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RECOVERY OF NATIVE AND ENDEMIC PLANT SPECIES IN GALAPAGOS: THE NURSERY AS AN IMPORTANT TOOL IN ECOLOGICAL RESTORATION

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*The **Galapagos National Park Service** has its headquarters in Puerto Ayora, Santa Cruz Island, Galapagos and is the Ecuadorian governmental institution responsible for the administration and management of the protected areas of Galapagos.*

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***Galapagos Conservancy**, based in Fairfax, Virginia USA, is the only US non-profit organization focused exclusively on the long-term protection of the Galapagos Archipelago.*



Photograph: Patricia Jaramillo

Recovery of native and endemic plant species in Galapagos: The nursery as an important tool in ecological restoration

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Ecological restoration involves the return of a degraded ecosystem to a condition close to its original state through the acceleration of changes in the composition and structure of the vegetation, or by reinitiating succession processes. Ecological restoration processes often require access to large quantities of diverse, high quality plant material. A conservation nursery provides a useful mechanism for the production of the plants needed to implement resource protection and ecosystem recovery strategies. The conservation nursery is also designed to contribute to the management of native and endemic species that are not commonly produced or handled by commercial nurseries.

In Galapagos, 352 native and 238 endemic plants have been recorded (Galapagos Herbarium, CDF - 2008). One of the main threats to Galapagos ecosystems is the introduction of species via anthropogenic activities (Loope *et al.*, 1988); the spread of invasive species often results in the displacement of native and endemic species. From a total of 190 endemic plant species evaluated, it is estimated that nearly 13% is critically endangered, 15% endangered and 32% vulnerable, which means that 60% of the endemic flora of Galapagos is threatened (Tye, 2002). Recent data indicate that the number of introduced plant species has exceeded 917, with the highest concentration of introduced and invasive species occurring in urban and agricultural zones of the inhabited islands, from which their seeds then disperse to areas of the Galapagos National Park (Schofield, 1973; Lawesson & Ortiz, 1994).

Critically endangered species face a high risk of extinction and their future depends entirely on conservation actions, especially in the inhabited islands such as Santa Cruz, San Cristóbal, Isabela and Floreana (Tye, 2007). Exploitation or overexploitation of native forest resources, such as *Piscidia carthagenensis* and *Psidium galapageium*, and the fragmentation of *Scalesia pedunculata*, *Psychotria rufipes* and *Zanthoxylum fagara* forests have given way to the expansion of agricultural areas, which has endangered certain species (FUNDAR, 2008). Because of this, it is necessary to develop restoration strategies using management tools to increase and improve the quantity and quality of vegetation and restore ecosystem connectivity.

This article presents the results obtained by the Galapagos National Park Service (GNPS), from September 2010 to December 2011, related to the production of native and endemic plants and efforts to advance ecological restoration processes in agricultural and protected areas.



Figure 1. *Scalesia pedunculata* plants produced in the GNPS nursery - Santa Cruz.

The conservation nurseries initiative

Currently the eradication or control of introduced plant and/or animal species is the primary tool used in Galapagos for restoration of native vegetation. However, such measures are insufficient, especially in highly degraded areas. To achieve the long-term vision for the conservation of the biodiversity of Galapagos ecosystems, planting native or endemic species is required, especially in certain degraded areas of the inhabited islands. In 2010, the GNPS began a long-term restoration program through the production of large numbers of native and endemic Galapagos plants in its conservation nursery. These plants are then transplanted in degraded areas of high ecological value to advance ecological restoration.

Nurseries play an important role in restoration and conservation projects. They permit the production of large quantities of target species to meet the demands of restoration programs, and promote an appreciation for native forests. The nursery project of the GNPS also generates knowledge to help determine which species work best and how to produce a quality product with reduced mortality rates in the field. This strategy helps to increase plant survival and reduce establishment costs (Figure 1).

Methodology

The work presented in this report was carried out in the conservation nursery of the GNPS, located in the Salasaca

sector on Santa Cruz Island. During 2010 and 2011, the nursery worked with 11 plant species (Table 1). Plants were produced via sexual methods (seeds) and asexual methods (cuttings).

Species were selected based on the conditions of the areas identified for restoration. For example, areas with a great deal of sunlight require species with rapid growth that need high levels of light, such as *Scalesia pedunculata*.

Two methods were used to germinate seeds: soaking them in water for 24 to 72 hours, and alternating soaking-drying and scarification (scratching). Mature, healthy seeds were selected and inspected to insure they did not have mechanical damage and were of an appropriate size for the species. Once the treatment was completed, the seeds were sown directly into germination beds, with a base of peat and coconut fiber.

Once germinated, seedlings were kept in the nursery for 70 to 90 days. When they reached a height of 7-12 cm, they were transplanted to growth containers (black polyethylene bags filled with substrate). Transplanting occurred when the seedlings reached 45 to 75 cm in length (Figure 2). Cuttings used to produce plants measured between 15 and 25 cm depending on the species, and were planted directly onto the substrate. Organic products were used to facilitate rooting.

Results

Between September 2010 and December 2011, 50,339 native and endemic seedlings were produced: 16,308 in

Table 1. Native and endemic plant species grown in the nursery of the GNPS, 2010-2011.

Family	Species	Common name	Origin
Verbenaceae	<i>Clerodendrum molle</i>	Glorybower	Native
Boraginaceae	<i>Cordia lutea</i>	Yellow cordia	Native
Malvaceae	<i>Gossypium darwinii</i>	Darwin's cotton	Endemic
Euphorbiaceae	<i>Hippomane mancinella</i>	Poison apple	Native
Celastraceae	<i>Maytenus octogona</i>	Maytenus	Native
Fabaceae	<i>Piscidia carthagenensis</i>	Piscidia	Native
Myrtaceae	<i>Psidium galapageium</i>	Galapagos guava	Endemic
Rubiacea	<i>Psychotria rufipes</i>	White wild coffee	Endemic
Asteraceae	<i>Scalesia helleri</i>	Heller's Scalesia	Endemic
Asteraceae	<i>Scalesia pedunculata</i>	Tree Scalesia	Endemic
Rutaceae	<i>Zanthoxylum fagara</i>	Cat's claw	Native

2010 and 34,031 in 2011. The increase in the number of seedlings in 2011 is due to the fact that 11 species were produced that year, compared to only six during the previous year.

The seedlings were used for ecological restoration programs in Santa Cruz. A total of 41,559 specimens were planted on nearly 54 ha distributed in the agricultural zone and in protected areas of the Galapagos National Park (GNP). The restoration sites within the GNP were primarily sites where introduced plants are controlled, such as Los Gemelos (1.5 ha). Forty hectares of the 100-ha parcel in Salasaca that was incorporated into the GNP as a protected area in 2009 (and where the conservation nursery is located) were restored with endemic and native seedlings. Twelve hectares of coffee plantations associated with the endemic species *Scalesia pedunculata* were also restored.

The number of seedlings of each species depended on the needs of the different restoration programs. Since most of the restoration sites were located in the humid and transition zones, the species that were most produced in the nursery were *Scalesia pedunculata*, *Clerodendrum molle*, *Piscidia carthagenensis*, *Zanthoxylum fagara* and *Psidium galapageium*.

Conclusions and recommendations

During the first two years of the restoration program (September 2010 to December 2011), the conservation nursery produced a total of 50,339 plants. Of these, 41,559 were planted on 54 ha designated for restoration, including agricultural areas and areas within the GNP.

In order to improve and increase the variety of plant species in both agricultural and protected areas undergoing ecological restoration, the number of species included in the nursery was slowly increased, reaching a maximum of 11 species in late 2011.

The results have shown that the most useful plants for ecological restoration should be: 1) native to the restoration site; 2) easily propagated; 3) resistant to limiting conditions such as low fertility, drought and compacted soils; 4) rapid growth species with good production of organic matter such as leaf litter, and 5) species that favor restoration of other species of native and endemic flora and fauna by providing minimum habitat conditions for their development.

The species of greatest demand was *Scalesia pedunculata* (17,959 plants produced), followed by *Clerodendrum molle* (8758 plants produced). These two species were the most useful in restoration areas. Both grow well by sexual and asexual reproduction, in comparison with other species. Therefore, large-scale production of these two species was initiated.

It was determined that the best season for planting or transplanting is during the winter when the quantity and frequency of rainfall provides sufficient conditions for plant survival. The nurseries associated with the ecological restoration programs in San Cristóbal and Isabela use the same approach.

Every restoration project should define the type of plants required to meet its objectives. It is important that the GNPS knows what projects are underway within the region and what type and number of plants will be needed for restoration, so that annual goals can be established for the nursery. For coastal and arid areas, the development of native gardens in urban and rural areas should be continued to prevent the entry and spread of exotic species.

A restoration project can be considered successful when it has met both its short- and long-term goals. Continued monitoring of areas reforested with plants from the nursery is needed to determine the level of success and to make improvements to the program. Success requires continuity of effort from the initial work in the



Figure 2. Development and acclimatization of *Scalesia pedunculata* plants in the GNPS nursery.

nurseries through the recovery of ecosystem dynamics, functionality, resilience and stability; in other words, until the restored area is self-sustaining.

The strategies for the conservation of biodiversity of the flora of Galapagos include management of biological corridors, the establishment and improvement of living fences (ensuring that they do not impact migration of giant tortoises and other endemic and native animals), and habitat improvements in remnant and connecting areas. Restoration projects should give priority to the establishment of native and endemic plants, producing

a high number of plant species that are adapted to the climate and soil conditions of each location. Success requires "the right plant in the right place," depending on the location of each area that is to be restored.

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Scalesia pedunculata forest. Photograph: Patricia Jaramillo.