Agrisost | Vol. 25, No. 1, January-April, 2019: 1-9

ISSN-e: 1025-0247

Diversity of Plant Species on Six Farms in the Municipality of Minas, Camagüey, Cuba

José Luis Céspedes Cansino[1], Mercedes Jiménez Rodríguez[2] & Manuel Ramón Estévez Domínguez[3]

[1]ORCID https://orcid.org/0000-0003-0541-9436, Ignacio Agramonte Loynaz University, Department of Agronomy, municipality of Camagüey, Camagüey province, Cuba, [2]Ignacio Agramonte Loynaz university, Department of Agronomy, municipality of Camagüey, Camagüey province, Cuba, [3]University of Camagüey, Municipal University, Department of physical Culture, Minas, Cuba.

Citation: Céspedes Cansino, J., Jiménez Rodríguez, M., & Estévez Domínguez, M. (2019). Diversity of Plant Species on Six Farms in the Municipality of Minas, Camagüey, Cuba. *Agrisost*, *25*(1), 1-9. Retrieved from https://revistas.reduc.edu.cu/index.php/agrisost/article/view/e2953

DOI (preprint): https://doi.org/10.13140/RG.2.2.36576.94727

Received: June 5, 2018 Accepted: April 17, 2019 Published: April 27, 2019

Funding source: none.

Conflicts of interest: no conflict of interest has been declared.

Email: jose.cespedes@reduc.edu.cu

Abstract

Context: The forms of production implemented in Cuban agriculture call for changes in terms of productive structure and diversity of crops established in the agroecosystem. Therefore, it is important to move beyond the typical inventory based on qualitative data on the existence of species, for which the application of biological indexes with a more detailed information about the diversity of agroecosystems is required.
Objective: To characterize the diversity of herbaceous, shrub, and arboreal species found on six farms in the municipality of Minas, Camagüey, Cuba.
Methods: This research took place between September 2016 and April 2017. Samples were taken from 0.24 ha lots per farm, in order to determine the number of individuals, genus, and species. Seven indexes for comparative studies, and the effects of implemented farming practices on the agroecosystem were estimated.
Results: the indexes of diversity showed low of diversity, dominance, and equitability for the most part, except on two farms whose indexes were average. On a general basis, the farms were floristically different. Hence, it was concluded that the herbaceous species showed greater specific richness than the arboreal species and low indexes of proportional presence and relative abundance of species, which implies low equitability and differences in flowering. Farm management was based on inappropriate use of agroecology principles, leading to negative environmental effects on the agroecosystem.
Conclusions: The diversity found on the farms studied comprises 67 herbaceous and 35 arboreal species. The indexes of diversity were low, especially of arboreal species, with low equitability and differences in flowering. Farm management was not properly based on agroecological practices, which led to a negative environmental impact on the agroecosystem.

Key words: plant genetic resources, agroecosystem, diversity index.

Introduction

Reconversion of farm production has a new connotation today; it is not only necessary to reduce the negative impacts of conventional agriculture, but to achieve resilience of agroecosystems and food sovereignty in face of globalization and climate change (Bonet, 2015).

The main goal during reconversion from conventional to sustainable agricultural production systems is biodiversity (productive and general). It is important not only how to integrate and diversify production plants and animals (agrobiodiversity), but also greater complexity must be reached to implement multi-functions that speed up reconversion and improvements in the efficiency of agricultural production systems (Heywood, 1994).

Many new experiences are generated along these processes, which might be useful to stakeholders, such as the National Program of Suburban

Agriculture in Cuba, started in mid-2009, as a good example of reconversion in agriculture, based on an agroecological approach to attain sovereignty, sustainability, and resilience in Cuban cities (Machín et al., 2010).

In a few decades, plant biodiversity has been acknowledged, domestically and abroad, as a fundamental element of food generation and manufacture of medications or raw materials for certain industrial activities. Therefore, its knowledge, quantification, and analysis, are fundamental to understand the natural world in connection to plant species developed in agroecosystems, as well as changes induced by human activity (Vázquez et al. 2012).

One of the most shocking environmental problems today is the loss of biodiversity as a consequence of human actions, directly (over-exploitation) or indirectly (changes in habitats). The media have created such an impact, that governments, private initiatives, and the society in general, are considering making major efforts in preservation programs, as a priority. The basis for an objective analysis of biodiversity and its transformation lies in adequate evaluation and monitoring (Berovides & Gerhartz, 2007).

Today, significance and importance of biodiversity are doubtless; quite a few parameters have been established as indicators of the state of ecological systems with a practical applicability in terms of environmental preservation, management, and monitoring (Altieri & Nicholls, 2007).

Throughout the diversity study of an ecosystem, it is important to go beyond the typical inventories that provide qualitative data on the existence of species in different productive models adopted by the authors. The list of species that grow in a particular area have no usefulness for management planning. Therefore, the current trend is to quantify the floristic information by means of different plant coverage categories in the agroecosystem. The sampling data can be used to generate structural parameters: density, abundance, dominance, frequency, index of importance, and indexes of diversity and similitude that help measure diversity and interpret the real state of flora preservation in a given sector (Magurran, 1989).

This information allows researchers to learn about the way forests and other types of plant coverage work, creating a tool for planning and implementing management. From that perspective, it is important for forestry, agronomy, environmental, and biology engineers to learn the use of methodological tools in order to characterize the state of diversity in different ecosystems (Altieri & Nicholls, 2007).

Materials and Methods

This study was done between September 2016 and April 2017, on six farms owned by different proprietors in the municipality of Minas. The farms are located in different points of the region, and have three different types of soils: Red-brown fersialitic, carbonate slitic humic gleysol, and brown mulled, humic, and carbonate, according to Hernández et al. (2015).

The method used was generated and developed by the Environmental Exploration and Monitoring Group, at Alexander Von Humboldt Institute of Biological Resources Research, in Colombia (2004), and was adapted to the conditions of the place.

Samples were collected from six transections of the farm areas comprising 0.24 hectares each. Accordingly, these areas were divided into six transections (80 x 5 m), which, in turn, were divided into 16 smaller areas of 5 x 5 m, in order to facilitate identification of species present in the transection. Overall, 96 small sampling areas (5 x 5 m) were created, where the presence of different plant species was determined. The transections were established at random to prevent overlapping. The distance between transections was 20 m maximum. An 80 m-long rope with notches every 5 m was used to limit the transections. The 5 x 5 m lot size was determined by measuring 2.5 m on either end of the rope.

The Alpha and Beta diversity indexes were used to study biodiversity.

Alpha methods to measure diversity.

Range	Significance	Interpretation
0 to 0.33	Disimilar	Floristic distinct or different
0.34 to 0.66	Mid similar	Mid floristic distinct
0.67 to 1	Very similar	Floristic similar

Margalef diversity index

D_{Mg}= S-1/ ln N

Where:

S = number of species

N = total number of individuals

Simpson´s dominance index

$\lambda = \Sigma\, p_i^2$

Where:

pi = proportional abundance of the species *i*, i.e. the number of individuals of species i divided by the total number of individuals in the sample (pi= ni/N).

Interpretation

When the value is between

0–0.33 Low diversity, high dominance.

0.34–0.66 Mid diversity, mid dominance.

> 0.67 High diversity, low dominance.

As their value is inverse to equity, diversity can be estimated as 1 – λ.

Shannon-Wiener index of equity

H' = – Σpi x ln pi

Interpretation

Values between 0 and 1.35, low diversity.

1.36–3.5 Partial diversity.

Greater than 3.5 High diversity.

Pielou equity or uniformity index

E=*H*´/lnS

H´: Corresponds to the values of diversity achieved.

S: Number of species collected.

Table 1. Analysis of values

Values	Significance	
0–0.33	Heterogeneous abundance	Low diversity
0.34–0.66	Slightly heterogeneous abundance	Mid diversity
> 0.67	Homogeneous abundance	High diversity

Jaccard´s similarity coefficient

I_J= c/ a+b-c

Where:

a = number of species present on site A.

b = number of species present on site B.

c = number of species present on both sites (A and B).

Table 2. Analysis of values

Range	Significance	Interpretation
0 to 0.33	dissimilar	Floristic distinct or different
0.34 to 0.66	Mid similar	Mid floristically distinct
0.67 to 1	Very similar	Floristic similar

From a similitude value (s), dissimilitude can be easily calculated (d) among the samples: d=1-s (Magurran, 1989).

Sorensen simiItude coefficient

$$I_{Squant} = \frac{2pN}{aN+bN}$$

Where:

aN= total number of individuals on site A

aN= total number of individuals on site A

pN= sum of the lowest abundance of each species shared between the two sites.

Interpretation

When the value is between 0 and 0.33, it is dissimilar, distinct or different.

Mid similar 0.34-0.66, mid floristically similar.

Very similar 0.67 – 1 floristically similar.

Analysis of effects of farming practices implemented on the agroecosystem

It comprised,

- Diversity values per farm.
- Soil tilling methods for sowing or plantation of various crops.
- Covered soil levels on the farms.
- Recycle of stalks and herbaceous plants after incorporation to the soil.
- Frequent use of fertilizing alternatives (organic matter, green fertilizers).

This information was collected from interviews to farmers, and corroborated through observation.

Results and discussion

The samples comprised 7185 individuals from 34 families, 89 genus, and 102 species.

The diversity of tree species on the farms was made of 3-14 families, and 3-19 species. The most commonly found plant families were, Rutaceae (3), Annonaceae (2), Arecaceaena (2), and Anacardiaceae (2). Twenty of these tree species may somehow contribute to human nutrition. The downside of this analysis was the fact that one of the farms in the study produced three families and the same number of species, represented by fruit trees of economic value, such as *Persea americana* Mill (avocado), *Psidium guajaba* L (guava), and *Cocos nucifera* L (coconut), which greatly simplified the diversity of arboreal species. Consequently, it jeopardizes stability and resilience of the agroecosystem, which is another negative element, along with the type of soils (shallow, fersialitic red-brown soils with a high calcium-magnesium ratio), which fail to meet the nutritional requirements of fruit trees, causing adverse effects.

Regarding herbaceous and tree-like species, 20 families, 60 genera, and 67 species were recorded, of which only four species are used for human consumption, which is negative in terms of solution to human feeding problems. The variety and quantity of foods offered by these farms is limited, thus risking food safety of households and the community, who demand plenty of quality foods. Also important is that the most commonly found herbaceous and arboreal families spotted in the agroecosystems were Poaceae, Solanaceae, Euphorbiaceae, represented in five of the six farms studied. Although family Bromiliaceae was represented by one species (*Bromelia pinguin* L), known as *Piña de Raton* or *Maya* in Camagüey, it was recorded on four farms, being used as hedges on the borders. Moreover, families Convolvulaceae and Fabaceae were present in four of the six farms; the latter represented by three-six different species, whose significance lies in their soil improving qualities.

Because this study was done in the dry season, the influence on plant development was significant, which must be considered due to the poor presence of herbaceous and shrub species used for animal nutrition (Table 3).

These results were similar to the ones achieved by Vargas et al. (2016) and Vargas et al. (2017) in the dry season in research done on suburban and urban farms in Santiago de Cuba.

Table 3. Botanical composition during the period

Gp	Ti	Fam.	Gen.	Sp
Total	7185	34	89	102
Hp and Sh	6704	20	60	67
Ap	481	20	29	35

Legend: Gp: group; Sp: species, Hp: herbaceous plants, Sh: shrubs, Ap: arboreal plants.

Margalef index of diversity

An analysis of Margalef index of diversity (Table 4) shows that the values found for herbaceous plants and shrubs were between 1.35 and 4.14, which is linked to the heterogeneity of certain farms in relation to others, with a varying range of low-high indexes. The values estimated for arboreal plants tended to have low and very low values on one of the farms (0.40); only one of the ecosystems studied showed a high value (3.61).

These values demonstrated the existence of little tree diversity in the productive system, which may be seen as a limiting factor in relation to services that might be offered to the community, and in keeping with an agroecological standpoint.

These values are higher, especially in the category of herbaceous plants, than the ones stated by Valdés (2004), in native pine tree ecosystems in San Andres, and the ones described by Paneque (2004) in gallery forest ecosystems in the upper basin of Sandiego River

Vargas et al. (2016) and Vargas et al. (2017) found, for the most part, that works done on urban and suburban farms in Santiago de Cuba tended to variable indexes in each period studied, in all the plant groups from season to season (dry to rainy seasons). This particular research only comprised a single season (dry), so the variations found among farms owed mainly to the type of predominant soil, and also, due to farming techniques implemented by farmers.

Table 4. Margalef diversity index for herbaceous plants, shrubs, and arboreal plants

Farms	Ph and Sh	Ap
El Mamey	4.14	1.40
La fe	2.86	2.02
La Caridad	1.35	0.40
Los Mangos	1.58	3.61
La Nena	2.59	1.37
La Nilda	2.34	2.82

Legend: Hp: herbaceous plants; Sh: shrubs; Ap: arboreal plants.

Simpson dominance index

It shows the likelihood of two individuals taken at random from a sample belonging to the same species.

Table 5 shows the results of Simpson dominance and diversity index of species recorded on all the farms studied (arboreal and herbaceous plants, and shrubs). In that direction, it can be seen that, according to Simpson indexes for herbaceous and shrub species, most farms showed values indicating their existence as low-dominance species. In other words, it explained the presence of high diversity with dominance values between 0 and 0.33, and diversity values above 0.67, excluding two farms with average values of dominance and diversity. Regarding the results for such indexes in arboreal plants, except for one farm whose dominance and diversity values were average, the outcome was between 0.34 and 0.66 in both cases. The other five values were above 0.67 diversity, and 0-0.33 dominance, indicating high diversity and high dominance of one species in relation to others.

Analysis of Simpson's values resulted in that uniformity and equity require indexes pointing mostly to high diversity, which is opposed to the dominance of one species over others. Hence, this result is one important element which favors proper functioning of the agroecosystem. However, this should be analyzed with caution, since there is high diversity of species linked to the high number of individuals representing each species, though the number of species is short, since out the 66 herbaceous plants recorded, only three are used as sources of foods for humans (4.54%), with many specimens of each, but limited in terms of diversity of species. The situation is more favorable to arboreal species, as the 18 edible species out of the 35 recorded species accounted for 51.42%. It limits the possible variability of foods supplied by productive systems of the community, particularly herbaceous species whose main function, though limited, is to provide plenty and variety foods.

These results show a different trend from the reports made by Peet (1974) and Magurran (1989), cited by Moreno & Halffer (2001), where the values are arranged in average variety, along with the values achieved by Vargas et al. (2016) and Vargas et al. (2017), on urban and suburban farms in Santiago de Cuba, where this index is evaluated from one season to another, with a varying tendency observed in different groups of plants and farms analyzed. However, some of these agroecosystems studied tended to increase dominance during the dry season and toward the rainy season.

Table 5. Dominance and diversity indexes of farms studied in the municipality of Minas

Farms	Dom. Hp and Sh	Div. Hp and Sh	Dom. Ap	Div. Ap
El Mamey	0.21	0.79	0.14	0.86
La fe	0.19	0.81	0.20	0.80
La Caridad	0.48	0.52	0.23	0.77
Los Mangos	0.17	0.83	0.18	0.82
La Nena	0.16	0.84	0.43	0.57
La Nilda	0.39	0.61	0.19	0.81

Legend: Hp: herbaceous plants; Sh: shrubs; Ap: arboreal plants; Dom.: dominance; Div.: diversity.

Shannon-Wiener equity index

The estimation results of this index are shown in table 6; the values of herbaceous plants and shrubs corresponded to mid diversity (1.36-3.5) on three farms. The other farms were between 0 and 1.35, indicating low diversity; one of the farms was 0.44, which was very low.

Upon analysis of the values in the table, arboreal plants showed mid diversity values (1.36-3.5) on four farms. The other two farms ranked within low diversity (0-1.35).

This index demonstrates the existence of values for the number of specimens of species cultivated on some farms, under the indicators of agroecosystem equity; therefore becoming an indicator of farmer priority, depending on economic interests that jeopardize proper stability of the agroecosystem, and improved performance of all its components. This must be duly taken care of by all actors, represented by farm-owners.

These values are higher than the ones stated by Valdés (2004), in native pine tree ecosystems in San Andres, and the ones described by Paneque (2004) in ecosystems of forest galleries in the upper basin of San Diego River, cited by Sánchez (2010), where the values for herbaceous and arboreal plants are not higher than 1.5. These show lower equity values in the number of species of either plant category. A comparison of the results of Vargas et al. (2016) and Vargas et al. (2017), on urban and suburban farms in Santiago de Cuba, showed their superiority to the values reported on farms of Minas, Camagüey, in the two seasons studied, though diversity was better in the latter.

Table 6. Shannon-Wiener equity index of farms studied in the municipality of Minas

Farms	Hp and Sh	Ap
Mamey	1.75	1.68
La fe	1.90	1.95
La Caridad	0.44	0.95
Los Mangos	1.90	1.81
La Nena	1.34	0.62
La Nilda	1.01	2.23

Legend: Hp: herbaceous plants; Sh: shrubs; Ap: arboreal plants.

Pielou's index of uniformity or equitability.

These results are shown in Table 7, in which herbaceous plants and shrubs on most farms tended to a slightly heterogeneous abundant agroecosystem, which corresponds to mid diversity (0.34-0.66). The exception was on La Caridad farm (0.19), with poor abundance of species, and low diversity. This table also shows similar results to the ones above in reference to arboreal plants; five out of six farms ranked within the slightly heterogeneous-abundant category (mid diversity), mid diversity within the heterogeneous-abundant, low diversity agroecosystem (0.26), on La Nena Farm. All the Pielou's index of uniformity corroborated that the in the communities studied (six farms), the existing species were insufficient to achieve a balanced agroecosystem with higher uniformity of individuals for each farm species, thus making the farm more vulnerable to the negative effects of extreme weather conditions.

Altogether, these values are comparable to the values stated by Valdés (2004), in native pine tree ecosystems in San Andres, and the ones described by Paneque (2004) in ecosystems of forest galleries in the upper basin of San Diego River, cited by Sánchez (2010).

Table 7. Pielou's uniformity or equity index on six farms studied in the municipality of Minas

Farms	Unif or Equi Hp and Sh	Unif or Equi Ap
El Mamey	0.57	0.78
La fe	0.67	1.19
La Caridad	0.50	1.88
Los Mangos	0.93	1.20
La Nena	0.53	0.58
La Nilda	0.48	1.37

Legend: Hp: herbaceous plants; Sh: shrubs; Ap: arboreal plants; Unif: uniformity; Equi: Equity.

Beta index of diversity

The Beta index of diversity or inter-habitat diversity index, was used to study the relation of a species in a community with others.

Jaccard's similitude or dissimilitude coefficient

The values calculated from the samples taken in two communities in the study are shown in Table 8.

Table 8. Jaccard similitude or dissimilitude coefficient

Comp. between farms	Sc Hp and Sh	Dc Hp and Sh	Sc Ap	Dc Ap
Mam-Lfe	0.29	0.71	0.33	0.67
Mam-Lcar	0.11	0.89	0.37	0.63
Mam-Lman	0.03	0.97	0.23	0.77
Mam-Lne	0.15	0.85	0.19	0.81
Mam-Lnil	0.13	0.87	0.10	0.90
Lfe-Lcar	0.06	0.94	0.07	0.93
Lfe-Lman	0.03	0.97	0.24	0.76
Lfe-Lne	0.14	0.86	0.15	0.85
Lfe-Lnil	0.26	0.74	0.37	0.63
Lcar-Lman	0.00	1.00	0.16	0.84
Lcar-Lne	0.00	1.00	0.08	0.92
Lcar-Lnil	0.00	1.00	0.06	0.94
Lman-Lne	0.04	0.96	0.11	0.89
Lman-Lnil	0.05	0.95	0.22	0.78
Lne-Lnil	0.03	0.97	0.19	0.81

Legend: Sc: similitude coefficient; Dc: dissimilitude coefficient; Hp: herbaceous plants; Sh: shrubs; Ap: arboreal plants. Mam: El Mamey, Lnil: La Nilda, Lne: La Nena, Lfe: La Fe, Lcar: La Caridad, Lman: Los Mangos.

It shows the possible species composition comparisons on six farms studied. Regarding herbaceous plants, it was corroborated that the farms ranked in the dissimilar category, according to the three categories used in the literature to interpret the results achieved through Jaccard index, with values between 0 and 0.33, which explains their dissimilitude or floristic difference. Importantly, the most dissimilar farm in terms of herbaceous species recorded was La Caridad, with values of up to 1.00, when compared to three of the other farms in the study. It may have been caused by the type of predominant soil on the farm, determined by the existence of species commonly found in these soil types, like red brown fersialitic soil, according to Hernández et al. (2015).

The table shows the analysis of Jaccard index of arboreal species, most comparisons coincided with the dissimilar category, which means that they were dissimilar or different floristically, with values between 0 and 0.33. The exception was the comparisons of farms El Mamey-La Caridad, with red-brown fersialitic, and brown mulled, humic, and carbonate soils, according to Hernández et al. (2015), and La Fe-La Nilda, with red-brown mulled and carbonate (the former), and slitic gleysol, humic (the latter) soils, according to Hernández et al. (2015), belonging to inherited property, whose 0.37 ranks it in the mid similar (0.34-0.66), or mid dissimilar floristically. The comparison between El Mamey and La Fe showed values within the limit of the inferior category, dissimilar or different floristically (0.33). The upside of these results is that the dissimilitude of agroecosystems is and advantage in terms of food variety offered by the agroecosystem to the community (socially), and as an important crop pest control factor (agroecologically).

These results show a similar trend to the reports made by Salas et al. (2009) in the municipality of Lousã de Portugal, but not as high as the results of Vanegas, 2010, in Antioquia, Colombia, and Vargas et al. (2016) and Vargas et al. (2017), in research done on suburban and urban farms in Santiago de Cuba.

Sorensen's similitude coefficient

Table 9 shows the comparison of two communities, though the number of recorded individuals was from two farms, which were given the name of Sorensen's coefficient. The table shows that in terms of herbaceous and shrub species, all the farms were within the dissimilar category (0-0.33), which meant that they were dissimilar of floristically different. La Caridad continued to have the highest dissimilitude of all (1.00), with the maximum comparison value. It was observed though the parity with farms Los Mangos, La Nena, and La Nilda. The farms with the highest dissimilitude value had different soils; therefore, this huge difference in the number of existing plant species may have been conditioned by this factor. In other cases, it was influenced by the presence of greater or lesser weed population densities in the crop areas.

Concerning arboreal species, excluding the comparison El Mamey-La Caridad (0.36), and La Fe-La Nilda (0.39), whose Sorensen's values placed them within the mid similar category (mid floristically dissimilar), all the other comparisons corresponded to the lowest category (dissimilar), with indexes of 0-0.33, being floristically dissimilar in relation to the number of individuals that corresponded to every recorded species per farm. These results may have been caused by previously mentioned factors influencing herbaceous plants, along with the economic factor and the experience of farmers in the case of cultivated arboreal species.

These results show a similar trend to the reports made by Salas et al. (2009) in the municipality of Lousã de Portugal, and below the results of Vanegas, 2010, in Antioquia, Colombia, and Vargas et al. (2016) and Vargas et al. (2017) in research done on suburban and urban farms in Santiago de Cuba.

Table 9. Sorensen similitude or dissimilitude coefficient for the number of individuals

Comp. between farms	Sc Hp and Sh	Dc Hp and Sh	Sc Ap	Dc Ap
Mam-Lfe	0.20	0.80	0.11	0.89
Mam-Lcar	0.01	0.99	0.36	0.74
Mam-Lman	0.02	0.98	0.05	0.95

Mam-Lne	0.01	0.99	0.02	0.98
Mam-Lnil	0.03	0.97	0.04	0.96
Lfe-Lcar	0.001	0.999	0.14	0.86
Lfe-Lman	0.06	0.94	0.31	0.69
Lfe-Lne	0.12	0.88	0.03	0.97
Lfe-Lnil	0.11	0.89	0.39	0.61
Lcar-Lman	0.00	1.00	0.04	0.96
Lcar-Lne	0.00	1.00	0.01	0.99
Lcar-Lnil	0.00	1.00	0.03	0.97
Lman-Lne	0.01	0.99	0.03	0.97
Lman-Lnil	0.03	0.97	0.22	0.78
Lne-Lnil	0.002	0.998	0.05	0.95

Legend: Sc: similitude coefficient; Dc: dissimilitude coefficient; Hp: herbaceous plants; Sh: shrubs; Ap: arboreal plants. Mam: El Mamey, Lnil: La Nilda, Lne: La Nena, Lfe: La Fe, Lcar: La Caridad, Lman: Los Mangos.

Effects of managing practices on the agroecosystem

Analysis of the effects of activities generated by humans as a transforming entity of natural ecosystems (essential components of the environment), by imposing re-designs with new farming systems. It reveals the level in which actors respect processes and components of nature throughout productive actions, and structural changes in the agroecosystem.

In that sense, studies conducted in all the farms demonstrated that diversity was the first factor affected, by reducing the number of natural plant species in the ecosystem with crops which are generally less diverse, as on La Caridad Farm. This simplification of diversity implies simpler and more dependent chains, less stability and greater dependence from external ecosystems. Greater diversity favors the existence of biorregulating refuges for pests infesting edible crops, which coincides with the study of Vázquez et al. (2012). Moreover, keeping low vegetation indexes on the farms means interrupting their essential functions, since it helps capture and transform solar energy as an access gate of energy and matter to the food chain. It stores energy and provides shelter to the fauna, acts as an anti-erosion agent on the soil, regulates the local weather, controls atmospheric pollution and noise, and it is a source of raw material for humans, a source of cultural and spiritual wellbeing due to its aesthetic, recreational, and educational values.

Regarding soil preservation measures as the main environmental resource, soil management was evaluated, following tilling before production on farms. The system used was exclusively traditional, based on inversion of the soil surface (discs and disk ploughing) in large extensions, and animal traction for smaller areas. Implements that keep the soil surface in place were not used, first, due to their unavailability on the farms, and second, because of farmer inexperience.

Maintaining soil coverage is another important aspect to protect soils between cropping, or when resting. The presence of almost barren soils (poor vegetable coverage) was corroborated. It was demonstrated by the low indexes of coverage on most farm areas (5-25%), which was a significant aspect leading to increased soil erosion, favoring direct negative action of winds, rain, and ultraviolet rays that produce sterility by removing the beneficial microbial flora. This is one of the most negative elements as to the implementation of methodologies and farming techniques in the productive systems evaluated. Furthermore, recycling stalks and accompanying plants was made after their incorporation onto the soil, almost exclusively, during tilling and inversion of soil surface, thus placing vegetation under the soil. Other forms of maintenance, like dead or live coverage, are not used to prevent soils from being barren, though they are healthy for the agroecosystem.

Regarding alternative sources of fertilization, using natural fertilizers, the general trend is not to avoid this possibility, with ensuing loss of benefits brought by this practice to increase soil fertility, improvements of physical, chemical, and biological properties that make farming systems more sustainable and productive.

Conclusions

The diversity found on the farms studied comprises 67 herbaceous and 35 arboreal species.

The indexes of floristic biodiversity were low on the farms, especially arboreal plants, with little equity, and floristically different.

Farm management was not properly based on agroecological practices, which led to a negative environmental impact on the agroecosystem.

Author contribution

First author, José Luis Céspedes Cansino, worked on the theoretical design of the research, planning and organizing the study by stages. Then he worked on data collection and processing, and in the analysis and redaction of the document.

Mercedes Jimenez Rodríguez worked alongside with the main author, on sample collection from productive systems, and data collection, as well as on bibliographic review and processing.

Manuel Ramon Estevez Domínguez worked alongside with the main author, on sample collection from productive systems, and data collection, as well as on bibliographic review, processing, and review of the redaction.

Conflicts of interest

Not declared.

References

Altieri, M., & Nicholls, C. (2007). *Biodiversidad y manejo de plagas en agroecosistemas*. Barcelona: Ed. Icaria. Retrieved on March 12, 2018, from: https://www.socla.co/wp-content/uploads/2014/BiodiversidadAltieriNicholls.pdf

Berovides, V., & Gerhartz, J. (2007). *Diversidad de la vida y su conservación*. La Habana: Ed. Científico-Técnica.

Bonet, A. (2015). *Gestión de Espacios protegidos*. Universidad de Alicante. Departamento de Ecología. Materiales docentes. Alicante. España.

Grupo de Exploración y Monitoreo Ambiental, (2004). *Manual de métodos para el desarrollo de inventarios de Biodiversidad*. Bogotá: Autor.

Heywood, V. H. (1994). The measurement of biodiversity and the politics of implementation. En P.L. Forey, C.J. Humphries & R.L Vane-Wright. (eds.), *Systematics and Conservation Evaluation*. (pp. 15-22.). New York: Oxford University Press.

Hernández Jiménez, A., Pérez Jiménez, J. M., Boch Infante, D., & Castro SpecK, N. (2015). *Clasificación de los suelos de Cuba*. (2015). La Habana: Instituto Nacional de Ciencias Agrícolas de Cuba. Retrieved on May 15, 2018, from: http://ediciones.inca.edu.cu/files/libros/clasificacionsueloscuba_%202015.pdf

Magurran, A. E. (1989). *Diversidad Ecológica y su Medición*. Barcelona: Ed. VEDRA.

Machín Sósa, B., Roque Jaime, A.M., Ávila Lozano, D. & Rosset, P.M. 2010). *Revolución Agroecológica: El Movimiento de Campesino a campesino de la ANAP en Cuba. Cuando el campesino ve, hace fe*. La Habana: Asociación Nacional de Agricultores Pequeños.Retrieved on February 2, 2018, from: http://www.socla.co/wp-content/uploads/2014/Campesino_Campesino_Cuba.pdf

Moreno, C., & Halffer, G. (2001). Spatial and temporal analysis of the α, β, and γ diversities of bats in a fragmented landscape. *Biodiversity and Conservation*, *10* (3), 367-382, doi: https://doi.org/10.1023/A:1016614510040

Paneque, I. (2004). *Caracterización de la composición florística de la vegetación leñosa de ribera de la parte alta de la cuenca hidrográfica del río San Diego*. (Trabajo de grado, Ingeniería Forestal), Universidad de Pinar del Río, Pinar del Río, Cuba.

Peet, R. K. (1974). The Measurement of Species Diversity. *Annual Review of Ecology and Systematics*, *5*, 285-307, doi: https://doi.org/10.1146/annurev.es.05.110174.001441

Salas, R., Fidalgo, B., Gaspar, J., & Morais, P. (2009). Índices de biodiversidad y de estructura vertical–utilidad de aplicación en bosques con manejo forestal. *Revista Latinoamericana de Recursos Naturales*, 5 (2), 74-85.Retrieved on September 5, 2018, from: https://www.itson.mx/publicaciones/rlrn/Documents/v5-n2-3-indices-de-biodiversidad-y-de-estructura-vertical-utilidad-de-aplicacion-en-bosques-con-manejo-forestal.pdf

Sánchez, J. 2010). Caracterización de la vegetación arbórea y herbácea de las áreas destinadas para el pastoreo de las Búfalas lactantes y sus crías en La Granja del MININT San Andrés. (Trabajo de grado, Ingeniería Forestal), Universidad de Pinar del Río, Pinar del Río, Cuba.

Valdés, N. (2004). Caracterización de la vegetación acompañante de los Pinares naturales de la Unidad Silvícola San Andrés [versión electrónica]. *Revista Electrónica Avance*, 2, (8): 23-35.

Vanegas Bilbao, M. A. 2010). *Efecto de la complejidad de hábitat en la composición de la comunidad de hormigas en bosques premontanos en el área de influencia de la Central Hidroeléctrica "Porce II". Departamento de Antioquia*. (Tesis de Grado presentada como requisito parcial para optar al título de Magíster en Ciencias). Universidad Nacional de Colombia, Medellín, Colombia. Retrieved on September 5, 2018, from: http://bdigital.unal.edu.co/3410/1/9732430.2010.pdf

Vargas Batis, B., Candó González, L., Pupo Blanco, Y., Ramírez Sosa, M., Escobar Perea, Y., Rizo Mustelier, M., Molina Lores, L., Bell Mesa, T., & Vuelta Lorenzo, D. (2016). Diversidad de especies vegetales en fincas de la agricultura suburbana en Santiago de Cuba. *Agrisost*, *22*(2), 1-23. Retrieved from https://revistas.reduc.edu.cu/index.php/agrisost/article/view/296

Vargas Batis, B., Candó González, L., Ramírez Sosa, M., Rizo Mustelier, M., Pupo Blanco, Y., González Pozo, L.,… Molina Lores, L. (2017). Diversidad de plantas objeto de cultivo en cuatro fincas de la agricultura suburbana de Santiago de Cuba. *Agrisost*, *23*(3), 90-110. Retrieved on September 5, 2018, from: https://revistas.reduc.edu.cu/index.php/agrisost/article/view/2114

Vázquez Moreno, L, Matienzo Brito, Y., Alfonso Simonetti, J., Veitía Rubio, M., Paredes Rodríguez, E., & Fernández Gonzálvez, E. (2012). Contribución al diseño agroecológico de sistemas de producción urbanos y suburbanos para favorecer procesos ecológicos. *Agricultura Orgánica*, *18* (3), 14-18. https://www.researchgate.net/publication/265905305