishing hides and/or other facilities in that area, both for the benefit of birdwatchers and other visitors and to afford protection to breeding birds by informing and restricting access to planned viewpoints (preferably hides).

Es Comú coastal dunes (comments by Nick Riddiford)

Considerable erosion is occurring at the head of the beach, exposing the roots of the ecologically important *Juniperus oxycedrus macrocarpa* community and completely or largely destroying the colonising head-of-the-beach community of grasses and allied herbaceous plants.

In an ideal world, I would recommend that tourists were discouraged from using this section of beach - which would best be achieved by the passive measure of leaving the band of dead *Posidonia* which builds up on the beach during the winter. The *Posidonia* could still be cleared from those sections of the beach nearest the hotels, but an untouched band would considerably reduce the numbers of tourists using that section of beach and allow natural processes to continue as they have done for centuries.

This is probably being too idealistic and radical because of the pressures placed on the Park by hotel and local council demands and requirements. A second-best solution would be to establish some erosion barriers which would deter access to the head of the beach and allow the vegetation there the chance to recover.

Landscape (comments by Nick Riddiford)

Many regular visitors to S'Albufera were dismayed by the sight of new buildings immediately opposite the Park entrance. The general feeling was that planners in many parts of the European Union would not have granted permission for such buildings. Having accepted that the buildings were to go ahead irrespective, it was nevertheless a shock to see the height of these buildings superseding the skyline which, until then, had been a natural skyline landscape of Pines.

I recommend, therefore, that the Park management plan makes a point about landscape and asks planners to consider the need to reduce the impact of buildings by restricting or stopping further development and to ensure that current developments do not impinge on the current scenic and landscape values by providing adequate screening and restricting building height to below the level of current natural screens and skylines.

Staff (comments by Nick Riddiford)

The staff do a superb job, from the Director-Conservador to that most important of maintenance

staff, the cook! It would be nice to think, with the ever increasing numbers and demands of visitors, a policy of budgeting for further staff to cater for these visitors could be envisaged in this plan (but perhaps I am being too hopeful!).

Whatever the future staff planning, the entire Project team (which includes educators and scientists involved in active interpretation of natural reserves and parks in Britain and abroad) considers that the S'Albufera Park's schools programme is a first-class arrangement which should be encouraged and given every support in its continuation and further development.

MANAGEMENT PLAN FEEDBACK - MANAGEMENT MONITORING

Re-population programme (comments by Nick Riddiford)

The re-population programme for *Netta rufina* and *Porphyrio porphyrio* has been an overwhelming success. The *Oxyura leucocephala* programme is still being developed, with an amended approach after the first relatively unsuccessful attempt. I recommend that every effort should be made, perhaps through SEO or WWF, to obtain funds to employ someone to study in depth any further re-population attempts (of birds or plants). This would have several beneficial elements: 1) it would obtain very useful information (for instance on feeding habits and/or habitat needs) which could serve to assist re-population attempts in other Mediterranean wetlands; 2) in the case of less successful programmes, it would reveal what were the adverse factors - which would allow for either those factors to be eliminated and the programme restructured or, if those factors cannot be eliminated, to culminate the programme; 3) in all cases, it would be a source of excellent publicity for the Park, demonstrating how careful planning, study and management can assist re-population successes and removing any criticism that might occur of poorly planned re-population attempts.

The *Netta rufina* and *Porphyrio* programmes should be highlighted in the new Management plan as an example of successes already achieved under protection and management; and the wish to obtain funding for studying further re-population programmes also clearly stated (even if funding does not follow, the statement will demonstrate good intentions).

General Management Monitoring (comments by Nick Riddiford)

If knowledge is to be gained of the impact of management, it is imperative that management events (for example, dates of moving grazing animals from one compartment to another) are routinely recorded. I am happy to say that this is now occurring (and has done for some considerable time) but it is probably worth confirming this as policy by writing it into the management plan.

I would also like to see a commitment from the government and/or electricity company to put into place a detailed monitoring programme of the impact of the Es Murterar power station now that it is doubling in size (minimum commitment to undertake long-term measurements of air quality and water/vegetation studies in parts of the Park immediately adjacent to Es Murterar). I do not know whether the management plan could request or recommend this?

ANNEX 5

Observations of roosting Starlings, 22nd October to 3rd November 1995 by Nick Owens

S'Albufera is well known as a major roost site for wintering Starlings *Sturnus vulgaris*, with a million or more roosting there in some winters. In most recent autumns, numbers of roosting Starlings have begun to build by late October and high six figure totals are not unusual in early November (Park ornithological records). They were, however, confronted with an unexpected problem in 1995 when a severe hailstorm in September flattened much of the reedbed, rendering it unsuitable for roosting birds. Virtually the only suitable undamaged reedbed was a relatively small unprotected area outside the Park - which presented the Starlings with another problem, that of disturbance, including through shooting activities. It became the objective of my study, therefore, to collect information on Starling roosting behaviour in relation to these problems, including which areas they had relocated to for roosting and how they reacted to disturbance. In addition, some observations were made of "normal" behaviour by birds approaching the site. There was not enough time to collect a lot of information but the following notes, taken from observations made at the time, give some detail of their behaviour during a period when roosting had probably been made more hazardous by the marked reduction in suitable roost sites.

Roosting behaviour (and see map for roost/pre-roost locations)..

22 Oct. Birds first seen assembling at S. end of park 1645, but this was a pre-roost gathering from which they departed to roost in the NW corner outside the park boundary.

23 Oct. 75 000 birds counted from tower hide, evening. Roosted in tall, undamaged reeds outside park. (This site used, despite shooting, until 2 or 3 Nov when moved to Son Carbonell area). Merlin present but did not attack starlings. Seen to chase a wagtail or pipit. 2-3 marsh harriers quartering roost area.

24 Oct. Birds departed 0710 after shooting. Two large groups left together of 30 000 and 35 000 birds approx. No raptors seen at roost, but misty.

27 Oct. Birds coming down at pre-roost to S of main roost. Moved into main roost at 1800-1830.

3 Nov. 100 000+ roosting in Son Carbonell area. The reeds are not storm-damaged here, but are not so tall as previous roost site. Change of roost site probably a result of repeated disturbance and shooting.

General description of roosting behaviour (and see sketches)

First arrival starts from 1630. Birds descend from great height like smoke. Waves pass through flocks, starting at upper edge of flock and travelling downwards. Upper birds seem to be forcing lower ones towards ground. Often then wave is 'reflected' back up as lower birds start to rise before reaching ground. When they finally descend to the reeds the birds drop almost vertically. The final move to the main roost is very low and made in semi-darkness in long flowing lines.

Marsh harriers patrol the pre-roost gatherings. Starlings flushed from reeds, but soon settle. Some starlings seen to follow/chase harrier away from roost area.

.....Starling notes and behavioural sketches HERE...

.....MAP OF STARLING ROOST SITES 1995 HERE.....

.....SKETCH OF STARLING ROOST BEHAVIOUR HERE.....

ANNEX 6

Report on an Earthwatch Expedition to S'Albufera de Mallorca, Spain by O'Kah Ebwekoh Monya

[We were very fortunate to receive as volunteers three dynamic, knowledgeable and talented Cameroonian volunteers on Team III, 13th-28th May 1995, which added a new dimension to the Project. All three wrote enthusiastically of their experience and I could have chosen any of the three reports to publish here. I chose the one by O'Kah because, in addition to informing us of the value they got from it, it gives such a good overview of what the project entails, in all its parts. *Editor*].

Description of work carried out

I missed the question mark behind the "O'kah?", as Michelle Chapman called out poking an EARTHWATCH plaque in front of her. Then I realised how clever she and Maria Zas had been. "Let's look out for the first black man who comes out, 99% chance it will be him". And so it was - me. We later laughed over it that morning as we drove from Palma airport, to S'Albufera. It was the beginning of such an exciting and cherished association that I was to regret ending two weeks later.

Arriving at S'Albufera at 10:30 am., and ahead of most people, I was shown around by a welcoming German, Alex and then allowed to use the rest of the day as I wanted. I chose to intimate myself with the Park. Maria Zas kindly accepted to show me round. By the time we turned in for the night and I met my other Cameroonian friends, I was not the most ignorant man in the world.

The next morning, the Principal investigator (Nick Riddiford), introduced himself to us, having returned from a journey late the previous night, then the project time table. Tasks included helping the studies on; (a) relationship between aquatic macro invertebrate communities and water quality; (b) monitoring vegetation recolonisation of a recently burnt area in the coastal sand dunes; (c) early morning transect walks to monitor fluctuations in bird populations; (d) late morning or early afternoon transect walks to monitor seasonality and fluctuations in butterfly populations; (e) the seasonality in moth populations and building up a reference collection for them; (f) the hydrochemistry and soil/sediment nutrient dynamics (preliminary study). Other tasks included participating in the on going mapping exercise, preparation of CD rom material for interpretation of the park, to be used by schools; monitoring at an international level, where the newly devised methodology for monitoring Mediterranean wetlands is to be tried. The methodology is devised by the EC supported "MedWet" programme. We were also to help with herbarium work and plant records. We were also welcome to help or watch a study on biometrics and genetics of the European pond Terrapin (*Emys orbicularis*), though not a strictly EARTHWATCH project.

Every night we put the moth trap on at about 09:00 pm., and took it in early the next morning at 06:00 am. During each of four days, at least two people joined Nick Riddiford to walk a transect and count birds early in the morning, getting started at 06:20 am. and returning at about 09:00 am, time for a quick cup of coffee before helping Nick again to identify moths caught that night or prepare them for identification if he couldn't do so there and then. Michelle Chapman and later Gillian Bourn then led us to some sampling points, where we collected water samples (using sweep nets) in pots, took them back and sat down to isolate the various groups of macro invertebrates, identify and then laboriously count them. At first this was neck breaking but I surprisingly started looking forward to the exercise. Then on some days we were taken out in the early afternoon to help with the butterfly count. This always passed so fast that we hardly realised when we finished a transect, as we were always busy calling out the numerous Speckled Woods or wondering whether that whitish job there was a Small or Large White.

Nick Riddiford kept us spellbound again when he proved that his knowledge of plant identification was as good as that for butterfly or moths or birds or anything. We helped carry out surveys on 20 quadrats, using the random selection method to choose our quadrats. Nick always allowed us to take turns doing various jobs; recording, pacing out, leading the random selection of a quadrat. He explained why it was of a particular importance to monitor the recolonisation of the burnt coastal dunes. We often helped going out with Maria Zas to look for plants for the herbarium or helped her to press them. We couldn't do much about the helping with the hydrochemistry analyses as Chris Baker (scientist in charge) explained that only collection was to be done at S'Albufera, while the analyses were to be done in the UK. He however explained the objective of the project stage by stage. Also, Nick explained that the "MedWet" methodology hadn't reached him yet, but explained to us what the idea was all about as well as how it was structured. A small handout was given out to this effect.

Knowledge gained

Being charged with a more or less similar role in my Project here in the Cameroon (advising on the ecology for the conservation of biological species and their habitats/ornithologist) to Nick Riddiford's at S'Albufera, I found my two weeks with him to be very fulfilling, considering his immense knowledge and experience in the field. I learnt quite a lot about:

BIRD MIGRATION: Through regular walks in the Park with Nick it was possible to watch birds and hence discuss lots of things about them including their migration. He explained the migratory route that passes through Mallorca and which birds use it, which breed there, which winter there, etc. I was working on aquatic and shore birds for the very first time and anything I could learn about them was very valuable, and I learnt a lot in the two weeks. I couldn't have gone to a better place for such knowledge. Nick explained however that we were not there at the very peak of migration. Cameroon has a good population of wintering ducks and Palaearctic waders. I hope, therefore, to spend time and the knowledge I acquired from the expedition to carry out studies on them when they are here.

BREEDING BIRD POPULATIONS IN S'ALBUFERA: I developed an interest in monitoring birds breeding, as I watched Shelducks, Coots, Black-winged Stilts, Kentish Plovers, Moorhens, Purple Gallinule; and their young. I had the opportunity to learn to recognise the young of these

birds and I think that is very useful for me, especially those birds which don't breed here in Cameroon.

BIRD CALLS: I took advantage of our early morning bird counts, which relied more on recognising bird calls, to learn many calls. This particular exercise is what I use back home for my bird studies, though the birds themselves are sometimes different. Among the calls I learnt are some birds found even in Cameroon.

Nick's explanation on the result of his study on bird populations so far, and the recolonisation of a previously burnt area, by the Moustached Warbler, was very teaching. The importance of the ecological web was driven even further home when I realised how the various ongoing projects interrelated to bring out the nature of the health of the habitat - the Park.

It was noteworthy that S'Albufera staff carries out ecological research on a regular basis, results of which EARTHWATCH uses to complement her more methodic and standard but periodic researches. I greatly appreciated the harmonious working of this system and think I should investigate into ways we can adapt it to our own purposes here in Cameroon.

During the two weeks I learnt that I can easily carry out a basic fauna or flora count while soliciting and waiting for the help of a specialist. Hence I am already thinking on starting a number of studies here at my project, on butterflies, moths, ants etc. I can now establish a quadrat and take records of the vegetation and with a little help identify the plant species found within.

Above all the impact of group work, where there is lots of enthusiasm was greatly felt. I learnt how enthusiasm and dedication can be transformed to great advantage even where only skills and talents were thought to be necessary. Laborious and large amounts of work were quickly done with only a little guidance. This is very important to note, particularly for a country like Cameroon which needs a lot of such work to be done and in many domains. Our coming from different parts of the world, with different cultures, ideas etc. was a great opportunity for us to learn about each other's culture and way of doing things. I benefited enormously from this, as I think I stand a better chance now of understanding people better, than before I went to Spain. The Germans' dedication to their work; The English high sense of tolerance; The Spanish sense of duty and humour and Nick Riddiford's BIG sense of understanding and encouragement, were all leaves I borrowed to try out here now.

Other experiences of the project

Apart from the strictly project activities as outlined above, the stay was so organised that we spent time intimating ourselves with other aspects of both the S'Albufera and the entire Mallorquin community. It was very touching to note how hard everyone worked to make sure that we not only spent a wonderful time in Mallorca but learnt as much as our heads could take.

The staff of S'Albufera were the best teachers as they not only taught, themselves, but went ahead to even call in outside help. Biel Perelló saw to it that he gave us a detailed run down of both the structure and the working of his Natural Park and its affiliated projects. Coming from similar projects ourselves I could see how so very relevant and useful that lecture could be for me. Nature conservation being a relatively new concept in Cameroon, I thought S'Albufera's

relatively greater experience over the many years of their existence could be of greater value to us if carefully applied. Explanations on the procedure they use to carry out ecological monitoring of their Park was very teaching. I particularly took interest in the way they collected information to build up a long term data base, or a sustainable resource reservoir. This latter can serve as a reference centre for the university, classroom for environmental and nature studies for schools, as well as a reference for the future monitoring of the Mallorquin and Mediterranean environment, MedWet for example. Discussions with the Park ornithologist, Pere, were very informative. His method of day to day data collection was outlined. The increasing controversy between development and conservation was very glaring. One could not help but notice that right next door to the Park is a thriving Hotel industry which is feeding from the rich Mallorquin tourism resources. Even more annoying is the fact that these Hotels are "growing" the sky line, thereby becoming a physical feature of the very Park frontiers. The fact that the people have managed to secure the conservation of the Park grounds right in the face of the yearning to develop it, is worthy of praise. The visits to the Mountains and the cave were a good opportunity to experience both the Mallorquin countryside and how a people can take advantage of their natural resources to better their living. Another visit to a local farm still using the traditional methods of farming and a farmers' co-operative, was equally very educative. There was fear expressed though that the tourism industry has come to kill agricultural activities. It was explained that cultural methods of farming were a less threat to the environment than the aggressive modern methods with indiscriminate use of chemical fertilisers.

The humility with which the honourable minister and top notables came out to welcome us was a big lesson to me. The readiness and patience with which each responsible explained every aspect of their work is worth emulating. The methods of erosion control; water conservation; fire control; reforestation etc. were painstakingly explained and I think most of these will be useful here at one time or another. The Minister and his aids promised that in the case of need for any technical assistance that they can afford, they will be glad to oblige. It was a memorable experience to note what a friendly and hospitable people the Mallorquin people can be. I truly felt at home.

Above all we quickly learnt how to communicate by sign language if any of our numerous languages (Spanish, English, French, German, Mallorquin or pigeon) went out of control. It was very interesting, though, to note that we always managed to effectively communicate. That is the level to which the world has narrowed down to.

Expedition evaluation and recommendations

ORGANISATION:

It was evident that whoever designed the overall organisation of this expedition did a great job of it. From the time I got aware of the fact that I was awarded this fellowship, communication between EARTHWATCH and I never for once got a hitch, "Cameroon" notwithstanding. The People at the EARTHWATCH office gave the impression that they were always there to help solve your problems if they could. And they did solve many.

Moreover the local organisation was perfect, and this led to the kind of smooth running two weeks that we had. I very much admired the fact that duties were spread out so that everyone felt responsible to a small or large extent. From the principal investigator to us, the volunteers. I also

appreciated the fact that everybody, more or less took their duties seriously. From generally running the minute by minute activities of the project to cooking, helping serve food, and washing of plates.

PLANNING:

The fact that the work plan was ready and made available from the very first day was good judgement, since this prepared everyone beforehand about what work there was and when. The manner in which the activities were planned gave room for a continuous build up of energy and enthusiasm, both of which lasted throughout the entire two weeks, as a result. This was particularly owed to the neat balance in purely work activities and amusement, work taking priority, no doubt. Hence after a long day you could have half an hour to take a dip in the sea if you cared for that, or go for a walk in the park on your own etc. I saw our visits to the Mountains, the local farm and co-operative and the Dragon cave as excellent planning. This gave us the opportunity to work (meet people out, see Mallorca and learn, compare and get experience from what you see and see people do) and amuse ourselves at the same time (site seeing etc.).

Earthwatch projects

It was evident that, apart from complementing the monitoring process going on in the Park, the EARTHWATCH project is invaluable. These projects are based on a more systematic research principle and have a direct objective, unlike the Park's which are more or less at the mercy of conservation demands and hence dictates. The global sympathy and recognition generated by EARTHWATCH's EARTHCORPS expeditions is equally of immeasurable value. This latter is even truer for volunteers, who are given the real opportunity to do something as a contribution to saving nature, see the world in a more meaningful way or to develop valuable contacts.

One would have appreciated more, however, if fellows/volunteers from the same country could be evenly distributed among the various teams, so that chances of meeting with people from as various a range of countries as possible would be increased. I hold the opinion that people from the same country have less to learn from one another than if they came from different countries. If I could spend a little more time with Nick, to see what he did with his data after collection, it would have been even more fulfilling for me in particular.

Acknowledgement

When a guy makes the hitherto unthinkable journey round the world in only a couple of hours: or when you sit in Cameroon and watch your very neighbour kicking a ball at that same moment in the USA: or when you pick up a phone and speak to some one 7000 km away: you can't help but realise how narrow this world has become. This is even more dramatic for a poor third world country citizen, who can't think how he will have his next meal. Flying to another continent to see different cultures, people, Geography, fauna, flora, ways of doing things, etc. for him is a completely new dimension: a conscientious attempt to bring this world even closer. Thanks to EARTHWATCH's ingenuity to have devised this strategy and her efforts at keeping it going.

Many thanks to EARTHWATCH, for awarding me this fellowship and to the EC, for funding the entire trip to Mallorca. I want to thank: Dr. Martin Cheek, who, through his hard work first

introduced EARTHWATCH to me, in such a convincing way: Dr. Robert Barrington, for being such a captivating communicator: Gill Baker, who so efficiently facilitated my overcoming the ridiculous hassles we have here for communication and especially travelling to anywhere; Sr Joan Mayol Serra for seeing our visit to Mallorca in a far more fulfilling depth than we did ourselves; The staff of S'Albufera for the spirited welcome and co-operation throughout our stay; The Balearic Minister for Agriculture and Fisheries and the top personnel of his ministry, who through their very enlightened briefing on general as well as technical subjects, succeeded to seal a co-operative bond between our two countries; Nonie Culthard and Birdlife INTERNATIONAL, for being ever so caring and ready to help; Lady Pat Bishop and her wonderful friends, for such a wonderful evening and for all the care; The good people of Mallorca who laid out their culture and whole country for us to gain knowledge from.

Lastly thanks to all my fellow participants for sharing such a wonderful and teaching two weeks with me.

ANNEX 7

Assessment of functions and socio-economic values of natural ecosystems and protected areas: pilot study on the Parc Natural de S'Albufera de Mallorca by Macarena Mata (Landscape and Environmental Research Group, University of Amsterdam, The Netherlands)

Abstract

A study on the Parc Natural de S'Albufera, Mallorca, Spain, has been carried out with the aim to test a method for systematic assessment of the environmental functions system, developed by R. de Groot (1992), and the socio-economic benefits of protected areas. The outcome should contribute to the evaluation of the sustainability of long-term conservation projects compatible with a specific socio-economic context.

Environmental functions are divided into four categories: regulation functions are related to the maintenance of essential ecological processes; carrier functions are related to the space and suitable substrate that is provided by the ecosystem for human activities; production functions are related to natural resources that are directly harvested from the ecosystem; information functions are related to the opportunities for cognitive development the ecosystem provides. After assessing the functions existing within the study area, a total socio-economic valuation of the ecosystem is presented; value categories are as follows: active use values (consumptive and productive values), passive use values (conservation and option values) and non-use or intrinsic values (existence value). The methodology for an economic valuation is under research at present.

The Parc Natural de S'Albufera de Mallorca is a coastal wetland which was finally declared a National Park in 1988 after several conflicts, many of which are still present nowadays. The area's treasure is its bird-life, being a place visited by ornithologists from all over the world.

Results show that the main functions within the area refer to regulation, carrier and information functions. Within the regulation functions, the ones related to: regulation of water dynamics within the water catchment (groundwater dynamics, flood prevention), regulation of water quality (storage and recycling of organic matter, regulation of salinity) and maintenance of biological diversity are the most important ones. Within the carrier functions, recreation (tourism) and nature protection are of utmost importance, especially the former one because of the socio-economic impact. Within the information functions, aesthetic and historical information functions play an important role, but scientific and educational information functions are essential. Socio-economic values are thus: productive use value (tourism and nature protection); conservation value (regulation functions) and option and existence values (information functions).

Further investigation will include a conflict analysis of the area and an assessment of the health of the ecosystem.

ANNEX 8

GIS application to ecosystem valuation for land use planning: a case study of S'Albufera Natural Park, Mallorca by Sas Terpstra (Wageningen Center for Environment and Climate Studies)

Introduction

For balanced decision-making in land use planning, which takes account of both nature conservation objectives and cultivation needs, it is important to be aware of all the actual and potential functions of the planning area and of the relation between various management regimes and the function performance. How spatial patterns in the landscape affect and are affected is a useful way of gaining further understanding of the complex linkages between physical, ecological, climatic and human components of the landscape ecosystem (Haines-Young *et al.* 1993). Any useful functional assessment methodology must be able to evaluate functions using easily obtained data and it must be robust enough to use in almost every situation (Verhoeven *et al.* 1994).

Landscape models are important for three reasons. First, they are predictive tools that enhance our ability to compare key elements of a system. As such, landscape models are important for estimating natural changes without having to wait for them to occur in real time. Second, they are non-destructive experiments for testing regional management scenarios. Finally, spatial modelling is important because it simulates human and natural impacts together. Rather than optimize for a single resource, the goal of most biological models in the past, a landscape model can be used to combine them all for a more comprehensive examination of cumulative impacts (Sklar *et al.* 1994). Development of comprehensive functional analysis procedures are essential in unlocking present planning and decision-making conflicts (Maltby 1991).

This study is based on an evaluation method of environmental functions as described by de Groot (1992). The method is used to translate ecological data in a systematic way into useful information for decision-making in land use planning. De Groot distinguishes 38 environmental functions, which can be grouped into four major function groups: regulation, carrier, production and information functions.

With this list the potential benefits of the natural environment can systematically be determined. The capacity of an area to provide environmental functions depends on environmental characteristics that can be very different for various ecosystems. Even in cases where complete quantification of functions is not possible the checklist of functions and associated hazards (in case of over-use) gives a comprehensive overview of the many trade-offs involved.

Problem definition

One major problem in practising the method is the amount of required information about the study area. Often much information is not adequately available. Therefore it would be interesting to find the most important environmental characteristics that could describe the environmental functions in an area. This project emphasises the functions that have a major influence on the spatial representation of the study area. Using a Geographical Information System (GIS) could help to evaluate the functions in a more objective way if the underlying environmental characteristics (parameters) have been quantified. Possible conflicts between different functions can be analysed and estimates about the most sustainable way of combined land use options can be made.

A problem in finding the most suitable combination of environmental functions and assessment parameters is the fact that many functions are determined by more than one parameter and that one parameter may influence more than one function. This underlines the importance of a holistic approach to understand the functioning of ecosystems in the field of ecosystem ecology and other related disciplines.

The data needed to quantify the essential variables should be collected within a reasonable time-period. A choice must be made and selecting the appropriate parameters and criteria for assessing and evaluating the function performance of a given ecosystem or natural area is essential to the practical application of the proposed function-evaluation system.

Objectives

The main objective of this thesis is to make a GIS application to the valuation of ecosystems for land use planning, focussing at Natural Parc s'Albufera, Mallorca.

1 Understand the relationship between environmental characteristics (parameters) and environmental functions

This study mainly aims to understand the parameters that determine the spatial representation of the environmental functions in the study area. The relationships between both characteristics and functions must be understood to learn those main factors.

2. Define parameters in GIS

The main parameters should be built into a GIS. This means the parameters must be translated into workable data that are available for the study area. The available data have to fit in a data model. Quantification of the parameters makes it easier to understand the actual and potential availability of environmental functions.

3. Extract a manual

Eventually the results of the proposed procedures should be incorporated into a manual, which could be used to have a first impression of the potential factors and how the analysis could be initiated.

4. Apply a conflict analysis

In more than one way there can be conflicting interests in an area. Different functions claim space and the interactions between them can result in conflicting situations. Optimising by

compromising between the different functional claims can result in an optimal land use plan of the study area.

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