

THE VEGETATION OF ISLA SANTIAGO—PAST AND PRESENT

By: Ole Hamann

In October 1991, the Charles Darwin Research Station (CDRS) and the Servicio Parque Nacional Galápagos (SPNG) participated in a special visit to the Galápagos by H.R.H. Prince Henri of Luxembourg. The visit included field excursions to Islas North Seymour and Santiago, and on Isla Santa Cruz, so that the Prince could see conservation projects in action and get a firsthand impression of the problems facing the SPNG in safeguarding the flora and fauna of the Galápagos (Evans 1992).

Together with Rodrigo Crespo, Vice-President (Ecuador) of the Charles Darwin Foundation; Oswaldo Sarango, Acting Head of the SPNG; Edgar Muñoz of the CDRS; and Gabriel Almeida of the SPNG, I had the fortune to participate in the excursions. On Santiago we camped in the highland with the hunters and park wardens who spend long periods in the field hunting feral pigs and goats. During the few days available, park personnel demonstrated how the pig control program is carried out, and how this successfully has protected the nests of giant tortoises (*Geochelone*) and Dark-rumped Petrels (*Pterodromaphaeopygia*). We met with CDRS botanists Hugo Valdebenito and Lenin Prado, who were doing botanical research in the highlands, and we saw some of the fenced vegetation quadrats, established to protect small remnants of native vegetation.

It was a great experience to see conservation in action, and we were all impressed by the dedication and efficiency of the CDRS and SPNG teams. They clearly demonstrated that conservation in the field is hard work, carried out under very difficult conditions.

This visit, although short, also gave me the opportunity to compare the present state of Santiago with that of 19 years before, when I made my first visit to the Island. Obviously, the feral pigs and goats have had a very destructive impact on the Santiago ecosystems during this period, so the current major efforts by the CDRS and the SPNG towards eradicating these introduced mammals are not only justified but also very urgent.

THE VEGETATION OF SANTIAGO WAS GREEN AND FLOURISHING

During his famous visit to the Galápagos with HMS *Beagle*, Charles Darwin visited Isla Santiago (James) in October 1835. Darwin camped on shore for a week with the ship's surgeon, Benjamin Bynoe, and three sailors, and was particularly fascinated by the animal life. Of the land iguanas (*Conolophus subcristatus*) he noted "I cannot give a more forcible proof of their numbers than by stating that when we were left at James Island we could not for some time find a spot free from their burrows on which to pitch our single tent." On the plants and vegetation he noted, "As in the other islands, the lower region was covered by nearly leafless bushes, but the trees were here of larger growth than elsewhere.... The upper region, being kept damp by the clouds, supports a green and flourishing vegetation" (Darwin 1845).

Since Darwin's time, much has changed on Santiago. The land iguanas, then so numerous, have disappeared. When the California Academy of Sciences' 1905-06 expedition visited the Island, they only found a few bones, and no live land iguana has been recorded since. However, the vegetation was apparently in comparatively good shape at that time, according to the botanist of the Academy expedition, Alban Stewart. Although goats were introduced to Santiago for the first time already in 1813 by the U.S. frigate *Essex*, and then again in 1906 by Rollo Beck of the Academy expedition (Hoeck 1984), Stewart made no reference to the occurrence of goats on Santiago. If there were any on the Island by then, they must have been very few in number.

Stewart wrote the first extensive description of the vegetation zones of the Island, and it is worthwhile quoting his observations on the highland vegetation: "The rolling plateau ... is covered with forests of *Pisonia floribunda*, *Psidium galapageium*, *Scalesia pedunculata*, and *Zanthoxylum fagara*. The *Scalesia* trees are the most abundant in this region, and form true *Scalesia* forests, as on some of the other larger and higher islands of the group.... The *Scalesia* for-

ests extend nearly to the top of the main crater on the leeward side, but on the windward side, which is bathed almost constantly by the strong southeast trade winds for several months of the year, the trees begin to thin out a short distance above the base of the crater and there are none at the top, although *Zanthoxylum* persists here as small gnarled bushes. Bushes of *Psychotria rufipes* are very common on this side and around the top" (Stewart 1915).

THE DESTRUCTIVE INFLUENCE OF GOATS AND PIGS

In August 1972 my wife and I spent a week in the Santiago highland together with Fausto Llerena, Galo Torres, and Angel Sanchez of the SPNG. While they checked tortoise nests and hunted goats and pigs, my wife and I investigated the plant communities. At that time it was still possible to discern the vegetation zones described by Stewart, but the Island had obviously suffered from the presence of large numbers of feral goats and pigs. In general, closed forest had been changed into steppe forest with large open areas devoid of trees in between. The *S. pedunculata* forests had almost completely disappeared; only small groups of old trees were found, mostly on cliffsides that were inaccessible even to goats. No regeneration of *Scalesia* trees was recorded. Large areas were covered with dense scrubby vegetation dominated by the shrubs *P. rufipes* and *Cordia scouleri*, and groves of tree ferns, *Cyathea weatherbyana*, were common on the steeper slopes of the many small craters. *Zanthoxylum fagara* was the most common tree all the way to the top of the Island; being long-lived and spiny, adult individuals were apparently not grazed or browsed by goats. However, the regeneration was very poor, and in many places the *Zanthoxylum* trees formed very open stands composed of old individuals only (Figs. 1 and 2), some of which had started to die off (Hamann 1981).

Several thousands of pigs and perhaps more than 100,000 goats were estimated to be present on Santiago by the early 1970s, and regular hunting expeditions became a prominent part of the work program of the SPNG, with the main focus on protection of the nests and nesting areas of the giant tortoises. In 1974-75 Lucho Calvopiña and Tjitte de Vries took the initiative to establish a series of seven fenced vegetation quadrants in order to study and preserve

small remnants of the different vegetation types of Santiago (Calvopiña and de Vries 1975, de Vries and Calvopiña 1977). Since then, these fenced quadrants have been maintained and they have served a comparative study of plants in fenced enclosures and nearby open plots, thereby providing quantitative data on the impact of introduced grazers on the native vegetation. The results of this long-term comparative study were recently evaluated by Valdebenito and Prado, who found a striking difference in vegetation within the enclosures compared with the open areas where goats have access. Inside the enclosures, endemic and native species such as *Opuntia galapageia*, *Z. fagara*, *S. pedunculata*, and *P. galapageium* are all increasing in abundance, while outside the enclosures several species, including *Zanthoxylum* and *Scalesia*, are disappearing completely from the vegetation. Valdebenito and Prado concluded by recommending that several additional fenced enclosures should be established on those areas where the vegetation is vulnerable. Such fenced enclosures have three important objectives: they provide accurate data on the impact of the vegetation by introduced grazers, they provide protection against grazers for the native plant species, and they are "living seed banks" that in the future may serve as the nuclei from which the plants can start recolonizing the Island, once the introduced mammals have been eliminated (Hamann 1975, Valdebenito 1991, Valdebenito and Prado 1991).

ARE THE PLANTS ON THE VERGE OF EXTINCTION?

The deterioration of the vegetation on Santiago has clearly continued rapidly during the last decades, which is illustrated by the sets of photographs taken in 1972 and in 1991 (Figs. 1 and 2). During many years, the natural regeneration of numerous plant species has been almost totally prevented by grazing mammals, and whole vegetation zones have almost completely disappeared.

In general, seeds deposited in the soil seed bank may survive for a number of years, but eventually they germinate or die; if all emerging seedlings get eaten by goats, the remaining soil seed bank is gradually emptied. The only source for natural regeneration is, then, the seed production of the surviving, mature individuals, which on Santiago, however, are becoming fewer and fewer in number as



Figure 1 a. Highland area of Isla Santiago in 1972. The *Zanthoxylum fagara* trees obviously endured the intensive goat grazing longer than most other plant species. But in many places, only old individuals could be found, many were dying off, and almost all natural regeneration was prevented by the goats (above). *Zona alta de la Isla Santiago en 1972. Los árboles de Zanthoxylum fagara han soportado más el intenso pastoreo que otras especies de plantas. Sin embargo, en muchos lugares, sólo se han podido encontrar ejemplares viejos, muchos muriendo, y casi toda la regeneración natural ha sido impedida por los chivos (arriba).*

b. Dead *Zanthoxylum* trees in 1991. Large areas looked like this, being completely without any living trees or seedlings of woody plants (below). *Arboles Zanthoxylum muertos en 1991. Grandes áreas sin árboles o plántulas (abajo).*





Figure 2 a. View from the highland towards north in 1972. In the foreground open steppe forest vegetation composed of dark *Zanthoxylum fagara* trees (above). Vista de la zona alta hacia el norte en 1972. En el frente, el bosque abierto con la vegetación compuesta por árboles oscuros de *Zanthoxylum fagara* (arriba).

b. View of the same general area in 1991 (note the two small hills in the center). The *Zanthoxylum* vegetation has almost completely disappeared, and only a few old trees are left (below). Vista general de la misma área en 1991 (nótese las dos mismas pequeñas lomas en el centro). Los *Zanthoxylum* casi han desaparecido con excepción de unos pocos ejemplares viejos (abajo).



they die of old age or are being destroyed by goats and pigs.

It is not known exactly how long the seeds of native Galápagos plants are able to survive under natural conditions. But for many species it is probably several years. Experiments carried out in the Botanic Garden, University of Copenhagen, have shown, for example, that seeds of the genus *Scalesia* are able to germinate after several years of dry storage (Hamann, in press), and that both arid zone and humid zone species of *Scalesia* keep their viability after years of dry storage. This means that the species probably are able to persist as seeds for some years in nature, in situ; it also means that it is possible to conserve the *Scalesia* species ex situ, outside their natural environment.

The native flora of Galápagos comprises some 596 taxa, of which 224 are endemic. Of these native taxa, 2 appear to be Extinct, 20 are considered Endangered, and 16 Vulnerable on an archipelago scale, according to the International Union for the Conservation of Nature and Natural Resources classification for threatened species (Lawesson 1990). One of the presumed extinct species, *Blutepharon rigidum* (of the Amaranth family), was only known from Santiago, from where it was collected twice, first by Baur in August 1891 and later by Stewart during the Academy expedition in 1905-06. Since then *Blutepharon* has never been found despite several searches, but it is impossible to say whether its extinction has been caused by the goats or by volcanic activity (Lawesson 1990).

However, other species are clearly close to extinction because of the goats. One is *Scalesia atractyloides*, a pretty shrub with narrow leaves and relatively large flowerheads. It only occurs in the arid zone on Santiago, and it is classified as an Endangered species. In the mid-1980s, the species was known to survive

in very small populations at Buccaneer Cove and James Bay in the western part of Santiago and at one locality on the northeastern coast (Lawesson 1990; H. Adersen, pers. comm.). One of these populations was reported as surviving some 3-4 years ago by Henning Adersen, but during the last couple of years botanists from the CDRS have been unable to find any living bushes of this *Scalesia* in the western part of the Island (H. Valdebenito, pers. comm.). It may well be that *S. atractyloides* now is extinct in the wild.

Other Santiago plants threatened on an archipelago scale are the fern *Doryopteris concolor*, *Scalesia stewartii*, and *Mollugo crockeri*. However, many more species are very much threatened on Santiago although they are common on other Islands and therefore are not categorized as threatened on an archipelago scale. One such example is *S. pedunculata*, which is still abundant on Isla Santa Cruz. Consequently, if we consider the conservation status of the plants and the vegetation on Isla Santiago only, the picture is grim. Without doubt, several plant species are very close to disappearing from Santiago, and unique plant communities have, to a large extent, been destroyed by feral goats and pigs. It is not even certain, for example, that the *S. pedunculata* forests with all their many component species—forests which formerly were so abundant—will be able to regenerate at all, even when (or if) goats and pigs are removed. In the lower, arid parts of the Island, the land iguanas that lived there when Darwin visited in 1835 are long gone. But we do not know if other “key species,” e.g., invertebrates that are vital for pollination or seed dispersal of plants in the highland, have disappeared by now; nor do we know whether soil erosion has reached a level that will prevent the original vegetation types to regenerate, even if the “right” species are still present in small numbers.

HOPE FOR THE FUTURE?

The general conclusion that has to be drawn on the basis of botanical observations and investigations during the last decades is that it is high time to act if the unique ecosystems of Isla Santiago, with their many plant and animal species, are to be saved.

This is realized by the CDRS and the SPNG, so the conservation of the flora and fauna of Isla Santiago is accorded top priority. Major programs are now un-

derway for eliminating first the pigs and then, afterwards, the goats, and for protecting the vegetation. The reason for attacking the pig problem first is twofold. The pigs are a direct threat to such native animals as giant tortoises, Dark-rumped Petrels, and even marine turtles, simply because the pigs dig out nests and eat the eggs or the young. But since the vegetation now is very open because of goat grazing, it is possible to find and hunt the pigs. If goats were eliminated first, the vegetation would presumably become closer again and it would be extremely difficult to find and eliminate all pigs. So the first task is to get rid of the pigs, and then afterwards a large campaign against the goats can be mounted.

At the same time, the efforts towards protecting the vegetation are now being reinforced. One very important element in this is the ongoing establishment and maintenance of fenced enclosures in different types of vegetation, which can serve as nuclei for the future regeneration of the natural vegetation. Another important element yet to be carried out is to take out the last insurance against extinctions, viz. make sure that acutely endangered plants are conserved ex situ, either in seed banks or in conservation stands outside their natural environment. Ex situ conservation of endangered plant species may serve several purposes, but one very important one is to safeguard material that eventually can be used for reintroducing the species into their natural habitats once the conditions for their survival have improved. Ex situ conservation measures seem now to be justified for such plants as the threatened species of *Scalesia* on Santiago.

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