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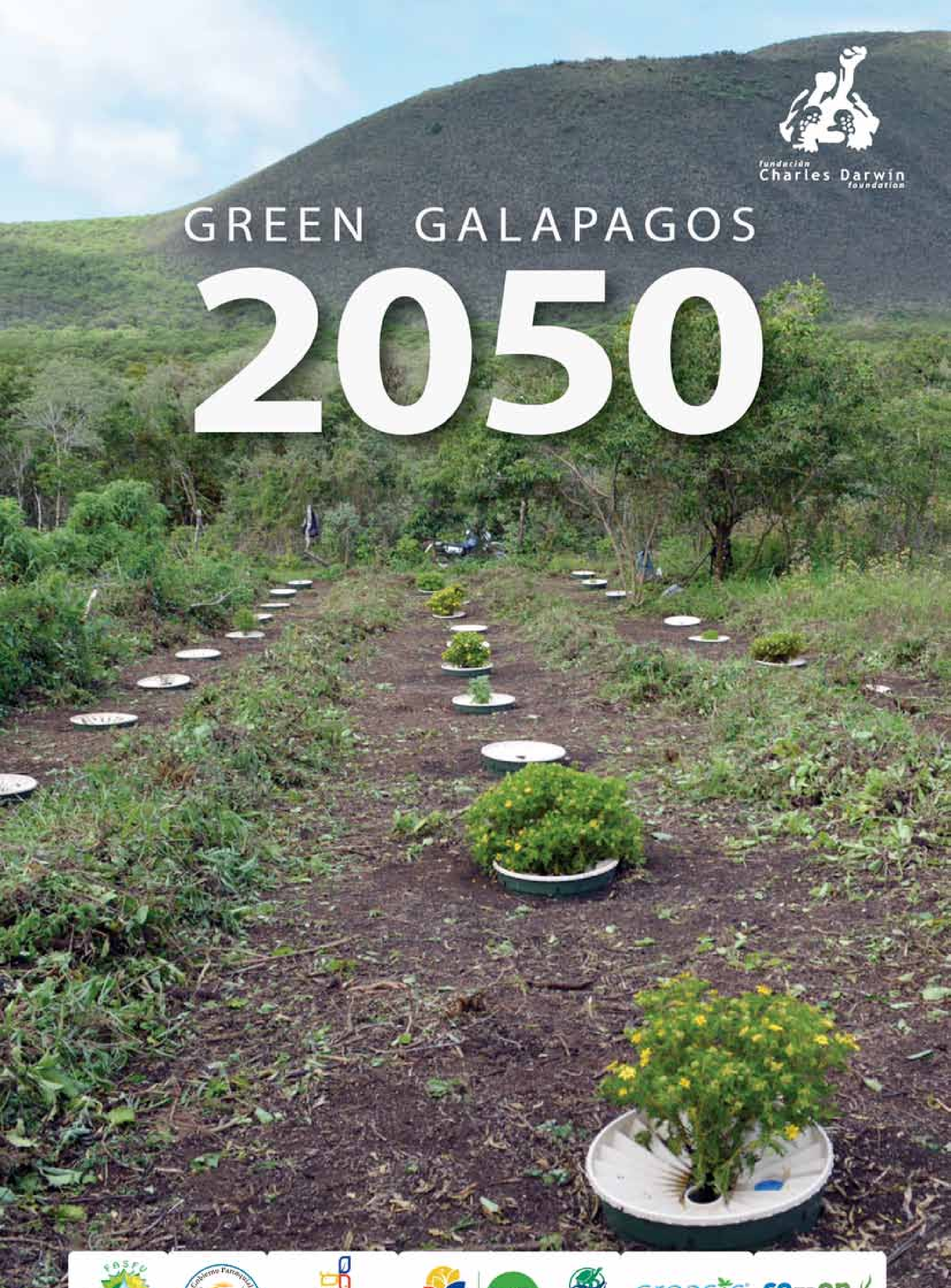
GREEN GALAPAGOS 2050



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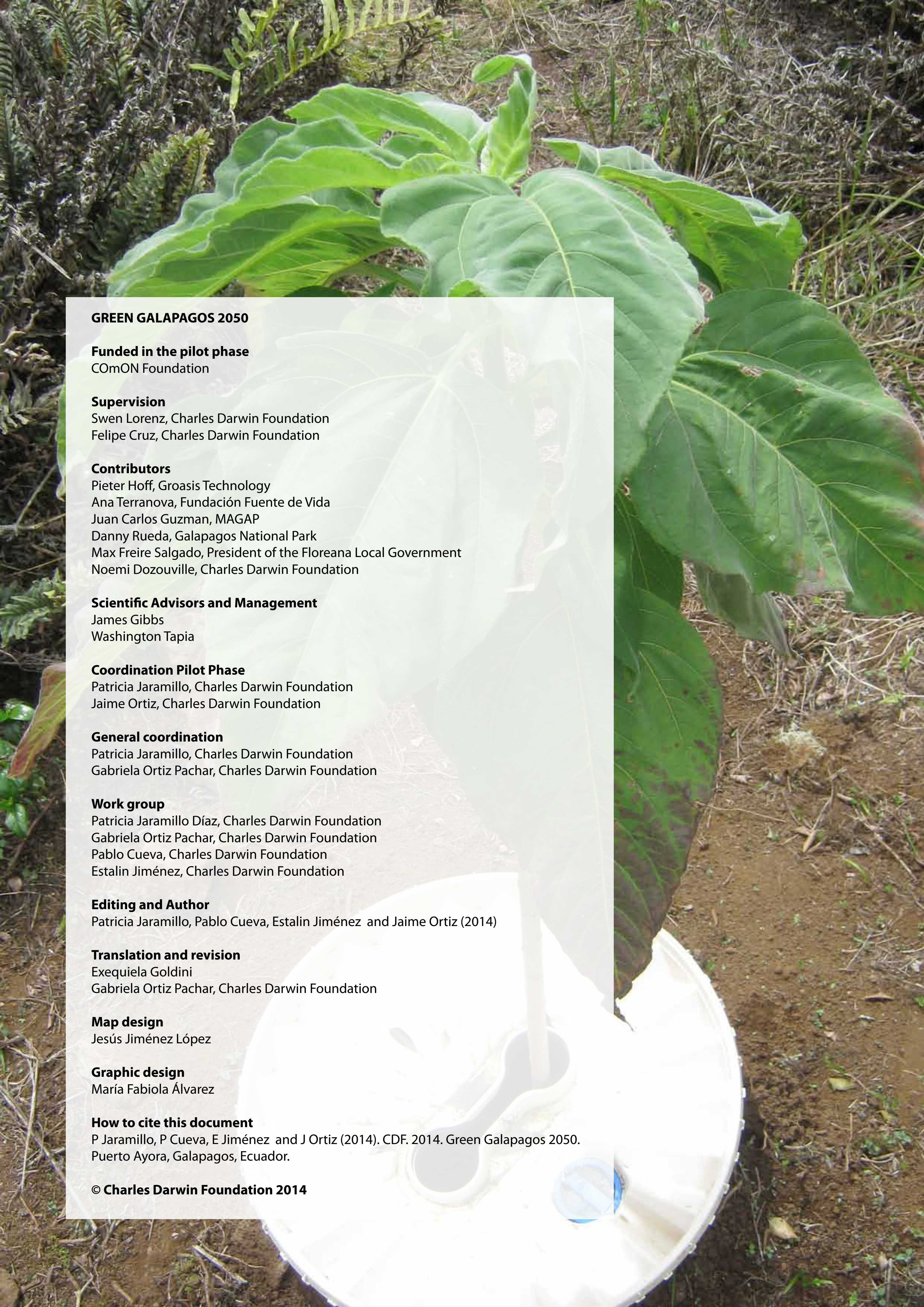

GREEN GALAPAGOS 2050

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WHAT IS THE

GREEN GALAPAGOS 2050 PROYECT?

OPINION OF KEY STAFF INVOLVED IN THE PROJECT

"Once again, it all started in the Galapagos Islands"

SWEN LORENZ
Executive Director, Charles Darwin Foundation

In his time, Charles Darwin was at the forefront of scientific advances. As it bears the name of one of the greatest men in the history of science, the Charles Darwin Foundation (CDF) has the responsibility to continue to cross barriers. We do it with focus and effort that uses solid scientific evidence to achieve ambitious conservation projects in total alignment with the priorities of the Government of Ecuador.

This report is the result of an initial meeting in a café near Amsterdam's main train station during 2012. Using the unique global network that my organization has built over the past five decades, we are constantly on the look-out for innovative approaches to solving problems in conservation and eco-system restoration. There isn't a corner of the globe where the CDF, an organization created in 1959 to help protect the Galapagos Islands, doesn't have contacts and supporters. We seek out the world's brightest minds and best solutions, and bring them back to these unique, world-famous islands.

Just two years later, an initial conversation has already leaded to the following results:

- Scientific evidence shows clearly that the use of the Groasis Waterboxx Technology is suitable for restoring large parts of the Galapagos Islands in a financially feasible and sustainable way, and to create models for sustainable agriculture in a place that currently is heavily dependent on food being shipped here from the mainland.

- Key Governmental institutions, such as the Galapagos National Park and the Ecuadorian Ministry of Agriculture, have joined in as partners to help make this vision of eco-system restoration and sustainable agriculture a reality.

- Donors have started supported this initiative up to the point where we have proof of concept. We can now raise the funds that are necessary to scale it up across the archipelago and turned into a multi-year, ambitious project with clear outcomes.

Our joint project with the COmON Foundation and Fundación Fuente de Vida has reached a stage where we can present the success of the work done so far, and plan the steps necessary to turn this into the most ambitious, most impactful eco-system restoration and sustainable agriculture project ever undertaken in the Galapagos Islands.

The ultimate aim of this project extends well beyond the Galapagos Islands. Just as Darwin used these special islands to teach the world about a new way of thinking, does the CDF aim to demonstrate to the world a new model for restoring nature, creating sustainable models for food supply, and help solve some of the world's most pressing problems.

In a few years, when similar efforts will be underway in other parts of the world, I'll be pleased to say: *"Once again, it all started in the Galapagos Islands. "*

JAMES P. GIBBS, Ph.D.
Professor of Vertebrate Conservation Biology and Director of the Roosevelt Wild Life Station. Department of Environmental and Forest Biology. Scientific Adviser, Green Galapagos 2050.

The ecological restoration of islands is a great opportunity to recover the Galapagos' terrestrial ecosystem in addition for generating significant ecological, social and economic benefits. For example, the need for ecological restoration on Baltra Island is very great due to the destruction caused by the former military base and its operations. However, the potential for its restoration is also very great, as just outside the former Baltra aviation complex there are plant communities that are largely intact and that can serve as sources of biological material useful for setting into motion ecosystems in damaged areas of the island. Unlike other restoration projects in the Galapagos Islands that take place on remote and rarely visited islands, many tourists and residents pass through Baltra, thereby creating a unique opportunity to disseminate and strengthen the "Citizen Science" network by directly involving many visitors in the island restoration process.

WASHINGTON TAPIA, M.Sc.
Head of the Department of Applied Research. Galapagos National Park Directorate.

From my perspective as a believer in applied research, the Green Galapagos project is an interesting proposal for interdisciplinary work for using Groasis Technology to contribute to the sustainability of the archipelago, as any tool that is able to accelerate the processes of ecological restoration and promote self-sufficiency in agricultural products as well, should be seen as an opportunity to be exploited and used.

PIETER HOFF
Groasis Technology inventor.

Nature has a tool that can help solve what I call the "world's seven problems": the tree. The FAO and IUCN have published that we have over two trillion hectares of man-made deserts. So, if this area was once green, it can be green once again. And, if it was small enough to cut, is also small enough to plant. This is what happens with the "world's seven problems" if we implement Groasis Technology for planting trees:

1. **Erosion** – the trees would cover the earth, making it fertile again.

2. **Poverty** – each hectare of trees creates about US$ 10,000 in income. This is an additional US$20 trillion for economic development.

3. **Food crisis** – each hectare of fruit trees can produce five tons of food. Two billion hectares is one trillion tons of extra food.

4. **Climate Change** –two trillion additional hectares of fruit trees eliminates 10 trillion tons of CO_2. This is more than what we produce annually with fossil fuels. Thus, we can neutralize all current CO_2 pollution to zero by planting food-producing trees.

5. **Unemployment** – each hectare of trees creates direct and indirect employment. Two trillion hectares of fruit trees create two billion jobs.

6. Rural-urban migration – when there are two billion new jobs in rural areas, people migrate back to rural areas.

7. Sinking of groundwater levels –the trees turn the eroded soil back into a "sponge" and the groundwater layers will rise rather than fall.

Since 2008, governments around the world have spent eight trillion dollars in order to save the banks. We need only two trillion dollars in order to plant two billion hectares with fruit trees. So, money cannot be the problem: what we need is inspiration.

In order to inspire the world to plant two billion hectares, we need a source of inspiration in an inspiring place. An example that would appear daily in newspapers, on TV and on the Internet and that we hope will be fully supported by the Ecuadorian government with the aim of other governments following along. But we – the people – have to make this happen; we have to get things moving. We must show our leaders that we want them to begin to reforest the world. In 1959, the UNESCO, IUCN and a global team of conservation leaders created the Charles Darwin Foundation. Without their vision, we would have already lost much of the unforgettable Galapagos Islands. They were the visionaries who taught us that we should care for and conserve Mother Earth in a better and different way. Let's begin restoration; let's follow their example!

With this proposal, the Charles Darwin Foundation sets a new challenge and takes a huge step forward. With the "Green Galapagos 2050" initiative, the CDF teaches us that we must not only maintain – but also restore – our environment. They have shown us that we can no longer accept that the world is turning into a huge desert as a natural landscape, and it is for this reason that the CDF, in collaboration with many strategic partners, proposes to give mankind the greatest possible example. Esperamos que este ejemplo inspire a todos. Sin duda, me inspiró a mí y me siento orgulloso y agradecido de que puedo ser un socio en este proyecto. I hope that when you read "Green Galapagos 2050" you'll decide to partner with us as well!

ANA FERNANDA TERRANOVA, CPA
Director of Fuente de Vida Foundation.

The obvious damage and abuse that human beings unconsciously inflict on nature is what motivates the presentation of the Green Galapagos 2050 Plan as a viable solution to preserving our environmental heritage: a little piece of Paradise called the "Galapagos Archipelago".

Groasis Technology has been identified as the tool needed to implement a model that is eco-friendly and sustainable, characteristics that are essential to maintaining this natural ecosystem which is unique in the world.
We cannot deny this legacy to future generations: the delight of visiting and appreciating the uniqueness of the various forms of life present on the Islands. Nor can we ignore the rights of nature itself. The inspiration exists; it is now time to begin an arduous, but not impossible, task: Preserving the Galapagos Islands' special, marvelous ecosystem, maintaining the balance between its natural system and the socio-economic development which will allow its inhabitants to enjoy a good standard of living.

DANNY RUEDA, M.Sc.
Director of Ecosystems
Galapagos National Park Directorate.

As part of its integrated management of protected areas, Galapagos National Park Directorate has been developing reforestation processes using native and endemic species in ecosystems of great ecological value that have been altered by the presence of invasive species of flora. This reforestation promotes the processes for restoring the ecological integrity of these protected ecosystems. Weather conditions for reforestation processes are not suitable during at least six months of the year due to the scarcity of rain and the difficulty of providing irrigation in reforested areas. In order to strengthen these actions, we have tried Groasis Technology mainly in coastal and arid ecosystems, and have been able to show that the development of reforested seedlings was optimal. This allows us to assure growth and coverage of reforested areas. In the future, we want to implement Waterboxx in larger areas and on uninhabited islands as a tool in the processes for restoring altered ecosystems.

JUAN CARLOS GUZMAN, Economist
Provincial Director of Ministry of Agriculture, Livestock, Aquaculture and Fisheries, Ecuador (MAGAP).

"The change in the model of agricultural production on the Galapagos Island that is being led by this Ministry considers the rational and efficient use of production factors – which due to their availability on the islands, are limited – an initial criterion. Under these restrictive conditions, and in order to boost agricultural production to ensure local food independence, the use of cutting-edge technology for managing water resources is a key factor. Thus, Groasis technology with the use of WaterBoxx is considered the feasible alternative to be implemented, considering its practicality from a socioeconomic and environmental perspective."

Naval Lieutenant-Su,
ALEX FLORES ESCOBAR
Puerto Ayora's Harbormaster Office.

Aware of the Galapagos Islands' great natural wealth, the Ecuadorian Navy – represented by the Puerto Ayora's Harbormaster's Office – considers the "Green Galapagos 2050" project to be an example of an ecological initiative for the recovery and reforestation of the endemic flora of Puerto Ayora, especially the urban part of Santa Cruz Island, Galapagos's main tourist attraction. The Groasis Technology allows water – a scarce resource in the island – to be used properly, in addition to creating the optimum environmental conditions for plant development. This has been recognized and admired by domestic and foreign tourists who see this initiative as an alternative to be applied not only in the Galapagos National Park, but also on the continent, where environmental mismanagement and the callousness of human beings have caused deforestation, bringing about the disruption of the earth's natural balance.

MAX FREIRE SALGADO, Technologist
President of the Decentralized Autonomous Parochial Government of Floreana.

In places such as Floreana Island, where plant cultivation is difficult due to the lack of permanent water sources, the Groasis technology has shown that there is an excellent option for production under such extreme conditions. Waterboxx has become a true production alternative.

EXECUTIVE SUMMARY

GREEN GALAPAGOS 2050

VIEW

"Galapagos Green 2050 " is a multi - institutional and interdisciplinary project that actively contributes to the conservation of the natural capital of Galapagos and the good living of its human population , using Groasis technology as a tool to implement a successful model of sustainable agricultural production and ecological restoration that allows humans live in harmony with nature.

GREEN GALAPAGOS 2050 PROJECT

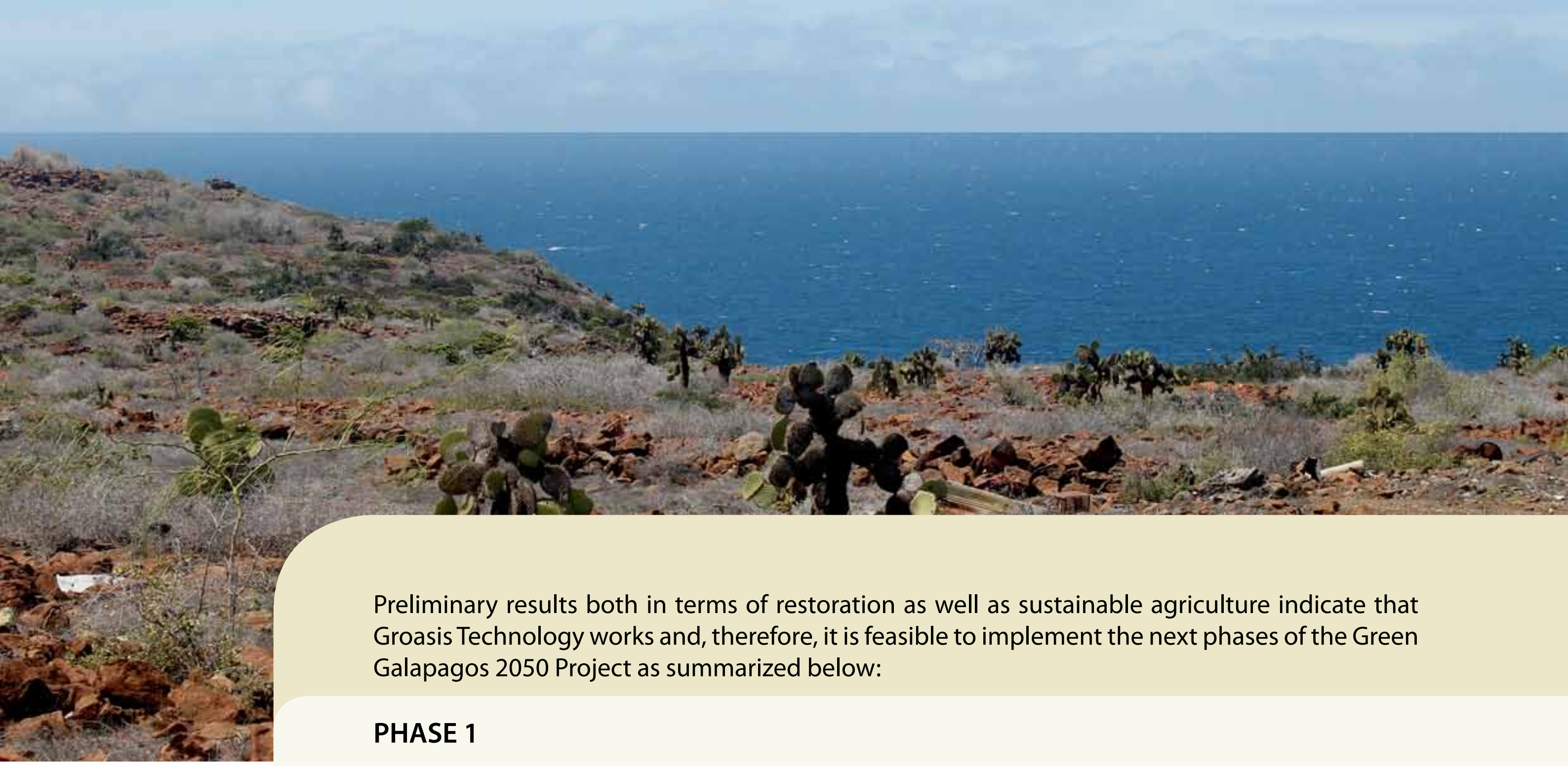
Green Galapagos 2050 began with an agreement between the Fuente de Vida Foundation (FFV) of Ecuador as a representative of the Dutch organization Groasis, and the Charles Darwin Foundation, and received initial (Pilot Project) funding from the COmON Foundation. The objective of this agreement was to develop a pilot project to test Groasis Technology in the Galapagos archipelago.

Considering the possibilities of using this technology as a tool for ecological restoration, the Charles Darwin Foundation (CDF) partnered with Galapagos National Park Directorate (GNPD) to carry out a pilot project under the guidelines of the Management Plan for the Protected Areas in the Galapagos Islands for a Good Standard of Living that was framed specifically around the goals of the Ecosystem Conservation and Restoration programs and the Rational Use of Ecosystem Services and their Biodiversity for Conservation and Development, for which two strategies of action were established: a) ecological restoration and b) sustainable agriculture. The results of this were also coordinated with the key government entities on Galapagos.

There is coordination and joint work among the Decentralized Autonomous Parochial Government of Floreana, the Provincial Technical Management of MAGAP on Galapagos and the Harbormaster's Office in Puerto Ayora; the strategic partner most involved in this initiative is the GNPD, the organization with which the pilot program for ecological restoration on the Floreana, Baltra and Santa Cruz Islands project was carried out.

In Floreana, work was done on a model farm in order to test the results of this technology before being implemented in the protected areas. In Baltra, the restoration of a highly deteriorated area located on a site previously used to operate a garbage dump was initiated. Based on preliminary results, in Santa Cruz the decision was made to use this technology in a small visitor's site area known as "Los Gemelos". Finally, in search of ecological restoration in urban areas, thanks to the opening of the Puerto Ayora Harbormaster's Office, the eradication of several invasive species within its facilities was begun, and these were replaced by endemic species using Groasis Technology.

Moreover, in relation to the sustainable agriculture component, the implementation of family vegetable gardens was initiated with community support in coordination with the Decentralized Autonomous Parochial Government of Santa Maria Island (Floreana) (Spanish acronym GADPF). With the support of the Provincial Technical Directorate of the MAGAP, a test of this technology with cocoa plants was developed on the island of Santa Cruz with future plans to work with local farmers based on these results.



Preliminary results both in terms of restoration as well as sustainable agriculture indicate that Groasis Technology works and, therefore, it is feasible to implement the next phases of the Green Galapagos 2050 Project as summarized below:

PHASE 1

Beginning in January 2014 and running to December 2016. During this period, it is anticipated that ecological restoration actions will be carried out on Baltra Island in areas where ecosystems and priority sites such as the nesting areas of land iguanas are located. On Santa Cruz Island, work in Los Gemelos will be expanded with the goal of achieving a recovery of at least 15% of this ecosystem of great value to the ecology and to tourism. In addition, 1 Ha will be restored between the Mirador and Garrapatero areas with Scalesia affinis, an endangered species. As for the implementation of actions for sustainable agriculture, support will be provided to the MAGAP to achieve coverage of up to 25% of the agricultural area used for agroecological production, in accordance with the zoning established by this government institution and, under the Bioagriculture Plan for Galapagos, which promotes integrated production systems under the agroecological approach (MAGAP, 2014).

PHASE 2

Beginning in January 2017 and running until December 2018. During this period, the plan is to implement actions for ecological restoration in priority ecosystems on Floreana defined as such by the GNPD, while on Isla Española, the aim will be to achieve a restoration of the Opuntia megasperma var. occidentalis of at least 20%. With regard to the sustainable agriculture component, on Floreana, it is expected that 100% coverage will be achieved in the farming area set aside for agroecological production, based on the intervention plan that MAGAP establishes for this island.

PHASE 3

The last and most extensive phase of the project will start in January 2019 and run until December, 2050. During this extended period, is expected that the benefits of Groasis Technology can be projected to restore the ecosystems and species defined by the GNPD through the Management Plan for the Protected Areas in the Galapagos Islands as priorities on both populated islands as well as on Santiago, due to there being an invasion of introduced species of flora and fauna. Furthermore, the full recovery of populations of cactus is anticipated on Plaza Sur and Española Islands. Meanwhile, regarding the sustainable agriculture component, the plan is to include 100% of the agricultural area for agricultural production, thereby helping to attain one of the goals set out by the MAGAP in terms of implementing the new agricultural production model in the island (Figure 1).

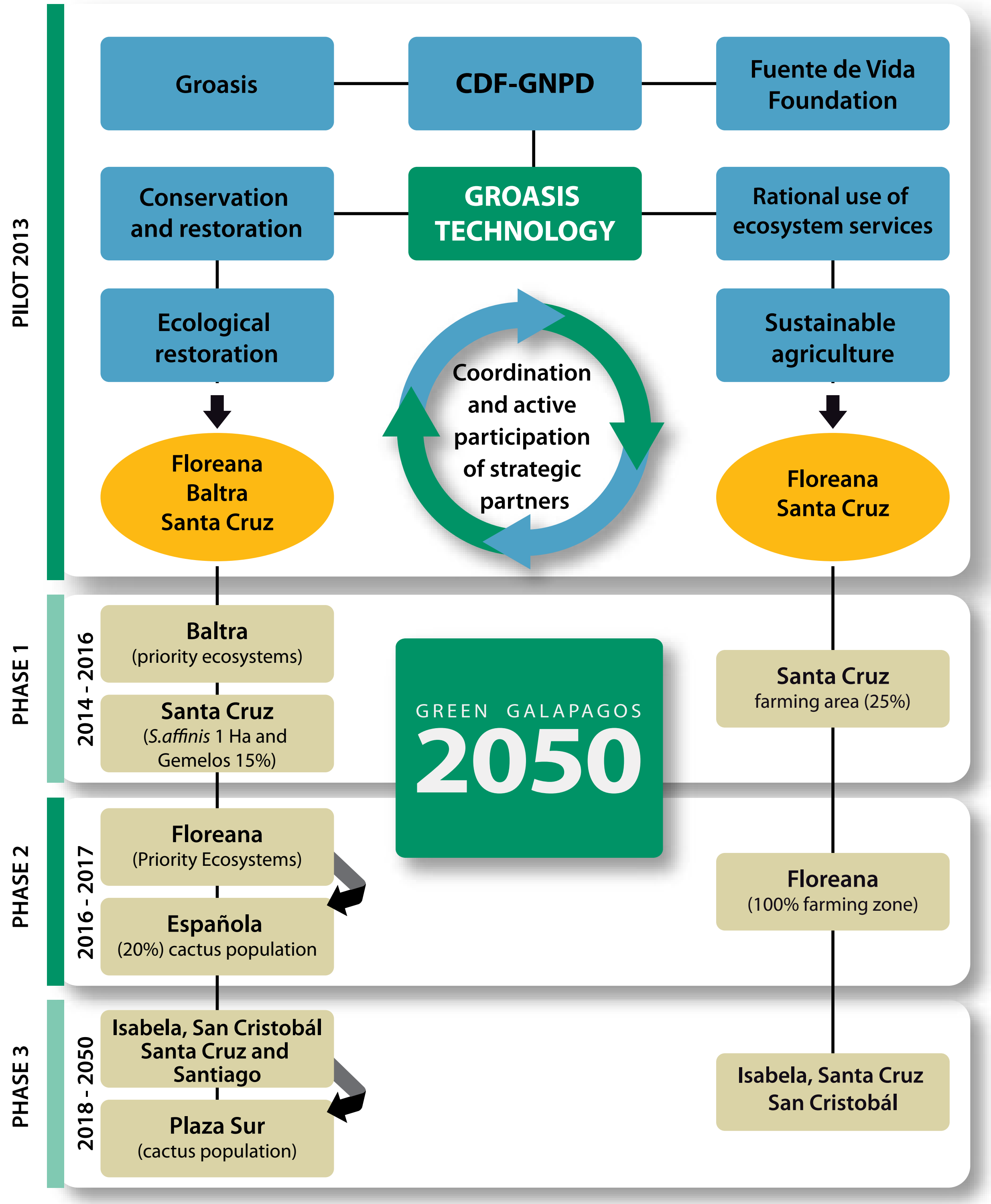


Figure 1. Timeline for the "Green Galapagos 2050" project using Groasis Technology.

INTRODUCTION

The Millennium Ecosystem Assessment conducted in 2007 (DPNG, 2013), recognized four categories of ecosystem services. For the purposes of this project based on the Management Plan for the Protected Areas on Galapagos for a Good Standard of Living, three services categories are recognized: supply, regulation and cultural (Figure 2).

Figure 2. Relationship between the "Green Galapagos 2050" project and the ecosystem services of the Galapagos Archipelago described in the Management Plan for the Protected Areas on Galapagos for a Good Standard of Living.

Supply services are goods or products obtained directly from the ecosystems; thus, with its sustainable agricultural production component, the "Green Galapagos 2050" initiative seeks to help maintain these services to ensure the food independence and security of the local population in some agricultural sectors. However, there is also a focus on both the restoration and/or maintenance of regulatory services, which are the benefits obtained indirectly from ecosystems – in this case through controlling soil erosion – as well as on the maintenance of cultural services, since this project includes removing invasive species and achieving the regeneration of endemic species, thereby returning a natural attractiveness to sightseeing sites such as Los Gemelos, among others.

OBJECTIVE

The "Green Galapagos 2050" project intends to contribute to the conservation of Galapagos and to a decent standard of living for the local population through the use and transfer of Groasis technology for ecosystem restoration and sustainable agricultural production.

THE PROBLEM OF INVASIVE SPECIES IN THE GALAPAGOS ISLANDS

Introduced species are the single greatest threat to the terrestrial biodiversity of the Galapagos Archipelago. There are currently some 900 species of introduced plants in the islands, of which at least 229 species (26%) are naturalized and 131 species are already invading natural spaces in the archipelago (Buddenhagen *et al.*, 2004; Guézou and Trueman, 2009; Jaramillo *et al.*, 2013; Soria *et al.*, 1999).

The highlands (wetlands) of the inhabited islands of Galapagos are the most deteriorated ecosystems in the archipelago, with a 23% rate of deterioration on Isabela, and an alarming rate of 96% on San Cristobal. The wetlands' ecosystems have been greatly modified by invasive species and agriculture (Table 1, Figure 3). On some islands, this has caused the nearly total loss of unique natural ecosystems, as in the case of the Scalesia forest, which currently cover less than 1% of their original range on the island of Santa Cruz and 0.1% in the Sierra Negra Volcano (Isabela) (Gardener *et al.*, 2010; Jäger *et al.*, 2007; Mauchamp and Atkinson, 2008-2009; Rentería and Buddenhagen, 2006).

Table 1. Percentage of vegetation zones deteriorated by invading species on each one of the four populated islands, adapted from (Watson, 2009); "very wet" categories are included under the "wet" category.

Islands	VEGETATION ZONES		
	WET	TRANSITION	ARID
San Cristobal	96	23	2
Santa Cruz	86	25	0.4
Floreana	38	2	0.5
Isabela Sur	23	4	0.2

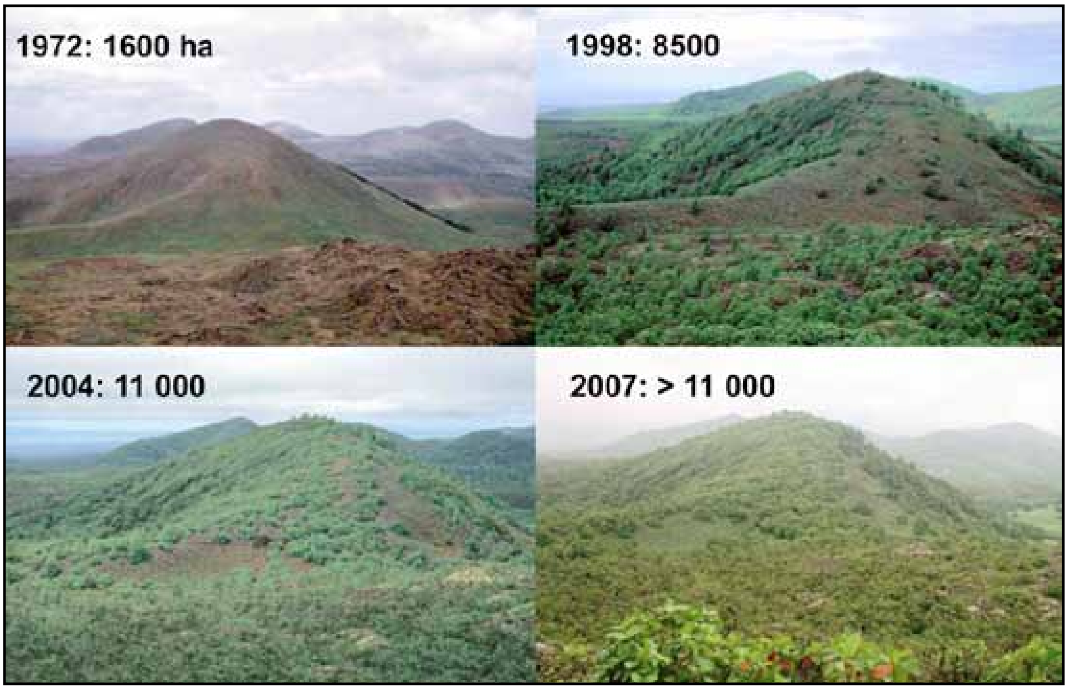


Figure 3. Change in the landscape caused by invasive plants (mainly Cinchona pubescens) in Santa Cruz (Gardener, 2010).

As can be seen in the images, the impacts of invasive species on the Galapagos Islands are devastating to the point that they have transformed large areas of natural ecosystems. Moreover, invasive species adversely affect the province's socioeconomic processes in the sense that the entry of pests causes crops to be lost and land abandoned, thus increasing the importation of organic products from mainland Ecuador and the constant danger of exotic species being introduced to the islands. This process becomes a vicious circle in which invasive species have been gaining ground, creating environmental, social and economic impacts (Figure 4).

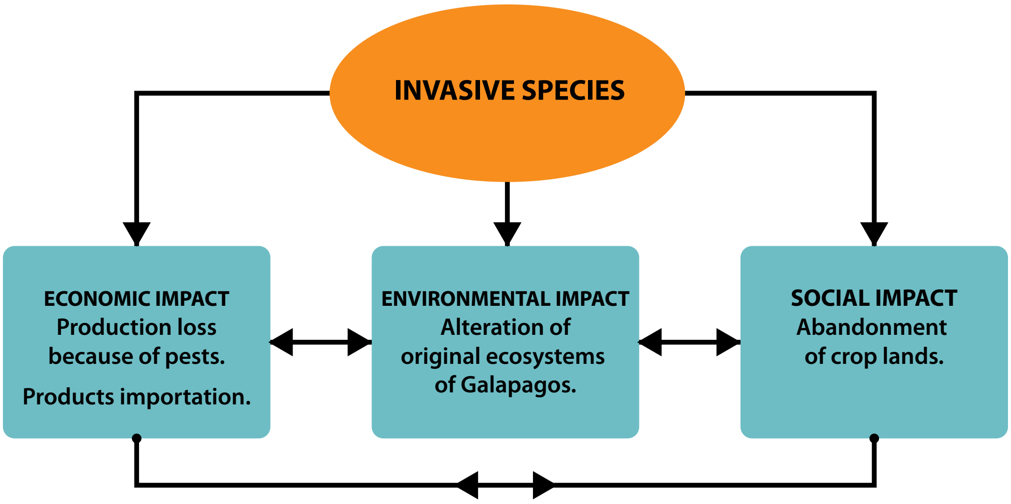


Figure 4. Cycle of the impacts of invasive species on the Galapagos Islands.

MAIN PROJECT STRATEGIES

ECOLOGICAL RESTORATION

The conservation and/or restoration of the ecological resilience and integrity of the ecosystems of the Galapagos Islands are one of the safest strategies for the overall conservation of the ecosystems' capacity to generate services, as well as for acting on the causes of the rich and varied flow of environmental services to society (DPNG, 2013) (Figure 5).

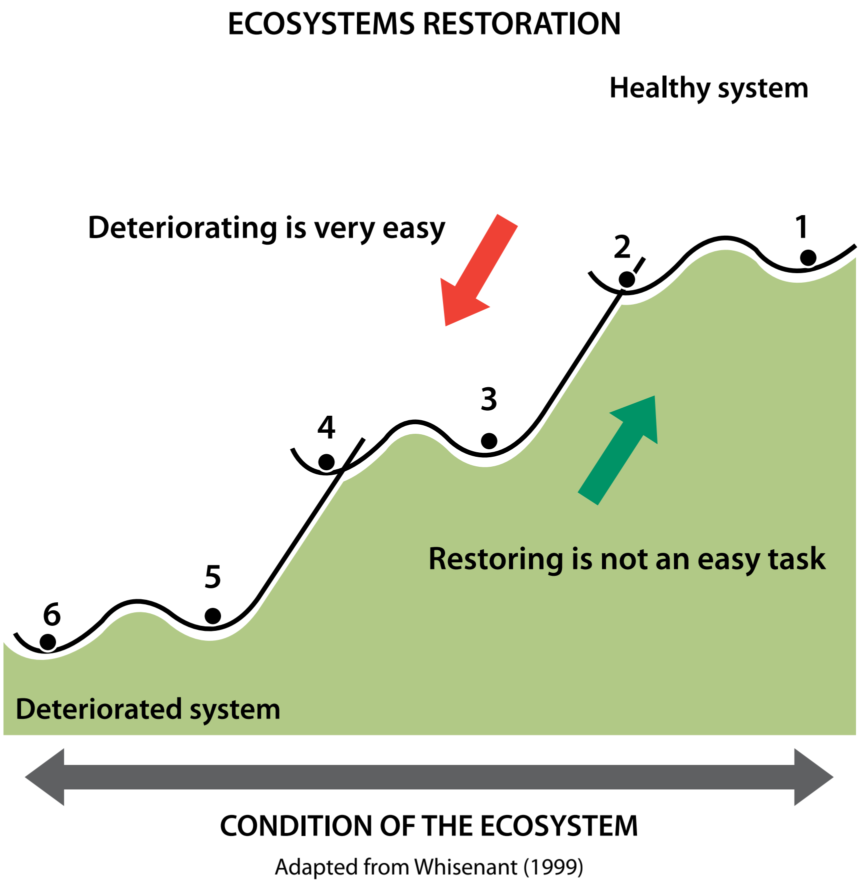


Figure 5. Overview of the ecosystems' resilience.

As can be seen in Figure 5, the deterioration of the ecosystems has an accelerated flow, whereas the restoration of these deteriorated ecosystems towards a healthful system is much slower, more complicated; this is even more true when they are fragile ecosystems like the Galapagos Archipelago (Restrepo *et al.*, 2012; Wilkinson *et al.*, 2005). For example, attempts to recover the islands' highlands have been implemented on a small scale in a sporadic fashion, and without any success (Carrión & Rentería, 2012; Gardener, Atkinson, & Rentería, 2010), and the present state of several species in the wetlands of Galapagos has been assessed (Adsersen, 1990; Itow, 1992; Jaramillo, 1998; Jaramillo, 1999; Jaramillo and Tapia, 1999; Mauchamp and Atkinson, 2008-2009; Rentería *et al.*, 2009; Rentería and Buddenhagen, 2006; Yanez *et al.*, 2003). What is needed, therefore, is a tool like the Groasis Waterboxx, which has been implemented around the world and has attained a survival rate of up to 90% in restoration programs using reforestation (Hoff, 2013), allowing us to achieve a high success rate in restoration programs and to reduce to the minimum the costs associated with controlling invasive plants in the extreme conditions of the Galapagos Islands.

SUSTAINABLE AGRICULTURE

A recent analysis of the ecological state of the (rural) highlands of the inhabited islands in the Galapagos Archipelago indicates a nearly total loss of a zone of vegetation, produced and accelerated by a combination of ways the earth has been used and invasive species (land abandonment) (Gardener *et al.*, 2010; Guézou *et al.*, 2010; Rentería and Buddenhagen, 2006; Tye *et al.*, 2001; Watson, 2009) (Figure 6).

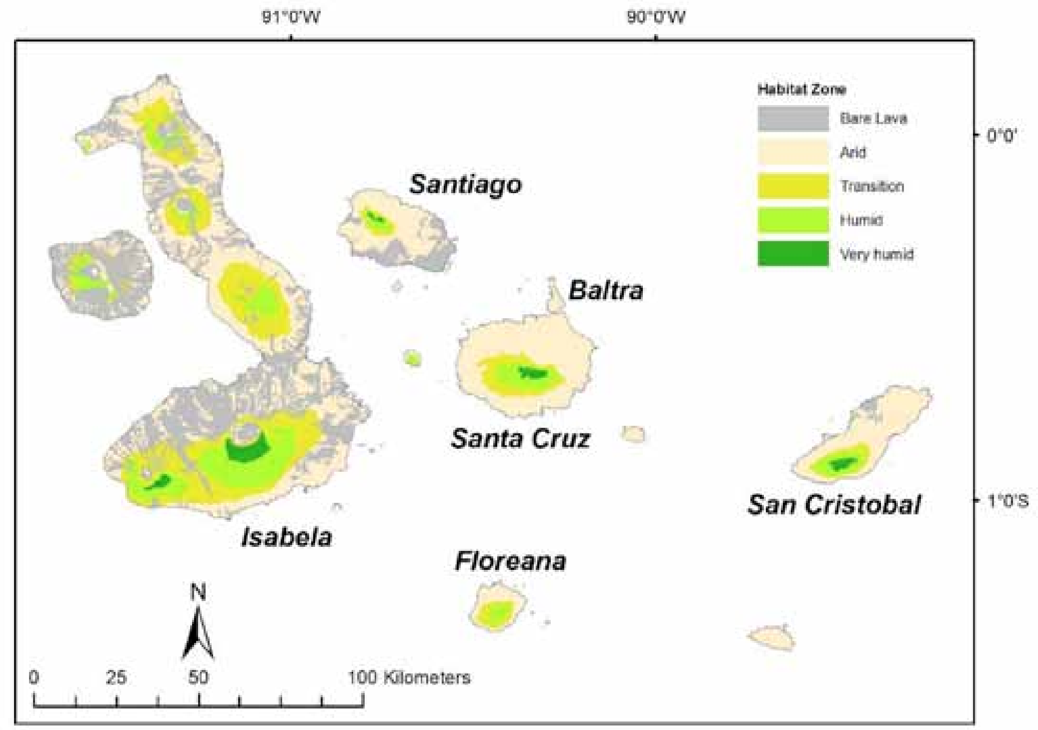


Figure 6. The Galapagos Archipelago. The wetlands and very wet wetlands on the populated islands are the most deteriorated areas (Gardener *et al.* , 2010).

This is why it is essential to reinforce the role of the highlands of the populated islands. These were originally occupied in order to establish agricultural areas and are currently involved in a process of urban development in terms of both conserving the natural heritage and biodiversity as well as in a "decent living standard" quality of life for the citizens and in the sustainability of the province (DPNG, 2013).

One problem that has contributed to increasing the entry of invasive species to protected areas is land abandonment (DPNG, 2013). This problem becomes an endless vicious circle, since it is the invading species which cause the farmers to abandon their land which consequently become focal points for the spread of invasive species towards the protected areas of the Galapagos Islands (Figure 7).

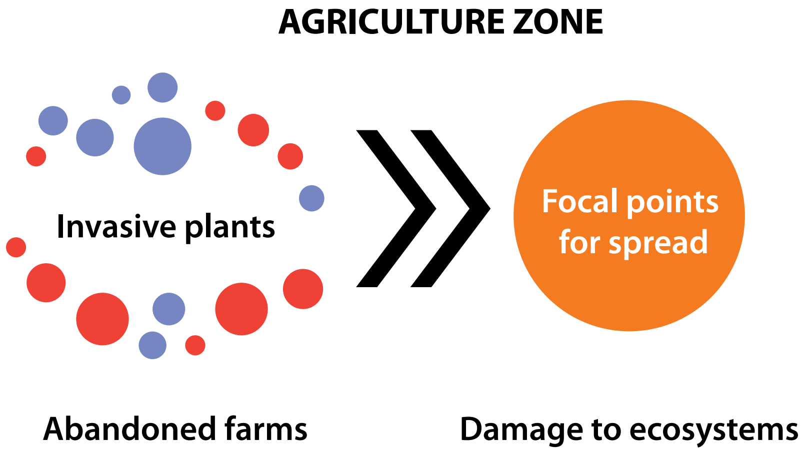


Figure 7. Cycle of ecosystem deterioration resulting from abandoned farms, which become focal points of the spread of invasive species.

By implementing actions to promote sustainable agriculture as a strategy of the "Green Galapagos 2050" project, the aim is to achieve the conservation of the wetlands' most vulnerable ecosystems; the aim is to reduce the importation of organic products via an incentive for sustainable production and, in doing so, the danger of invasion by alien species (FEIG, 2007; Martínez and Causton, 2007; Trueman, 2008; Trueman, 2010). One added value would be the contribution to the food security of the Galapagos' population, as established by the National Plan for a Good Standard of Living (SENPLADES, 2013).

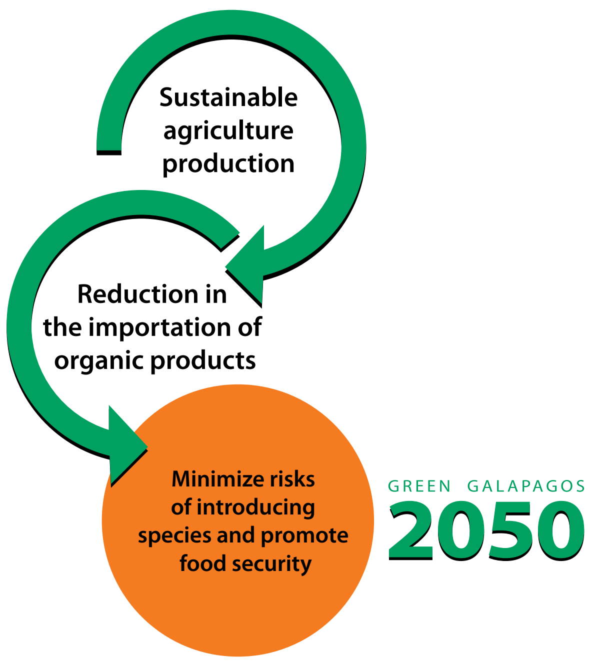


Figure 8. Benefits of sustainable agricultural production.

Due to the geological and hydrological characteristics of the Galapagos Islands, there are limits to the availability of fresh water, compared to other tropical islands such as Hawaii (D'Ozouville, 2008). This problem of lack of water leads to the difficulty of maintaining stable agricultural production throughout the year, which in turn generates a greater reliance on the importation of organic products (Figure 8). Groasis' innovative technology allows us to farm with minimal water consumption. Several studies have shown that this technology enables a water savings of up to 98% more than drip irrigation. Tests are currently taking place with several short-cycle fruit species in the province of Santa Elena in continental Ecuador (Hoff 2013), and this will provide technical data on this factor.

PRELIMINARY RESULTS OF THE PILOT PROJECT (2013)

As noted above, the success of the coordination process with government institutions has been the cornerstone for the implementation of the pilot project on each of the islands selected for this preliminary phase. Moreover, without a doubt this has been the first successful step towards achieving a "Green Galapagos by 2050".

During the implementation of this pilot project, Groasis Technology was used to plant various species native and endemic to the islands of Santa Cruz, Floreana and Baltra (Annex 1). Similarly, several species for agricultural production were used on Floreana and Santa Cruz (Annex 2 and Figure 9).

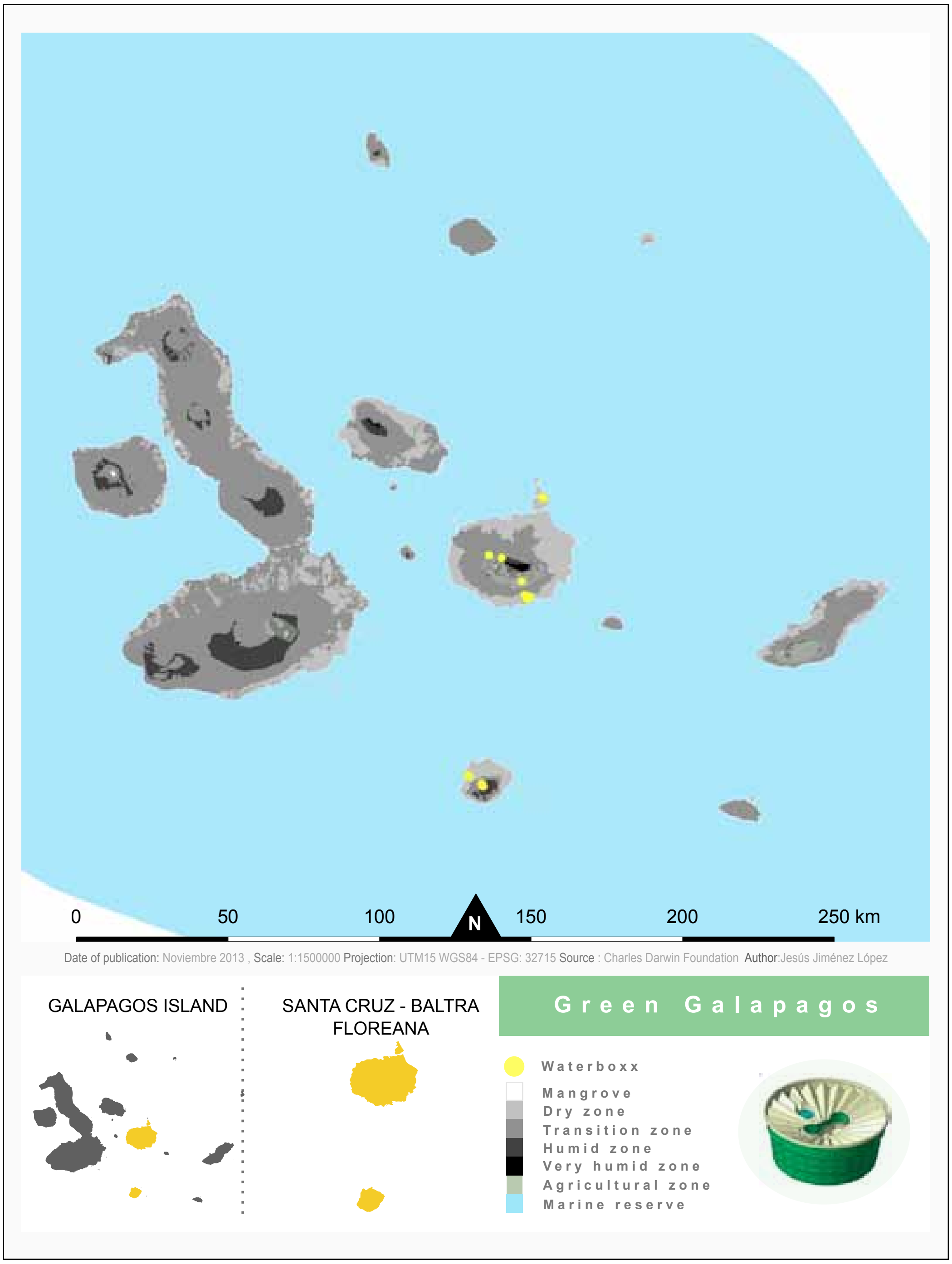


Figure 9. Map showing the distribution of all sites involved in the implementation of the pilot project on the islands of Santa Cruz, Floreana, and Baltra.

Due to the islands' geological and climatic characteristics, there are different vegetation zones, each with similar altitudes, which varies depending on the size of the island (Geist, 1996; Geist, 2000; González *et al.*, 2008; Itow, 1992; Trueman and d'Ozouville, 2010; Trusty *et al.*, 2012; Tye and Francisco-Ortega, 2011).

Plants with Groasis Technology are distributed in various vegetation zones at different altitudes and with different substrates. In total, on the three islands where the pilot project phase was implemented, eight different substrate types (Figure 10) were included.

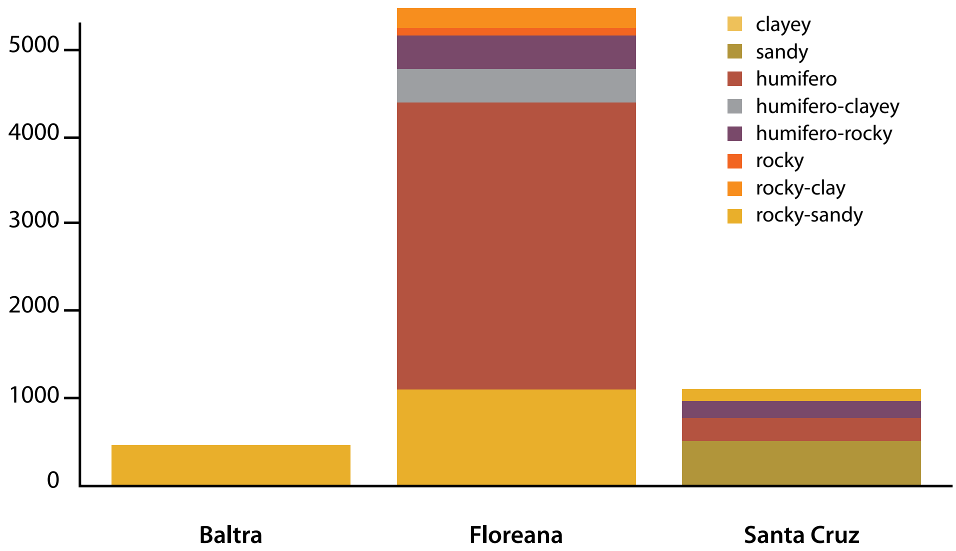


Figure 10. Substrate types recorded in the islands where Groasis technology was tested during the pilot phase.

To make it easier to understand the results obtained in the pilot phase of the project, they are showed categorized in accordance with the strategies established, i.e., ecological restoration and sustainable agriculture:

ECOLOGICAL RESTORATION

ARID ZONE

BALTRA ISLAND

Baltra Island has an area of 27 km^2 and a maximum altitude of 100 masl. The archipelago's main airport is located on this island, and is the main flight connection between the Galapagos Islands and mainland Ecuador (Geist *et al.*, 1985). However, since the entire island is part of Galapagos National Park, the Charles Darwin Foundation and Galapagos National Park Directorate worked together on the restoration of deteriorated ecosystems in an area near the airport where, until recently, a garbage dump was operated (Figure 11).

Figure 11. Map of the geographical location of the two sites of implementation of the pilot project in Baltra.

This island has a very interesting scenario since – besides having undergone an alteration of its ecosystems due to the presence of the U.S. military base during World War II (González *et al.*, 2008; Trueman *et al.*, 2010; Trueman & d'Ozouville, 2010), as it is a low island, it is very arid and there is almost no rainfall (Itow, 1992). Consequently, considering that Groasis Technology is characterized by stimulating any plant to grow with a minimum amount of water. An assessment was made of six species that are native and endemic to this island (*Acacia macracantha* Humb. & Bonpl. ex Willd., *Bursera malacophylla* B.L. Rob., *Castela galapageia* Hook. f., *Opuntia echios* var. *echios* Howell, *Parkinsonia aculeata* L. y *Scalesia crockeri* Howell), for the purposes of stimulating their growth and development.

Preliminary results show that, due to the physical characteristics of Baltra's soil (Figure 8) – which is very clayey – and the stress suffered by the seedlings during planting and from the intense heat, survival and growth were affected. However, the growth rate of the seedlings planted in Waterboxxes – e.g., *Opuntia echios* var. *echios* – showed an accelerated growth rate. It should be noted that in this case "accelerated" meant that the seedlings multiplied their average natural growth. Usually, the species of this genus have an annual average growth rate of two cm (Coronel, 2002; Estupiñan and Mauchamp, 1995; Hicks and Mauchamp, 2000), which contrasts with the growth recorded with the Waterboxx, as its average growth rate was 1.5 cm per month, suggesting that, if this growth rate continues, it could grow more than 10 cm per year (Figures 12).

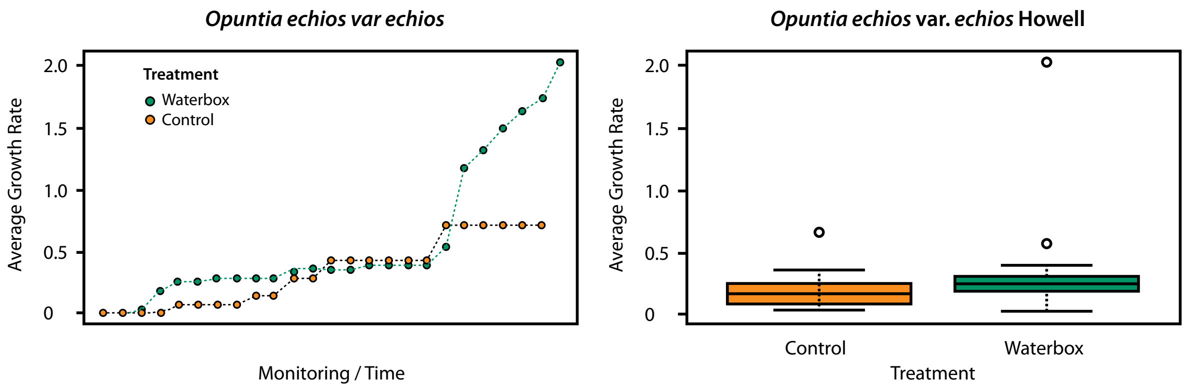


Figure 12. Average growth rate of Opuntia echios var. echios during the Waterboxx pilot project on the island of Baltra..

It is important to stress that, due to the extreme conditions on Baltra Island, only 50% of the volume of water required by Waterboxx boxes was used in this pilot project in order to prove its feasibility under extreme situations of water scarcity and where access to it is very limited both by lack of water sources and the difficult terrain.

WETLANDS

FLOREANA AND SANTA CRUZ

The changes that have taken place in the islands ecosystems due to the presence of invasive species and the elimination of native, endemic vegetation on the populated islands in order to make way for agriculture and cattle ranching have caused the nearly total loss of several unique natural communities on the islands; this is the situation with the *Scalesia pedunculata* forest that historically occupied the areas currently occupied by the farming area, reason why only small remnants of these forests remain (Mauchamp and Atkinson, 2008-2009) (Figure 13 and 14).

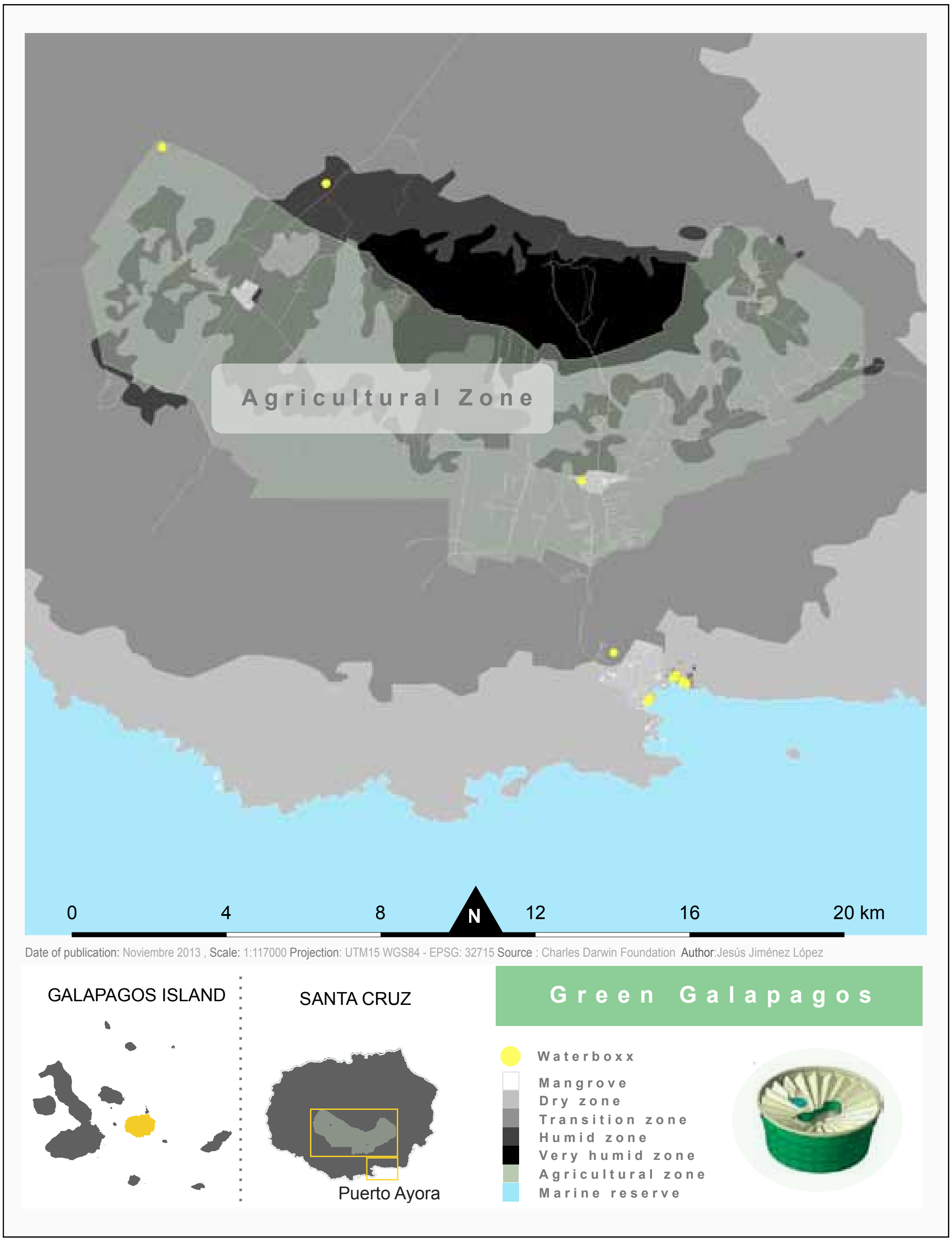


Figure 13. Map of the geographical location of the pilot project implementation sites on the island of Santa Cruz.

The pilot phase was implemented in the highlands of Floreana and Santa Cruz, where seven different endemic species and three native species were chosen and planted in Waterboxxes. Preliminary results showed that, for example *S. pedunculata* had a growth rate much faster than the others (Figure 15).

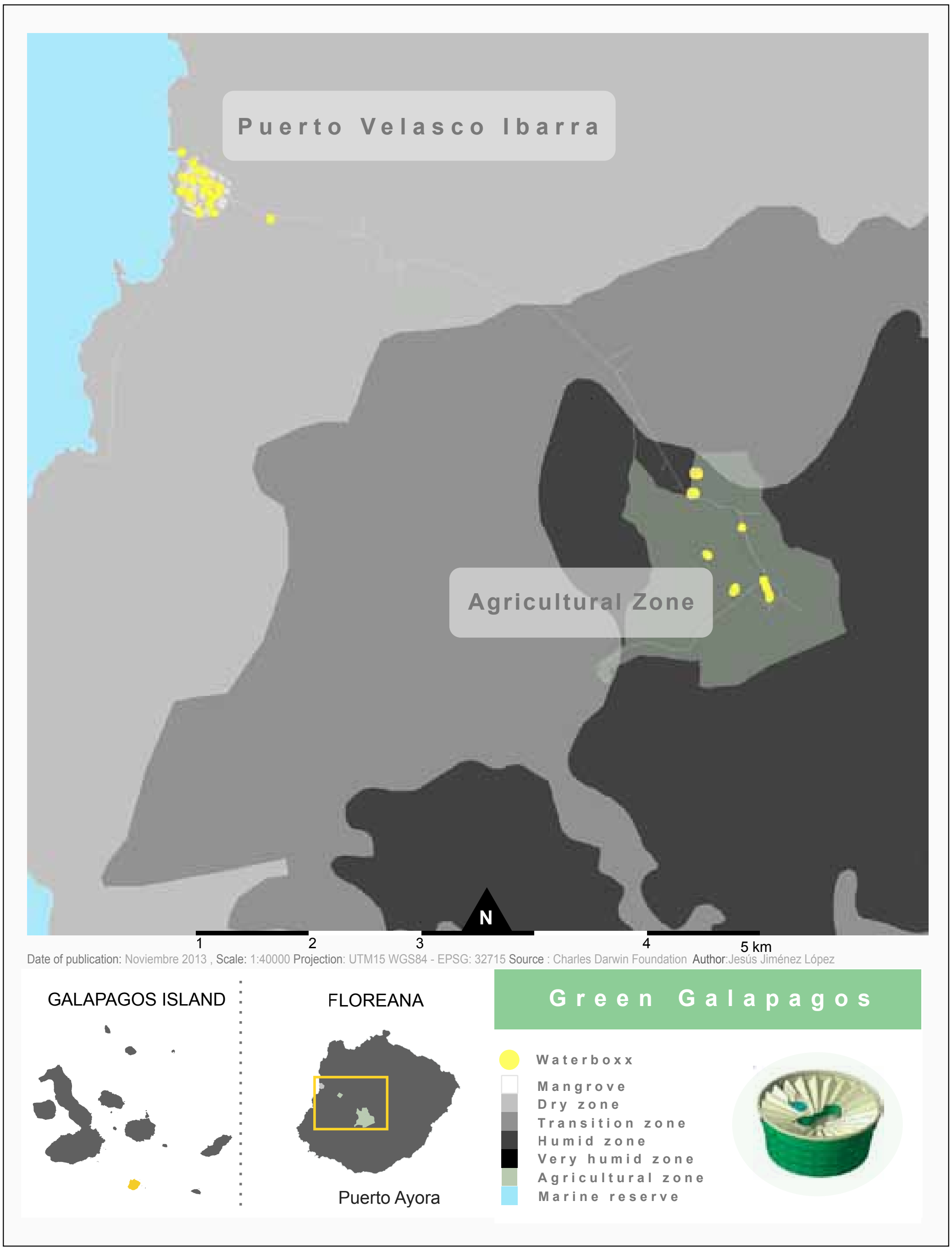


Figure 14. Map of the geographical location of the pilot project implementation sites on the island of Floreana.

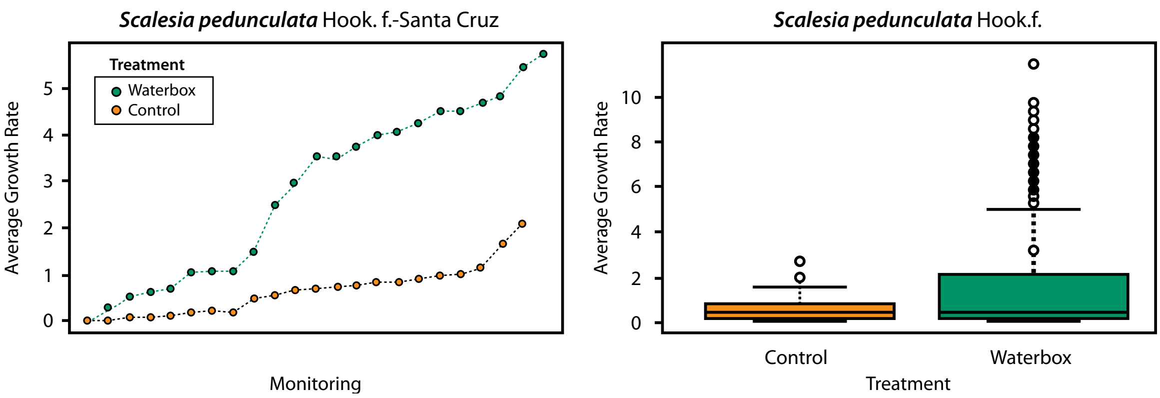


Figure 15. Growth rate of *Scalesia pedunculata* during the Waterboxx pilot project on Floreana and Santa Cruz Islands.

SUSTAINABLE AGRICULTURE

ARID AREA AND WETLANDS

FLOREANA ISLAND

The dependence of the population of the Galapagos Islands on imported food from mainland Ecuador not only increases the risk of introducing invasive species and pests into island ecosystems, but also prevents the quality of life of local farmers from being improved (Martínez and Causton, 2007; Palacios, 2012). Additionally, the shortage of fresh water for crops is a pressing problem in the Galapagos Islands, specially in Floreana (Guyot-téphany *et al.*, 2012).

The pilot project was implemented in the arid areas and wetlands of Floreana (see Figure 13) (family gardens and farms). Several species were selected, mostly fruit trees: *Allium fistulosum L., Annona cherimola Mill., Capsicum annuum L., Carica papaya L., Citrullus lanatus* (Thunb.) Matsun. & Nakai, *Citrus reticulata* Blanco, *Citrus x limon* (L.) Osbeck, *Citrus x sinensis* (L.) Osbeck, *Cocos nucifera L., Cucumis melo L., Jatropha curcas L., Mangifera indica L., Ocimum campechianum* Mill., *Persea americana* Mill. y *Solanum lycopersicum L.* (Appendix 3).

The results so far achieved with the cooperation of farmers have been positive for all species, especially in the cases of tomatoes and watermelons (Figures 16 and 17). The next step will be to share the results with the community of Floreana and, by doing so, provide control of invasive species on Galapagos and generate, over the long term, sustainable production.

It must be emphasized that due to the extreme scarcity of water on Floreana, the water was reduced to 30% of the normal amount of water required for the boxes to work.

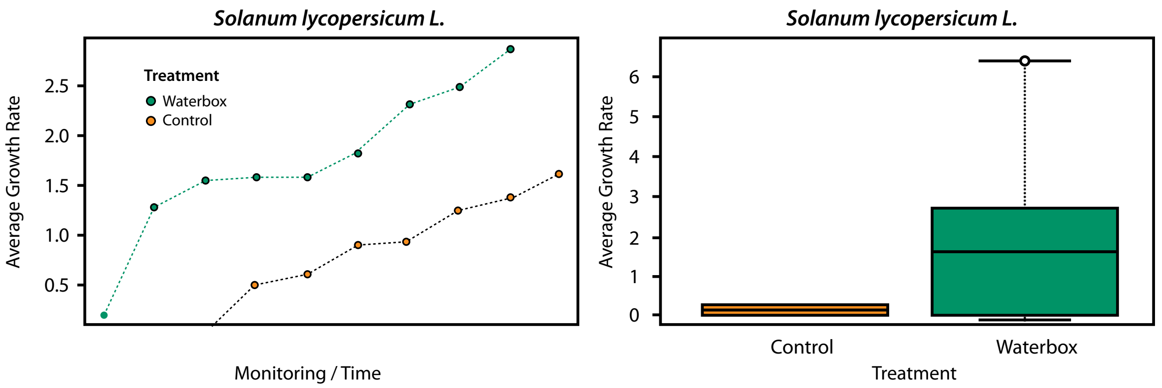


Figure 16. Growth rate of *Solanum lycopersicum* (tomato) during the Waterboxx pilot project on Floreana Island.

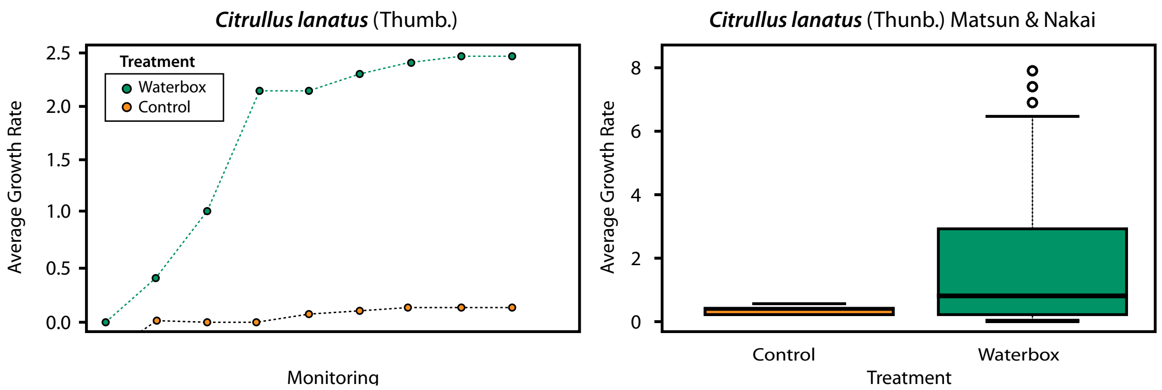


Figure 17. Growth rate of *Citrullus lanatus* (watermelon) during the Waterboxx pilot project on Floreana Island.

GREEN GALAPAGOS 2050

A CHANCE TO RESTORE THE GALAPAGOS

Understanding Galapagos as a social and ecological system means that the ecosystems and society should be conceptualized and managed as a whole, as a single integrated and unitary entity (Tapia *et al.*, 2009; Tapia *et al.*, 2008). This way of thinking and acting would help break the dichotomy between conservation and development, since any action aimed at properly managing would focus primarily on the systemic management of the relationships and processes that link human and natural systems (DPNG, 2013). With these principles in mind, we should consider the Green Galapagos 2050 project as a tool leading us from an altered ecosystem state to a healthy ecosystem (not the original one, but one that is as close as possible to it) on a regional scale, where we can have a real impact on the Galapagos social and ecological system of the Galapagos Islands (Figure 18).

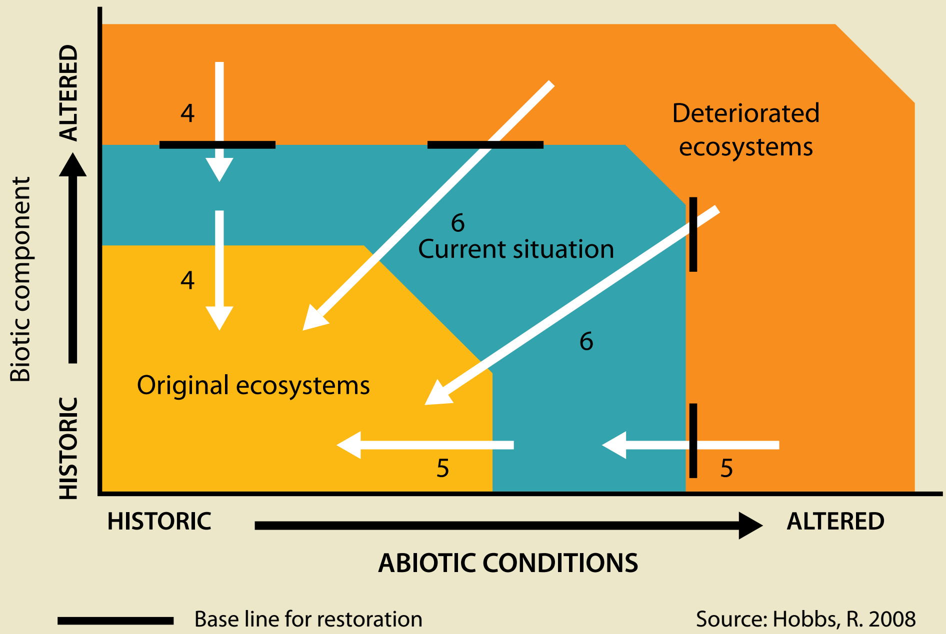


Figure 18. Model for the restoration of original and deteriorated ecosystems adapted to the situation in the Galapagos Islands (Hobbs, 2008).

IMPLEMENTATION PLAN FOR THE

GREEN GALAPAGOS 2050 PROJECT

The “Galapagos Green 2050” project will be implemented in several phases; these phases have a strategic implementation process as detailed below:

PRIORITY AREAS

The first step is to define – together with strategic partners – the priority areas where the problem to be solved by the project is found; in this case, each phase must identify the priority ecosystems on each of the islands that will be included in the project.

DEVELOPMENT STRATEGIES

In the second step, we must set goals and measurable results for the ecological restoration of the priority ecosystems and agricultural production areas chosen in the previous step. This will help us to detail the extent of implementation in each of the project phases. For example: Phase 1 = Baltra and rural area of Santa Cruz.

IMPLEMENTATION PLAN

In this third step, we must detail the restoration and sustainable agricultural production actions to be carried out during each of the phases in coordination with the project’s co-executor.

MONITORING

In this fourth step, we – along with our strategic partners – must define a Monitoring Plan which will provide detailed geographical distribution maps for each of the phases and will also detail the indicators that will be assessed. To do this, a virtual platform will be used for both entering data as well as the free publication of information about the project.

EVALUATION RESULTS

In this step, a technical analysis of the data recorded during the previous step will be carried out. Said data will be submitted to the interested parties in the form of technical reports.

IMPLEMENTATION OF CHANGES

Lastly, during this process, it is necessary to modify the actions for implementation based on the technical reports submitted in order to correct mistakes and solve problems quickly and efficiently. This means that the Green Galapagos project is based on adaptive management, aligning itself with the conceptual basis of the new Management Plan for the Protected Areas on Galapagos for the Good Standard of Living (Figure 19).

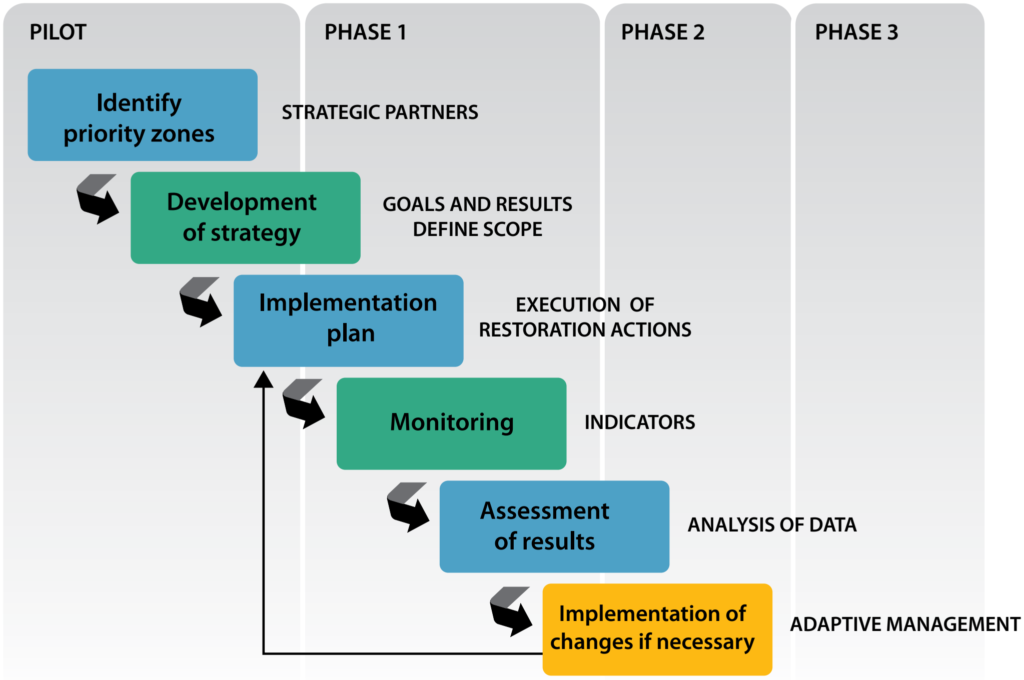


Figure 19. Strategy for the implementation of the Green Galapagos Project 2050.

PROJECT IMPLEMENTATION

As we have seen in the strategic planning, the work is planned over three phases, each of which will have a geographic scope established by islands (Figure 20).

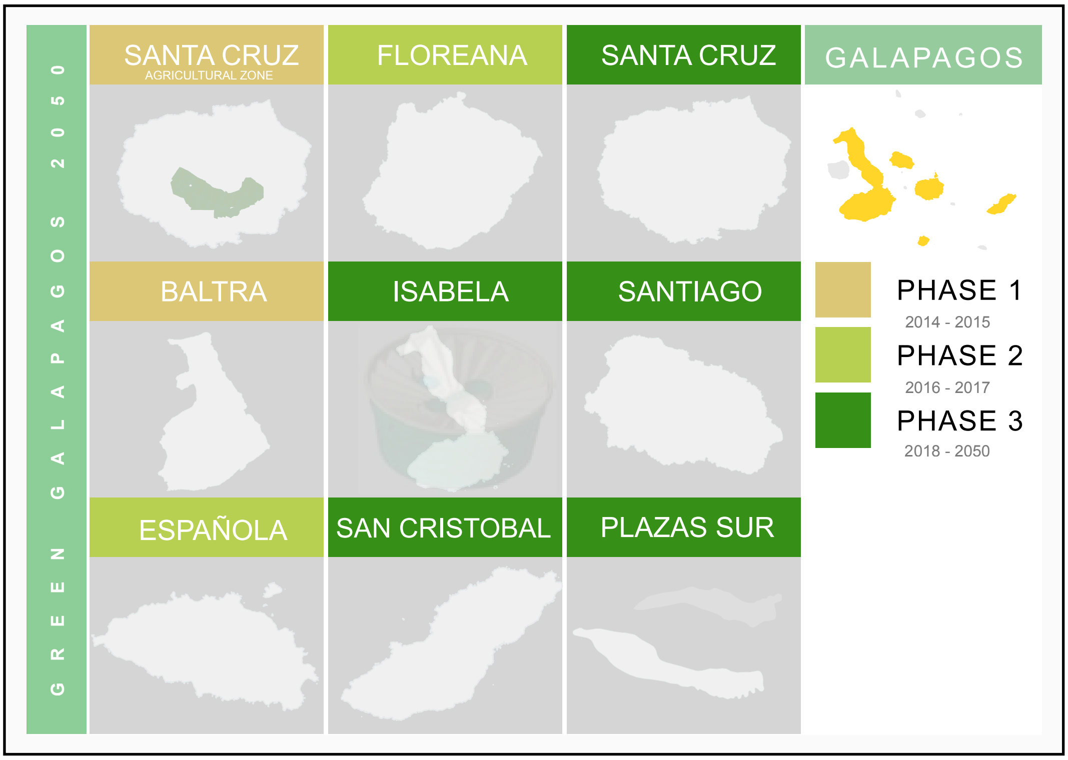


Figure 20. Explanatory maps showing the scope of the implementation of each of the phases in the Green Galapagos Project 2050.

PHASE 1 (2014-2016)

During this phase, ecological restoration actions on Baltra Island will be focused on areas with priority ecosystems in accordance with prioritization carried out with strategic partners, particularly the GNPD. On Baltra, there is a unique land diversity distributed on the outskirts of the airport (Jaramillo, 2009).

The restoration of Baltra Island is a great opportunity to recover one part of the archipelago's land-based ecosystem, the same one that generates significant ecological, social and economic benefits. The need for ecological restoration in Baltra is a priority; its high rate of deterioration has been caused by the former military base and its operations. However, the restoration potential is very high; outside the former aviation complex on Baltra there are plant communities which are largely intact and which could serve as sources of biological material for setting into motion ecosystems in damaged areas of the island.

Similarly, this is an important opportunity for combining restoration activities with educational activities or initiatives aimed at publicizing the restoration process in arid zones, up to now Baltra currently serves as the main entry point in the whole archipelago. Thousands of visitors enter the airport each year, creating a unique opportunity for spreading the word about the project and perhaps encouraging visitors to directly participate in the process of restoring the island, unlike other restoration projects in the Galapagos Islands that are difficult to learn about or visit, especially those implemented in the more remote islands. The scientific potential for the restoration of Baltra Island is also very great, as the restoration of Baltra could serve as the starting point for generating new knowledge about how the arid ecosystems of the Galapagos Islands work as well as generate much-needed information on the island's biota.

The specific considerations for the restoration of terrestrial ecosystems of Baltra must include the following:

- Restoration efforts should focus on the plant community in the central area of the island where there was a great deal of deterioration as the result of the former military base and vehicular traffic.

- The creation of a network of corridors of native plants would create connections throughout the island between the least-disturbed area in the northern part of Baltra and the shrub community to be recovered near the former military base in the southwest, e.g.:

  Opuntia echios var *echios* is a key species on Baltra and should be a priority species used for the intensive restoration of the island.

  Restoration efforts should also seek to recover ecologically important species such as *Bursera malacophylla*, S*calesia crockeri*, *Solanum cheesmaniae*, and other native species similar to those found in northeast of Baltra and Seymour Norte.

- El Niño events should be considered from a strategic perspective as windows of opportunity for launching the recovery of plant communities.

- Reference or "control" sites are critical to quantifying the success of the restoration. The nearby islands of Seymour Norte and the coastal areas north of Santa Cruz can serve as controls.

- The large debris generated from the abandoned structures could be manipulated to make it similar to the areas of volcanic rock and ash that provide a habitat of great importance for catching seeds by providing shade and moisture, thereby facilitating the germination of pioneer species and benefiting high-priority species, as for instance, *Opuntia*.

- Herbaceous species play a valuable role in the ecosystem, so it is also very important that they be taken into consideration as part of an effective restoration, e.g., *Crotalaria pumila* is a legume that provides nitrogen fixation with showy flowers that attract endemic butterflies. *Amaranthus squamulatus*, *Ipomoea triloba* and *Tiquilia galapagoa* are examples of plants that attract pollinators and provide soil stability via the provision of protection and cover.

- Endemic fauna play an important role in the restoration of the plant community through the seed dispersal of mature plants from the entire restoration area; this process can be accelerated by placing a large network of artificial branches for birds, as has been shown in many other restoration projects.

- Assessment of the structure of the special role of nurse plants and ecological engineering methods such as Groasis Technology is of great importance for the restoration of the nuclei of the plant community in greatly disturbed areas; this technology could accelerate the process of recovering the plant community in the arid conditions characteristic of Baltra.

- Management of invasive species is necessary for the restoration of endemic plant communities on Baltra; alien species are of particular concern in the airport area.

- Accidents such as aircraft and motor vehicle collisions are a hazard faced by the birds and reptiles on Baltra; therefore, it is important that they be taken into consideration with an impact mitigation plan.

- The habitat of the Galapagos Hawk was Baltra Island; however, sightings on this island have been declining. Consideration could be given to reintroducing it to this island.

- The Galapagos land iguana is a large and charismatic species that deserves special consideration in the restoration of reptiles populations. It should be assured through monitoring that the population of land iguanas on Baltra remains stable or increases and mortality on roads and the airport runway is reduced.

- An expert workshop should be convened – perhaps on the island of Baltra itself –for daily outings to sites of interest on the island aimed at generating a specific plan to move forward with the restoration of the whole island. This would be an investment worthy of the time and resources required.

It is likely that the natural recovery of the deteriorated areas will progress slowly, based on the recovery track record of similar arid ecosystems.

The restoration of Baltra Island is a unique opportunity for balancing multiple competing uses, including the recovery of endangered species, the restoration of ecosystems, the integration of tourism as part of the restoration process, the renewal of the lighting infrastructure, and perhaps the preservation of historic sites, all of which is to be carried out in a highly visible place where the work of Galapagos National Park and the Charles Darwin Foundation can be presented (James Gibbs 2013 pers. com.).

On Santa Cruz Island, in contrast, work will be done on the restoration of two vegetation zones: arid and wetland. On the Mirador and in the west of the Garrapatero, 1 Ha of the endangered species *Scalesia affinis* will be restored, while on the wetland work will be done on the Gemelos, continuing with what had been undertaken in the pilot phase which is aimed at achieving the recovery of up to 15% of the original ecosystem (Figure 21).

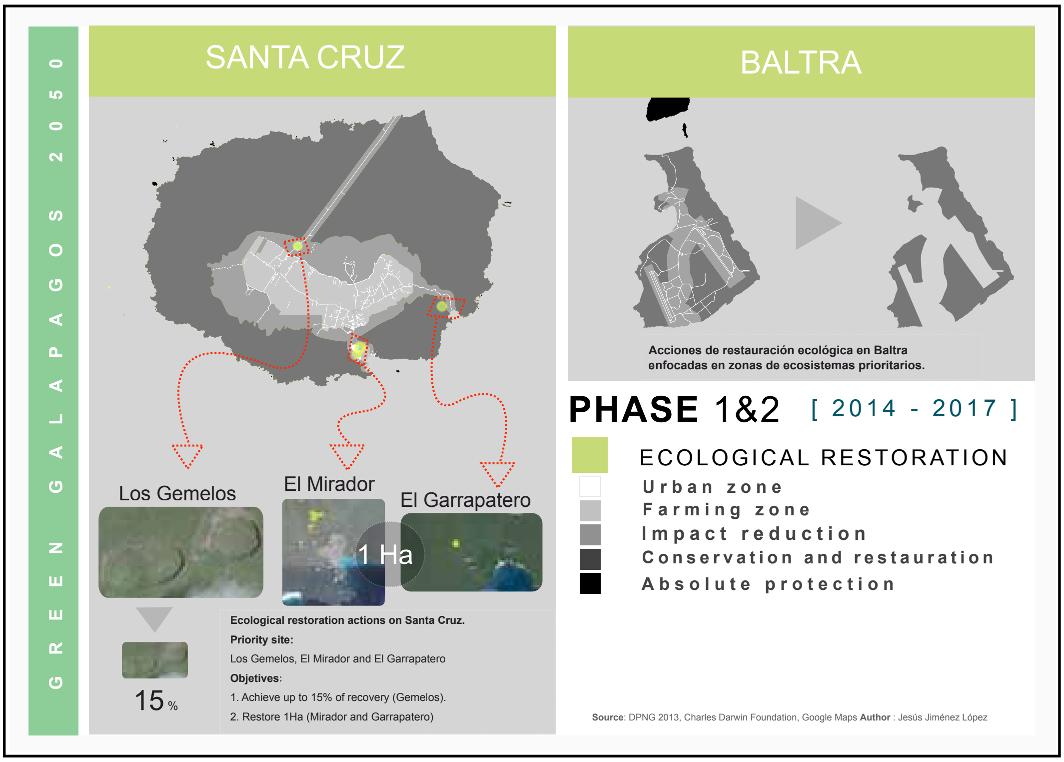


Figure 21. Informational map showing the scope of Phase 1 in the ecological restoration component of the Green Galapagos 2050 project.

The implementation of actions for sustainable agriculture will be done in coordination with the MAGAP in order to attain a coverage of up to 25% of the agricultural areas on Santa Cruz Island intended for agricultural production in accordance with the zoning established by this government institution, in accordance with the Bioagriculture Plan for Galapagos (MAGAP, 2014) (Figure 22).2014) (Figure 22).

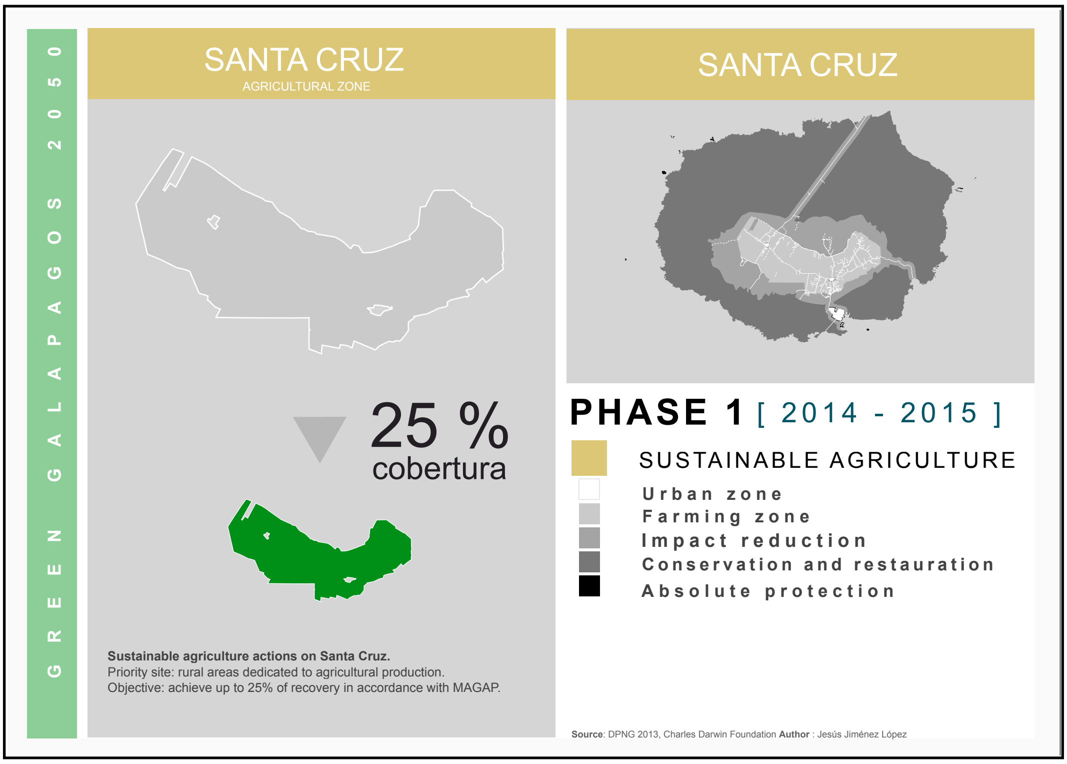


Figure 22. Informational map showing the scope of Phase 1 in the sustainable agriculture component of the "Green Galapagos 2050" project on Santa Cruz Island.

PHASE 2 (2017-2018)

During this phase, ecological restoration work will be done in priority ecosystems on Floreana according to the prioritization made with strategic partners based on workshops, field trips and studies in strategic sites (Jaramillo, 1998; Jaramillo and Tapia, 1999; Simbaña and Tye, 2009; Tye, 1997; Tye *et al.*, 2001) . To implement actions aimed at achieving sustainable agriculture, consideration is being given to cover up to 100% of the rural area used for agroecological production, based on whatever intervention plan is defined by the MAGAP for this island (Figure 23).

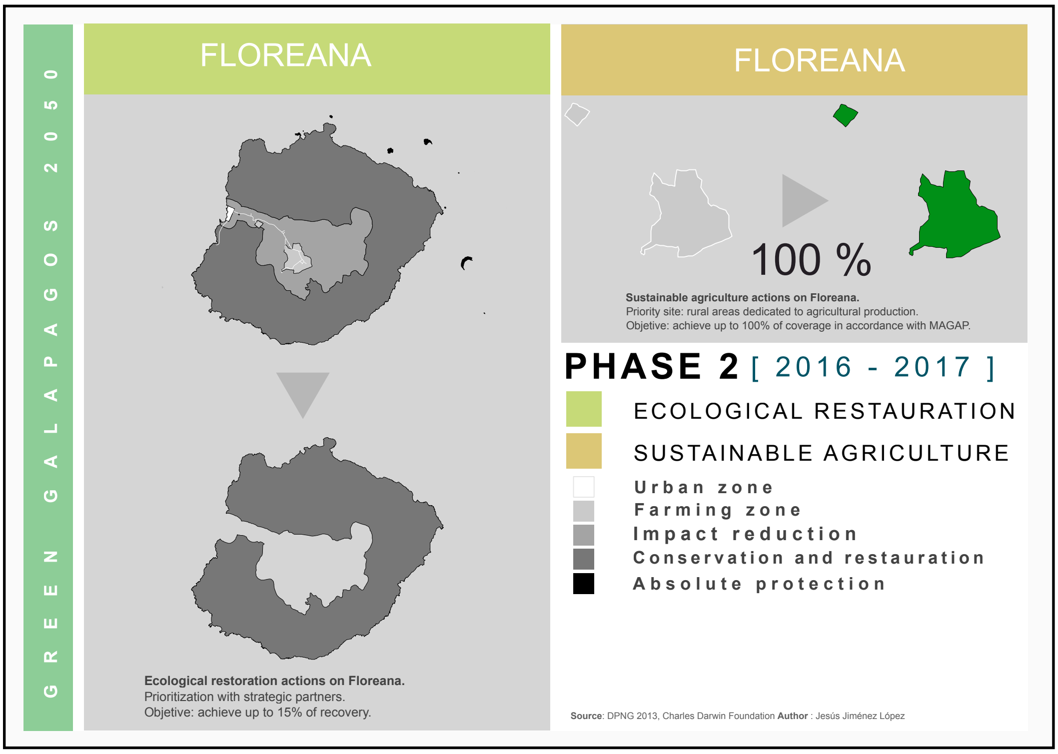


Figure 23. Informational map showing the scope of Phase 2 in the ecological restoration component of the "Green Galapagos 2050" project on Floreana Island.

On the island of Española, the goal will be to achieve a restoration of at least 20% of the cactus (*Opuntia megasperma* var. *Orientalis* Howell) population. Due to the impact caused by introduced goats, this work is needed in order to maintain interactions between this endemic cactus and the giant tortoises. (Blake *et al.*, 2011; Coronel, 2002; Gibbs *et al.*, 2008) (Figure 24).

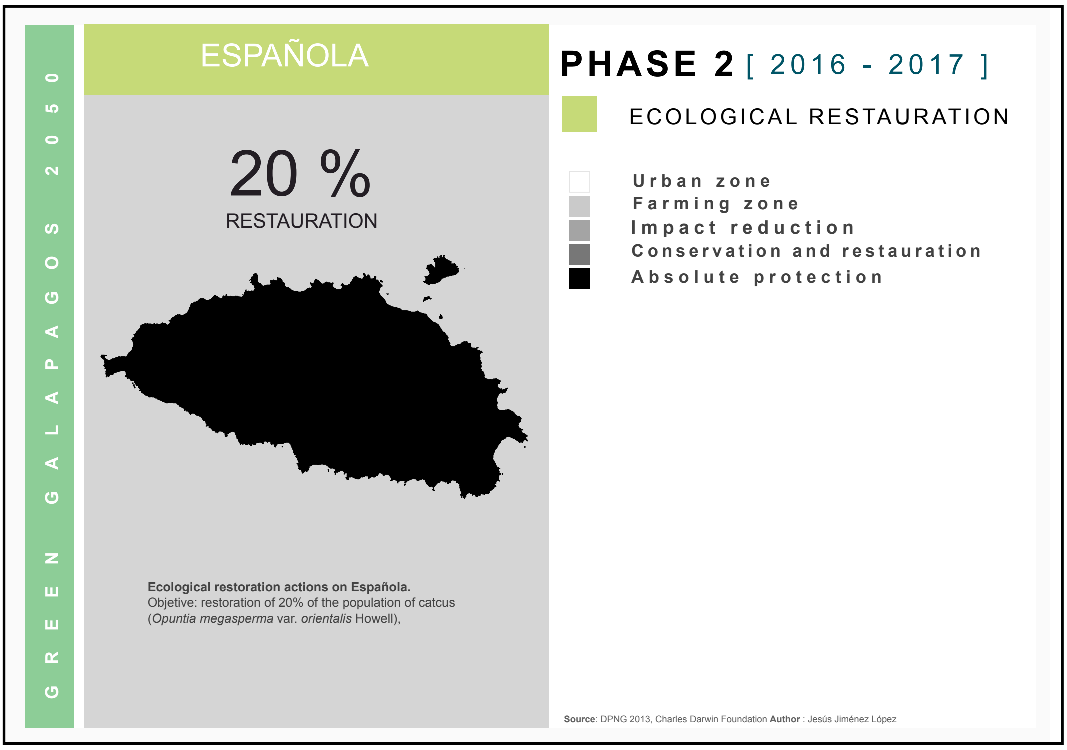


Figure 24. Informational map showing the scope of Phase 2 in the ecological restoration component of the "Green Galapagos 2050" project on the island of Española.

PHASE 3 (2019-2050)

The plan is to project the benefits of Groasis Technology to restore priority ecosystems on all inhabited islands, and uninhabited islands such as Santiago, Española and Plaza Sur that, in accordance with Management Plan for the Protected Areas on Galapagos, are considered priorities for restoration. In addition, more emphasis will be given to the wetlands where – as has already been mentioned – several endemic species, such as *Scalesia sp*. continue to decline drastically.

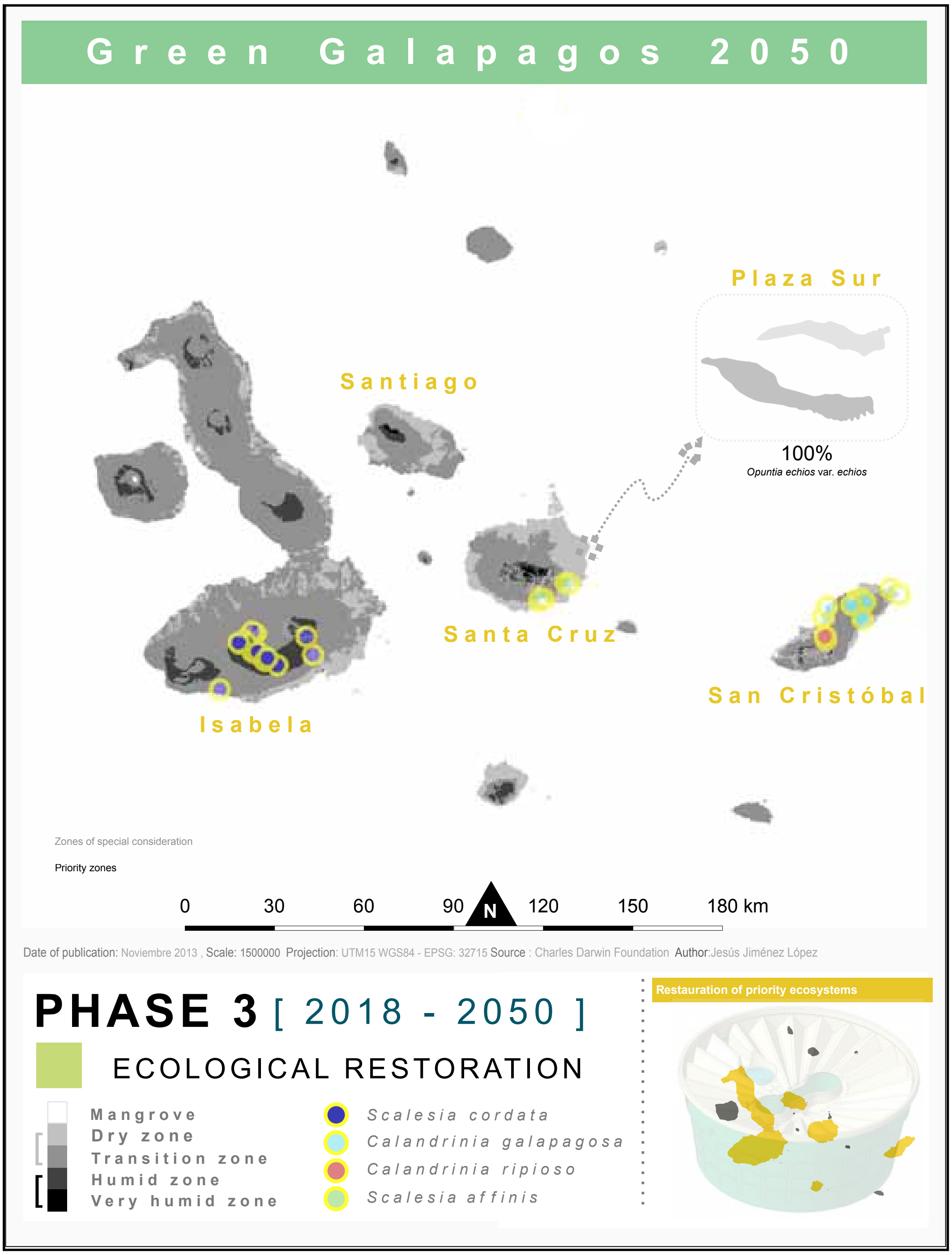


Figure 25. Informational map showing the scope of Phase 3 in the ecological restoration component of the "Green Galapagos 2050" project on the island of Española.

Transitional and dry areas where populations of endemic species are critically endangered will also be taken into consideration, such as the case of *Scalesia affinis* on Santa Cruz Island, *Calandrinia galapagosa* on San Cristobal, *Scalesia cordata* on Isabela Island, and several species of the *Darwiniothamnus genus* on Isabela, Santa Cruz, Floreana, and Santiago Islands (Atkinson *et al.*, 2010; Gardener *et al.*, 2010; Hicks and Mauchamp, 2000; Itow, 1992; Jaramillo *et al.*, 2011; Jaramillo and Chávez, 2007; Mauchamp and Atkinson, 2008-2009; Nielsen *et al.*, 2000; Rentería and

Buddenhagen, 2006; Simbaña, 2007; Simbaña, 2002; Yanez *et al.*, 2003). On Plaza Sur, the plan is to recover 100% of the population of *Opuntia echios* var. echios Howell, which has decreased drastically (Snell *et al.*, 1994) (Figure 25).

As for the implementation of actions for sustainable agriculture, the plan is to cover 100% of the agricultural area used for agroecological production at the regional level with short-cycle products (populated islands) according to the zoning established by MAGAP and based the new model of agricultural production on the islands (MAGAP, 2014) (Figure 26).

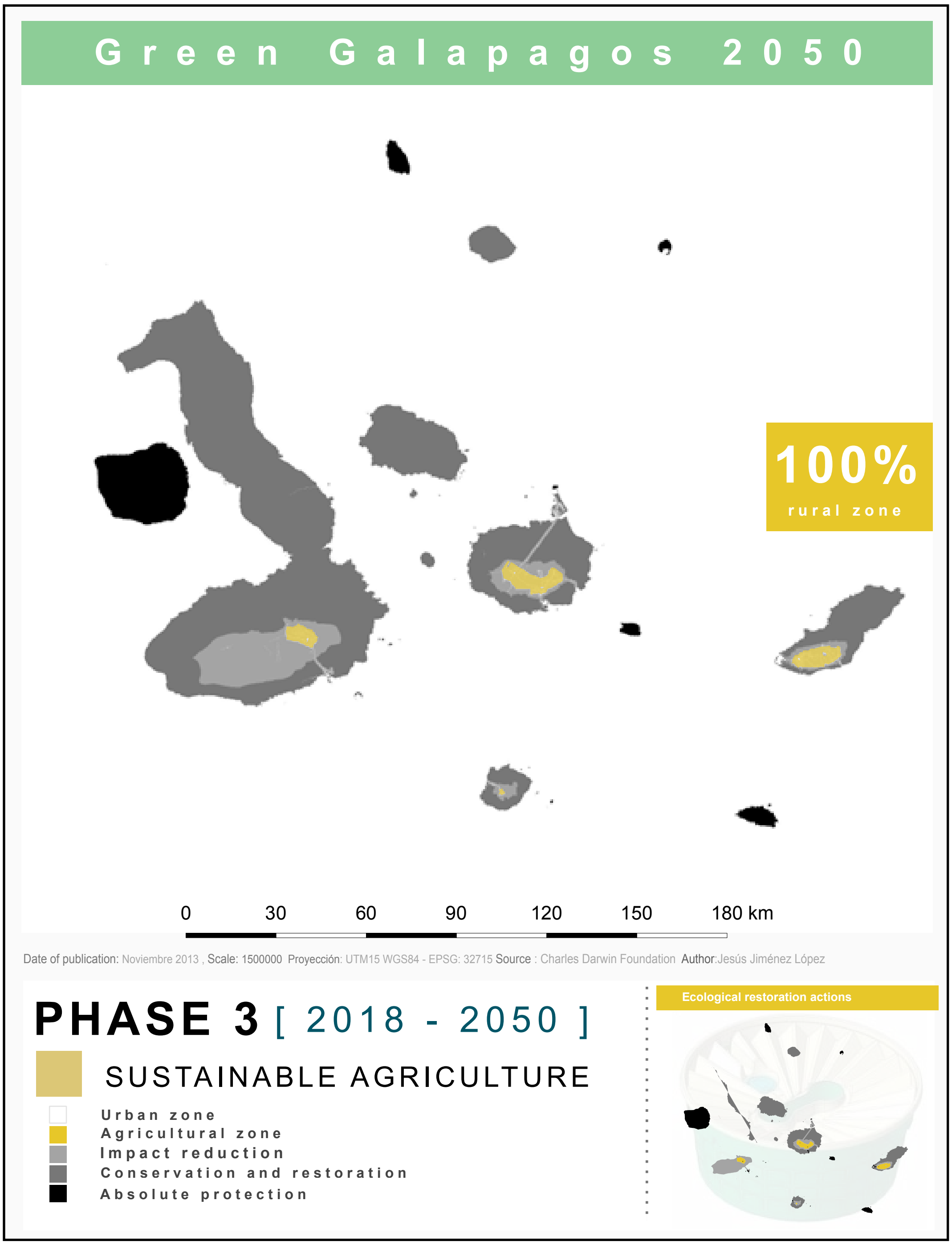


Figure 26. Informational map of the scope of Phase 3 in the sustainable agriculture component of the "Green Galapagos 2050" project on Santa Cruz Island.

WHY IS
GREEN GALAPAGOS 2050
ECONOMICALLY VIABLE?

Green Galapagos 2050 is a multi-institutional and interdisciplinary initiative. Its implementation is not only based on technical and scientific parameters, but in the sum of experience in scientific investigation, management of protected areas, sustainable production and, particularly, the restoration of ecosystems by means of megaprojects involving the eradication of feral mammals presented by organizations that function as the project's strategic partners. Additionally, the Charles Darwin Foundation (CDF) is responsible for project coordination. This organization has more than 50 years of experience in contributing to the protection of the archipelago. Based on such a variety of experiences, this innovative plan is presented with the goal of, on the one hand, and as is understandable, contributing to the sustainability of Galapagos by means of restoration labors and sustainable agriculture, and on the other hand, becoming an example to show the world that sustainable development is possible.

One of the major problems that the archipelago faces as regards achieving sustainability is that of introduced species, not only those that are already present and have a severe impact on some ecosystems and species, but also those that, despite preventative efforts, are continually entering associated with agricultural products that are imported for human needs. Therefore, by implementing Green Galapagos 2050, the central points of which are the ecological restoration of degraded ecosystems and sustainable agricultural production, a holistic solution that involves putting the sustainability cycle into practice is clearly proposed. This solution includes:

a) Contributing to the restoration of degraded ecosystems for the purpose of recovering and/or maintaining its capacity to produce services for human beings.

b)Control and/or eradicate invasive species in areas of high ecological value.

c) Accelerate the recuperation process of native and endemic archipelagic species that have a very slow natural growth rate.

d) Decrease the risk of the entry of foreign species by means of sustainable agricultural production, which implies contributing to local self-sufficiency.

e) Contribute to energizing the economy by means of sustainable agricultural production, throughout the year.

All of the aforementioned entails contributing to the well-being of the human population of Galapagos, which is in line with the National Plan for a Good Standard of Living, as well as the Millennium Development Goals, which is the only intelligent way to ensure the sustainability of the archipelago, and therefore, the best investment that anyone could make.

ANALYSIS OF THE INVESTMENT REQUIRED FOR THE IMPLEMENTATION OF THE

GREEN GALAPAGOS 2050 PROJECT

LOCAL SOCIO-ECONOMIC CONTEXT

The Galapagos Islands have a population of more than 25,000 people. (INEC, 2010a; INEC, 2010b). The cost of living on the islands is higher than on the Ecuadorian mainland, due to their isolation from the latter. This is reflected in the basic salaries that are paid in the islands and the general costs of goods and materials. On the other hand, the isolation and limited development in the areas of the Galapagos National Park means that the logistics of bringing materials and equipment from the continent is costly, as well as is internal transportation.

The insularity and the volcanic nature of the islands present another distinctive feature: the scarcity of natural resources. This is especially the case on those lands that are underdeveloped. Natural water resources are also limited. Not to be overlooked is the fact that climatic conditions are very variable from one year to the next.

This context highlights the importance of having technology available that: 1) is easy to transport; 2) has a long useful life; 3) is capable of being implemented in zones with different substrate and weather characteristics; 4) saves water; 5) does not require a considerable amount of specialized labors or equipment; 6) that trains local inhabitants; and, 7) that is not very costly.

CURRENT SITUATION

The pilot phase of the program had the financial support of the ComON Foundation. It lasted approximately eight months, in which field tests involving the effectiveness of Groasis Technology and its economic viability were carried out, both for ecological restoration and agricultural production, as shown by the section named “Preliminary Results of the Pilot Project” of this document.

CRITERIA FOR FINANCING

It is evident that, in order to carry out an ambitious project, with clear objectives and the execution of which involves various stages, it is necessary to have sufficient economic resources available. In this context, this section will explain the general guidelines to be considered for the implementation of Green Galapagos 2050, from the financial standpoint and with a high level of efficiency and effectiveness.

Once resources have been obtained, they will be administered by the CDF and will serve to finance all required activities required for the implementation of the project, which will include, among others: acquisition of equipment and materials, payment of salaries, payment of scholarship students and volunteers, research activities, restoration and agricultural production, etc.

Ensuring long-term financing of Green Galapagos means guaranteeing financial sustainability until the objectives and vision of the project have been achieved. This document is not designed to formulate the project's "financial strategy". However, it does describe the aspects to be considered as regards development of said strategy as well as to demonstrate to any reader that, in spite of the project's cost, it is technically and economically viable.

CRITERIA FOR DONORS

A minimum of five hundred million dollars is needed for full implementation of Green Galapagos 2050, which will be raised from various financial non-governmental sources and international cooperation agencies. These funds will be managed according to the following criteria:

- Consideration of various sources that ensure backup funds in the event that one of the sources fails or is not usable.
- Access to public funds provided in kind by the institutional parties of the collaborating agencies. It is hoped that governmental agencies will assume this responsibility in the future.
- Donations from international bodies and non-governmental organizations. The ideal situation would be that conservation and sustainable development of Galapagos would not have to depend on donations from international bodies. However, the reality is that international resources and funds are of prime importance in order to achieve the project's success.
- The private sector is a potential source of financing for conservation projects. Therefore, the necessary and appropriate legal, administrative and financial instruments must be established, in order to foster this alternative and offer incentives to those companies and individuals interested in collaborating with the conservation of Galapagos' ecosystems by means of the Green Galapagos 2050 project.

PHASE 1 - REQUIRED BUDGET: 2014-2017

Phase 1 of the project includes:

1. The restoration of at least 50% of the surface area of Baltra, in which, due to having been used as a military base during the Second World War, there is a high level of degradation. That is why, although it is part of the Galapagos National Park, its ecosystems are completely unsettled, and technology will be required to achieve its restoration up to a level that would have been reached if there had been no human intervention;
2. The restoration of at least 15% of the invaded surface area by plants that have been introduced in the Los Gemelos area, also one hectare of *Scalesia affinis* in Santa Cruz;
3. As for agricultural production, the goal is to aid at least 25% of the farms on said island.

For this reason, the initial budget required for Sub-Phase 1 is six million six hundred thousand dollars ($6,600,000 USD).

PROJECT SUMMARY		
Sub-phase 1: Baltra - 2014	US$	$ 6.600.672
Sub-Phase 2: Baltra & Los Gemelos - 2015	US$	$ 6.633.809
Sub-Phase 3: Santa Cruz - 2016/2017	US$	$ 37.562.854
Sub-Phase 1 Survival Rate (90%)		133.650
Total HA Phase 1	ha	743
Phase 1 - Investment per hectare	US$	$ 8.890
Phase 1 - Nursery size (area)	m^2	831
Total Project Cost. Sub-phase 1 (Baltra 50% in 2014-2015)	US$	**$ 6.600.672**

INTEGRATION OF THE "GREEN GALAPAGOS 2050" PROJECT WITH LOCAL, NATIONAL AND INTERNATIONAL POLICIES

The Green Galapagos 2050 project is an initiative involving ecological restoration and sustainable agricultural production that will be implemented on a regional level. For this reason, it is perfectly adapted with current planning tools: on an archipelagic level with the Galapagos Plan for a Good Standard of Living for the Administration of Protected Areas, the Galapagos Bioagriculture Plan, and with what will be the Sustainable Development and Land Management Plan of the Special Regime for the Galapagos Islands; on the national level with the National Plan for a Good Standard of Living, and on the global level with the Millennium Development Goals of the United Nations (Chart 2 and Figure 27).

Table 2. The main planning tools at different scales with which the Green Galapagos 2050 is in alignment.

INSTRUMENT	SCALE	OBJECTIVES WITH WHICH GREEN GALAPAGOS 2050 COINCIDES
Sustainable Development and Land Management Plan of the Special Regime for the Galapagos Islands	Regional	Under construction
Management Plan for the Protected Areas on Galapagos for a Good Standard of Living (GNPD).	Regional	1. Manage the conservation of the Galapagos Islands' ecosystems and biodiversity in order to maintain their ability to generate services.
		2. Incorporate and coordinate conservation policies in protected areas into and with the Sustainable Development and Land Management Plan of the Special Regime for the Galapagos Islands in order to attain a rational use of the services of the archipelago's ecosystems.
		3. Increase and integrate interdisciplinary scientific and technical knowledge applied to the management of the interaction between ecosystems and the socioeconomic and cultural systems of the province of Galapagos within the context of Global Change (GNPD 2014).
Bioagriculture Plan for Galapagos (MAGAP)	Regional	1. Convert agriculture in the main human activity bearing co-responsibility for the conservation of the archipelago's natural heritage, particularly the control of invasive species, through the design and implementation of high-efficiency agroecological production systems.
		2. Contribute to the sustainability of the local economy through locally based production linkages and the organized participation of all stakeholders.
		3. Consolidate a research system based on knowledge sharing and knowledge dialogue, expanding the local capacity to create and innovate (MAGAP, 2014).
National Plan for Good Standard of Living 2013-2017 (SENPLADES)	National	7.12 Strengthen environmental governance of the special regime of the Galapagos Archipelago and strengthen comprehensive planning for the Amazon (SENPLADES 2013).
Millennium Development Goals (UN)	Global	7. Ensure environmental sustainability (ONU, 2013).

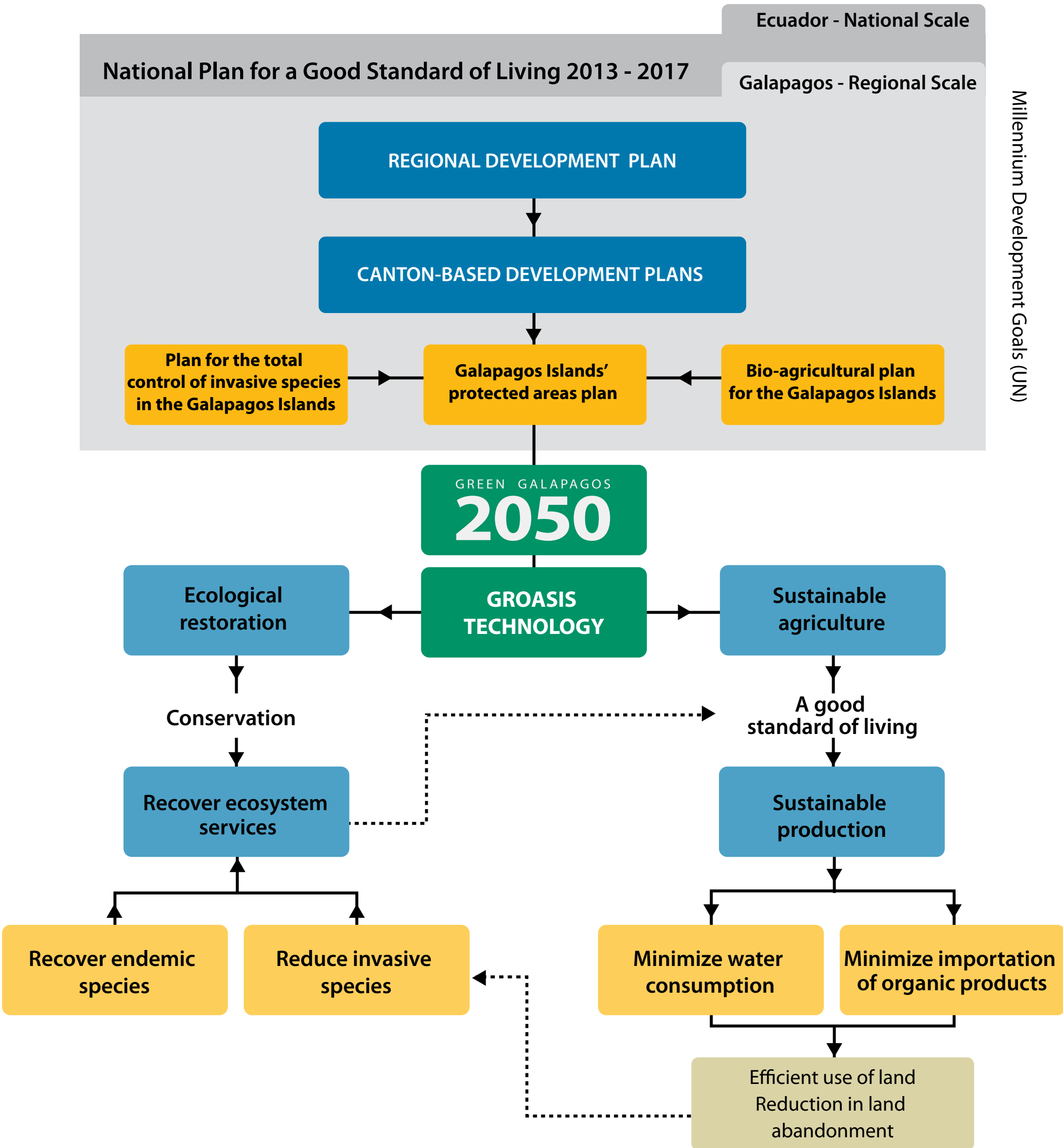


Figure 27. Integration of the "Green Galapagos 2050" project with the environmental policy at all management levels.

As can be confirmed in Figure 26, there is a perfect alignment between the "Green Galapagos 2050" and the various planning tools at different spatial scales (Regional, National and Global). It is also clear that the project's strategies with their MLAs seek to inescapably achieve conservation of the ecological integrity of the archipelago and good living of its inhabitants, using state-of-the-art technology as a tool that allows the reduction of invasive species and the optimization of the use of both agricultural land and the water, thus helping to maintain the capacity of ecosystems to generate services for the local population.

STRATEGIC PARTNERS OF THE GREEN GALAPAGOS 2050 PROJECT

The management of the archipelago to achieve its conservation and a good standard of living for the local population requires cooperative work among institutions as well as between these institutions and civil society. Consequently, "Green Galapagos 2050" did not want to be the exception to this management model, and since its inception has implemented actions to strengthen ties of cooperation among several strategic partners. This has undoubtedly been of great importance in obtaining good results from the pilot phase and is the guarantee for implementing the subsequent phases of this project (Figure 28).

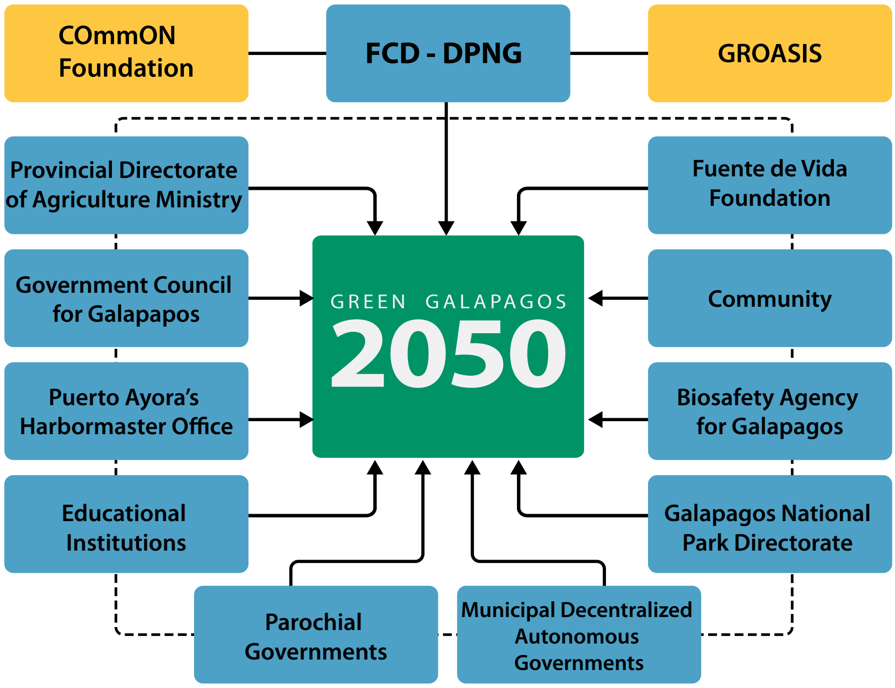


Figure 28. Strategic Partners for the Green Galapagos 2050 project.

TEAM OF STAFF FROM CHARLES DARWIN FOUNDATION RESPONSIBLE FOR THE GREEN **GALAPAGOS 2050 PROJECT**

PATRICIA JARAMILLO DÍAZ, PhD

Main Coordinator and Project Leader Senior Investigator
Biodiversity and Restoration, Charles Darwin Foundation

Green Galapagos 2050 is a large-scale project linking a new, attractive and useful technology to the implementation of an important part of the strategies of two of the priority programs in the "Management Plan for the Protected Areas on Galapagos for a Good Standard of Living" namely that of "Preservation and Restoration of Ecosystems and Biodiversity, and the Rational Use of Ecosystem Services". Moreover, by focusing on both ecological restoration and sustainable agriculture, it is not only a contribution to the conservation of the archipelago, but also an economic opportunity for the local people, since it can not only help to improve their production but also to control invasive species, and this is a double benefit. For these reasons, I strongly believe that the routine use of the Groasis Technology will be very important to helping restore endangered species of flora as well as agricultural production thereby entailing a decrease in the importation of products from mainland Ecuador.

PABLO CUEVA

Research Assistant, Charles Darwin Foundation

The Waterboxx project in the Galapagos Islands is of transcendental importance, not only because the goal is to optimize the scarcest and most valuable of resources – water – but because, the aim is to, by means of this project, regenerate deteriorated ecosystems. The institutions and the community have been involved in the project and thus have become aware of and begun to seek immediate solutions to the islands' problems.

ESTALIN JIMENEZ

Field Assistant, Charles Darwin Foundation

In the Galapagos Islands, we have areas of plants deteriorated by introduced plants and animals; there are arid zones where it is hard for plants to regenerate easily. The implementation of Groasis Technology "Waterboxx" is very important because it is a tool that, due to its features – such as saving water and accelerated plant growth compared to natural growth – shows us that in the future we can facilitate the reforestation of these areas with endemic and native plants that are very important to the ecosystem of the Galapagos Islands.

GABRIELA ORTIZ

Research Assistant, Charles Darwin Foundation

Galapagos is an example of both a natural and social system in action. In this particular context, Galapagos Verde 2050 is a project that fits well as it responds to the needs of both the conservation of ecosystems and the requirements of the welfare of its population. The scale of the proposal is both a challenge and an opportunity to show that both approaches can be part of a sustainable Galapagos.

JAIME ORTIZ, MSc

Outreach Program Coordinator and leader of Galapagos Green Pilot Project 2050 (March to December 2013). PhD Candidate in Natural Resources Cornell University. U.S.A.

Perhaps the Green Galapagos 2050 can be seen as a utopia for the Galapagos Islands. Achieving the restoration of the archipelago's deteriorated ecosystems is, without a doubt, a great challenge for all of us who live on these islands. In addition, meeting this goal of restoration and, at the same time, promoting sustainable development of the inhabitants of this "living laboratory" makes any restoration program seem impossible. Through the efficient use of water resources, Groasis Technology offers us a viable solution for achieving ecological restoration in an effective fashion while also promoting truly sustainable community development, with the latter effected through the transfer of technology aimed at promoting sustainable agriculture. This is how the Green Galapagos 2050 project can become that utopia we so badly need in the Galapagos Islands and which will help us on our path towards the ecological restoration of the islands and a good standard of living for its population.

IS GREEN GALAPAGOS 2050
IMPORTANT FOR THE WORLD?

The Galapagos Islands are not only a single territory, but everything is interconnected as well and – although administratively it is divided into different units – in practice the interconnections between these different territorial or management units are undeniable, because one must understand that each island is part of the archipelago, each canton is part of the province, the province is part of the Republic of Ecuador and the country is part of the planet.

Therefore, we must be aware that when we make decisions, we must assure not only the optimization of economic and financial resources but that our activities are framed within the capacity of the ecosystems, which are the basis of the development of local society, and the generation of conditions suitable to achieve human well-being in both the present and the future (DPNG, 2014; Tapia and Guzmán, 2013; Tapia et al., 2009; Tapia et al., 2008) (Figure 29).

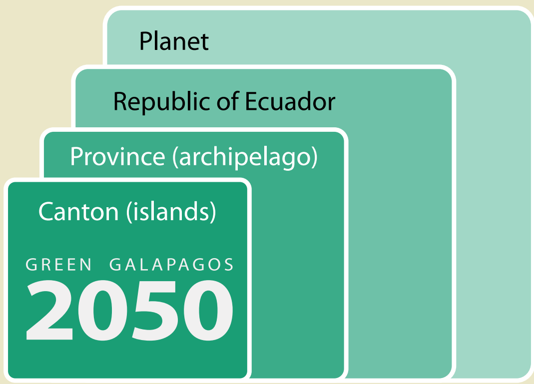


Figure 29. The social and ecological system of the Galapagos Islands, adapted from the Management Plan for the Protected Areas on Galapagos for a Good Standard of Living.

Against this background, "Green Galapagos 2050" is presented as a part of the solution in which political decision, science and community support must be combined in order to successfully implement a project for ecological restoration and sustainable development through agricultural production that will become a true model of sustainability throughout the world (Figure 30).

Figure 30. "Green Galapagos 2050" in the context of an integrated vision of management for the Galapagos Islands.

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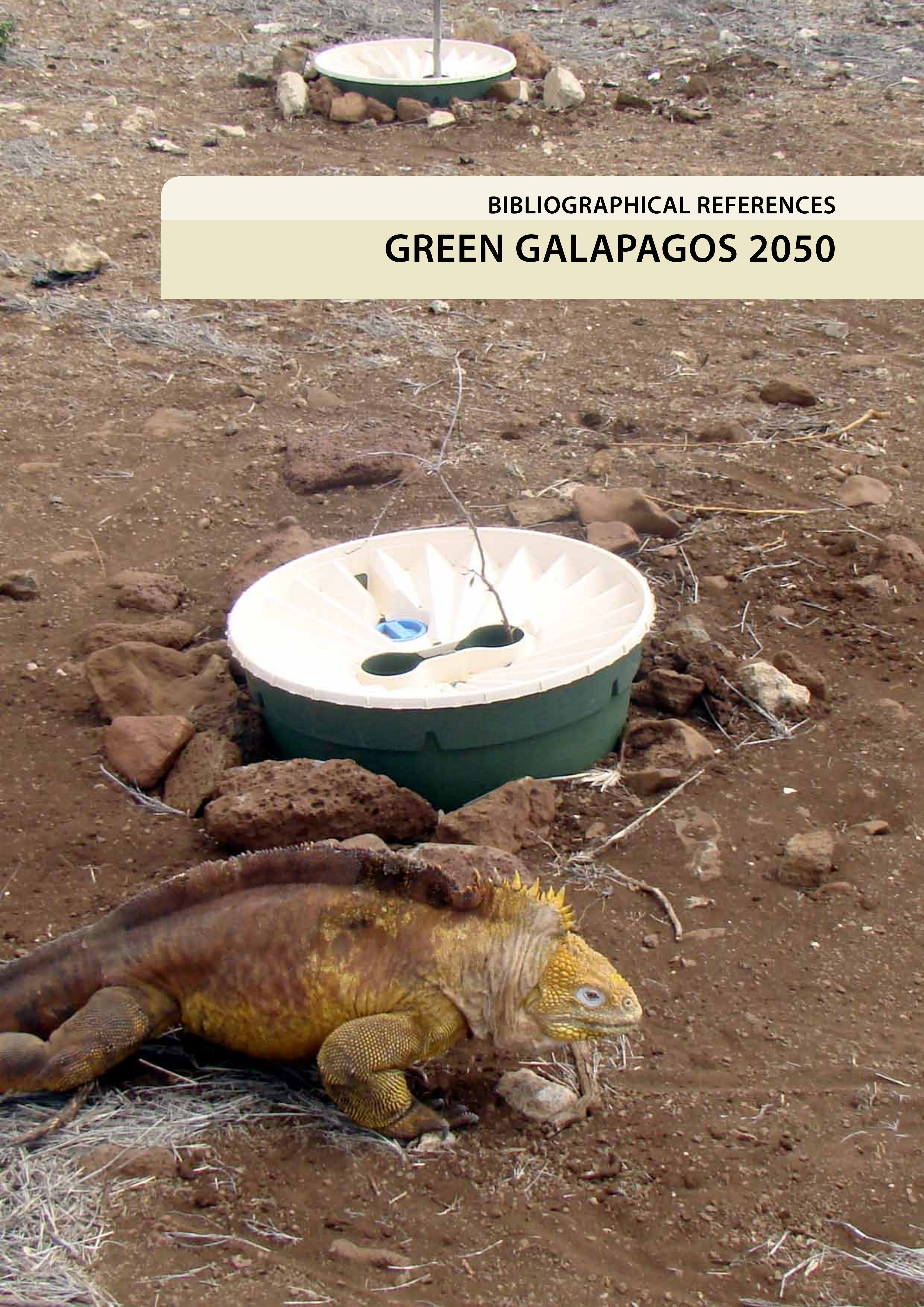

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APPENDICES

GREEN GALAPAGOS 2050

APPENDIX I
PLANT SPECIES PLANTED WITH GROASIS TECHNOLOGY ON SANTA CRUZ ISLAND

Amaranthaceae. *Alternanthera echinocephala*. Native.

Amaranthaceae. *Alternanthera filifolia*. Endemic.

Asteraceae. *Scalesia affinis*. Endemic.

Asteraceae. *Scalesia helleri ssp. santacruziana*. Endemic.

Asteraceae *Scalesia pedunculata*. Endemic.

Cactaceae. *Opuntia echios gigantea*. Endemic.

Celastraceae. *Maytenus octogona*. Native.

Convolvulaceae. *Ipomoea pes-caprae*. Native.

Rubiaceae. *Psychotria rufipes*. Endemic.

Sterculiacea. *Theobroma cacao L*. Introduced.

APPENDIX II
PLANT SPECIES SOWN ON BALTRA ISLAND USING GROASIS TECHNOLOGY

Mimosaceae. *Acacia macracantha*. Native.

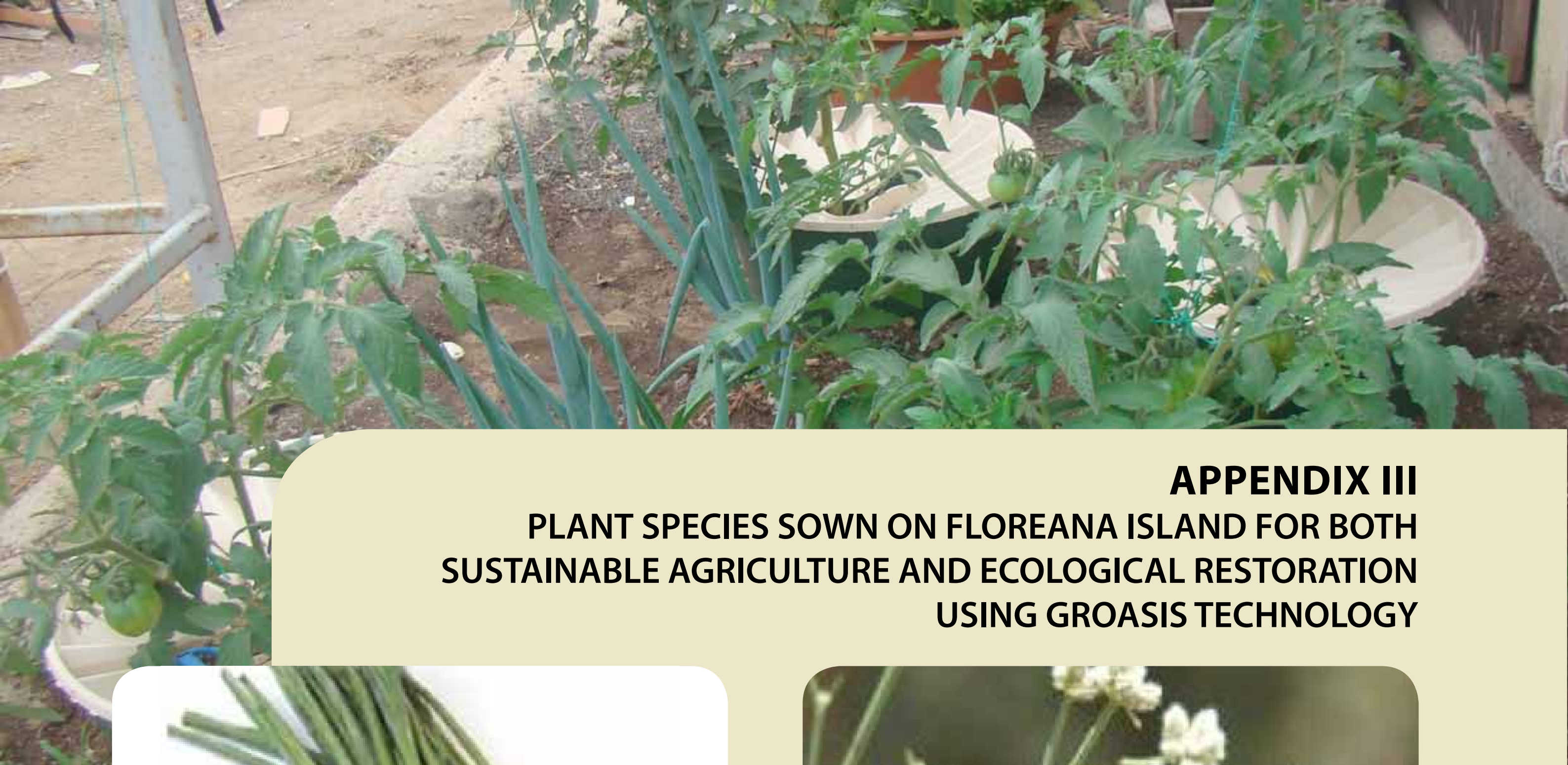
Burseraceae. *Bursera graveolens* (Kunth) T. Native.

Simaroubaceae. *Castela galapageia* Hook. F. Endemic.

Cactaceae. *Opuntia echios* var. *gigantea*. Endemic.

Caesalpinaceae. *Parkinsonia aculeata L*. Native.

Asteraceae. *Scalesia crockeri* Howell. Endemic.



APPENDIX III
PLANT SPECIES SOWN ON FLOREANA ISLAND FOR BOTH SUSTAINABLE AGRICULTURE AND ECOLOGICAL RESTORATION USING GROASIS TECHNOLOGY

Alliaceae. *Allium fistulosum L.* Introduced.

Amaranthaceae. *Alternanthera filifolia*. Endemic.

Annonaceae. *Annona cherimola Mill*. Introduced.

Burseraceae. *Bursera graveolens* (Kunth). Native.

Cannaceae. *Canna indica L*. Introduced.

Solanaceae. *Capsicum annuum L*. Introduced.

Caricaceae. *Carica papaya L.* Introduced.

Cucurbitaceae. *Citrullus lanatus*. Introduced.

Rutaceae. *Citrus reticulata Blanco.* Introduced.

Rutaceae. *Citrus x limon* (L.) Osbeck. Introduced.

Rutaceae. *Citrus x sinensis* (L.) Osbeck. Introduced.

Verbenaceae. *Clerodendrum molle* Kunth. Native.

Arecaceae. *Cocos nucifera L*. Introduced.

Boraginaceae. *Cordia lutea Lam*. Native.

Cucurbitaceae. *Cucumis melo* L. Introduced.

Asteraceae. *Darwiniothamnus tenuifolius*. Introduced.

Euphorbiaceae. *Jatropha curcas* L. Introduced.

Asteraceae. *Lecocarpus pinnatifidus*. Decn.

Linaceae. *Linum cratericola Eliasson*. Endemic.

Verbenaceae. *Lippia salicifolia* Andersson. Endemic.

Anacardiaceae. *Mangifera indica* L. Introduced.

Apocynaceae. Nerium oleander L. Introduced.


Lamiaceae. *Ocimum campechianum* Mill. Introduced.


Lauraceae. *Persea americana* Mill. Introduced.


Plumbaginaceae. *Plumbago scandens* L. Native.


Rubiaceae. *Psychotria angustata* Andersson. Endemic.


Asteraceae. *Scalesia affinis* Hook. f. Endemic.


Asteraceae. *Scalesia pedunculata.* Endemic.


Aizoaceae. *Sesuvium portulacastrum* (L.) L Native.


Solanaceae. *Solanum lycopersicum* L. Introduced.

Sterculiaceae. *Waltheria ovata* Cav. Native.

Rutaceae. *Zanthoxylum fagara* (L.) Sarg. Native.