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FOREST MANAGEMENT PROPOSAL IN "PUNTA LA CUEVA" FARM, CIENFUEGOS MUNICIPALITY

PROPUESTA DE ORDENAMIENTO FORESTAL EN LA FINCA "PUNTA LA CUEVA", MUNICIPIO CIENFUEGOS

José R. Mesa Reinaldo[1]
E-mail: jrmesa@ucf.edu.cu
ORCID: https://orcid.org/0000-0001-5987-4528
Gladys Vega Córdova[2]
E-mail: gladysvega849@gmail.com
ORCID: https://orcid.org/0009-0005-4973-1511
Juan Manuel García Bacallao[1]
E-mail: jmgarcia@ucf.edu.cu Teléfono: 43549846
ORCID: https://orcid.org/0000-0002-8628-2437
Ileana Fernández Santana[3]
E-mail: ileana@jbc.cu
ORCID: https://orcid.org/0009-0009-7254-4721
Emilio Bermúdez Cuellar[4]
E-mail: daisyemilio66@gmail.com
ORCID: https://orcid.org/ 0009-0009-2784-8064
Yudith Miranda Torres[1]
E-mail: ymiranda@ucf.edu.cu
ORCID: https://orcid.org/0000-0001-9799-1186
[1]Universidad de Cienfuegos "Carlos Rafael Rodríguez". Cienfuegos, Cuba.
[2]Cuerpo de Guardabosques Cienfuegos. MININT. Cienfuegos, Cuba.
[3]Jardín Botánico de Cienfuegos. CITMA. Cienfuegos, Cuba.
[4]CCS Dionisio San Román. ANAP Cienfuegos, Cuba.

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ABSTRACT

With the objective of developing a forest management proposal, which would demonstrate the compatibility between different forms of agricultural production and forests, this work was carried out during the period from April to November 2022, on "Punta La Cueva" farm.", Cienfuegos municipality, Cienfuegos province. For its development, an inventory of the forest biodiversity of the farm is carried out, the management developed on it and those that are compatible with forestry and livestock activities are identified. At the end of the work, a proposal is prepared for the organization of the forest area, the existing mangrove belt, the silvopasture area and the living fences, with which the forestry activity is reorganized, guaranteeing the confrontation with soil degradation and climate change, which constitutes the first proposal for forest management on a sustainable basis to the Peasant and Cooperative Sector of Cienfuegos, and will serve as a reference on the multifunctionality of the use of trees within agricultural systems. The obtained results to date are validated and it is determined that an annual economic impact equivalent to more than 988,656.30 CUP is achieved and 250.0 t of carbon are captured.

Keywords:

Climate change, sustainability, agroforestry.

RESUMEN

Con el objetivo de elaborar una propuesta de ordenamiento forestal, que permitiera demostrar la compatibilidad entre las diferentes formas de producción agrícola y los bosques, se desarrolló este trabajo, durante el periodo comprendido de abril a noviembre del 2022, en la finca "Punta La Cueva", municipio Cienfuegos, provincia Cienfuegos. Para su desarrollo, se realiza el inventario de la biodiversidad forestal de la finca, se identifican dentro los manejos desarrollados en la misma y aquellos que resultan compatibles con la actividad forestal y la ganadería. Al concluir el trabajo, se elabora una propuesta de ordenamiento del área boscosa, de la faja de manglar existente, el área de silvopastoreo y las cercas vivas, con la que se reordena la actividad forestal, garantizando el enfrentamiento a la degradación de los suelos y el cambio climático, la cual constituye la primera propuesta de ordenamiento forestal sobre bases sostenibles al Sector Campesino y Cooperati*vo* de Cienfuegos*,* y servirá de referencia sobre la multifuncionalidad del empleo de los árboles dentro de los sistemas agrícolas. Se validan los resultados obtenidos hasta la fecha y se determina que se alcanza un impacto económico anual equivalente a más de 988 656,30 CUP y se capturan 250,0 t de carbono.

Palabras clave:

Cambio climático, sostenibilidad, agroforestería.

INTRODUCTION

One of the biggest problems on the contemporary global agenda is climate change. It is unquestionable that its consequences for the planet can be catastrophic and that actions must be taken to reverse it, as well as to adapt to the scenarios it presents.

Taking into account this situation, agroforestry emerges as a productive alternative that contributes to the reduction of vulnerability and the impact of human activities on fragile ecosystems, since it creates a similar agroecosystem to the natural one before being intervened, protects soils from heavy rainfall, maintains the hydrological cycle and biological diversity, therefore, guarantees greater sustainability compared to systems such as monocrops (Torres et al., 2008).

Punta la Cueva farm is located on the road to the Hotel Punta La Cueva, km 3. It has a coconut plantation, with more than 45 years of exploitation, plantations of other fruit trees and various crops, a coastal area of 1, 0 km long, with a mangrove formation with associated forest that is highly anthropized and affected by climatic phenomena. It presents silvopasture areas with their perimeter fences and the lack of a coherent forest management policy is observed, although, a group of actions have been carried out to protect the mangrove, the associated flora to this formation and the remaining areas linked to the forestry activity. So, the objective of this work was to prepare a proposal for forest management of the farm and validate its fulfillment.

Body

MATERIALS AND METHODS

The research was carried out during the period from April to November 2022, on "Punta La Cueva" farm, Cienfuegos municipality, province of the same name. It is located at Latitude: 22.1160 and Longitude: -80.4269, in Punta La Cueva community, belonging to the Junco Sur neighborhood and is situated around the road to the Hotel Punta La Cueva.

To complete the research objectives, the following tasks were planned:

Study of forest biodiversity on the farm. Biodiversity inventory

To carry out the biodiversity inventory of forest and fruit species existing on the farm, the field work consisted of walking tours around the area with the objective to identify all the productive forms present, determining their extension as well as the different plant species in each one of them. For the identification of the present agroforestry methods, the proposal of Álvarez (2003) was taken into account.

In those areas where there are forest formations, an inventory was carried out using the method proposed by Mostacedo and Fredericksen (2000), in which, within each piece of ground of 10 x 20 m, 3 sub piece of ground of 1m x 1m were built (to carry out the inventory of the natural regeneration of the forest) two located at each end and the third in the center of the parcel, in which all the species of the natural regeneration were identified and recorded.

In the case of living fences and boundaries, an inventory of biodiversity was carried out, with the objective to achieve the economic, ecological and social functions of sustainable use, considering that the appropriate distance to complete the tree plantation should be 2.0 m between each tree in the fence.

The identification of the vegetable species was carried out through:

- Participation in field inventories of specialists from the Cienfuegos Botanical Garden.
- Taking photographic samples of them.
- Collection, herbalization and subsequent consultation and identification.

The identification of the indicator forest species for the type of forest formation was carried out based on the descriptions of scientific works such as: León and Alain (1951; 1953 and 1957), Capote and Berazain (1984), Rodríguez et al. (1988) and Bisse (1998).

The determination of endemism and threat categories in the flora of the study area was carried out in the latest edition of the bulletin "The 50 most threatened plants in Cuba" (González et al., 2016).

The determination of invasive species was done taking into account the work of Ricardo and Herrera (2017).

The determination of the appropriate number of samples for the study was carried out through the species-area curve method.

The Importance Value Index (IVI) was calculated, which indicates how important a species is within the community. The species with the highest IVI means, among other things, that it is ecologically dominant, that it absorbs many nutrients, and that it occupies more physical space (Curtis & Macintosh, 1951). The formula that was used:

(1) IVI= AR+DR+FR

Where:

AR (relative abundance) = (number of individuals of species i/total number of individuals of all species) x 100

DR (relative dominance) = (basal area of species i/basal area of all species) x 100

FR (relative frequency) = (absolute frequency of species i/ total absolute frequency) x 100

Once determined, the weighted IVI Classification was applied to estimate the ecological value of a species, proposed by Aguirre (2013):

- IVI: o – 33% unimportant species in the community (PI)
- IVI: 34 – 75% important species in the community (I)
- IVI: 76 – 100% ecologically very important species in the community (MIE)

The percentage of reforestation of living fences (Pcv) was calculated using the following formula

(2) Pcv: $\left(\frac{a}{a-b}\right) \times 100$

Where:

a: corresponds to the average number of trees present in the sampled sections.

b: corresponds to the average number of absent trees in the sampled sections.

Identification of the management developed on the farm that is compatible with forestry activit

To identify the management developed on the farm, compatible with forestry activity, the behavior of the different base systems for agroforestry was defined, applying the definitions of Álvarez (2003).

The following aspects were taken into account:

- Soil management in protected forest areas.
- Use of agroforestry methods compatible with the social purpose of the farm and environmental sustainability.
- Use of forest and fruit species.
- Pruning cycles and diversification of species in living fences.
- Use of FONADEF economic incentives for agroforestry.

Proposal for forest management compatible with forestry activity for the farm

When carrying out the corresponding analysis for the forest management proposal, the following were taken into account:

1. the current regulations in Law 85. Forest Law of 1999 towards those areas with special regulations (Section Two, Article 35):

- Protection zones (coastal belts, rivers and reservoirs hydroregulatory belts).
- Areas with slopes susceptible to erosion (+ 10%).
- Areas of interest for the defense of the country.

2. Those agroforestry activities that are financed by the National Forestry Development Fund (FONADEF) for state interest:

- Financing of reforestation of living fences.
- Planting trees in agricultural crop areas.
- Planting dispersed trees in livestock areas.

Elaboration of thematic maps about the current situation and perspective of the farm

In the elaboration of the thematic maps of the different productive forms present on the farm, the route was carried out bordering each of the present productive forms and those areas that should be reorganized with the use of a Garmin 78 GPS.

Once the current planning was determined and how the area should look in the future, the office work was carried out with the use of the free Geographic Information System QGIS 2.18, Las Palmas de Gran Canaria version.

Assessment of the ecosystem services provided by the farm

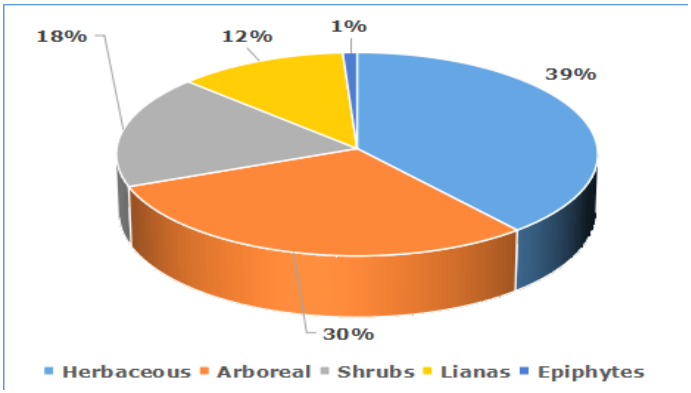
To carry out the evaluation of the ecosystem services provided by the farm, the ecosystem services provided by the farm and an economic estimate of the work were determined.

RESULTS AND DISCUSSION

Studies of forest biodiversity on the farm

When carrying out the study of forest biodiversity (Figure 1), a total of 67 plant species were identified, grouped into 33 families with the following life habits (%):

Figure 1. Behavior by life habit of forest biodiversity on the farm Punta La Cueva



As the herbaceous habit of life is the best represented in a forest ecosystem, it is indicative of a forest with low tree density, where open spaces with strong light intensity and abundant herbaceous species predominate, with incomplete tree occupation, no predominance on the forest soil of a natural tree regeneration and accentuated anthropization, which allows us to affirm that we are in the presence of a Forest with a high level of degradation.

These results coincide with those presented by Peri et al. (2017), which affirm that the density of regeneration allows us to differentiate between degraded and non-degraded communities, since null or little recruitment of tree species could produce significant changes in medium or long term on the recovery of native forest areas without upper

canopy cover; determining the different levels of degraded states.

When analyzing the behavior by forest biodiversity family on the farm, it was determined that the Malvaceae family was the most represented, with 8 species, followed by Boraginaceae with 6, and that there are 17 families, represented by a single species, which it endangers the biodiversity of the population, especially in an area close to the sea, where the climatic effects specifically cyclones become more notable. In contrast to the above, the most abundant families in relation to species richness do not group the majority of the individuals listed, as families were found represented by one or two species but with a large number of individuals, such as: Caesalpinaceae with only two species and a total of 59 individuals, typical behavior of ecologically altered forest areas and dominance of generalist or invasive species.

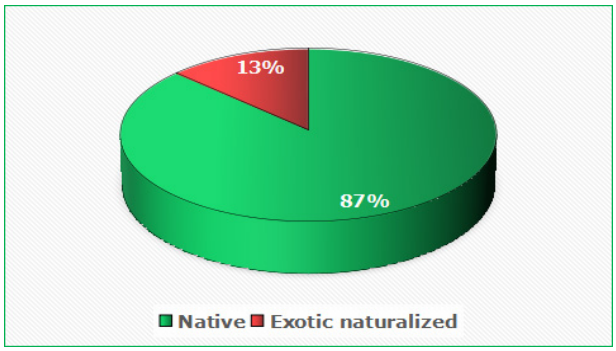
It is important to highlight that the predominance of herbaceous species observed, it is an indication of forest degradation and compromises the integral continuity future of the forest, since the competition developed for light and nutrients between small tree species and herbs has a negative impact in the mortality of young trees.

In this regard, Vistin, (2018) points out that anthropogenic actions increase the vulnerability of many plant species to adverse environmental conditions, also causing the creation of new habitats for other more general species such as exotic or invasive species.

Similar behavior was found by Jiménez, (2015) when studying the mesophilic semi-deciduous forest in the western sector of the "Sierra del Rosario" Pinar del Río biosphere reserve, where in the areas with the highest incidence of illegal cutting there was greater dominance of generalist species, which in conserved areas they are not dominant.

When studying the behavior of forest biodiversity in Punta La Cueva farm according to its origin (Figure 2), it was determined that a high percentage of the total species have the category of native, according to the classification criteria proposed by Acevedo and Strong (2012) and those of Greuter and Rankin, (2017).

Figure 2. Behavior of forest biodiversity according to its origin (%)



A total of 6 species classified as invasive are located in the studied population (Table 1), for 9% of the total. Knowing which plant species behave as invasive in the national territory, which are most aggressive at the current time, threatening Cuban biodiversity, and which could constitute a threat in the near future increases the probability of success in prevention management, early detection and control of these biological invasions, elements taken into account by the authors when developing the proposal.

Table 1. Classification of the invasive forest flora of the farm

Family	Common name	Scientific name	Origin
Boraginaceae	Glue berry	Cordia alba (Jacq.) Roem. & Schult	Native
Bromeliaceae	Mouse pineapple	Bromelia pinguin L.	Native
Euphorbiaceae	Cardon	Euphorbia lactea Haw	Naturalized exotic
Fabaceae	Sweet acacia,	Acacia farnesiana (L.)	Native
Fabaceae	false tamarind or wild tamarind	Lysiloma latisiliquum (L.) Benth	Native
Mimosaceae	Marabou	Dichrostachys cinerea (L.) Wight.	Naturalized exotic

Source: Prepared by the author

Current state of the forested area

The forest formation present on the farm corresponds to the mangrove forest, a group of trees that have certain adaptations that allow them to survive and develop in waterlogged lands subject to saline or brackish intrusions. They are distributed along the coasts of tropical countries and within them the Caribbean region is a great example of their presence (Guzmán & Menéndez, 2013).

Cuban mangroves are fundamentally made up of 4 main species:

Red mangrove (Rhizophora mangle L); dark mangrove (Avicennia germinans (L.) Stearn); Pataban (Laguncularia racemoso (L) Gaertn.F.) and Yana (Conocarpus erectus, L).

In the most distant part of the water you can find other species such as false tamarind or wild tamarind (Lysiloma latisiliquum (L.) Benth), gumbo-limbo or copperwood, (Bursera simaruba (L.) Sarg.), Arabo (Erythroxylum confusum Britton), Caleta grape (Coccoloba uvifera (L.) L.) and Black Jucaro (Terminalia buceras Wr) (Guzman & Menéndez, 2013).

The sampling work carried out allowed us to determine that of the four main species that make up the mangroves, in the studied area only the red mangrove and black mangrove are present, the other two are absent.

Despite the importance of the coastal belts, it was determined that the coastal vegetation of the farm has suffered

a noticeable degree of deterioration due to natural disasters (hurricanes and climate change), anthropic factors (illegal cutting, fires) and the absence of guided management to restore, regulate and rehabilitate this formation.

Determination of the Importance Index

The Importance Value Index (IVI) was calculated, which indicates how important a species is within the community (Table 2). The species with the highest IVI means, among other things, that it is ecologically dominant, that it absorbs many nutrients and that it occupies more physical space (Curtis & Macintosh, 1951).

As a result of the work, it was possible to determine that:

- No species was classified as very ecologically important and the only species classified as ecologically important is not characteristic of this type of forest formation.
- The marabou is one of the main species present (not typical of it, invasive and exotic).
- There are two species that are not typical of the type of forest formation and are invasive (Brasilete and Marabou) and three species that are typical and crucial to this type of forest formation, which are poorly represented (Dark mangrove, Caleta grape and Carbon ebony).
- There is a total absence of two of the four typical mangrove species: Pataban and Yana.

Table 2. Behavior of the IVI of the tree species present in the mangrove

Species	Dr/esp (%)	Ar (%)	Fr (%)	IVI (%)	Clasif. IVI
Brasilete (tree)	2.72	27.31	8.33	38.37	Important
Marabou	3.51	12.96	16.67	33.14	Less important
Gumbo-limbo, Copperwood	8.13	13.89	8.33	30.35	Less important
Coconut	25.59	0.46	4.17	30.22	Less important
Glue berry	2.18	19.44	8.33	29.96	Less important
Black Jucaro	14.99	3.24	4.17	22.39	Less important
Black mangrove	7.93	4.63	8.33	20.89	Less important
Gumbo-limbo or copperwood	12.80	0.93	4.17	17.89	Less important
Arabo	1.51	2.78	8.33	12.62	Less important
Caleta grape	3.68	4.17	4.17	12.02	Less important
Brasilete (liana)	3.80	3.24	4.17	11.21	Less important
Carbonero ebony	2.79	4.17	4.17	11.12	Less important
Sweet acacia	2.84	1.39	4.17	8.40	Less important
Male Guairaje	3.51	0.46	4.17	8.14	Less important
Calyptrantes bush	2.01	0.46	4.17	6.64	Less important
Simaruba(Paradise tree)	2.01	0.46	4.17	6.64	Less important
TOTAL	100	100	100	300	

Source: Prepared by the author

AR (relative abundance) = (number of individuals of species i/total number of individuals of all species) x 100

DR (relative dominance) = (basal area of species i/basal area of all species) x 100

FR (relative frequency) = (absolute frequency of species i/ total absolute frequency) x 100

Behavior of natural regeneration due to lifestyle habits

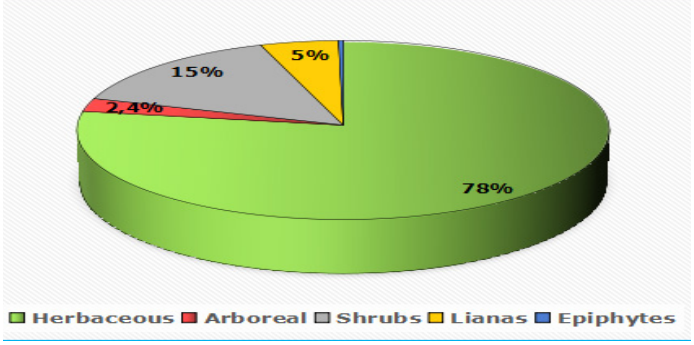
The behavior of natural regeneration in the area was studied (Figure 3), where it was observed that 77.6% of the species found correspond to herbaceous species and only 2.4% to the arboreal (tree) species, which may compromise natural regeneration.

Jiménez, (2015) suggests that anthropogenic disturbances can contribute to regulating the dynamics of regeneration, and therefore the structure and composition of tropical forests. These disorders can combine many factors and strongly affect the structure and quality of natural regeneration.

For all of the above, the authors consider that there is a high degree of anthropization of the mangrove forest, which has led to a high degree of degradation.

Menéndez, (2013) found similar results in his study on the state of mangroves in the Cuban archipelago, where their fragmentation and reduction is conditioned by unregulated wood extraction and the advance of the agricultural frontier.

Figure 3. Behavior of natural regeneration due to lifestyle habits



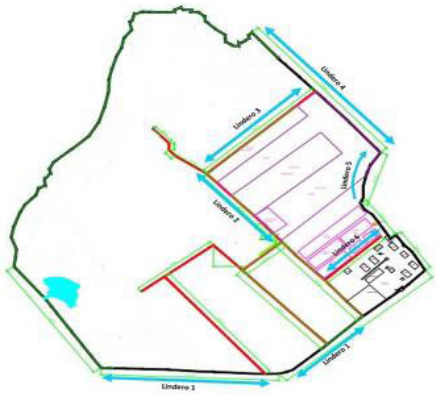
Current state of biodiversity in living fences

The survey and measurement of the existing living fences was carried out (Figure 4), taking into consideration the important role they play in the reforestation of the farms, since according to the wide traditional concept of living fence exposed by Reyes and Martínez (2011), today it is considered an agroforestry technique, which provides broad environmental, economic and social benefits to the owners, among which we can highlight the following:

- They achieve a clear and safe delimitation of the property.
- They act as protection barriers against winds.
- They reduce the economic costs of maintaining traditional fences.
- They increase the scenic beauty of the farm, which contributes to improve the landscape.
- They contribute to achieve connectivity between the forest patches and the different areas of the farm, becoming vegetation corridors that allow shelter to the birds.
- They provide derived forest products (poles, firewood, pollen and fruits).

Nowadays, it was determined that there is a total of 900.30 m (0.90 km) of fences throughout the farm area, distributed according to the different established forms of production.

Figure 4. Inventory of live fences



The floristic inventory of the living fences and boundaries was carried out, where a total of 10 tree species were identified, grouped into 9 botanical families and 8 genres (Table 3). For this, the identification of indicator forest species for the type of forest formation present was carried out.

Table 3. Biodiversity and classification of species used in living fences

Family	Common name	Scientific name	Distribution	Category
Arecaceae	Coconut	Cocus nucifera L.	Naturalized Exotic	
Boraginaceae	Glue berry	Cordia alba (Jacq.) Roem. & Schult.	Native	invasive
	American Glue berry	Cordia collococca L.	Native	
Burseraceae	Gumbo-limbo or copperwood	Bursera simaruba (L.) Sarg.	Native	
Fabaceae	False tamarind or wild tamarind	Lysiloma latisiliquum (L.) Benth.	Native	invasive
Mimosaceae	Marabou	Dichrostachys cinérea (L.) Wight. Arn.	Naturalized Exotic	invasive
Moraceae	Roxburgh fig	Ficus auriculata Lour.	Naturalized Exotic	
Moringaceae	Moringa	Moringa oleífera Lam.	Naturalized Exotic	
Sapindaceae	Plum	Spondian sp.	Native	
Sapotaceae	Satinleaf	Chysophyllum oliviforme L.	Native	

Source: Prepared by the author

The Percentage of reforestation of living fences (Pcv) was determined, that reached a value of 53.3%, which means that only 53% of them has been planted: 267 trees of 500 that should have existed for each km on the fences.

In addition to the above, the Participation Percentage of tree species in the farm's living fences was calculated (Table 4) and some characteristics of these species were identified. The plum stands out as the dominant species on the fences.

Table 4. Percentage of participation of tree species in the farm's living fences

Species	% participation
Plum	39
Coconut	17
Gumbo-limbo or copperwood	11
False tamarind or wild tamarind	11
Marabou	11
Coral bean	5
Glue berry	2
Satinleaf	2
American glue berry	1
Moringa	1

Source: Prepared by the author

Among the main characteristics of the species present in living fences, the following can be noted:

- Plum: loses its leaf at one season of the year (dominant in the tree planting of the farm fences).
- False tamarind or wild tamarind: considered an invasive species.
- Coral bean: contraindicated by MINAG because it is considered toxic.
- Glue berry: considered an invasive species. (Cordia obliqua)
- Marabou: considered an invasive species, it does not provide food for fauna.

This means that there has not been a policy for the use of appropriate species for this activity.

Other characteristics of the farm's live fences were also determined, including the following:

- Incomplete reforestation.
- Use of inappropriate species (they lose their leaves at one season of the year, do not provide food for wildlife, contraindicated by MINAG, exotic species, invasive species).
- Borders with a single species.
- Inadequate pruning management (pruning without taking into account the phenology of the species, of all trees on the same date).

This scenario differs from that described by Reyes and Martínez, (2011) for most of the live fences in Central America, where a notable heterogeneity of species predominates, achieving scenic beauty and diversified production.

Agroforestry management developed on the farm compatible with its social objective

Three agroforestry management systems were determined on the farm:

Silvopasture

When analyzing the silvopasture structure of the farm, it was determined that:

- There is a total of 7.67 ha in the cattle management regime under the main crop of the farm (Coconut), combined with low quality natural pastures and the presence of invasive species.
- The main crop is incompletely occupied and with pests on some plants.
- The system for using the main crop is inadequate, contraindicated by forestry legislation and facilitates the entry of pests and diseases into the plants.
- Inadequate application of weed control (to the main crop).
- Invasion of undesirable plants in the main crop areas, mainly White Aroma and Marabou.

Living fences

There are 0.90 km of fences in the entire area of the farm with incomplete tree planting and only responding to the economic objective, about that was explained previously.

Forest areas

The geomatic survey work carried out allow to determine the existence of 3.08 ha of forests, corresponding to the Mangrove type, with a high degree of anthropization and degradation, which also presents an incomplete structure, absence of two of the four typical mangrove species (Pataban and Yana), where the marabou constitutes one of the main species present (not typical of it, invasive and exotic) and the black mangrove, the Caleta grape and the Carbon ebony (key species in this type of formation) are poorly represented .

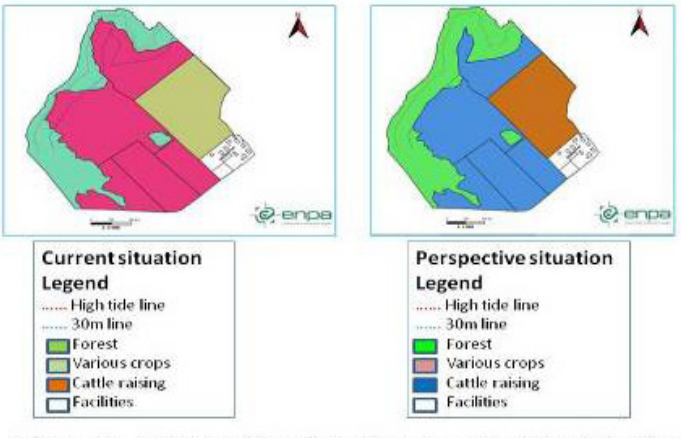
Although the forests in coastal areas have been declared Coastal Protective Forests by Law No. 85. Forest Law (Chapter IV OF FORESTS AND THEIR CLASSIFICATION, Article 20), those belonging to the property are not properly protected. The aforementioned Law, in Chapter V (FOREST MANAGEMENT), second section (Forestry and Reforestation), article 35, states that: Reforestation will be mandatory on the lands that form the coastal belt and Chapter IV, article 43, states that: The afforestation and reforestation of forest belts is the responsibility of the administrators or owners of the areas in which they are located, for which they will prepare the corresponding program, that will be approved and its execution controlled by the Municipal SEF.

Development of a forest management proposal compatible with the corporate purpose of the farm

Preparation of thematic maps

To prepare the thematic maps of the different productive forms present on the farm, the route was carried out bordering each area and those that should be rearranged with the use of a GPS. Once the current arrangement was determined, and established how the area should be in the future (after consulting with the usufructuary), office work was carried out. It allowed the preparation of thematic maps of each forestry activities, based on the current situation and the proposed perspective situation elaborated for the farm (Figure 5). This proposal starts from the tide line, to suggest an increase in the forested area and the km of living fences, taking into account the use of suitable species for the activity and silvicultural management of the area.

Figure 5. Proposal for forest management of the farm



The different parts that make up the proposal are detailed in Table 5:

Table 5. Current and future distribution of land use on the farm

Indicator	Current situation	Perspective situation	Difference
Wooded area (ha)	3,08	4,01	+ 0,93
Silvopasture area (ha)	7,67	6,74	- 0,93
Kilometers of living fences (km)	0,93	2,03	+ 1,1
Various crop area (ha)	2,5	2,5	-
Facilities (ha)	0,61	0,61	-
TOTAL	13,86	13,86	-

Source: Prepared by the author

Proposal for arrangement the forest area

This proposal, among other important aspects, considers the transformations in the agricultural activity of the farm shown:

1. Extend the forested surface until completing the width of the coastal belt required by current forestry legislation (Law No. 85), 30 m wide from the normal water level (0.93 Ha).
2. Reforest the arboreal area with species typical of the Mangrove Forest type.
3. Development of a technical nursery to guarantee the production of the necessary species, typical of the mangrove.
4. Eradicate from the Mangrove those exotic and invasive species that compromise its original composition.
5. Present to CITMA a project that approves the reforestation of the coastal belt on a scientific basis and its execution can be financed through the Territorial Program of Science, Technology and Innovation-01: Environmental Management for Sustainable Development in Cienfuegos, led by the CITMA Delegation.
6. Present to the SEF a project that supports the reforestation of the forest and its execution can be financed through FONADEF.
7. Establish criteria and indicators that allow monitoring of its reforestation and structure.

The proposal of species to be used for the reforestation of the mangrove was made, proposing the following:

- Dark mangrove
- Pataban
- Yana
- Black jucaro
- Arabo
- Carbon ebony
- Gumbo-limbo or copperwood
- Caleta grape
- Majagua of Florida

This proposal coincides with that made by Moreno et al. (2021) by stating that forests subject to good forest management increase forest mass, recover degraded areas, capture a large amount of carbon and protect soils from erosion.

Proposal for arrangement the silvopasture area

1. Prioritize coconut plantation as the main crop and livestock farming as aggregated value.
2. Achieve complete occupation of the main crop.
3. Eliminate trees with pests and replace those that have decreased their production.
4. Establish a maintenance program that guarantees the elimination of undesirable weeds and invasive plants.
5. Establish a harvesting system that does not damage the plants.
6. Present to the SEF a project that supports the use of trees in crop areas and its execution can be financed through FONADEF.

For Moreno et al., (2021) adequate management of silvopasture is justified because traditional livestock farming is an important economic activity that provides food, employment and economic security to billions of people, but is associated with deforestation, erosion, loss of biodiversity, degradation of pastures and greenhouse gas pollution.

Proposal for the arrangement of living fences

1. Increase the survival rate of fence arborization and complete their reforestation.

2. Use species with the appropriate characteristics for this purpose.
3. Achieve species diversity in all living fences.
4. Eradicate exotic and invasive species from fences.
5. Establish a pruning program where the entire fence is never pruned at the same time and the phenological cycle of the trees is respected.
6. Present to the State Forestry Service (SEF) a project that supports the use of trees in living fences and its execution can be financed through FONADEF.

The proposal of species to be used to complete the living fences was made, which includes the following:

Gliricilia sepium (Quickstick)

Bursera simaruba (Gumbo-limbo or copperwood)

Cordia collococca (American Glue berry)

Spondias mombin (Jobo)

Guazuma ulmifolia (West Indian Elm)

Samanea saman (Rain Tree or Monkey pod)

Anacardium occidentale (Cashew)

Chrysophyllum oliviforme (Satinleaf)

Moringa oleifera (French Paradise, Moringa)

Reyes and Martínez, (2011) state that living fences are important habitats for the biodiversity conservation, especially those that have a greater species diversity and structure, attributes that must be increased to improve their ecological functions.

Assessment of the ecosystem services provided by the farm

An analysis of the ecosystem services that the farm provides and an economic estimation of the work was carried out.

1. The main ecosystem service was the ***In situ*** forest biodiversity Conservation of a natural forest associated with the existing mangrove formation on the farm, with a biodiversity of 66 plant species, belonging to 33 botanical families and 58 genre. Which was heavily anthropized, with the typical behavior of ecologically altered forest areas and dominance of generalist or invasive species, in which work is currently being done to reverse this situation.
2. The production of food and medicinal plants constitutes another important ecosystem service related to the existence of the farm, whose products are delivered through the CCS and direct sales to Acopio and other organizations.
3. Work is underway to implement an Agrotourism Project by the FCEE, the MINTUR and the FCA, aimed at promoting the service of Agroecological Tourism, environmental education and healthy recreation, related to the beauty of its natural spaces and the richness of its flora and fauna, in which excursions and hiking can be carried out.
4. There is a legacy or inheritance value, an ecosystem service that reflects the usefulness of preserving a certain estate for the enjoyment of future generations, in this case, the conservation of plants species and fauna present in the mangrove and knowledge associated with its use, care and the protection it provides as a border of agricultural areas.
5. An important environmental service has resulted in the improvement of the physical, chemical and microbiological properties of the farm's soils verified through laboratory analysis, which is not economically quantifiable, but has a significant environmental impact.
6. It also provides the service of Environmental Education, given by the development of an Interest Circle formed with children from the Community and a University Classroom, with an Agreement signed by the Rector and the President of the CCS, in which students from Agronomy and other Agricultural Sciences Faculty specialties do their practices.

Impacts

The impacts of the work carried out on the farm have not been fully quantified economically, but from an environmental point of view, the following were determined:

1. The Geomatic survey of the existing mangrove formation on the farm was carried out; The existence of 3.08 ha of forests was determined, corresponding to the Mangrove type, with a high degree of anthropization and degradation, which also presents an incomplete structure, absence of two of the four typical species of the Pataban Mangrove (Laguncularia racemosa) and the Yana mangroves (Conocarpus erectus), where the marabou constitutes one of the main species present (not typical of it, invasive and exotic), and the black mangrove, the Caleta grape and the Carbon ebony (key species in this type of formation) are poorly represented. A proposal was prepared for the recovery of the mangrove and the coastal belt, and reforestation actions of the associated forest were initiated, with forest formation typical species.
2. The botanical classification was carried out taking into account the importance of the species located in this forest formation. It was determined that there are a 52 naturalized species, 10 exotics and 4 endemics, of all these, 6 are invasive, so a proposal is made for their elimination.
3. The food Production value and medicinal plants was determined, products that are delivered through the CCS, direct sales to Acopio and other organizations. They reach the annual value of more than 400,000 CUP per year.
4. The calculation of the increase in biodiversity indicators and forest cover on the farm is equivalent to

12,719.48 USD (the unit price of 4,129.70 USD/ha is adopted according to Rangel et al. (2012), for the technique of replacement costs, multiplied by the Mangrove area of 3.08 ha and associated forest, whose total value was estimated at 305,267.42 CUP at the official exchange rate in 2023.

5. The calculation of Carbon Retention on the farm was carried out, which reaches the number of 250.0 t, applying the methodology proposed by Rügnitz et al. (2009).
6. Value of CO2 retention: 7 500.00 USD. (as a reference price for the ton of carbon retained, 30 USD/t is taken, according to the International Carbon Action Partnership (ICAP 2020) and multiplied by the carbon retention, which represents a value of 180,000.00 CUP per current official exchange rate.
7. Value of pharmaceutical potential: To calculate this indicator, the methodology of Rangel et al. was adopted. (2013), assuming the price of 2 461.64 USD/ha, based on the gross profit method, multiplied by 1.75 ha of plants with medicinal properties in the ecosystem, which corresponds to a value of 4 307.87 USD, equivalent to 103,388.88 CUP at the current official exchange rate.
8. An important environmental service has resulted in the improvement of the physical, chemical and microbiological properties of the farm's soils, verified through laboratory analysis, which is not economically calculable, but has a significant environmental impact.
9. These results represent an annual impact equivalent to more than 988,656.30 CUP, in addition to the results that could not be accounted such as: the legacy value that is produced, the value of the area's tourism potential and the other environmental impacts achieved.

The farm has become a carbon drain, in total correspondence with Strategic Actions 3 and 4 of the Life Task and Objectives 13 and 15 of the 2030 Agenda. The results of the territorial Danger, Vulnerability and Risk (PVR) studies have been taken into account, as well as, the state plan to face climate change LIFE TASK by having the farm with a belt of 1.0 km of highly anthropized mangrove, unprotected coastal area with possibilities of saline intrusion and floods, which requires a deep rehabilitation work, an action on which we are working.

Actions developed to date

- Production of Caleta Grape seedlings and start of reforestation.
- Preparation of a technical nursery to guarantee the production of the necessary species, typical of the mangrove and the remaining areas.
- Delimitation of the area to be reforested and introduction of Gumbo-limbo or copperwood, Caleta grape and other species in it.
- Contacts with the JBC, Flora and Fauna for the reproduction of the species to be introduced in the area associated with the Mangrove, which do not exist on the farm.
- Inventory of trees scattered in the pastures to determine whether or not they remain in the area, depending on their occupation category and elaborate a proposal for the introduction of other species.
- Determination of ecosystem services and their economic impact.

With these three proposals for forestry activity, there must be a total reorganization of the activity within the farm, on a sustainable basis and assuring the confrontation with soil degradation, climate change on the farm and the community in general. It constitutes the first proposal for forest management on a sustainable basis to the Peasant and Cooperative Sector of Cienfuegos province, and will serve as a reference on the multifunctionality of the use of trees within agricultural systems.

CONCLUSIONS

There are 67 species from 33 families was determined in the forest area, with 6 of them invasive.

A mangrove forest is presented where the coastal vegetation has suffered a marked degree of deterioration due to natural disasters (hurricanes and climate change) and anthropogenic factors (illegal cutting, fires).

There are 900 m of living fences with 53.3% reforested and 10 species, 50% of them inappropriate for this agroforestry technique.

The Silvopasture area has low quality pastures and presence of invasive species.

An annual economic impact equivalent to more than 988,656.30 CUP is achieved and 250.0 t of carbon are captured.

A Proposal is elaborated for the Reordering of forestry activity on a sustainable basis and the developed actions to date are validated.

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