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The strategy for conservation of terrestrial biodiversity in Galápagos

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1. Introduced species - the central problem

Introduced species, such as insects, mammals, plants, and diseases, are the principal threat to the biodiversity of Galápagos. Indeed, they are the only threat that is likely to lead to extinctions in the near future. All isolated archipelagos are vulnerable to alien species, introduced deliberately or accidentally by man, and Galápagos is unique in that so far the invasive species have caused very few extinctions of species. However, this is principally because man arrived only recently and the human population and frequency of transport remained low for many years.

The situation has deteriorated rapidly in the last 20 years and the ecological degradation continues, notwithstanding isolated successes of the Galápagos National Park Service (GNPS) and the Charles Darwin Research Station (CDRS) in eradicating goats in some islands and responding rapidly to some new plant introductions. Experience in Hawaii, New Zealand, and other islands shows that it is very difficult, perhaps impossible, to maintain a town in an island, with all the concomitant transport of goods and people, yet prevent a steady influx of new plants, insects, diseases, and the like. Yet we must try. Perhaps, if population and transport are stabilized at modest levels, thorough quarantine systems are installed, and people become very careful in their behaviour, the rate of new introductions can be reduced to a minimal level and the endemic species of Galápagos can survive in the long term. But the challenge is daunting — already Galápagos has almost as many introduced plants as native ones, while we cannot even keep track of the influx of invertebrates. Thus, the introduced species problem represents a massive obstacle to the objective of combining local development with long-term preservation of the islands' biodiversity.

This paper explains the strategy being followed by the Charles Darwin Foundation (CDF) and the Galápagos National Park Service (GNPS) in order to address this predominant problem. After introduced species, the second major issue for Galápagos is the misuse of marine resources. However, this paper does not describe the marine conservation strategy, which is covered in other presentations. Nor does the paper cover issues such as use of natural resources (e.g. timber), management of non-biological waste, or preservation of aesthetic values. Though they do have impacts on the ecosystem and are highly relevant to the ''island lifestyle'' referred to in Section 3 below, they are not in themselves critical to dealing with the introduced species problem. Lastly, the paper focuses on activities in the islands, but does not describe the important work done by CDF, Instituto Ecuatoriano Forestal y de Áreas Naturales y Vida Silvestre (INEFAN), WWF, Fundación Natura, Comité Ecuatoriano para la Defensa de la Naturaleza y el Medio Ambiente (CEDENMA) and others on the mainland to build national and international support for conservation of Galápagos and provide advice to the government.

The activities of the GNPS and CDRS are guided by the Galápagos National Park Management Plan of 1996 and the Station Master Plan of 1992 respectively. The ''Law for a Special Regime for the Conservation and Development of the Province of Galápagos'', approved in March 1998, creates a new legal and institutional framework within which these plans will be executed. Comments on how the new law affects the strategy are incorporated in the strategy description, but four general statements in the law that relate to introduced species are worth noting:

* Its preamble recognizes that ''the principal threat to the biodiversity of the province of Galápagos is the presence of exotic species''.
* The definition of sustainable development includes a specific requirement that the development must not run the risk of causing directly or indirectly the introduction or dispersion of alien species.
* The glossary also includes a comprehensive definition of ''total control'' of introduced species, which covers all aspects of control and eradication, including both prevention of new introductions and eradication of those already present.
* Two of the seven guiding principles for policy-making and planning are (a) the maintenance of the ecosystems, taking account of genetic isolation; and (b) the need to reduce the risks of introducing alien organisms.

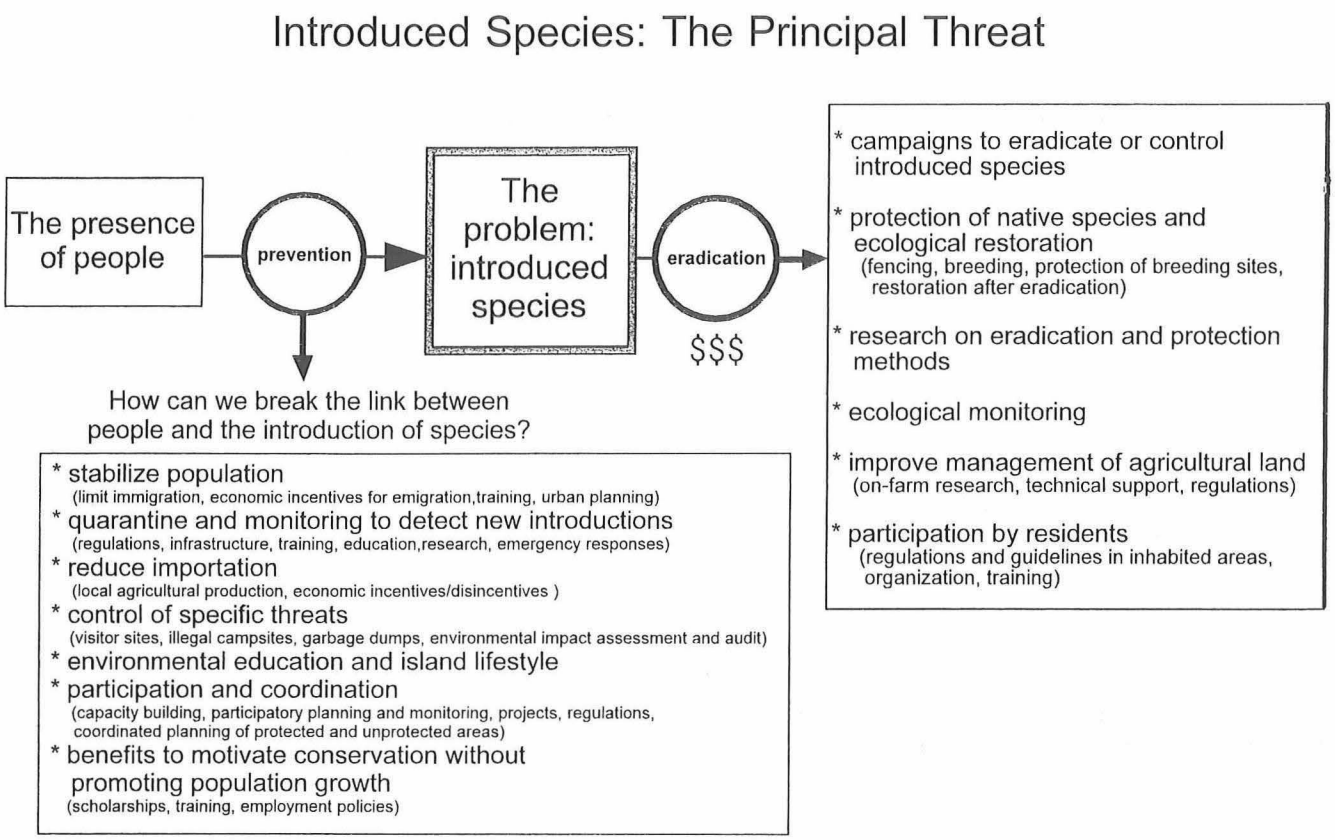

Fig. 1. — Diagram illustrating the strategy for tackling the problem of introduced species.

2. Strategy after alien species have been introduced

The overall strategy is summarised in Figure 1. It comprises two components: dealing with the problem of alien species already present in the islands, and the prevention of further introductions. The actions under the first component are:

Eradication and control of introduced species

Eradication and control of alien species are highly demanding tasks, for there is a vast amount to be done against goats, pigs, cats, rats, dogs, some 20-30 highly invasive plants, plus numerous insects and unknown diseases. The Galápagos National Park Management Plan prescribes the norms and guidelines for the work, which is primarily the responsibility of the GNP, although the CDRS collaborates on technical aspects and, in some cases, on funding. Current priorities include eradication of pigs in Santiago, eradication of goats in Pinta, control of quinine (*Cinchona succirubra*), lantana, guava (*Psidium guajava*), and bramble (*Rubus* spp.) in highland areas, and eradication of fire ants (*Wasmannia auropunctata*) in Marchena Island. But the looming challenge is the eradication of goats from northern Isabela, where some 100,000 of them threaten to devastate the island which has over half the land area of Galápagos, as well as half the races of giant tortoise. A detailed eradication plan has been prepared but it will cost some US$8 million over 5 years, if the funds can be raised. This example shows the extremely high cost of eradication of alien species once they are established. Prevention is obviously far better and cheaper than cure!

Protection of native species and ecological restoration

While we tackle the problem of introduced species, threatened native species must be protected. The best known example, and one of the world's conservation success stories, is the captive breeding and repatriation of endangered races of giant tortoise. There is also a land iguana breeding and repatriation programme. Another form of protection is the fencing of endangered plants, such as the handful of surviving *Scalesia atractyloides* on goat-plagued Santiago, and of *Linum cratericola*, the Floreana flax, which was rediscovered in 1997 having been thought to be extinct. A third form of protection is the control of rats and cats in nesting areas of breeding birds — for example, the endemic dark-rumped petrel, whose catastrophic crash towards extinction has been halted. Last but not least is the task of finding which populations are endangered: there are several rare plants,

land birds, and even reptiles, for which we have no up-to-date data. Most protection programmes are joint efforts by GNPS and CDRS. Looking beyond eradication of alien species, the concept of "protection" is expanded to include ecological restoration. Interventions such as replanting, thinning, or reintroduction may be needed to enable the original native ecosystem to be re-established.

Research on eradication and protection methods

For most introduced species, we do not even know how to eradicate them. Research is needed to understand their ecology and impacts, and develop and test methods for control and eradication. The CDRS has lead responsibility for this work. Current subjects of study include goats, rats, introduced plants (including quinine and bramble), wasps, the biting fly (*Simulium bipunctatum*), and the cottony cushion scale (*Icerya purchasi*). Studies by CDRS have already (up to April 1998) identified over 20 native plants affected by the cottony cushion scale, and the number is rising. We are studying the possibility of using biological control through the introduction of a natural enemy, a technique requiring special care in a vulnerable island ecosystem. Research on introduced diseases is a priority for the future, for diseases can devastate island populations. Protection of native species also requires research. For example, the saddle-back tortoise breeding programme took a decade of research to reach its current level of success and we need to repeat some of the studies for the dome-shaped tortoises of southern Isabela, which are the next priority.

Ecological monitoring

Much information has been accumulated about the flora and fauna of Galápagos. However, we have had no systematic programme for periodically measuring key indicators of the status of the ecosystem, especially the populations and distribution of native and alien species. This limits our ability to assess in quantitative terms the trends in the struggle against alien species. Monitoring results would be of use to GNPS, CDRS, local authorities, the tourism sector, farmers, donors, and others involved in the management of Galápagos. Some of these groups could participate in data collection. The CDRS is identifying ecological indicators and collaborating with the GNP and others on the development of a Geographic Information System, to be used for the monitoring programme.

Improve management of agricultural land

Agriculture in Galápagos is characterised by a vicious cycle of low productivity, poor marketing arrangements, and continuing encroachment of alien pests. Many alien plants and insects proliferate on farmland, large areas of which are abandoned, and thence invade the Park. Both GNPS and CDRS are working with farmers and the Ministry of Agriculture to tackle this problem. Furthermore, the Special Law makes control of invasive species a basic policy for agriculture and obliges all residents to collaborate. The strategy is far from straightforward, for merely stimulating improved agriculture could also stimulate an influx of labour. In addition, research is needed to develop farming systems that could help solve the ecological problems as well as improve productivity. Productivity improvements may be more readily achieved by intensifying agriculture in a small area, than by bringing abandoned land into production, in which case abandoned land might be available for ecological restoration. Agricultural land management is an important issue, because the highlands of the inhabited islands, especially Santa Cruz, are among the most important areas for biodiversity and, as they are located predominantly in the agricultural zone rather than the National Park, have suffered substantial loss of natural habitat. Solutions must be worked out with the farmers, in order to break out of the vicious cycle.

Participation by residents

Farmers are obviously key partners in alien species control, but four-fifths of Galápagueños live in towns. There is much that they could do to keep the towns as free as possible of alien species. A start has been made with dog and cat sterilisation campaigns and municipal ordinances on control of domestic animals. Both GNPS and CDRS have programmes to promote environmental education and participation, and to build the capacity of local conservation groups. We operate a Fund for Local Conservation Action, which supports local efforts, with a particular focus on introduced species. The Special Law not only obliges institutions and individuals to participate in control of alien species, but also enables regulation of transport, cultivation, possession, and so on, and provides tax incentives for organisations financing eradication programmes.

3. Prevention of new introductions

The root cause of the introduction of alien species is the presence of people. So far in Galápagos, as in other oceanic islands, the presence of people has been associated with an influx of alien species that has increased exponentially as inward migration has fuelled rapid population increase (thought to be over 5% per year), with frequency of transport increasing even faster. The conservation strategy must find ways to break the link between human presence and the introduction and spread of alien species, as well as stabilizing the population. It is a tough challenge. The CDF's vision of the future for Galápagos society is that it be limited in size, have ingrained in its culture norms of behaviour that minimise risks of introducing alien species, and be well educated

and trained so that each person has options for making a living in a way that is environmentally friendly, either in Galápagos or, if he/she prefers, elsewhere. The elements of the strategy are:

Stabilize population

To have any chance of containing the introduced species problem, the human population must be stabilized, i.e. net outward migration must balance natural growth. The first step is to reduce the current extremely high growth rate, through control of immigration. Thereafter, to continue the downward trend eventually to a zero growth rate will require a socially sensitive package of measures, based on a careful analysis of factors such as general education, family planning, and economic considerations. The Special Law is a great step forward, because it introduces residency controls that should curb inward migration. However, overgenerous criteria that give residency rights to some people who in fact have settled elsewhere (and may never have lived in Galápagos), unlimited inheritance of permanent residency rights, lack of mechanisms for voluntary resignation of residency rights, and strong economic and employment incentives to move to (or stay in) Galápagos, are expected to result in continued population growth. This growth may undermine not only efforts to prevent introduction of alien species but also any improvements in social and economic conditions achieved by the people of Galápagos. Nevertheless, the concept of residency control has been introduced and the priority now is to make sure that it works. This is the responsibility of the Instituto Nacional de Galápagos (INGALA). Improvements in living standards and education in Galápagos could themselves help to reduce birth rates in the islands.

Quarantine and monitoring to detect new introductions

The Station, Park, Agriculture Ministry, and INGALA are all involved in an initiative to establish a quarantine inspection system for Galápagos. Though required under agricultural regulations since July 1994, the system has been slow to take off, partly for lack of funds and partly due to the sheer complexity of introducing a multi-institutional programme, with components 1,000 km apart, that affects the lives of all Galápagos residents as well as the tourism business. Nevertheless, an inspection and control system was designed and committees established; then in mid-1997, a pilot programme was implemented in Santa Cruz Island for inter-island boat traffic. More funds and the active participation of SESA, the government agricultural inspection service, are needed in order to extend the system to the mainland ports serving Galápagos. The Special Law reinforces this system and provides some financing for running it (though not for the initial investment). A final line of defence under the system is monitoring in and around ports and depots in Galápagos, in order to detect and eradicate new introduced organisms before they can become established.

Reduce importation

We assume that the main channel for inadvertent introduction of plants, insects, and diseases is the foodstuffs, especially fresh produce, brought from the mainland for consumption by local residents. Stimulating local self-sufficiency in fresh foods can therefore help to reduce the influx of alien species. This is an element of the CDRS's programme with local farmers, but it is only in its early stages. Economic incentives for local production combined with disincentives (e.g. taxes) for importation could be effective mechanisms to reduce importation. The Special Law seeks to promote local production, but it also maintains air travel subsidies for residents and creates new subsidies for cargo. These subsidies, while socially beneficial, are bad for conservation because they favour importation (and travel generally) over local production.

Control of specific threats

Certain sites carry a high risk of being the point of entry for alien species to the archipelago or to a specific island. Visitor sites are an obvious example and the GNPS has a well established and sophisticated system for minimising the risk. The system, described in the management plan, limits visitor access to specific sites and trails, trains guides to lead, educate, and control the visitors, restricts numbers of visitors at each site, restricts the number and capacity of tour boats, and regulates waste disposal, etc. There is still room for improvement, for example to reduce inter-island transport of insects on boats, but Galápagos tourism activities are amongst the most carefully regulated in the world. Other high risk sites are garbage dumps, where GNPS and CDRS have been trying to impose environmental conditions and monitor introduced plant density in the face of difficult social pressures. Illegal campsites, especially those of the sea cucumber fishermen on Fernandina and Isabela, are very high risk sites in highly sensitive areas. The GNPS and CDRS remove them and monitor the sites, but it is expensive work because of the remoteness of the locations.

Environmental education and lifestyle

The introductory paragraph to this section described a vision of a Galápagos society which could minimise the link between human presence and alien species. Both the GNPS and the CDRS are expanding their education programmes and taking a more strategic approach based on the introduced species theme. We are working with schoolchildren, teachers, clubs, fishing cooperatives, and other groups, establishing educational resource centres, producing radio and television programmes, writing newspaper articles, and organising special events. The aim goes beyond changing attitudes and behaviour. It is to incorporate into the emerging island culture (or cultures, for each of the four island communities is different) a

universal understanding of the vulnerability of Galápagos and concern to defend the islands against alien organisms. It will take time. Many residents moved to Galápagos only in recent years and do not know which species are native and which are not, nor do they feel that alien species are undesirable. Reduced immigration rates should simplify the task of environmental education. The Special Law also includes requirements and incentives for environmental education that should help the campaign a great deal.

Participation and coordination

Though the marine reserve is the prominent example of participatory planning and management by GNPS and CDRS, similar ideas are being applied to the problem of alien species. The aim is to encourage and enable farmers, tour operators, traders, fishermen, and other residents to help prevent introduction and dispersion. The CDRS quarantine education programme is an example of this approach. Involvement of residents and visitors in conservation is one of the four general objectives of the Park Management Plan. The Special Law requires planning to be participatory, requires town councils to contribute to all aspects of the introduced species problem, including prevention, and gives INGALA responsibility for coordinating planning throughout the province. The latter provision could, if used well, do much to bring all local institutions into a concerted effort to reduce the flow of alien species from inhabited areas into the park.

Benefits to motivate conservation without promoting population growth

Careful judgement is needed to find ways to create incentives for conservation without stimulating population growth. Economic benefits from tourism have been both the principal incentive for conservation and the driving force behind immigration over the past 20 years. The Park has organized workshops on opportunities to increase local residents' participation in and benefit from the tourism sector, while emphasising that it is imperative to curb migration and ensure that all tourism respects the ecological vulnerability of the islands. The Special Law promotes locally based tourism and gives residents exclusive rights over future tourism development, whilst maintaining most of the restrictions on expansion. It also contains several measures to improve socio-economic conditions, such as confirming salary differentials with the mainland and improving various social services. While such universal benefits may generate amongst local people goodwill and a desire to defend their islands, they may also act as incentives for net migration to the islands, i.e. increased inward and reduced outward migration. The CDRS favours incentives focused on individuals and more directly linked to conservation (e.g. benefits from tourism) and especially advocates training as an incentive — i.e. building people's skills and employability, and hence their options in life, whether in Galápagos or elsewhere. The law encourages this, too, through tax breaks for training Galápagos residents. Training in conservation-related disciplines is an important function of the CDRS, which is increasing its scholarship programmes, receives local volunteers and secondary school interns, is incorporating training of farmers and fishermen in its programmes with them, and has initiated some local training in computer skills. The GNP, too, has local training activities, as well as leading the training of naturalist guides, with assistance from the CDRS.

4. Financing the strategy

The problem of alien species is socially and scientifically complex, and the strategy is correspondingly broad and expensive to implement. Yet it is hard to see any other way to overcome this massive obstacle to harmonious coexistence between people and nature in Galapágos. Available financial resources are far from adequate to implement the strategy in full, particularly the component dealing with already introduced species, whose eradication requires many millions of dollars worth of research and management actions. This is still the case even with the Special Law, which increases the GNPS's revenue to 40% of tourist entry fees plus 5% for quarantine and 5% for the marine reserve. This should represent some US$2 million per year. In addition, the Government is to fund recurrent personnel costs (they may take some persuading to do so in the present, 1998 economic climate). Town councils share 20% of fees, whilst INGALA gets 10%, the Provincial Council 10%, the Navy 5% and the national protected areas system 5%.

The Charles Darwin Foundation receives nothing under the law and continues to rely on private donations, project grants from aid agencies and foundations, funds raised by Friends of Galápagos organisations, sales of goods to visitors, and a small endowment fund. In the past two years it has managed to increase its annual expenditure to about US$1.5 million in 1997. However, it is susceptible to large fluctuations, as the majority of funding is related to relatively short-term projects and a frustratingly high percentage of senior staff time is spent on fund-raising and adapting to changes in funding.

The major elements of a project, supplementary to the above revenue, to implement the strategy might be as follows. The dollar signs are a reminder that the first two items, especially the first, are the most expensive, and prevention is obviously better than cure:

$$$$ Introduced species research and eradication
$$ Native species research, protection, and ecological restoration
$ Ecological monitoring
$ Quarantine and detection of new introductions

$ Reducing specific threats (which could also be very expensive in the case of garbage dumps)
$ Building capacity of local government institutions to fulfill their conservation responsibilities
$ Capacity building and support for local groups (fishermen, farmers, tourism sector, etc.) to implement their parts of the strategy
$ Environmental education and development of local participation in conservation
$ Support for training
$ Law enforcement

The annual cost of such a project would be limited mainly by the capacities of the institutions involved, but would be several million dollars a year. Eradication programmes for goats on northern Isabela and, say, three of the most noxious invasive plants would already imply a cost of some US$15-20 million over 5 years.

5. Conclusions

The Galápagos National Park is one of the most intensively and scientifically managed national parks in the developing world. However, its unique flora and fauna are threatened by the complex problem of introduced alien species. This problem is a daunting obstacle to coexistence between man and nature in the islands. The GNPS and CDF have a strategy which attempts to address the problem and are implementing aspects of the strategy, within the limits of available resources. The recently approved Special Law generally gives strong support to the strategy, although its provisions to promote the stabilization of population are not adequate.

Notes

[1] Director, Charles Darwin Research Station.
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[3] Former Head of the Technical Department, Galápagos National Park. He died in an air crash on 20 April 1998 while returning from Belgium to Ecuador after participating in this Symposium.

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