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Actions to Restore Degraded Soil in the Southern Coastline of Guantanamo

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ABSTRACT

In the southern coastline of the province of Guantanamo, Cuba, there are communities that have lost several hectares of soil and biodiversity due to land mismanagement. "*Los Cerezos*" community is located in the municipality of Imias, as part of the "*Eliomar Noa*" UBPC (Basic Unit for Cooperated Production), which uses 99.2% of their areas for livestock raising. The land is on hills covered with xerophytic bushes; signs of degradation are clearly observed. Restoration is one alternative to revert this situation. It constitutes an effective preservation technique implemented by man to achieve optimum recovery of degraded ecosystems close to their original states. The aim of this paper is to evaluate the results achieved after recovery of local soils, using restoration techniques. Research was done in a fragmented forest, on typical red-brown fersiallitic soil, where the limiting factors were determined (rills, slopes, effective depth, organic matter content, rocks, and erosion), as well as other negative factors that may have an effect on vegetation growth. Common Ligum-vitae (*Guaiacum officinalis* L.) was used for reforestation due to its adaptability to the ecosystem. The restoration works helped create the conditions for progressive recovery of the areas and mitigate soil degradation, with a decrease in losses of 1 036 t. ha^{-1} every year, thanks to barrier accumulation.

KEY WORDS/: *Guaiacum officinalis*, erosion, restoration, preservation, reforestation

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INTRODUCTION

The forests from the southern coastline are scattered and sparse, mainly due to widespread felling in previous years. In addition to it, the natural dry conditions of the lands did not favor the development of exuberant forests. González (1999) claimed that the main reasons for local deforestation comprised tree felling for construction of warehouses, homes and furniture; cattle expansion; and burning wood for the sugar industry, homes and pottery.

In addition to it, the geography of the area is strikingly unique. Hills covered with xerophytic brushes are found in most of the site, mainly used for sheep, goat and cattle raising. Extensive agriculture is applied by cooperatives and single farmers, whose limited financial resources hamper livestock rotation (Urquiza, *et al*., 2009).

These ecosystems are highly degraded or destroyed, and have lost their regeneration mechanisms. Consequently, it is important to provide assistance in the form of active or assisted restoration (directed or assisted succession). Active restoration implies human intervention to help the ecosystem overcome the stress that causes the lack of regeneration, and guarantee the implementation of restoring processes (Vargas, 2011).

One alternative to recover the degraded areas is known as ecological restoration, that backs up restoration of a degraded, damaged or destroyed ecosystem (SER 2004; Clewell *et al*., 2005). All that occurs in addition to restoration of the environmental conditions (vegetation, flora, fauna, water and soil) of the altered ecosystem (Aronson *et al*., 2007) and an increase in ecosystem resilience (Lamb *et al*., 2011).

This process is not only directed to rescue species, but also interactions and ecological processes in which the species are related to one another and to the abiotic environment (Jiménez *et al*., 2002). Overtime, they can recover their structure, composition, species diversity, and function close to their original state.

Matos and Ballate, (2006) considered it as the most effective preservation technique to achieve the optimum recovery of degraded ecosystems, by means of human intervention, closest to their original conditions, because it relies on particular species of the ecosystem, and it is directed to the recovery of local or regional habitats, their diversity, abundance, dynamics, and physignomic traits. This technique includes the study of plant species development since their early phases, until maturity (physiology and reproduction). Also included are soil studies, physical changes, study of plant biological diversity, integration of soil organisms, food production for humans and animals, erosion control and soil fertility (Sol *et al*., 2001). In other words, social, economic and scientific factors affecting spaces, people, expectations and different interests must be correlated (Jiménez *et al*., 2002).

Therefore, the aim of this paper was to make ecological restoration actions for degraded soil recovery in the southern coastline of the province of Guantanamo.

MATERIALS AND METHODS

The study was made between February 2014 and October 2016, at *Eliomar Noa* UBPC (agriculture cooperative), located between *Sierra del Purial* and the southern coast, known as *Los Cerezos*, municipality of Imias, province of Guantanamo.

The area is semi desert, with high temperatures throughout the year, and tending to rise. The annual mean is 26.6 ºC. Relative humidity increases from the coast into the mountains and northern tier, with annual means of 84 and 86 %. Rainfall is very scarce, only 554.0 mm annually, and there is a significant seasonal variety (Baza, 2012).

The research area was chosen within a xerophytic forest from which tree species were identified by random systematic samplings (Bisse, 1988), on rectangular lots of 500 m^2. Its current state was assessed and the relative abundance of the species was calculated, according to Lamprecht (1990) and Keels *et al*. (1997).

Absolute abundance (Aa).	Relative abundance (Ra).
Aa = Number of individuals within a species	Ra = Number of individuals within a species x 100 Sum of Aa in all the species

The limiting factors (rills, slopes, effective depth, organic matter content, rock accumulation and erosion), derived from a genetic study of soils in the province of Guantánamo (Soil Map Scale 1:25 000, 1990), according to the methodology established by the Ministry of Agriculture (1982), with the application of Genetic Classification (1975), and correlation with the New Version (Hernández *et al*., 1999).

Two hectares were chosen for rehabilitation works. Reforestation was made especially intensive on barren patches, in small groups, according to the methodology used by Matos and Ballate, (2006). Additionally, the existing rills were stabilized, according to Fuentes and Martínez (2001). The soil preservation actions were implemented according to Cuban Standard NC 881:2012

The methodology described in the manual for MST procedures (Urquiza *et al*., 2011) was used to determine soil retention at the barriers.

Guaiacum officinalis L plantlets from the Cajalbo nursery, Integrated Forest Company of Imias, were used. They were planted in 30 x 40 cm holes, along levelled curves, in clusters of three, at 2.5 x 2.5 m. Wormcasting was applied at 2.5 Kg/ hole.

Care to plantations was made according to Álvarez and Varona (2006), and the soil was covered with plant stalks to prevent water evaporation and weed sprouting. The survival percentage was evaluated every six months.

RESULTS AND DISCUSSION

Examination of the xerophytic forest showed fragmentation caused by the destruction of the habitat due to human activities, agriculture and livestock raising, which can turn natural ecosystems into segmented landscapes of vegetation patches.

The forest inventory resulted in 62 individuals spread in 14 species and 14 genera from 12 families (Table 1), *G. officinalis* and *L. leucocephala* were the most abundant species, with more than 10 individuals, which confirmed *G. officinalis* adaptability to soil and climate conditions in the area. The *Mimosaceae* family outstood for its abundance.

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Table 1. Flower inventory and abundance in the xerophytic forest, in *Los Cerezos*, Imias.

Family	Common name	Scientific name	Aa	Ra
Boraginaceae	Baria	*Cordia gerascanthus L*	2	1.64
	Raspa lengua	*Bourreria virgata var virgata*	8	6.56
Caesalpinaceae	Carbonero	*Cassia tora L*	5	4.1
Clusiaceae	Espuela de rey	*Rheedia polyneura urb*	3	2.46
Erythroxylaceae	Frijolillo	*Erythoxylon rotundifolium Lunan*	6	4.92
Fabaceae	Yamaquey	*Belaria mucronata Grises.*	5	4.1
Meliaceae	Caoba antillana	*Swietenia mahagoni (L.)Jacq*	2	1.64
Malpighiaceae	Palo bronco	*Malpighia albiflora ssp. Antillana*	7	5.74
Mimosaceae	Leucaena	*Leucaena leucocephala (Lam) de Wit*	11	9.02
	Sickle bush Marabú	*Dichrostachys cinerea (L.) Wight & Arn*	6	4.92
Oleaceae	Negra cuba	*Thouinia sp div.*	5	4.1
Sterculaceae	Guásima	*Guazuma ulmifolia Lam*	4	3.28
Titiliáceae	Guásima baria	*Luehea speciosa Willd*	5	4.1
Zygophyllaceae	Guayacán	*Guaiacum officinalis L*	13	10.66

Aa: Absolute abundance   Ra: Relative abundance

Trees and xerophytic shrubs were predominant, with year-round foliage, some had thorns or dented thorny leaves, like Agaves, cactus Stenocereus fimbriatus (Lam.), Yamaguey (Belaria mucronata Grises), Espuela de Rey (Rheedia polyneura urb), Negra Cuba (Thouinia sp) and Guayacán (Guaiacum officinalis L.), the most predominant species in the association.

Other authors have highlighted the presence of those trees and shrubs as part of vegetation to determine the classification of plant formations (Bisse 1988). These plants are strongly influenced by various xerophytic trees, and can be classified as dry brushes.

The results suggest that this particular forest had species with little value, and secondary vegetation, like L. *leucocephala*, G. *ulmifolia* Lam, D. *cinerea* and *C. Tora* (Álvarez and Varona, 2006) who said these are fast growing species that live in the forest, where the native vegetation has been destroyed, mostly due to human intervention, including agriculture. As a result, the habitats have been affected, turning into scattered landscapes or vegetation patches.

The presence of invading species like L. *leucocephala* and D. *cinerea* in vast extensions may have effected on the poor generation of native species. Oviedo, *et al* (2012) made reference to the impact caused by the plant on other species, so it was reported as an invading plant in the national inventory of such species in Cuba. Regalado, *et al* (2012) said that these are exotic species with

self-replaceable populations over several life cycles, producing abundant fertile offspring at considerable distances from their parents or the introduction sites, and with the capacity to widespread and cause considerable damage to other plantations.

The area selected for restoration is on fersiallitic red-brown soil, lixiviated, on basic igneous rocks and saturated. It has shallow lithic manifestations, partly humid, with strong erosion, sandy, gravelly (16-50%), rocky (0.2-3%). The effective depth in the highest spot is 10 cm, and 20 cm in the lowest. The slopes are very wavy (8.1-16.0%), with excessive drainage.

The KCl pH was slightly alkaline (7.41), (MINAG, 1984). Organic matter (OM) was considered high 4.47%. Assimilating phosphorous (P2O5), 2.00 mg.100g^{-1} was low, whereas assimilating potassium (K2O), 50.0 mg.100g^{-1} was high. The deeper the area, the lower the values for either case.

Considering the limiting factors identified, a number of actions were taken to improve and preserve soils as a way to fight the negative impact of erosion observed in most areas. Some of them were setting barriers (63) and rill correction (17). As a result, 1 036 t of soil was retained.

Analysis of G. *offinalis* survival (Table 2) showed that it was initially able to withstand the environmental conditions, since no deaths were observed during the period. It may be related to the effects caused by forestry actions taken to preserve the species, which also included irrigation. In that sense, Álvarez and Varona, (2006) claimed that to achieve adequate survival in the first months after plantation, there must be optimum soil preparation on the plantation site, along with proper agrometereological conditions.

Table 2. Survival percent of species in the areas evaluated

Area of scattered forest	Survival percent (%)			
	6 Months	12 months	18 months	24 months
Guaiacum officinalis L	100	80	78	78

Different results were found 12 months after, with a decline in survival percent, which may have been influenced by several factors, including the lack of water for irrigation, animal grazing, and lack of rainfall.

Nevertheless, the guayacan stakes could withstand the extreme drought, due to its slow growth, which can live in very poor limestone soils, with rocks and near the coast and the mountains. Therefore, this species can be used in dry forests as an alternative to restore degraded areas. John

(1993) and Ponce and Jiménez, (2003) reported positive results for this species in degraded areas with high salinity.

As to climate in Baza (2012), it was considered as a semiarid area, in which precipitations are scarce, with annual means of 550 mm. It also describes inter-annual variability and the presence of quasi-permanent drought processes.

The application of that result will allow to set up the initial steps to recover degraded areas in the community studied, which will contribute to the balance of these kinds of ecosystems. In that sense, Barrera (2005) claimed that enrichment of degraded forests during early stages is important to achieve ecological restoration, whose purpose is to recover the lost features of structure and function in altered areas.

CONCLUSIONS

The restoration actions taken helped create the conditions for progressive recovery of the areas and mitigate soil degradation, with a decrease of 1 036 t . ha^{-1} of lost soils every year, through barrier accumulation.

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