Conserving the Rare Flora of Central Argentina

DARWIN INITIATIVE

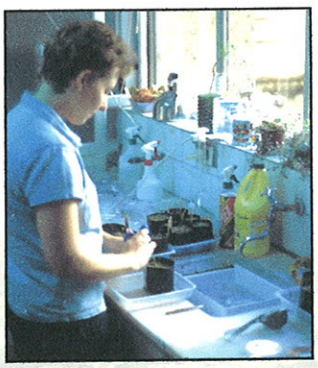
Final Report

08-116

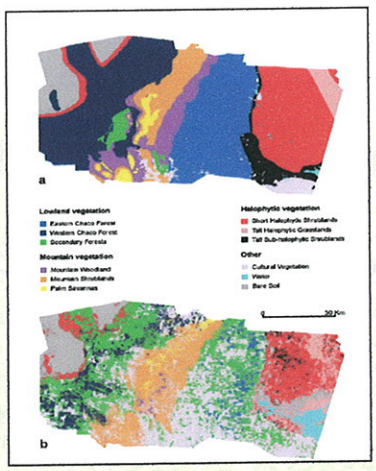
Project Reference No. 162/8/116

April 1999 - May 2003

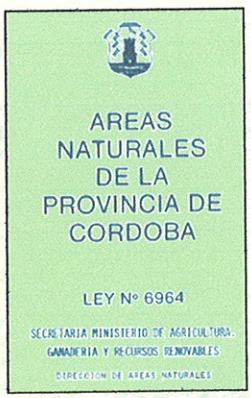
STUDY



DISCOVERY
Vegetation change 1969-1997



RECOMMENDATIONS



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Darwin Initiative for the Survival of Species
Conserving the Rare Flora of Central Argentina
Final Report

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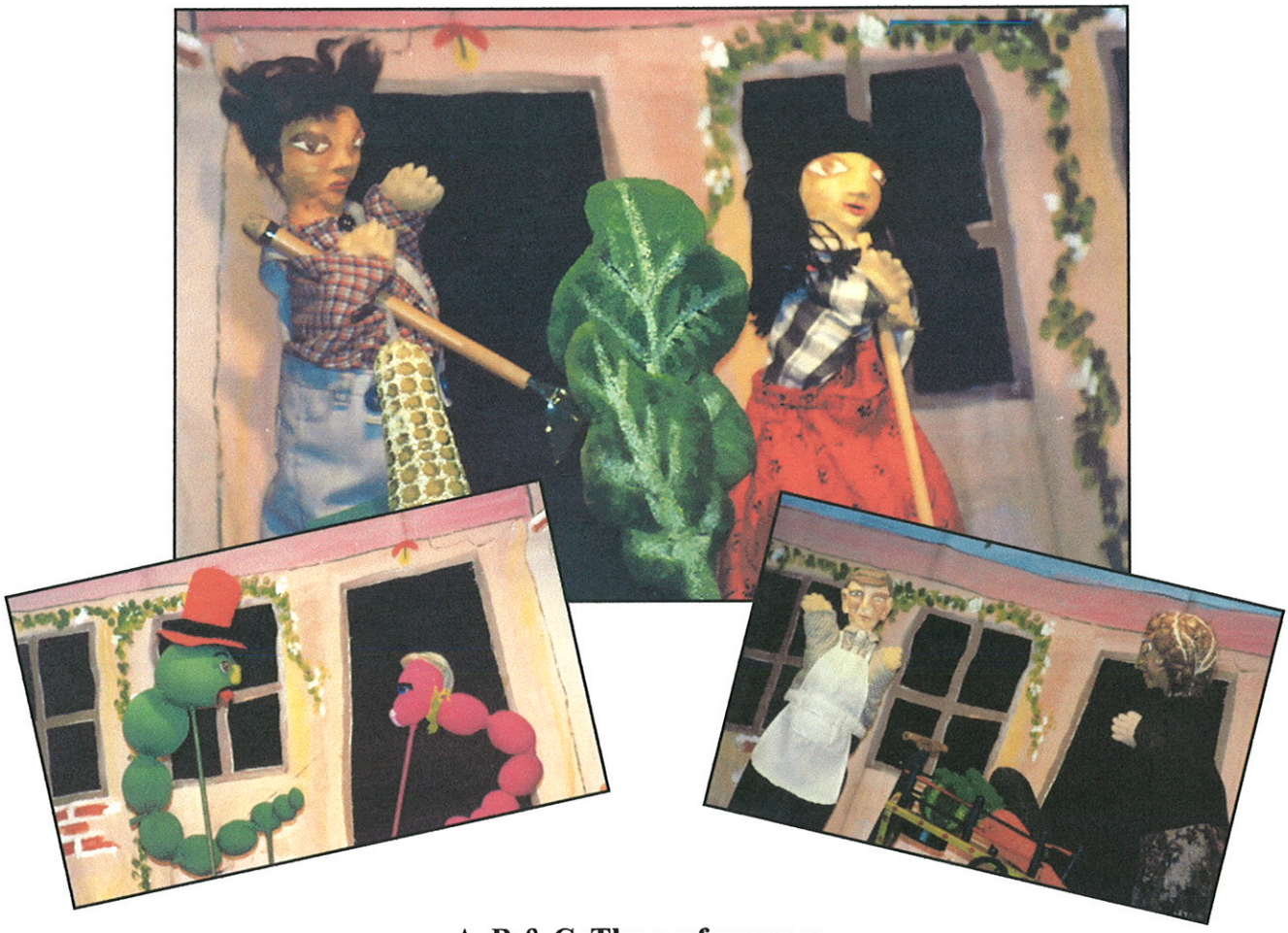

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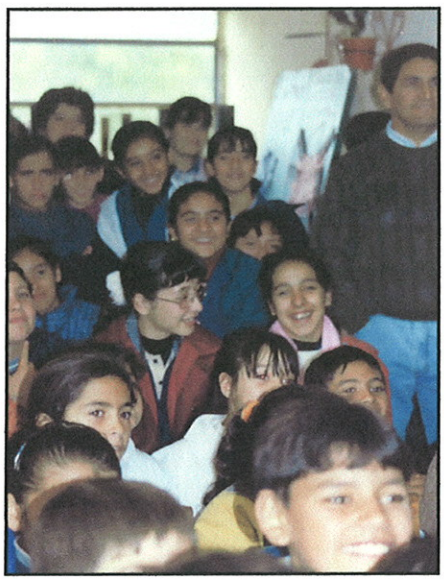

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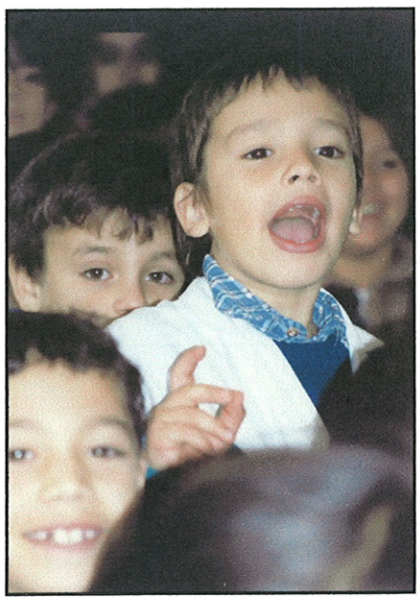

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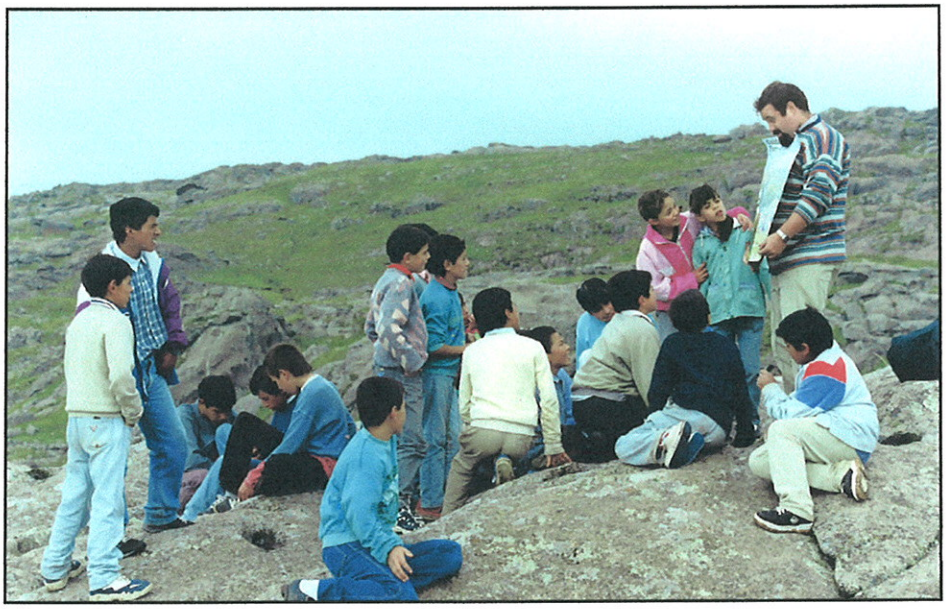

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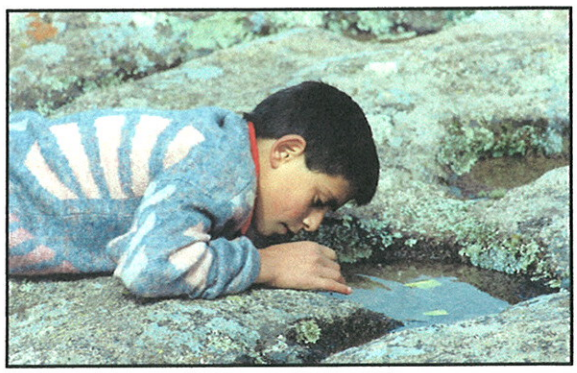

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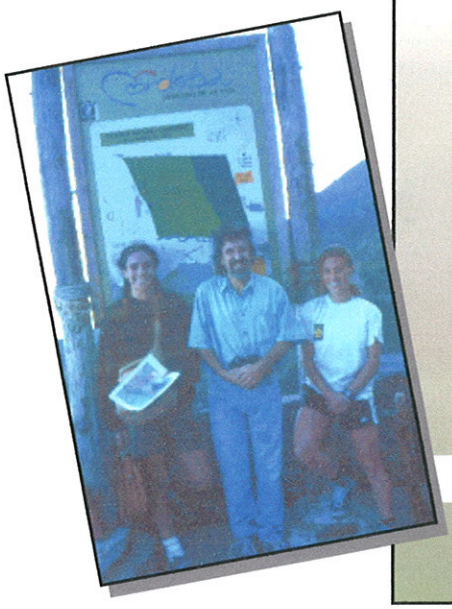
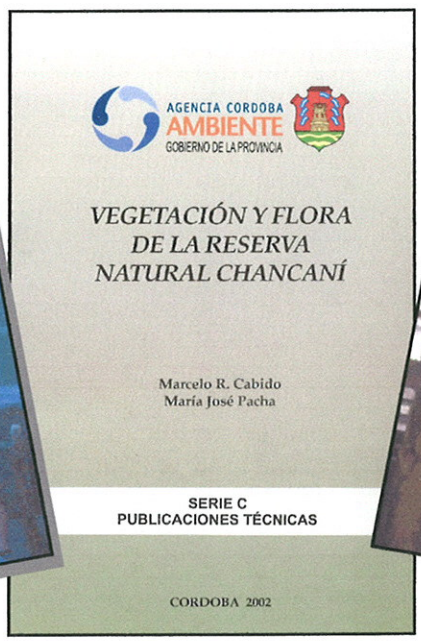


Reserve guide



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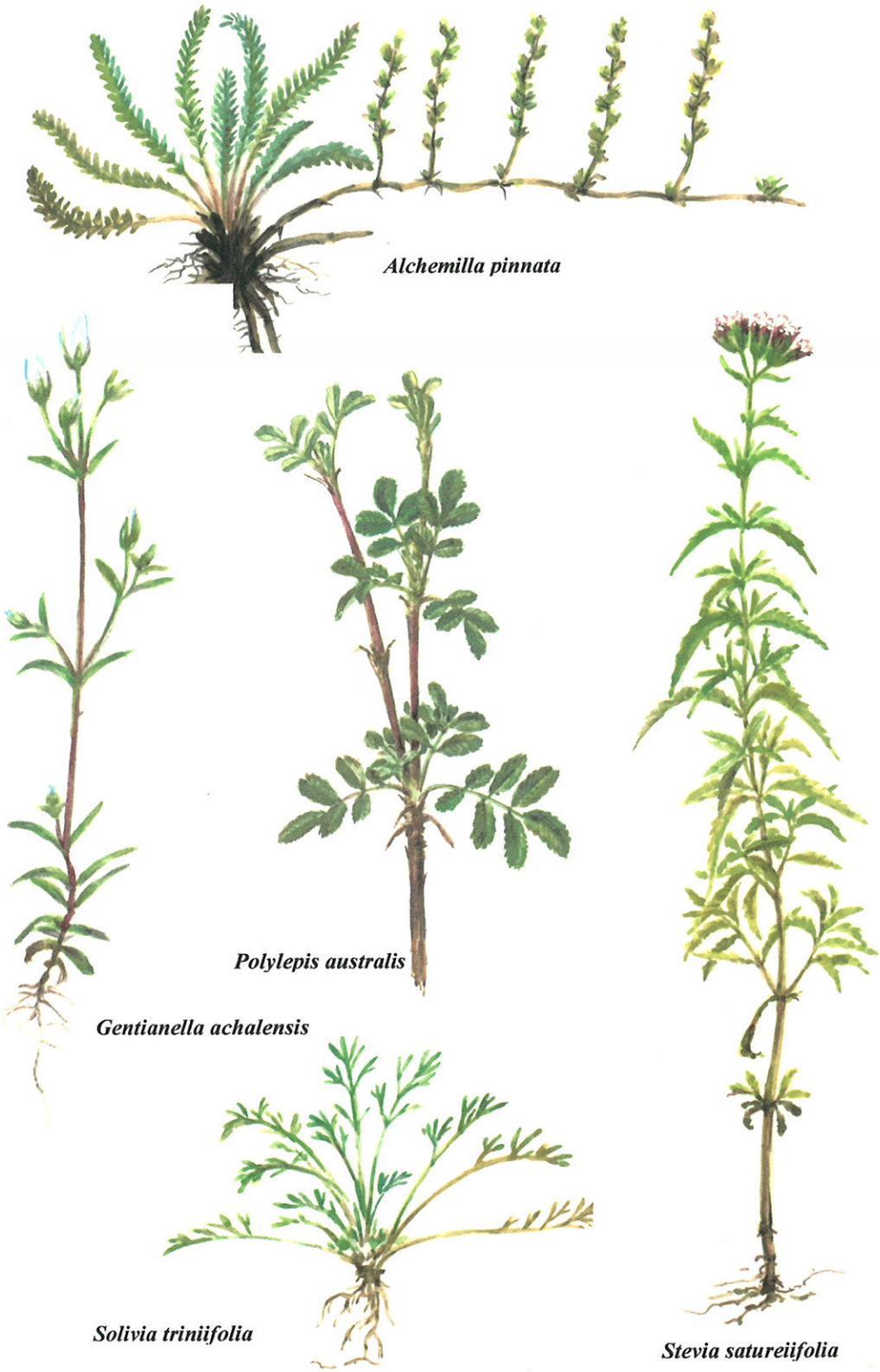


Alchemilla pinnata

Polylepis australis

Gentianella achalensis

Solivia triniifolia

Stevia satureiifolia

1. DARWIN PROJECT INFORMATION

Project title	Conserving the Rare Flora of Central Argentina
Country	Argentina
Contractor	University of Sheffield
Project Reference No.	162/8/116
Grant Value	£209,200
Staring/Finishing dates	April 1999-March 2002 (extended to October 2002)

2. PROJECT BACKGROUND / RATIONALE

2.1 INTRODUCTION

Central Argentina is the meeting point of species belonging to different geographical regions and evolutionary histories (Andean, Chaquenian, Pampean, Patagonian, NW mountains). However, little is known about the community dynamics of the flora. The ecological characteristics and historical events that have determined the distribution of rarer species have not been described nor has their role in ecosystem function. Equally, we do not know what effect a change in management will have on vulnerability to invasion by aliens. Information on all these matters is essential in order to produce adequate guidelines for natural reserve management, which could also be applied to the sustainable management of farms outside protected areas. The present project seeks to study the conditions required for the survival of many of these species, and to make recommendations to conservation agencies for their future protection. As well as scientific and practical conservation objectives, the project also seeks to provide a lasting legacy in training both in conservation practice and theory, helping to increase awareness amongst the younger generation in Argentina of environmental issues, and the importance of the conservation of biodiversity in particular. Thus, the project has two distinct elements, science and education.

- The ultimate conservation/educational aims of the project are twofold (a) to make recommendations to the Regional Government for a programme of adequate protection and management of protected areas and (b) to generate awareness of biodiversity and conservation issues within local communities and to encourage sustainable land management.
- The ultimate scientific aim is to begin to understand the ecological processes that govern how Argentine plant communities function. This information has direct relevance to conservation management.

The project has concentrated on two protected areas and their rare species and communities but a full range of communities has been studied.

2.2 ECOLOGICAL BACKGROUND

Major problems for plant ecologists include the large number of species present in the world flora and the poor correspondence between taxonomy and ecology. Knowing which genus and family a species belongs to generally tells us little about the habitat and key ecological characteristics of a species. This is in marked contrast to inorganic chemistry where the Periodic Table provides a classification of elements that strongly relates to their chemical behaviour. Ecology is in desperate need of a similarly simple functional classification for species. A mechanism is needed to reduce the taxonomic complexity of vegetation so that we can understand underlying ecological processes.

Species are taxonomically unique but their ecological properties are not. Some are fast-growing; some are not. Some produce a persistent seed bank in the soil; some do not. Data of this type would allow us to replace the taxonomic complexity of a species list with information on functional characteristics. We would then begin to describe vegetation in terms of what its component species do. We would arguably be in a better position to predict impacts of changing land use on the composition and sustainability of vegetation of conservation importance.

Against this background we have produced an ecological database for a small part of the Argentine flora. The database contains simple functional attributes of plants (i.e. attributes that relate to how plants survive in their natural environment) and will provide an ecological profile, albeit fragmentary, for each species. The attributes utilised wherever possible have been validated against 'hard' laboratory or distributional data. Priority was given to attributes relevant to the study of impacts of land use change.

We illustrate the functional approach with one example, an assessment as to whether species grow in fertile habitats (see Section 4.1.4.2). A review of the ecological literature reveals that species from fertile habitats tend to grow rapidly and to produce watery, short-lived leaves. These leaves have a high nitrogen and phosphorus content and are generally palatable to unspecialised herbivores. Attributes such as specific leaf area (leaf area/leaf weight), leaf toughness and leaf dry matter content will be good ecological predictors. Moreover, they are very quick to measure and we do not need to rely upon a conservationist with a lifetime of experience (a declining resource) for our ecological insights. This approach needs only correctly identified plant material and a competent technician. The database can then be used, alongside more conventional sources, for informed management at the species, community and landscape levels.

2.3 CONSERVATION BACKGROUND

Traditionally the cornerstone of conservation policy in Central Argentina has been to exclude the general public from most protected areas. In many instances this is necessary for the protection of flora and fauna. Such protectionism, which still exists in some quarters, can contribute to a lack of public appreciation of the biodiversity of the Argentine flora and fauna and may even antagonise local communities. Before the onset of the project there had been no meaningful dialogue between conservation agencies and local communities at our study sites. We considered it essential that this situation should change. Where at all possible conservation

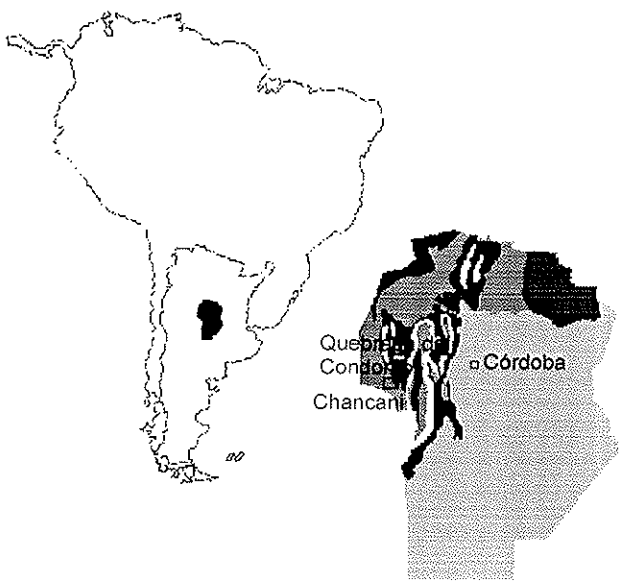
activities should be relevant and beneficial to local communities as well as to scientists and policy makers. The rural communities are very poor. The Darwin Initiative can do little by itself but it can act as a catalyst. It can initiate discussion and self-help. Conservation can create jobs, boost tourism and provide advice and support to encourage sustainable agriculture. These benefits of conservation may not necessarily be large but to communities living in poverty they are potentially significant and hopefully represent an opportunity to start re-building local economies.

2.4 CHOICE OF SITES

Central Argentina is rich both in species and in habitats. Effective conservation policy requires information about the distribution of plant diversity and about how this diversity may be maintained. It must address the issue that the resources available for conservation, both scientific and economic, will be less than one would ideally wish for. It must also consider the local agricultural population. Traditional agriculture has shaped the Argentine landscape and sympathetic management will be required to retain biodiversity. Our sites had to be suitable for both scientific studies and educational work. Educational sociologists trusted both by us and the local people were working around Chancani and Pampa de Achala and we therefore chose to focus the project on these two areas. This choice also fitted in well with scientific objectives. The two areas were very different. One, Chancani, consisted primarily of semi-tropical, lowland wood pasture (chaco); the other, Achala, which includes both the provincial reserve Pampa de Achala and the adjoining Quebrada del Condorito National Park, was temperate, upland pasture. To increase the range of variation of plant characters included we also studied, albeit less intensively, the other major vegetation type of the region, monte, and sites of cultivation and roadsides, where alien species might be expected. The teaching element of the project is also best served by including as wide a diversity of species and situations as possible.

The locations of the two sites are illustrated in Figure 1.

Figure 1. Map of Argentina, showing location of study sites.



Chancani is a semi-arid subtropical area in the west of the Province of Córdoba. Maximum temperatures can exceed 40°C. Moreover, annual precipitation is between 400 and 600 mm $year^{-1}$ but evaporational water loss is 1000 mm $year^{-1}$. Rainfall, as in most of Argentina is confined to the summer months. The village of **Chancani** itself has c. 1000 inhabitants, supported only by subsistence agriculture. **La Reserva Natural Chancani** is 4960 hectares in area. The reserve consists of a flat lowland plain, altitude 300-500 m, including at its eastern edge the foothills of the Sierras de Pocho, up to c. 1100m. The predominant vegetation of the area is chaco forest. This is a type of woodland pasture consisting of thorny xerophytic scrub with a sparse herb layer and a few canopy trees. In the foothills of the Sierras de Pocho, which are wetter, this vegetation is replaced by mountain chaco, equally spiny but more verdant and lacking tall canopy trees. The reserve is grazed, not primarily for economic purposes but to prevent a build up of litter, which would increase the likelihood and destructiveness of fires. Past management has, however, been less sympathetic. Most canopy trees have been removed for timber and vegetation clearance has in some areas resulted in soil erosion.

Pampa de Achala is an upland temperate area also in the west of the Province of Córdoba lying between Chancani and the city of Córdoba. Temperatures are much lower than Chancani; the annual daily temperature is 8°C as opposed to 18°C. Rainfall is higher c. 900 mm $year^{-1}$. The area consists of two protected areas; **Quebrada del Condorito National Park**, managed by the national conservation agency and the other (**Pampa de Achala**) by the regional government. The predominant vegetation is grassland and land is given over to cattle-grazing except for the National Park, which is ungrazed. The educational work centred on three schools (Martín Fierro, in centre of area; Ceferino Namuncurá, south; La Ventana, north). These three schools serve a diffuse agricultural population of c. 370.

Other areas studied We wished to be in a position to understand ecosystem and land use processes not just in the two nature reserves but also in the general landscape. We therefore undertook fieldwork at additional sites and also included the other major vegetation type of the region, monte, which occurs in even more arid conditions, typically <350 mm rainfall $year^{-1}$.and resembles an open tree-less chaco and a range of roadside and disturbed and cultivated communities, where aliens might be expected.

2.5 Motivation for Project

Dr Diaz and Dr Cabido, the Argentine leaders of the project, are both very active, internationally respected ecologists and scientific ties have been maintained between Dr Diaz and the University of Sheffield since a collaborative project between Dr Diaz and Professor Grime between 1994-5. Dr Diaz was very sympathetic to our interest in plant functional types and at her recommendation Dr Cabido attended a practical workshop on plant functional types in Zaragoza, Spain in 1995 run by Dr Hodgson. Since that time there has been scientific dialogue between the Sheffield and Argentine groups but both parties had wanted scientific links to be stronger and mechanisms of effecting collaboration had been discussed for several months prior to the application. Dr Cabido and Dr Diaz are acknowledged experts on both the flora and ecosystems function in Central Argentina and have long been concerned about the extent of habitat loss. They have also been concerned with the plight of those involved in subsistence farming and how overexploitation was both damaging ecosystems and the livelihoods of the farmers themselves. They felt that there were

inadequate resources and ecological knowledge available within the country to ensure the conservation of the flora of Central Argentina.

There is evidence of Dr Cabido's and Dr Diaz's deep commitment to conservation in many parts of the report. Here, for brevity, we mention two examples, one showing a direct commitment to the project and one showing a more general commitment to conservation.

- The Argentine team have put a tremendous amount of enthusiastic effort into events involving local communities and Park authorities. These events have been a great success invoking much interest amongst both local groups and the media. These events have satisfied a local need and the work is set to continue even though funding of the Darwin project is at an end.
- Dr Cabido has used the prestige of the Darwin project to increase his impact on Argentine conservation. He is now involved in a number projects with national and provincial conservation agencies and as is indicated elsewhere in the report his opinions are much respected and his advice is invariably acted upon.

3. PROJECT SUMMARY

3.1 OBJECTIVES OF PROJECT

The primary objectives as stated in the original proposal were as follows:

- to use British expertise for collaboration with and training of local scientists in relevant field survey methods, techniques for measuring autecological characteristics of plants, database management, resource assessment and conservation management.
- to carry out survey work and develop a functional understanding of the causes of rarity and decline in the flora of Central Argentina with particular relation to land use and the impacts of grazing animals and fire on common, rare and alien species.
- building upon ECUS's considerable experience of developing biodiversity inventories, to produce a database which will help to evaluate the survey information and recommend future conservation measures.
- to review and evaluate existing conservation measures and to make recommendations concerning management for biodiversity within the two nature reserves studied. Advise also administrators of rural development projects and those responsible for agricultural policy in Argentina to promote policies of sustainability with biodiversity for Central Argentina.

These original objectives remained intact throughout the project. The work with local communities and conservation agencies, which was initially carried out as a part of the last objective listed above, has been very successful and a major part of the project. With hindsight it really deserved to be treated as a separate objective.

- education and discussions with local communities and conservation bodies about conservation, biodiversity and sustainable agriculture.

Another objective has also with the approval of the Secretariat been added since the start of the project.

- to produce ecological papers that address topics relevant to global conservation [The Argentine datasets have been created so as to be partially compatible with others collected in Iran (under another Darwin project – Grant 162/7/127), Spain and UK. We are attempting to combine these data sources to produce broadly based papers relevant to globally important issues relating to ecology and conservation. Participants have agreed to commit additional 'unpaid' time and resources to this objective. No redeployment of resources from the other parts of the project has been involved.]

3.2 ARTICLES UNDER THE CONVENTION ON BIOLOGICAL DIVERSITY (CBD) MOST RELEVANT TO PROJECT

The Argentine flora is large, poorly studied and extremely diverse. Thus the articles under the Convention on Biological Diversity (CBD) most relevant to project are

- Research and Training (30%) – many scientifically knowledgeable conservationists are required to secure the long-term survival of the biodiversity of the Argentine flora.
- Identification and Monitoring (30%) – vegetation surveys and effective monitoring are essential to conserve biodiversity at a time of changing land use (and ?climate).
- Public Education and Awareness (15%) – biodiversity and the natural landscape cannot be conserved without it being appreciated and valued by the Argentine people and without efforts being made to promote sustainable agriculture.

See also Appendix 1.

3.3 EXTENT TO WHICH OBJECTIVES WERE MET

Our achievements are as follows:-

To use British expertise for collaboration with and training of local scientists in relevant field survey methods, techniques for measuring autecological characteristics of plants, database management, resource assessment and conservation management.

Twenty-eight students have received training in laboratory and field techniques during the course of the project. All have also improved their computer skills during the course of the project.

To carry out survey work and develop a functional understanding of the causes of rarity and decline in the flora of Central Argentina with particular relation to land use and the impacts of grazing animals and fire on common, rare and alien species.

Vegetation surveys have now been carried out within all the major habitats of the region and functional attributes have been measured for 220 species. Recent impacts of land use have also been assessed using vegetation maps. There appear to be many reasons for commonness and rarity. Rare species often also exploit rare or ecotonal habitats. (e.g. vernal pools and scrub margins). However, as in W. Europe intensification of land use appears to be increasingly the major determinant

of abundance. Unproductive, undisturbed habitats are increasingly being replaced by productive and/or disturbed ones and species from habitats that are easily 'agriculturally improved' are in sharp decline (e.g. chaco forest). At present aliens are only an important component of fertile, irrigated systems.

Building upon ECUS's considerable experience of developing biodiversity inventories, to produce a database which will help to evaluate the survey information and recommend future conservation measures.

Two large databases have been compiled during the project. The first includes the results of the field surveys; the second contains functional data on plant species. These two databases can be interrogated together by Microsoft Access. These databases have been used to produce scientific papers. Moreover, they provide baseline data on the floristic quality of the two areas studied within the context of the general landscape. Data have been used to demonstrate that the Quebrada del Condorito National Park is losing biodiversity because it is ungrazed and that the adjacent Provincial Reserve, Pampa de Achala is in places overgrazed.

To review and evaluate existing conservation measures and to make recommendations concerning management for biodiversity within the two nature reserves studied. Advise also administrators of rural development projects and those responsible for agricultural policy in Argentina to promote policies of sustainability with biodiversity for Central Argentina.

Recommendations have been made concerning the management of the two conservation areas. In particular there is movement towards an integrated conservation policy for the Provincial Reserve, Pampa de Achala, which is in places overgrazed and Condorito National Park, where grazing is prohibited. For the first time in an Argentine National Nature Reserve there is now active management. Farmers from the overgrazed Provincial Park have signed agreements to reduce stocking rates and in compensation are allowed to graze in a strictly regulated way those parts of the National Park where biodiversity is declining. Our findings, relating to deforestation are also being acted upon. Landowners are being encouraged, with tax relief, to maintain their woodlands.

Education and discussions with local communities and conservation bodies about conservation, biodiversity and sustainable agriculture.

A series of discussions and innovative educational activities involving all interest groups and ages have been organised for local communities. These have created much interest both within the communities themselves and in the media. Enthusiasm for conservation and sustainable agriculture was greatly enhanced by visits, the first for over twenty years, by local people, both young and old, to nature reserves. Farmers immediately saw the better quality of soils within the reserve and important medicinal herbs now absent from the surrounding landscape were observed. Also for the first time local communities and conservation authorities have discussed problems and looking for economic solutions that will ensure the viability of sustainable agriculture. This is an on-going process that will carry on long after the Darwin funding ceases particularly in the Provincial Reserve, Pampa de Achala, where the Provincial Environmental Agency and the National Parks Authority both have secured sources of international aid and are enthusiastic supporters of the work. In Chancani, which is only a Provincial Reserve and where there is no international funding available, continuation will in the shorter term be sustained partly using money transferred from the UK travel budget, with the approval of the Darwin Secretariat, and partly on a voluntary basis by Carlos Szulkin. This work will become easier when in June or July the new school is opened. We are also in the

processes of twinning Argentine schools with schools in the Peak District National Park. This activity has the support of the Peak District National Park Authority.

To produce ecological papers that address topics relevant to global conservation

This is an additional objective of recent origin and involves international collaboration. The first paper in the series is based on a functional analysis of data from Iran, Argentina, Spain and UK. Powerful evidence is provided (a) for the existence of global patterns of ecological specialisation and (b) the possibility of assessing these from the simple measurements used in the project. In a second paper we link for the first time plant functional type and the economic value of vegetation for agriculture. We present evidence that the relationship between sustainable stocking rate and foliar nitrogen is exponential (i.e. an increase in fertility leads to a ten-fold increase in yield). This relationship is likely to have been a critical ecological driver of land use change particularly following the development of mechanised agriculture and cheap fertilisers. Moreover, in a third paper still in preparation we illustrate that vegetation of high biodiversity is associated with sites of lower fertility. Such sites appear particularly threatened by agricultural improvement.

The only major objective not achieved was that of submitting the final report on time. The reasons for the delay, which related to the collapse of the Argentine economy were accepted by the Darwin Secretariat and are outlined in Section 9.

4. SCIENTIFIC, TRAINING, AND TECHNICAL ASSESSMENT

4.1 SCIENTIFIC WORK UNDERTAKEN

The principal scientists involved in the project were as follows:

UK: Dr John Hodgson, Professor Philip Grime, Dr Ken Thompson, Chris Routh

Argentina: Dr Marcelo Cabido, Dr Sandra Díaz

The communications experts organising and co-ordinating activities with local Argentine communities were Carlos Szulkin (Chancaní) and Rafael Kopta, Federico Kopta and Sergio Bruno (Achala).

A species list for La Reserva Natural Chancaní is included in Cabido and Pacha (2002), a copy of which is appended to this report (Appendix VII.1). A species list for Pampa de Achala is included as Appendix VII.4 and detailed maps and a GIS in Appendix VII.2.

Following extensive vegetation surveys of the major regional vegetation types, the measurement of functional autecological data and intensive studies of the two nature reserves (chaco, monte, montane grassland and salinas) two large databases have been compiled, one including floristic and environmental data, the other functional data for 220 species. These two databases, which can be interrogated together by Microsoft Access, form the source of much of the information that appears in subsequent sections.

Conservation recommendations were only made after the fullest consultation and with the full agreement of both Argentine and UK members of the Darwin project. Moreover, to ensure that work has been both relevant and carried out to a high

standard our policy is that all papers of substance, other than monographs, are submitted to 'refereed journals'. Thus, peer review of the work will be an automatic consequence of publication.

4.1.1 Land use change in Central Argentina

Background and work carried out

The Amerindians had managed much of C. Argentina by burning to stimulate the growth of forage for native herbivores. However, most patches of forest remained unburned. These traditional practices died out more than 400 years ago when Europeans introduced cattle grazing. There followed a contraction in the area of pasture as burned grasslands were invaded by woody species to form a dense spiny scrub, 'fachinal'. Subsequent changes to the landscape were gradual and probably involved a further modest increase of woody species until 1900-1940 when with the expansion of the railways, wholesale timber extraction for fuel and the production of sleepers decimated the forest. Few canopy trees persist today. While these changes in land use have had a major impact on the vegetation and landscapes of the region, recent impacts, particularly the development of arable agriculture, have been even more profound. Accordingly, a study of the impacts of these recent and ongoing changes has been undertaken to provide background information on threats to the flora of Central Argentina. This study, relating to a 27,000 km^2 area in the northern part of Córdoba Province, has utilised vegetation maps from 1969 and 1999 and census data.

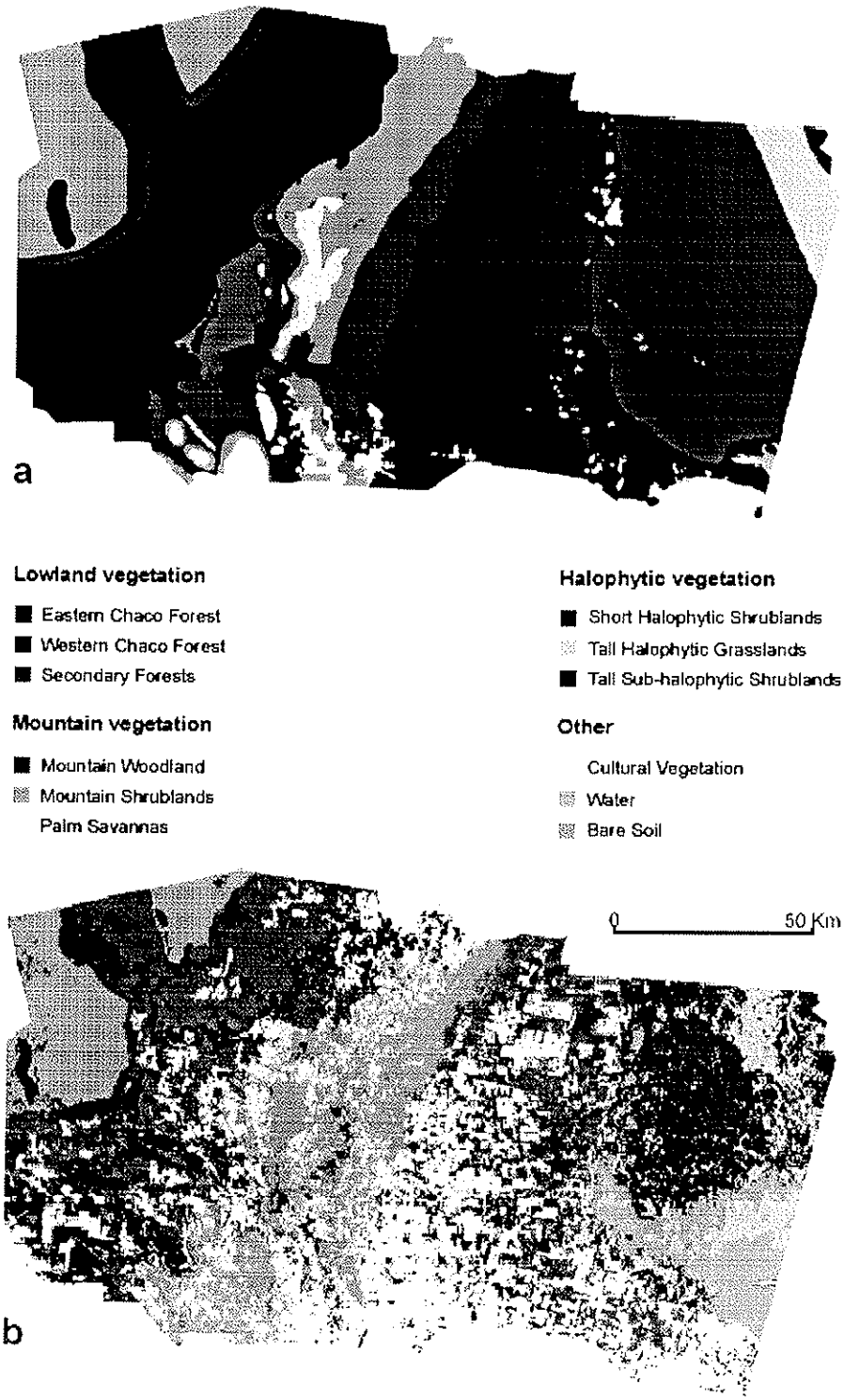
Conclusions and Outputs

The landscapes of Central Argentina have been greatly modified by changing land use (see Figure 2 and Table 4-1). The picture is a familiar one: the spread of more intensive systems of agriculture with larger farms and fewer people working the land.

Table 4-1. Recent changes to the vegetation of Central Argentina.

Vegetation type	Area in 1969 (ha.)	% study area	Area in 1999 (ha.)	% study area	% change
>70% decline since 1969					
Montane woodland	228,800	8.4	13,700	0.5	-94
Eastern chaco forest	554,800	20.5	57,900	2.1	-90
Western chaco forest	638,600	23.6	150,800	5.6	-76
Intermediate					
Tall sub-halophytic scrub	110,000	4.1	46,300	1.7	-59
Short halophytic scrub	549,600	20.3	284,200	10.5	-48
Palm woodland	55,900	2.1	51,300	1.9	-10
Bare soil	165,200	6.1	220,900	8.2	34
Montane scrub	206,200	7.6	300,900	11.1	46
Tall halophytic grassland	59,300	2.2	173,100	6.4	191
Water	9,000	0.3	52,300	1.9	533
>7 fold increase since 1969					
Arable land	83,600	3.1	746,000	27.5	787
Secondary forest	50,600	1.9	614,200	22.7	1095
Total	2,711,600	100	2,711,600	100	

Figure 2. Map of Cental Argentina, showing the vegetation in (a) 1969 and (b) 1997.



Since 1969 cultivated land has increased ten fold from 3.1 to 27.5% of the surface area while ancient lowland and montane subtropical woodlands have suffered a catastrophic decline. Over 80% of ancient woodlands have been lost or severely damaged. This loss of 1.2 million hectares since 1969 represents a decline of 2.2% $year^{-1}$, which is similar to that recorded elsewhere for tropical rainforest. Economic factors are likely to have caused this agricultural intensification but a small change in climate, increased rainfall in the eastern lowlands, appears to have accelerated the process. A scientific paper based upon this work is almost ready for submission.

The Provincial Environmental Agency are already using the results to establish policies restricting further deforestation and have identified regions where no further deforestation should be allowed. Moreover, they are using agreements conferring tax relief with landowners to reduce further problems and through one such agreement a private protected area of 5000 ha of forest has been created. The information so far obtained has also been incorporated into the National Forest Inventory. An extension of this work to the whole of Cordoba Province incorporating a study of the ecological and economic processes mediating land use change and biodiversity is now our next major scientific objective.

4.1.2 The impact of aliens

Background and work carried out

There are two divergent views about aliens and their impacts on the landscape. The first argues that aliens are a special case in invasion ecology; the second that invasions of plant communities are of common occurrence due to factors such as changing land use and that the processes are essentially the same irrespective as to whether the invaders are native or alien species. We subscribe to this second view and consider that invasions by aliens, or for that matter native species, are generally simply a symptom of habitat change. Aliens generally only have a major impact if they can do things that native species cannot. Thus, the most undesirable annual, biennial and perennial aliens in the UK flora are arguably Himalayan Balsam (*Impatiens glandulifera*), Giant Hogweed (*Heracleum mantegazzianum*) and Japanese Knotweed (*Reynoutria japonica*) respectively. All are taller and more robust than comparable native species. The high levels of eutrophication in the lowland landscape is unique in the history of the British Isles. The three aliens mentioned above are more aggressive and competitive than similar native species and have therefore been able to take advantage in dramatic fashion of an underexploited productive niche. These highly invasive aliens have grabbed the headlines but their success is just symptomatic of a more general competitive shift There are many other winners (e.g. Stinging Nettle (*Urtica dioica*)) and the losers (lower- or slower-growing plants) have mainly been replaced by these fast-growing, competitive, native species.

Our Argentine sites appear to have one characteristic that makes them vulnerable to the invasion of aliens, intensive land use change providing new habitats and many opportunities for colonisation (see previous section), and one that will tend to restrict invasion, an unusual climate with rain falling only in summer. To assess the risk that aliens pose to the conservation of the landscape we used vegetational and autecological data to compare the ecology and distribution of three contrasted groups of species: aliens (undesirable), species endemic to Argentina (desirable) and common species in C. Argentina.

Conclusions and Outputs

Results for the pasture from the Sierras de Córdoba, which include the Quebrada del Condorito National Park, are presented in Figure 3. Aliens, unlike the two native groupings, are largely restricted to fertile, moist habitats (Figure 3a-b). Nevertheless, their impact on the vegetation is slight. Their maximum contribution to total biomass is low (Figure 3c) and the small-scale biodiversity of vegetation with aliens is still relatively high (30 species m^{-2}; Figure 3d). Thus, aliens as a grouping tend to be more ecologically extreme than the native flora of the Sierras de Córdoba and as such pose a potential threat to the integrity of semi-natural communities. This threat is, however, only likely to be realised where pastures are agriculturally 'improved'. Thus **the threat to semi-natural montane grasslands stems from changes in land use; an increase in aliens would only be a consequence of this change.** Results for other more arid vegetation types (chaco and monte) are similar. There are many aliens on roadsides particularly in areas that received run-off water from the road and in moist grassland (irrigated in river valleys). Elsewhere aliens are virtually absent; even in areas of chaco and monte ploughed up to improve grazing. **Without irrigation, the critical first step in making these arid lands productive, the aliens currently growing in the region do not appear to constitute a significant threat to the existing chaco and monte.**

There are no immediate plans to publish findings. There is a broader research program on the alien species of C. Argentina and experiments are still in progress. This has not, however, led to any complacency in the National Park Administration and Drs Cabido and Diaz will continue to monitor the impact of aliens in their new work for the authority. Moreover, the study of aliens is going in new directions. Aliens are also considered to be successful because they have escaped their predators. Two students, Diego Gurvich and Paula Teco are preparing a forum article on this topic.

4.1.3 The distribution of endemics

Background and work carried out

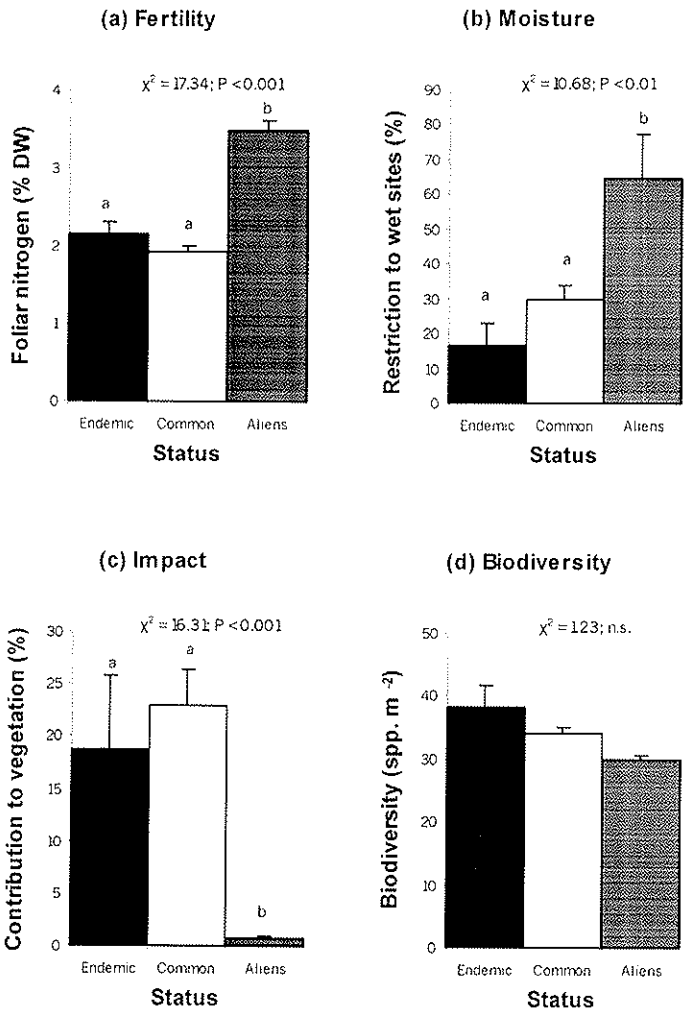
Argentine endemics are arguably the most important grouping of plants from a conservation viewpoint because they occur nowhere else in the world. Do these endemics have particular ecological characteristics that tend to restrict them to particular habitats, climates or management regimes? The answers to these questions have major implications as to how nature reserves and the wider countryside should be managed. Here we have assessed the ecological uniqueness of endemic species using databases on vegetation composition and functional species attributes.

Conclusions and Outputs

There is one simple relationship between rarity and habitat; many rare and rare endemic species are associated with rare habitats (e.g. *Deyeuxia eminens* restricted to wet habitats and *Solivia triniifolia*, that grows in vernal pools) or intermediate (ecotonal) ones at the boundary of two vegetation types (e.g. *Hieracium giganteum*). Other relationships are more complex, particularly with respect to endemism, as the results for the pasture from the Sierras de Córdoba, which include the Quebrada del Condorito National Park, illustrate (Figure 3 and Table 4.2). Some plant communities tend to have more endemics than others (Table 4.2) but the communities with most endemics are an ecologically disparate grouping including both xeric and tussock

Figure 3. A comparison of some ecological characteristics of endemic, common and alien species in the pastures of Sierras de Córdoba.

Values represent averages for the group + standard error. Columns with the same letter are not statistically significantly different from each other.



grassland types. Endemics include large, dominant species (e.g. *Festuca circinata*, *Poa stuckertii* and *Stipa pseudopampagrandensis*) as well as small subordinatespecies (e.g. *Aa achalensis* and *Arenaria achalensis*) and there are no consistent habitat or functional differences between species endemic to Argentina and the rest of the native flora (see Figure 3). Furthermore, our attempts to ecologically separate the two groups by discriminant analysis were totally unsuccessful. Owing to the close collaboration between the National and Provincial Park Authorities and the Darwin project, and because of generous additional funding from the British Council Ana María Cingolani has used GIS combined with vegetation mapping techniques to produce a much more detailed map of the 150,000 ha area and a much more exact picture of the vegetation and the geographical distribution of endemics than would have been possible if the work had been carried out as a part of the Darwin project. This work has shown that endemic species are not highly

concentrated into particular geographical areas. Thus, because aliens represent an ecological heterogeneous grouping, we cannot recommend a simple general management prescription for promoting the survival and spread of endemic species that can be applied at the landscape level. Moreover, because endemics are not aggregated into hotspots, specific areas cannot be targeted to the exclusion of others. Our search for generality has failed. **Each endemic must be treated as a special case and conservation can only be achieved by an appreciation of the habitat requirements and vulnerabilities of individual endemic species.** Ana's maps of vegetation, and the biodiversity of the full and the endemic flora will be invaluable for the future management of the area particularly in integrating conservation between the two parks. The level of endemism at our other study site, Chancani is much lower but similar scientific conclusions apply.

Table 4-2. The occurrence of endemics in the Sierras de Córdoba

[Plant communities dominated by an endemic species are given in bold.]

Community	Grassland	No. releves	No. endemic spp.	Endemics m^{-2}	Species m^{-2}
Rich in endemics and species					
Muhlenbergia peruviana	Xeric	7	9	5.3	52
Stipa pseudopampagrandensis	Tussock	13	15	4.2	33
Stipa juncoides - Sorghastrum pellitum	Xeric	26	14	4.0	39
Festuca circinata	Tussock	11	8	2.7	30
Intermediate					
Sorghastrum pellitum	Xeric	16	12	2.7	24
Poa stuckertii	Wet	11	6	2.5	19
Deyeuxia hieronymi	Tussock	20	9	2.4	22
Stipa filiculmis	Tussock	14	11	1.4	29
Paspalum quadrifarium - Eleocharis montana	Wet	26	10	1.3	21
Festuca hieronymi	Tussock	20	11	1.1	25
Aristida spegazzini	Xeric	15	7	0.9	27
Schizachrium salzmannii	Xeric	7	2	0.4	26
Poor in endemics and species					
Eleocharis dombeyana	Wet	11	5	0.9	15
Pycreus rivularis - Eleocharis albibracteata	Wet	15	4	0.9	18
Rhynchospora brownii - Pycreus niger	Wet	12	3	0.3	15

4.1.4 International collaboration

Drs Diaz and Cabido, Dr Jalili, the collaborator in our Argentina project, (Grant 162/7/127), and ourselves have a major commitment to conservation. We are also acutely aware that the problems addressed in our Darwin projects are simply local variants of a very general conflict between (a) practices commonly associated with maximising (agricultural) productivity and (b) a requirement both to conserve natural habitat and biodiversity and to ensure that land use is sustainable. Moreover, we

believe that the ecosystem processes and ecological problems that we have studied in various localities and in different countries, are not fundamentally different either from one another or from those studied in other Darwin projects. We are therefore attempting to define and promote greater understanding of some of the general rules governing the ecosystem processes that so critically affect conservation and sustainable agriculture. To these ends we have, with the approval of the Darwin Secretariat, instituted a new, international element to the work, combining our Darwin datasets with other similar data. This has been possible because as in previous Darwin projects, our approach has consistently involved the replacement of taxonomic descriptions of vegetation with more general mechanistic ones that relate to what plants do ('functional traits').

4.1.4.1 Identifying the plant functional traits that drive ecosystems

Our first goal was to identify the extent to which the simple functional attributes measured in the project were useful for examining the way that ecosystems function. We used eleven easily measured plant traits (leaf area, specific leaf area, leaf toughness, inrolling of lamina, leaf thickness, canopy height, twig density, mean distance between ramets, shoot phenology, life span, seed mass and seed shape). Our database included 640 vascular plant taxa from four countries (Argentina, 207 species; Iran, 186; Spain, 104 and UK, 143) and three continents. We used Principal Component Analyses to identify major axes of variation in functional traits in each of the four floras. The results from our first 'international' analysis, using a subset of 207 Argentine species, were very encouraging. Using Principal Component Analyses (PCA) we have identified the same major axes of variation in functional traits in each of the four floras (see Figure 4). The main axis of variation represented a fundamental trade-off between rapid acquisition of resources and conservation of resources within well-protected tissues. This axis was closely correlated with other independently-measured traits known to be strongly linked to ecosystem functioning, including relative growth rate, leaf nutrient concentration, litter decomposition rate and resistance to generalist herbivores. This trend was largely independent of phylogeny, land use and climate, suggesting it may be broadly applied to contrasting floras, environments and growth forms, and offering the prospect of a globally relevant functional classification of species. We were very pleased with the results and submitted them in a paper to *Science*. The paper was rejected at the review stage in *Science* primarily as a consequence of one unsympathetic American reviewer who argued on the basis of high profile work on experimental plots that a functional separation of plants into legumes, grasses and herbs was sufficient for understanding ecosystem processes. We strongly disagree! The manuscript has been now been submitted to *Journal of Vegetation Science.*

4.1.4.2 The relationship between plant functional traits and economic yield

In many parts of the world the greatest problem for those involved in conservation is the fact that economic pressures to maximise short term profit often appear to take precedence over moral, aesthetic and longer term planning considerations relating to the maintenance of high biodiversity and sustainable agriculture. Conservation projects that address only conservation issues may well fail in the longer term as different economic scenarios unfold, particularly in countries with fragile, 'free market' economies. A longer term objective of ecologists must therefore be to provide an understanding of the interrelationships between ecosystem and economic processes. 'Crisis management' of environmental issues can only be avoided if

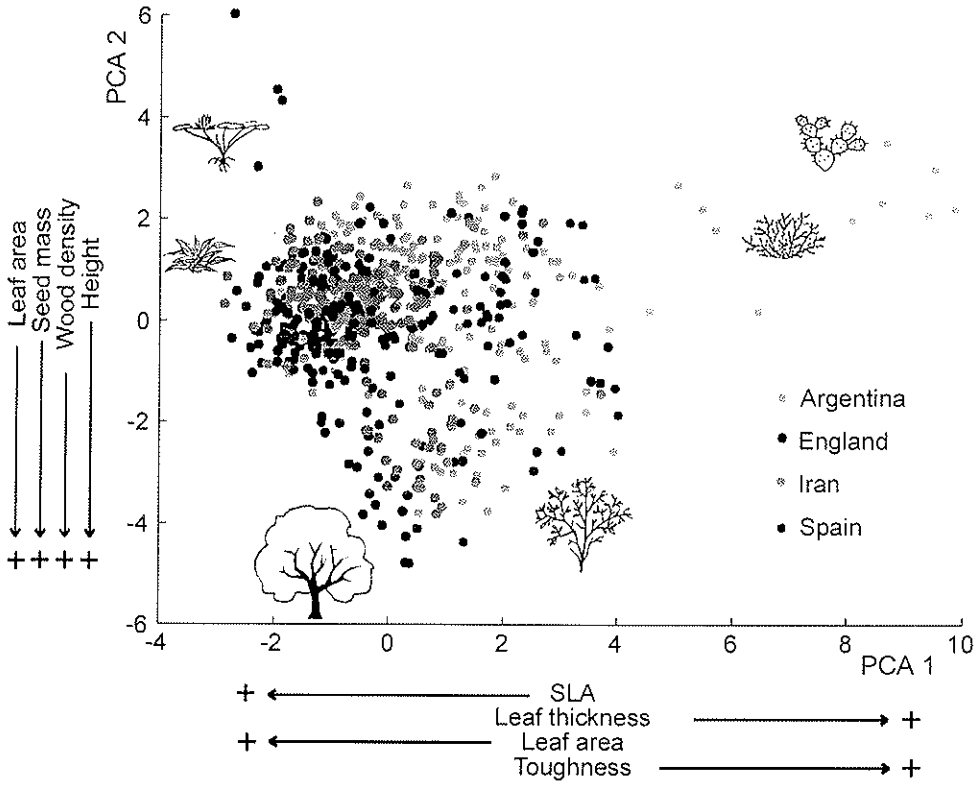


Figure 4. PCA ordination of 640 vascular plant species from Argentina, England, Iran and Spain, on the basis of 12 vegetative and regenerative traits.

PCA was based on the correlation matrix of variables, in which data are centred and standardized by standard deviation. PCA axes 1and 2 accounted for c. 40 % of the variance in the database (PCA 1 = 23.87; PCA 2 = 16.71). Labels display traits with the highest loading factors on PCA axes 1 and 2, with highest loading nearest axis. Stylised figures indicate extreme types, such as aquatics and tender-leaved ephemerals at the lower end of PCA axis 1, Cactaceae at the higher end of PCA axis 1, and large-leaved deciduous trees and shrubs at the lower end of PCA axis 2. A separate PCA excluding desert succulents produced very similar results, including the same rank of loading factors along both axes.

economic planning and conservation issues are dealt with within a single integrated decision- making process. As a first stage towards understanding the relationships between ecosystem processes and economic ones, we have considered the relationship between fertility and yield. We all appreciate that increased fertility increases yield but to date no one has identified a general globally applicable mathematical relationship between the two.

Our study, which deals with pastural systems, had two independent parts: one ecological run by the Darwin team, the other agricultural where data were generated by agronomic 'conscripts' to the project. In the ecological section we first identified that leaf structure can be used to predict 'active' nitrogen', the nitrogen concentration in the leaves, which is available to herbivores. Our results confirm the existence of a fundamental trade-off between rapid acquisition of resources and conservation of resources within well-protected tissues (see (a) above). For all countries, both separately and together, foliar nitrogen is a positive function of specific leaf area (leaf area/leaf mass) and a negative function of leaf toughness. Our predictor of foliar nitrogen is also significantly correlated with maximum relative growth rate, palatability to unspecialised herbivores, litter decomposition rate and the global productivity axis identified in (a) above. Next we calculated mean foliar nitrogen content for different types of vegetation using general lists published in the phytosociological literature.

While we were defining ecological characteristics agronomists in each country calculated the sustainable carrying capacity for livestock of these vegetation types. The results of this collaboration are included as Figure 5. Increasing fertility results in an exponential increase in livestock yield and economic profit. We suspect that the relationship illustrated has been such a powerful economic driver of agricultural land use change that arguments for sustainable land use and the conservation of biodiversity have often been ignored. These results will shortly be submitted to *Nature* in a short communication. We gratefully acknowledge the role of the **C**hanging **L**and Use and its **Im**pact on **B**iodiversity (CLIMB) workshops funded by the European Science Foundation both in helping to stimulate this research and in providing a vital source of agronomical and economic expertise.

4.1.4.3 The relationship between economic profitability and biodiversity

The role of biodiversity in ecosystem function is contentious. Here, we ignore this debate. Instead we ask the more practical question 'Where does species-rich vegetation occur in the field?' The species-richness of plant communities is affected by many factors (e.g. the size of the species pool within the landscape as a whole). Nevertheless high biodiversity in grazed systems appears largely confined to sites of low to intermediate fertility (i.e. low to intermediate agricultural profitability; Figure 6). We intend to study the ecological and economic consequences of these relationships further after the end of this project.

Conclusions and Outputs

Current ecological work focuses upon the role of biodiversity in relation to ecosystem function. Here, we attempt to take conservation research in a different direction by trying to generate some of the general ecological rules that relate to how and why land use change occurs. If this work, which is in its very early stages, is to have an impact on conservation policies, it must (a) integrate ecological and economic theory so that policies for development address both economic and ecological concerns and (b) be published in high profile journals: only through a high impact will we change minds and policies.. We are working with an ecologist with a very high scientific profile, Professor Philip Grime, FRS and economists to achieve the first objective. With respect to the second objective, we were disappointed that, after review, our first paper was rejected by *Science*. In fact Professor Grime was so upset by what he considered to be the biased review that he wrote to the editor but to no avail. Despite this setback, we are currently preparing other papers for submission to high profile journals.

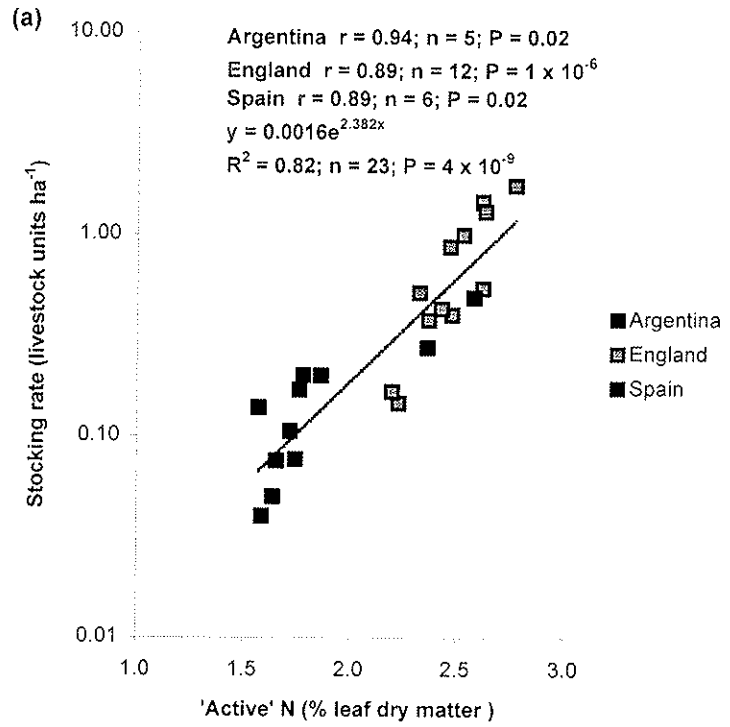
4.2 EDUCATIONAL WORK WITH LOCAL COMMUNITIES

During the visit to Argentina in Year 1 it was obvious that there is little national investment either in the management of our study areas or in environmental education. For this reason we decided to add a strong educational dimension to the project targeting both the park wardens and the local communities. This educational work was subcontracted to scientists and sociologists with good communication skills and proven experience in this field. The fact that these people are also known to, and trusted by, the local communities has been critical to the success of the project.

The local communities have played a vital role in shaping the present landscape and will continue to have critical impacts in the future. However, agricultural income, population size and knowledge of traditional land use skills are all decreasing. Our

Figure 5. The relationship between 'active' nitrogen estimated from leaf characters and (a) sustainable livestock yield and (b) economic profit.

Each data point relates to a plant community.



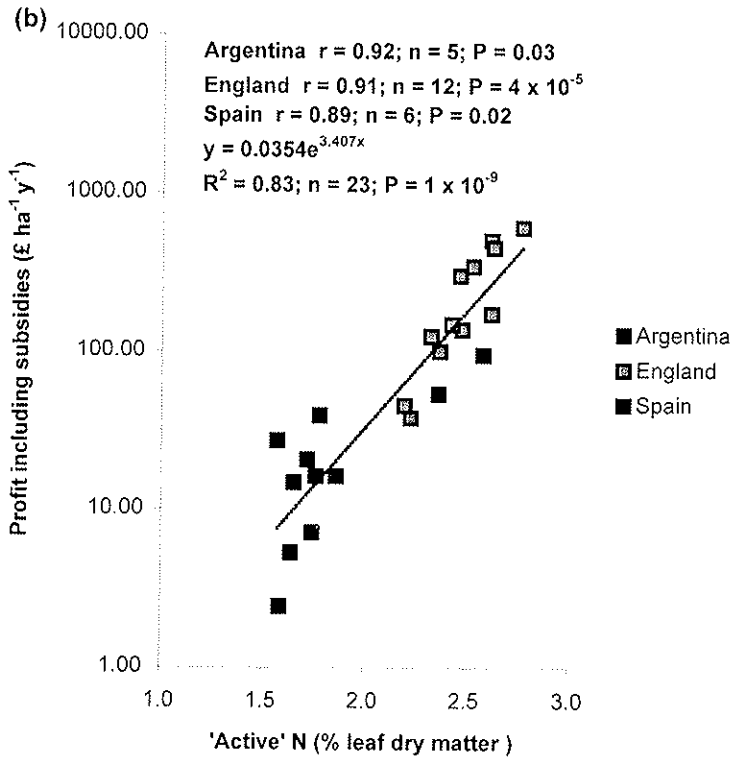
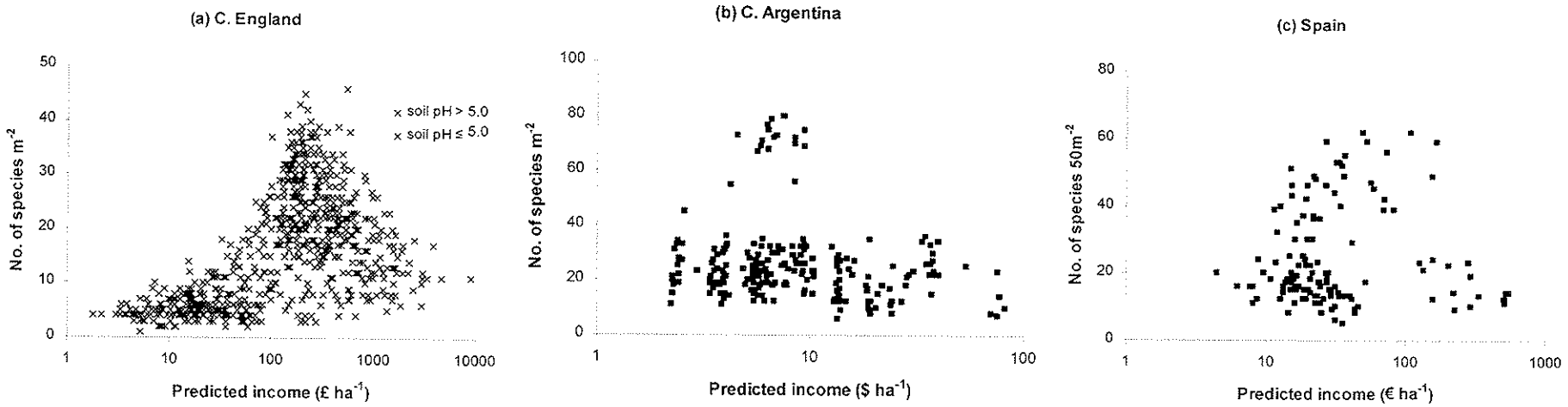


Figure 6. The relationship between profitability of land for agriculture and biodiversity.

Profitability estimates relate to the relationship between foliar N and sustainable yield in Figure 5.



long-term goal therefore is to try to arrest the economic and cultural decline of these people, and the degradation of the countryside in which they live, through

- educating local populations about biodiversity and how their ecological landscape functions
- increasing understanding and co-operation between conservationists and local populations
- exploring ways of making conservation policies of economic benefit to local populations
- promoting sustainable agriculture

To these ends a program of activities has been prepared for local communities by Carlos Szulkin Rafael Kopta, Federico Kopta and Sergio Bruno (members of ACUDE). This program is summarised in Table 4-3. The nature of the activities provided was designed to suit the peoples' disposition, extrovert in lowland Chancani, less so at the upland Pampa de Achala. Workshops were also arranged specifically for the Park Guards and others involved in conservation.

4.2.1 Pampa de Achala

Two workshops have been held at the rural schools in the area, with the participation of more than 60 children and over 50 adults, including teachers, local farmers, housewives, and wardens of National Parks Administration (see Table 4-3). They were organised by Sandra Díaz (staff member of the project) and Rafael Kopta, Federico Kopta and Sergio Bruno (members of ACUDE). A poster was produced at the end of the first year incorporating pictures of the local landscape, endemic plants and animals, group pictures of the children at the two local schools and, of course, the Darwin logo. Each family has a copy of the poster, a source of considerable pride, and many have found out about the past management of the region from their grandparents. Considerable interest has been shown in the fact that some of the plants and animals of their region are rare and endemic. The work with children is ongoing now supported by a grant to the National Parks Administration by the World Bank. Most recently (in January, March and May 2003), as in Chancani (see below), the children have been making puppets with Carlos Szulkin. In March 2003 Dr Hodgson was privileged to see rehearsals of their puppet displays at Ceferino Namuncurá School. These rehearsals were in preparation for a prestiguous conference on conservation at Huerta Grande, Cordoba. Their shows dealt with the conflicts between farmers and conservation such as predation of livestock. The stories about these conflicts were written by the children and were presented with considerable humour and charm. A video will be produced of these shows and a copy sent to Darwin. The video will be made with English subtitles for the benefit of English children (see below). Following the visit to Ceferino Namuncurá School Dr Hodgson has been arranging a school twinning with an English primary school in the Peak District National Park. Currently, a link is being organised with Bamford Primary School. The Peak District National Park Authority are enthusiastic about the scheme and have offered Bamford School their support.

4.2.2 Chancani

Marcelo Cabido, Sandra Díaz and their team and Carlos Szulkin and his team, organized a series of workshops for the local community, including adults, children and teenagers (see Table 4-3). A total of two hundred children attended (90 from

primary school, 70 in their first years of secondary school and 40 senior secondary school pupils), their teachers, their relatives, and the park guards in charge of the area together with the local co-ordinators of the National Agronomical Social Program (PSA), Miguel Villareal and Ricardo Aguadé have also participated. Activities with an environmental theme for primary schools included making posters, puppets and kites, puppet and kite shows, discussing their environment using pictures of trees and erosion, writing letters and role playing (hunter, warden etc.). Following a guided visit to the reserve, they made models of reserve and non-reserve landscapes. They wrote letters, made up questionnaires and interviewed different people involved with the environment (e.g. hunters and the elderly – what were things like fifty years ago?) Teenagers from the secondary school also analyzed photographs, debated conservation issues, painted a large 10 m mural and prepared a public programme with loud speakers, commentary and music. Everyone attended including the Press. Posters have also been produced based upon drawings by local children and a video of some of the activities has been produced. Some of this material has been incorporated into the Darwin promotional video produced by the Secretariat. In the last workshop the students prepared a newsletter (see Appendix VII.3) about the reserve and their environmental concerns. This was circulated to local schools. Bamford Primary School has expressed an interest in being additionally twinned to the school at Chancani. Efforts are currently being made to accomplish this and there has been encouraging progress.

4.2.3 Prospects

The policy of the governmental agencies has been to exclude people from nature reserves; people hunt, graze, cut timber and destroy nature. For their part, the local population saw the nature reserve as a haven for foxes that ate their chickens and for puma that ate larger livestock. Therefore, one of the most significant events that occurred early in the project was the provision of access into the nature reserve at Chancani. In particular, it was the first time that the people of Chancani had entered the reserve for 20 years, even though the reserve is only 8 km from their village. None of the children had previously seen undestroyed chaco vegetation. Everyone appreciated the abundance of trees and of grass. The children understood much better about the changes to the countryside in recent times (e.g. the demise of the charcoal industry because no trees were left). The farmers recognized, and were envious of, the better fertility of the soils in the reserve and the continuing survival of medicinal plants, long extinct from the surrounding countryside. From such events, there was a general consensus that current management practices outside the reserve could be and should be improved both for the farmer and for the conservation of biodiversity. The provincial government also became aware for the first time of the resentment of local people about the reserves due to loses of livestock. It has also come to appreciate the important contribution that local people make to the maintenance of biodiversity and landscape quality and is beginning to adopt a much more proactive approach. A dialogue is now taking place. Local people are now being employed on the reserve and there is now a visitor centre with nature trails and facilities for a barbecue, a very important recreational facility in Argentina.

As a result of these changes in attitude this community-orientated element of the project continues to develop a momentum of its own, driven by the interest of the local communities and the commitment of conservation agencies. This development has in Pampa de Achala been considerably strengthened by money for sustainable activities given by the World Bank (GEF) and the Interamerican Developmental Bank

Table 4-3. A summary of educational activities with local communities.

Location	Date	Attending	Some achievements
Quebrada del Condorito National Park.	30 - 31 March 2000	> 60 children & > 50 adults (incl. teachers, farmers, housewives, Park wardens)	Learning that some familiar plants and animals occur nowhere else in the world; discovering how the oldest members of the community used to farm; discussion of problems with National Park Authority; visits to nature reserve; poster of local landscape, endemic plants and animals and children from two local schools widely disseminated
Chancaní Provincial Reserve.	29 - 30 March 2000; 4 - 6 May 2000	200 children (90 from primary, 70 early secondary & 40 senior secondary school) + teachers, relatives, and local co-ordinators from National Agronomic Social Program (PSA)	Range of socio-artistic activities (kite making, puppet displays, painting, drawing, sculpture, and the simulation of a radio program relating to environment and protection of rare species); poster based upon drawings by local children; video produced; high profile coverage in national press and television
Chancaní Provincial Reserve	27-28 April 2001; 4 - 5 May 2001	50 students (senior secondary school) + teachers, co-ordinators, park wardens, university teachers)	Visit to reserve; looked at the characteristics and reasons for the existence of the protected area. They discussed concepts such as the environment, ecosystem and biodiversity. They also analyzed the benefits and problems of having a protected area nearby and for the first time spent a night at the reserve. They made drawings and posters aimed at communicating their experiences to the larger community.
Chancaní Provincial Reserve	18 - 19 September 2001	50 students (senior secondary school) + language teacher and co-ordinators.	'Literary workshops' at which the young people wrote stories and described economic, social and cultural aspects of their life and their feelings for the environment. They also made drawings and produced posters. A magazine *Mate Cocido* (300 copies) was published using material produced at the workshop.
Chancaní Provincial Reserve	29 - 30 July 2002	50 students (senior secondary school) + teachers and co-ordinators; 100 children and teachers from primary school.	The magazine, *Mate Cocido*, was showed to pupils and teachers at the school and the authors read their contributions and described the objectives and achievements of the workshop. The authors also visited other primary schools to present their work. Their activities were reported in the provincial press.

(BID). For example, efforts are being made to encourage tourism to reduce the rate of rural depopulation and the link with Bamford school is considered to be very important by the teachers at Ceferino Namuncurá School as a means of broadening the outlook of their students. In Chancani, where no such outside money is available, Carlos Szulkin continues to work with the local children and teachers, a process that will be made easier in June once the new school is open. It is hoped that a link with an English school will help to maintain the high profile that the educational work at Chancani now enjoys bringing further benefits to the area (see section 11). The work with communities carried out in this Darwin project has developed in promising directions and could act as a model for other initiatives elsewhere in Argentina (BID). For example, efforts are being made to encourage tourism to reduce the rate of rural depopulation and the link with Bamford school is considered to be very important by the teachers at Ceferino Namuncurá School as a means of broadening the outlook of their students. In Chancani, where no such outside money is available, Carlos Szulkin continues to work with the local children and teachers, a process that will be made easier in June once the new school is open. It is hoped that a link with an English school will help to maintain the high profile that the educational work at Chancani now enjoys bringing further benefits to the area (see section 11). The work with communities carried out in this Darwin project has developed in promising directions and could act as a model for other initiatives elsewhere in Argentina.

4.3 TRAINING AND CAPACITY BUILDING ACTIVITIES

The training activities undertaken were agreed between the UK and Argentine Darwin teams. The senior members of the Argentine team, Dr Marcelo Cabido and Dr Sandra Diaz were already high profile scientists with a good international reputation. Moreover, they have complementary skills with Dr Cabido being essentially a field ecologist and Dr Diaz an experimentalist. Together they are building up a team of young scientists who will both have their own projects and skills but will be encouraged to collaborate with others in the group in interdisciplinary studies. The training element for students has, therefore, concentrated upon areas where the Argentine team has less experience namely the measurement of the functional traits in the field and the laboratory and upon understanding the underpinning ecological theory. Considerable emphasis was also given to the creation and management of databases to ensure that the use of the extensive data holdings being accumulated could be both maximised and made more efficient. Dr Hodgson also talked on a one-to-one basis to all students and junior scientists about their projects both to give advice and encouragement and to look for potential links between related projects. Even the rejection of the paper to *Science* was used as a discussion forum. Thus, there was at least an instructive end to a disappointing chain of events.

A formal two day workshop was run at the start of Dr Hodgson's first visit. This included a mixture of supervised laboratory exercises talks on theory and methodology, data checking and problem solving., A training protocol was produced for the students (see Appendix 8) and copies of relevant scientific papers were deposited at the Institute for staff and students to read. This collection of references provided the theoretical background and practical knowledge needed to carry out the project. Most of Dr Hodgson's input has, however, been made during informal discussions in laboratories and in the field. The Argentines found the schedule for functional measurements useful

but have suggested methodological improvements to deal with succulents, a grouping poorly represented in the UK flora. This has resulted in the publication of a scientific paper (Vendramini *et al.* 2001 – see Appendix III). Senior Argentine staff was in charge of the day to day running of the project. It has been our policy to encourage visiting ecologists with special skills to participate in the Darwin project and we gratefully acknowledge the specialised training provided by three such visitors. Firstly, Peter Feinsinger (North Arizona University, Flagstaff), an internationally recognized expert in environmental education, gave an invited lecture at Cordoba entitled 'Enseñanza de la ecología en el patio de las escuelas'. This was attended by University students, high-school teachers and park wardens and managers. Second, Valério de Patta Pillar of Universidad Federal de Río Grande do Sul, Brazil ran a course for experienced field ecologists, both staff and students, on multivariate analysis of vegetation and environmental data. Third, Sandra Lavorel of Centre d'Ecologie Fonctionelle et Evolutive, Montpellier, France gave a talk on the relationships between biodiversity and disturbance in a changing world. Dr Lavorel is the co-ordinator for the workshops of the Task 2.2.1 of the Global Change and Terrestrial Ecosystems Core Project of the International Geosphere and Biosphere Programme of the United Nations and works closely on this project with Sandra Diaz. Also, with the permission of the Secretariat Dr Diaz carried out a hands-on training course on the measurement of the functional traits in the field and the laboratory for a group of 12 South African and French scientists and graduate students. This took place in the field, in a conservationally very important but threatened fynbo vegetation at Jonaskop, in the Cape region. It was a great success. The functional traits of 87 native plants were measured along a climatic gradient spanning from succulent karoo to the high-altitude grasslands. A paper is being prepared using the results obtained and equipment has been ordered so that the Darwin measurements can be continued in South Africa and France.
There has been a core of nine staff involved in the Darwin project from its onset to the present day.

At all stages of the project the key staff and other participants had various opportunities for improving their skills due to different training elements within the project, including:

- language skills (including help and advice on preparing scientific papers; students are strongly encouraged to publish in international journals and academic tenure is not possible without them)
- ecological survey and field sampling techniques
- identification of vascular plants
- laboratory skills
- database development
- data manipulation (including multivariate analysis)
- interpretation of ecological/functional data with respect to conservation needs
- working as a team

We consider that all of these skills are useful components for improving the capacity within the host country to conserve biodiversity in the future. The knowledge gained during the project, and also the computer databases of vegetation relevés and functional attributes will be widely used in the future.

Twenty four students, selected because of their good academic record and interest in

ecology, have received training in laboratory and field techniques during the course of the project. Three PhD and one MSc students contributed to the Darwin project on a part-time basis. They gained valuable experience in new ecological techniques and scientific teamwork and were able to incorporate data from the project into their theses. Nine graduate and eleven undergraduate students worked on the project each for a period of several months. They too came to the project with impressive academic references. These students received no formal qualification from their work on the project but their academic prospects have been enhanced through their participation. All major student contributors to the project are now in higher education or employment, where their training can be put to good use. However, most still work in the Cordoba area because of a national shortage of jobs.

5. PROJECT IMPACTS

The collaboration in a Darwin project provided two clear signals (a) the flora of Central Argentina is of international interest, and (b) a group of Argentine scientists were involved in a prestigious collaboration with a UK University. Both of these perceptions of the Darwin project have had a major, positive impact as to how our work has been received. Public lectures at Cordoba were well attended and the project has had very good coverage in the Argentine media. The project has also directly led to Marcelo Cabido, Sandra Díaz and their team being given contracts by the National Parks Administration for additional work on the management and biodiversity of nature reserves. Indeed, because of his involvement in the Darwin project and his other conservation work, Marcelo Cabido is now regarded by the provincial environmental agency as the 'jewel in its crown'. This regional body is anxious to raise its profile nationally and commissioned Marcelo to write a book entitled 'Areas Naturales Protegides de la Provincia de Córdoba'. This book, which is 'in press', was officially launched at a prestigious conference at Huerta Grande, Cordoba on March 28-30, 2003. This is the first book of its type to be published in Argentina and acknowledges Darwin. [There were also well received puppet displays by local children from Achala (also with an acknowledgement to Darwin) and children from Chancani talked about their Darwin experiences]. This is an encouraging development for the Darwin Project, which despite operating at a regional scale has always wished to have an impact at a national scale as well.

Another first for Darwin! There is now active management in one Argentine National Nature Reserve. Farmers from the overgrazed Provincial Reserve, Pampa de Achala, have signed agreements to reduce stocking rates and in compensation are allowed to graze in a strictly regulated way parts of the adjacent, formerly ungrazed Condorito National Park, where biodiversity is declining. Thus, there is movement towards an integrated conservation policy for both reserves agreed by the two different conservation agencies, another first. This could not have been achieved without additional funding from the British Council given to Ana María Cingolani. Ana used GIS combined with vegetation mapping techniques to produce a much more detailed map of the 150,000 ha area and a much more exact picture of the vegetation and the geographical distribution of endemics than would have been possible if the work had been funded only the Darwin project. The quality of the map was a significant factor persuading the National Park Authority that grazing could be regulated so as not to damage vulnerable sites.

Another major impact resulting from the project has been the excellent work carried out

by the Argentine team with local communities. To re-iterate some information from a previous section, the policy of the provincial governmental had been to exclude people; people hunt, graze, cut timber and destroy nature. For their part, the local population saw the nature reserve as a haven for foxes that ate their chickens and for puma that ate larger livestock. Therefore, one of the most significant events was access into the nature reserves. In particular, it was the first time that the people of Chancani had entered the reserve for 20 years, even though the reserve is only 8 km from their village. None of the children had previously seen undestroyed chaco vegetation. Everyone appreciated the abundance of trees and of grass. The children understood much better about the changes to the countryside in recent times (e.g. the demise of the charcoal industry because no trees were left). The farmers recognized, and were envious of, the better fertility of the soils in the reserve and the continuing survival of medicinal plants, long extinct from the surrounding countryside. From such events, there was a general consensus that current management practices outside the reserve could be and should be improved both for the farmer and for the conservation of biodiversity. The provincial government also became aware for the first time of the resentment of local people about the reserves due to loses of livestock. It has also come to appreciate the important contribution that local people make to the maintenance of biodiversity and landscape quality and is beginning to adopt a much more proactive approach. A dialogue is now taking place and local people are being employed in the reserves. Moreover, the work with communities is ongoing particularly in the Achala area, where conservation agencies have support from international banks. In particular the work with children continues to have a high profile and is featuring at an important conservation conference (see above). With the approval of the Darwin Secretariat money from the UK travel allowance is being used to keep educational work at Chancani also operating at a high profile. The most recent educational development is the twinning of Argentine schools involved in the Darwin project with one in the Peak District National Park. This process started only in May 2003 and has not yet been officially launched with press releases. It has the enthusiastic support of the teachers and conservation authorities of both countries and we confidently expect it have an impact in areas of public awareness where Darwin does not usually reach.

Another major achievement has been to provide a 'wake-up call' as to the potentially catastrophic vegetational changes now occurring within the region (see Figure 2). The Provincial Environmental Agency are already using the results to establish policies restricting further deforestation and have identified regions where no further deforestation should be allowed. Moreover, they are using agreements conferring tax relief to compliant landowners to reduce further problems. Through one such agreement a private protected area of 5000 ha of forest has been created.

The legacy of training provided by the project means that there is now a concentration of trained scientists in the Cordoba region. This nucleus of expertise is assisting in the implementation and development of regional conservation initiatives. It is hoped that, when the national economy improves and more jobs become available, these young scientists will find jobs in other parts of Argentina and have an impact upon national conservation. In addition, park rangers have an improved grasp of the management problems within reserves and a more sympathetic attitude to the problems of local people.

The major databases produced during the project are likely to have a major impact on ecological studies in Argentina particularly as we publish more papers on the subject. To date in Argentina there has been an emphasis on traditional phytosociological and

demographic studies. The databases make more mechanistic studies of ecosystem function more tenable. Moreover, as active management of reserves becomes more commonplace, we can ensure that decisions are taken on an objective scientific basis.

The project will also have an international impact. Our findings that the relationship between fertility and yield is exponential and the demonstration of a relationship between biodiversity and fertility have profound implications for conservation policies, which we will attempt to explore. For example, we are collaborating with the Peak District National Park Authority to see whether there is any relationship between take up of management agreements and site fertility: a negative one is predicted. Moreover, we are working with economists in an effort to link ecological and economic theory. In addition we are providing methodologies and datasets for the wider scientific community to use. Sandra Diaz has been particularly active in this respect. She has promoted our 'Darwin approach' at five meetings and has ensured that many of the Darwin methodologies have been included in a collective paper consisting of a handbook of protocols for standardised and easy measurements of plant funcitonal types worldwide. This manuscript, which acknowledges the help received by the Darwin Initiative, was also greatly improved through Dr Diaz's work in South Africa.

The project was seen as being able to help Argentina to meet its CBD obligations in the following specific ways:

1. collection and analysis of extensive data on the plants of Argentina;
2. establishment of databases and reference collections of plant materials;
3. training of local people in field survey and identification of flora;
4. training of local people in scientific laboratory techniques;
5. promoting sustainable agriculture and the benefits of conserving biodiversity within local communities;
6. herbarium collections have been enhanced;
7. publication of a guide to the Chancani reserve
8. dissemination of information to the international scientific and conservation communities;
9. Involvement of local stakeholders in conservation management.

6. PROJECT OUTPUTS

Project outputs, both those promised and those additionally achieved, are quantified in Appendix II using the coding and format of the Darwin Initiative Standard Output Measures. Conservation advice directed formerly or informally to the relevant statuatory body has in all cases been accepted and acted upon with due speed. Thus, we already have collaboration over management issues between the regional and national conservation agency at Achala to deal with grazing problems and a new policy is being actively implemented to stem the rate of deforestation. In addition, information has been disseminated in the form of scientific papers. This raises the profile of conservation issues important in Argentina and makes Argentine experience available to a wider audience. Moreover, the only significant cost is one of time. Correspondence and the transfer of data, so essential to a continuing collaboration, can be readily effected by e-

mail.

7. PROJECT EXPENDITURE

	Predicted	Actual	% variation
Staff salary costs:			
Postage, telecoms & stationery			
Travel etc.:			
Printing etc.			
Conferences, seminars etc.:			
Other: Capital items, consumables, computerware, data costs			
Total			

8. PROJECT OPERATION AND PARTNERSHIPS:

There has technically been only one local partner throughout the project, the University of Cordoba, with the project being jointly directed by Drs Cabido and Diaz. In practice, however, the project could not have operated effectively if (a) local and national conservation agencies had not given enthusiastic support and encouraged the involvement of their personnel and (b) Carlos Szulkin Rafael Kopta, Federico Kopta and Sergio Bruno (members of ACUDE) had not been so effective in their activities with local communities.

Project planning was carried out through face-to-face discussions and e-mails about conservation needs and work priorities. Drs Cabido and Diaz have a good knowledge of the problems facing the flora of C. Argentina. They also had clear ideas as to what was needed for the conservation of the flora and the involvement of local communities.

These ideas made eminent sense and we were happy for them to be incorporated into the project. UK partners have made suggestions, primarily about the scientific content of the work. These have been discussed and either accepted or rejected on grounds of relevance and feasibility. Drs Cabido and Diaz have been very supportive of our ideas and our general approach. We all see the need for conservation activities to be science-based and relevant to conservation issues.

Staff of Argentine bodies with similar interests have been kept informed of our activities and have attended the public talks given by Argentine and UK scientists and Argentine scientists, sociologists and conservation workers have collaborated in activities with local communities from the outset. Co-operation and communication is not however decreasing as the project comes to a close. Drs Cabido and Diaz are now contracted by the National Parks Administration to provide scientific data and advice on a wide range of conservation issues. Moreover, the links developed during the project mean that Marcelo Cabido is still in regular contact with those carrying out the continuing community orientated activities even though the Darwin project has finished. There are still further partnerships being developed through the school twinning project, which is still in its infancy. These will primarily involve local schools and communities and park authorities but contributors to the Darwin project, both in Argentina and UK will help when this is required.

The scientific aspects of the Darwin project are also still on-going. Drs Cabido, Diaz and their students are actively involved with Sheffield ecologists. Both partners are committed to maximizing the conservation and scientific output of the project. There are valuable underexploited databases to explore and major new conservation initiatives to prepare.

9. MONITORING AND EVALUATION, LESSON LEARNING

Marcelo Cabido and Sandra Diaz have kept a close check on progress in carrying out the Argentine part of the project. In accordance with good laboratory practice, there has been a high level of replication of measurements, checking for errors and some re-measurement to ensure that the database is of high quality. The Argentines have also assessed the sensitivity of their laboratory apparatus to ensure that quantities of material routinely used are appropriate. They have also suggested improvements to some of the protocols, and improved the design of some of the instruments. We have also been at pains to assess whether the procedures undertaken will maximize the conservation and scientific impact of the project. We are now confident that all measurements undertaken can now be incorporated into either a management plan or a scientific paper or both. Moreover, we are constantly looking for 'added relevance' of conservation outputs by consultation and 'added value' by increasing scientific outputs.

There are lessons to be learnt from the project. Because of the enthusiasm of our Argentine colleagues the project was very ambitious with extensive data collection from all major vegetation types within the region. This 'added value' to the project has meant that many additional analyses can now be carried out and that consequently the full impact of the 'functional type' approach both in relation to conservation and scientific outputs will not be realised for some time. Another problem has been that because we have attempted to make the project as relevant to the conservation and educational

needs of the area as possible, we have branched out into activities where we have little or no experience. In these situations we have both sought advice and carefully monitored relevant outputs. We have encouraged eminent visitors to Cordoba University to pass on their knowledge to students and park guards. This process of enrichment has continued throughout the duration of the project. Even as the final report was being written, Dr Hodgson is finding out from a Spanish ecologist the best person to contact on the wolf conservation work in the Cantabrian Mountains. The antagonism between Argentine farmers and pumas and Spanish farmers and wolves are similar and we believe that Argentine conservation authorities can learn a lot from the Spanish experience.

There were also three organisational problems:

1. We had agreed with the Darwin Secretariat that the project should finish in April 2002 but the collapse of the Argentine economy has strongly impacted upon life in Argentina. By delaying the final report we are also better placed to judge the effects of the collapse of the Argentine economy on the quality of the legacy left by the project. We wanted to assess this problem in the Final Report. The quality and quantity of work undertaken during the project has not suffered. The devaluation of the peso and the freezing of assets held in Argentine bank accounts added to the complexity of running a Darwin project but our Argentine colleagues used unfrozen funds from other sources and some work was done on a voluntary basis. The Final Report was further delayed by (a) a bereavement that delayed Dr Hodgson's last visit to Argentina and (b) while Dr Hodgson got the school twinning project off the ground. [During Dr Hodgson's last visit, he visited one of the Argentine schools and joined in with community life of the school. He offered to twin the school with one in the Peak District National Park.] Both delays were sanctioned by the Darwin Secretariat.
2. Because the study sites were far from Cordoba, there were major logistical problems in collecting material. Re-collecting plant material for checking and making field visits for seed collecting put excessive strain upon staff.
3. Marcelo Cabido wrote two guides, one for each area. Originally it was intended that these would be published directly as a part of the Darwin project but the conservation agencies offered to publish them using their own funds. Unfortunately, following a change in senior management, one conservation body declined to honour this agreement and the guide for Achala remains unpublished. It seems politically inopportune to press for publication at this moment.

There is also the more basic problem of conservation work involving communities who live in extreme poverty. The value of what we have achieved depends critically on the sense of empowerment and leverage within local communities that has been cultivated through the Darwin project and upon the subsequent availability of additional economic resources. We discuss these problems in Section 12. This concern strongly influenced the direction of our international research program (Section 4.1.4).

10. DARWIN IDENTITY:

On our first visit to Argentina the Darwin Initiative was promoted through a formal twenty minute talk by Dr Hodgson attended by over fifty scientists, some from the Institute, others from other research institutions. In this talk the origins, objectives and opportunities for funding associated with the Initiative were clearly explained. At least one member of the audience subsequently applied, I believe unsuccessfully for Darwin money. All other talks have also had the Darwin Initiative logo displayed at some point, usually on the title overhead or slide. Any laboratory apparatus large enough to support a Darwin logo sticker was so decorated and we are pleased to report that the stickers, though slightly battered, were still attached at the end of the project. The role of the Darwin Initiative has been emphasised during the school twinning exercise and we thank the Darwin Secretariat for providing a copy of the Darwin video and other illustrative material. Sandra Diaz was officially a Darwin Fellow during her visit to UK. However, in the informal atmosphere prevailing in Sheffield, this title was never really used.

The Darwin Initiative has a good reputation in Argentina. It is seen as a mechanism for collaboration with British Universities, whose educational standards are well respected. Moreover, the work with children continues to be regarded as an activity of the Darwin Initiative even though funding now comes from other sources

Some of the outputs, particularly those relating to regional conservation initiatives, were not initially expected and the role of Darwin was primarily that of catalyst. Nevertheless, both here and for the more central activities of the project, published outputs include an acknowledgement to the Darwin Initiative.

11. LEVERAGE

Drs Cabido and Diaz were impressed by the scientific background to the project and as a result provided many more resources (money, people, equipment) to the project than was initially promised. Nevertheless, there is a major problem in securing further funding while a Darwin project is ongoing. Potential sponsors, particularly international ones, are impressed by achievements. These are greater and can therefore be sold much more effectively once a successful 'track record' has been achieved. Thus, to date we have obtained only local investment in the project. This investment has however been substantial. Marcelo Cabido, Sandra Díaz and their team are additionally directly involved in research into the management activities at Quebrada del Condorito National Park. They have already signed two contracts with National Parks Administration, related to conservation of local biodiversity, livestock management, and mitigation of the consequences of the establishment of the Park on the livelihoods of local people. These additional activities will assist and add value for money to the Darwin project. In addition the 'in kind' support of conservation agencies in the implementation of the community orientated studies has been very gratifying. This support is set to continue particularly in Achala, where conservation agencies have secured funding from the World Bank (GEF) and the Interamerican Development Bank (BID). In addition, we have already seen that high profile conservation events have beneficial impacts on both conservation and conditions for stakeholders. Major expenditure by the regional government on the Chancani reserve followed swiftly after the well publicised activities with children. Moreover, following discussions between pupils and the provincial governor at the opening of the reserve visitor centre a new school is being built. We hope that the

conference on conservation held in March at Huerta Grande with the participation by Marcelo Cabido and children from Achala and Chancani and the twinning of schools (already supported in principle by local agencies) will prove similarly beneficial to local stakeholders.

We intend to study the factors determining the impacts of land use on the vegetation and biodiversity of the whole of Cordoba Province using vegetation mapping from aerial photographs and other sources, plant functional data and published and unpublished environmental and economic data. By identifying general relationships between ecological, climatic and economic factors, we intend to produce cellular automata models of the region, which will allow us to predict the impacts of different economic and climatic scenarios on the landscape and biodiversity. International support for this ambitious project cannot, however, be sought until after our results have been accepted for publication in influential journals.

12. SUSTAINABILITY AND LEGACY

The major achievements of the project are in three main areas

Science and Education

Despite its high biodiversity the flora of C. Argentina has been little studied ecologically. We have produced major databases that partially remedy this situation and Drs Cabido and Diaz are in a position to extend this study further to other parts of Cordoba Province, particularly now that they have been given further money by conservation agencies. At present finding a job is difficult in Argentina but we hope that students and junior research workers involved in the project will become employed in other research institutes and universities or conservation bodies. These trained scientists potentially represent a further legacy of ecological knowledge and expertise from the Darwin project. At present we are changing attitudes; national reserves need active management. Ultimately, we see functional data being routinely used in management prescriptions for nature reserves and intend to continue collaborating informally towards this end. The existing data will also provide a rich source of information for exploring pure and applied ecological problems.

Our studies also offer the prospect of defining general relationships that are potentially useful to those planning policies of conservation and sustainable development.

- We have collected detailed information on the devastating recent, vegetation changes associated with agricultural expansion and forest burning. We also have functional data for many of the species present in the vegetation and information on a range of geographical and economic aspects. We do not believe that anywhere else in the world are there better data for investigating the interactions between ecological and economic factors during the destruction of a semi-natural landscape. An understanding of the decision processes that have resulted in this destruction in the hope is vital so as to ensure that future planning policies prevent the occurrence of similar destructive events.
- Work included in Section 4.1.4 suggests that the approach of combining field data with simple plant traits represents a powerful tool in the search for generality about a range of conservation topics from sustainability to

biodiversity. We are all committed to this approach and will continue analysing data, liasing with economists and writing papers.

Conservation

There is now for the first time active management in one Argentine National Nature Reserve. Farmers from the overgrazed Provincial Reserve, Pampa de Achala, have signed agreements to reduce stocking rates and in compensation are allowed to graze in a strictly regulated way parts of the adjacent, formerly ungrazed Quebrada del Condorito National Park where biodiversity is declining. Thus, there is movement towards an integrated conservation policy for both reserves agreed by the two different conservation agencies, with very different conservation agendas, another first. Moreover Drs Cabido and Diaz and their team have already signed two contracts with National Parks Administration, related to conservation of local biodiversity, livestock management, and mitigation of the consequences of the establishment of the Park on the livelihoods of local people at Quebrada del Condorito National Park. Thus, there will be a further legacy of informed scientific involvement in conservation in C. Argentina.

Following the identification of massive vegetation change (Figure 2) the Provincial Environmental Agency is establishing policies to restrict further deforestation. Furthermore, it has identified regions where further deforestation should be prevented. Landowners are being given tax relief to maintain woodland and through one such agreement a private protected area of 5000 ha of forest has been created.

We are also pleased to note that six months after the work with children at Chancani, which received wide press and television coverage, a visitor centre and an information centre were opened in the reserve, new signboards have been produced and guided walks established. A majority of the displays in the visitor centre have been prepared by Matilde Cabido and thus donated by the Darwin Initiative. It should be noted that although Chancani is only a Provincial Reserve, it is a very important one. It is the only nature reserve for arid chaco vegetation in the whole of Argentina.

Work with local communities

If the natural biodiversity of the countryside is not appreciated by the people, nature conservation has no long-term future. In this context, one of the greatest legacies stems from the work with local communities. The hostility between conservation agencies and local people is gradually being replaced by understanding and respect. The conservation message about the importance of sustainable agriculture has been well received and the needs of local communities are increasingly being considered by park authorities. Moreover, at Chancani, the poorer of the two areas, the regional conservation agency now employs a few local people and at the opening of the visitor centre by the local governor, some students asked Marcelo Cabido for an introduction. The students told the governor about their tin school, how it was very hot in summer and very cold in winter. Now a new school is being built. It is due to open in June. In the short term, money from international banks will aid the joint processes of conservation and sustainable development at Achala. At Chancani it will be more difficult. Many have insufficient food to feed their family and without much more governmental assistance, major changes cannot take place. However, empowerment through Darwin has already resulted in a new school and the teachers, inspired by Carlos Szulkin, will carry on their work with the children. Links with schools in the Peak District National Park will also help both to keep the issues of conservation and sustainable agriculture high profile and to change attitudes and improve economic circumstance.

13. VALUE FOR MONEY

The project represents excellent value for money.

- The collaboration is viewed within Argentina as a high prestige project. In consequence conservation recommendations have been acted upon and it has been gratifying to see money from world banks being made available to conservation authorities in Achala and the investment in the reserve and in education at Chancani.
- The project is relevant to Argentina's conservation and scientific needs. For this reason Marcelo Cabido, Sandra Díaz and their team have become additionally involved in research into the management activities at Quebrada del Condorito National Park. They have already signed two contracts with National Parks Administration, related to conservation of local biodiversity, livestock management, and mitigation of the consequences of the establishment of the Park on the livelihoods of local people.
- The work was conducted on a much larger scale than originally envisaged due to the commitment of Drs Cabido and Diaz and their team. Twenty eight scientists have received training. Major autecological and vegetation survey databases have been set up to complement the field information. Moreover, Matilde Cabido produced several of the posters and a majority of the illustrative material in the visitor centre at Chancani at no charge. Her father refused to use Darwin money to pay family members and despite my attempts to persuade him otherwise he remains adamant in this respect.
- The project will eventually generate a large number of papers relevant to conservation (to date six have published or accepted for publication and several are at the review stage). The papers that have, or are being prepared, on global patterns of specialisation and on the relationships between fertility and sustainable yield and biodiversity represent a collaboration between scientists from many countries and are expected to have a large impact on ecological thinking in the current biodiversity debate (see Appendix 7). Moreover, these are additional outputs from the project prepared in the authors own time.
- Most importantly, the Darwin Project will have a role in shaping Argentine conservation policy. Active management of a national nature reserve is occurring for the first time and the success of the conservation activities with local people is promoting a conservation policy that is much more interactive with local stakeholders. This policy is set to continue. Moreover, work with local communities will continue. Carlos Szulkin, in particular, is passionately committed to the plight of local communities and will carry out work with the schools one way or another and John Hodgson will continue to be involved in an honorary capacity in the link between UK and Argentine schools for as long as the schools themselves wish to participate.

14. POST-PROJECT FOLLOW UP ACTIVITES

There are three elements from the outputs of the Darwin project that we are anxious to extend:

1. Conservation monitoring and recommendations
2. Studies relating biodiversity, economics and land use
3. Educational work particularly with children

The first element is essentially already funded. Dr Cabido has excellent relations with relevant conservation bodies and the continued funding of vegetation surveys, management plans and recommendations for conservation appears set to continue. [Should Dr Cabido decide to undertake an inventory of conservation areas for the whole of Argentina, we may however consider another major bid to Darwin.] We are hopeful that international funding can soon be secured to work on the second element, a 'hot' conservation topic. First, however, we will submit papers to high impact journals. The third element of our work is, however, problematic. There is at present some funding for educational work in Achala but none for Chancani. We therefore request money so that Carlos Szulkin can continue the educational work in Chancani. We would also like funds for a computer or fax machine for each of the two Argentine schools to be twinned with Bamford School in the Peak District. This will allow the children to make direct electronic contact rather than relying upon the slow and unreliable postal service. The required funding to continue this educational work would be very modest. Drs Cabido and Hodgson would monitor the project on an honorary basis and informal progress reports could perhaps take the form of a scrapbook of activities from Bamford school and publications and newspaper cuttings from Argentina.

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