The Rufford Foundation
Final Report

Congratulations on the completion of your project that was supported by The Rufford Foundation.

We ask all grant recipients to complete a Final Report Form that helps us to gauge the success of our grant giving. The Final Report must be sent in **word format** and not PDF format or any other format. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work. Please be as honest as you can in answering the questions – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please complete the form in English and be as clear and concise as you can. Please note that the information may be edited for clarity. We will ask for further information if required. If you have any other materials produced by the project, particularly a few relevant photographs, please send these to us separately.

Please submit your final report to jane@rufford.org.

Thank you for your help.

Josh Cole, Grants Director

Grant Recipient Details	
Your name	Grisel de la Caridad Cabrera Dávila
Project title	Application of soil macrofauna as bioindicator of soil quality in the urban agriculture environment in Cuba
RSG reference	16678-2
Reporting period	February 2015-February 2016
Amount of grant	£ 5000
Your email address	grisel.caridad@yahoo.com
Date of this report	March 2016

1. Please indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Characterisation of soil macrofauna in urban agricultural spaces as organoponics, organic farms and intensive production plots			x	The total soil macrofauna was separated up to family taxonomic level and the majority was identified at the genus and species level (when possible).
Promotion of the functional importance of the macrofauna and their use as practical indicators to assess and conserve soil quality, with capacitation to professionals, technicians and producers			x	
Validation of practical indicators of macrofauna from its relationship with physico-chemical soil properties and the knowledge of local communities about this fauna			x	This objective was fully achieved, but had to wait a longer time than the initially conceived to obtain the results on the physico-chemical soil properties of the different urban agricultural systems

2. Please explain any unforeseen difficulties that arose during the project and how these were tackled (if relevant).

The project initially stated the study in the Alamar and Cojímar localities but it was not possible because in the Cojímar locality the urban system proposed of intensive production plot was not available. Instead, all planned activities were possible to carry out in the Habana del Este and Alamar localities, both belonging to the Habana del Este municipality.

Also the results of the physical and chemical soil properties were obtained later than the time commitment. For this reason and in order to fully achieve the third objective of the project, the final report is being submitted in March 2016, 1 month after the correct date (February 2016).

3. Briefly describe the three most important outcomes of your project.

1. The taxonomic composition of soil macrofauna in all urban agricultural systems (organoponics, organic farms and intensive production plots) in Havana del Este Municipality was: three phyla, seven Classes, 17 Orders and 42 Families. At the level of genus and species, could be determined 29 genera and 22 species (Annex 1, at the end of the Report). This

inventory would be the first taxonomic list of soil macroinvertebrates referred for urban soils in Cuba.

The ecological characterisation allowed the evaluation of the practical indicators of macrofauna to assess soil quality, proposed in the 1st Rufford Small Grant Final Report and Practical Manual (Detritivores/No Detritivores and Earthworms/Ants Indexes), in the different urban agricultural systems from Habana del Este municipality. A higher abundance of detritivore organisms, in particular of earthworms, were found in organoponics and organic farms, with indexes values greater than 1; which may indicate better fertility conditions in these systems, where were made less aggressive soil practices such as organic fertility. Instead, there was a predominance of no detritivore organisms on detritivores and ants on earthworms in intensive production plots, with values lower than 1. This suggest lower quality soil for these agricultural systems, that had a higher tillage intensity and chemical fertilisation, which are management practices that damage soil biodiversity (Annex 2, at the end of the Report).

2. A pamphlet showing the taxonomic and functional composition of soil fauna, as well as the importance of its conservation was made. In this pamphlet, in addition to the macrofauna, were included organisms belonging to the soil mesofauna, as other components of importance in improving soil fertility (single document attached, out of the final report).

3. A poll to check the knowledge level about the composition and function of the macrofauna in the soil was developed (Annex 3, at the end of the Report). These polls were made to professionals, technicians and producers, whose interest is soil conservation and sustainable land use (Annex 4, out of the Final Report). The polls analysis showed that 72% to 74% of participants did not know exactly the macrofauna organisms nor their specific function in soil fertility (questions 2 and 3 in the poll, Annex 3). About the general ecological role of macrofauna and its use to indicate favorable fertility conditions (questions 4 and 5 in the poll, Annex 3), 50% answered correctly, 23% incorrectly and 27% did not answer precise criteria regarding these aspects. The obtained data suggest to make a broader dissemination work of this knowledge.

   Concerning to the results of physical and chemical soil properties, only those soil variables that had a strong relationship with the macrofauna and thus allowed to explain its behavior within each urban system studied, were shown. There was a greater abundance of total macrofauna, especially the functional group of detritivores, in organoponics and organic farms systems, which had better fertility conditions (lower bulk density and higher soil organic matter, available nitrogen and cation exchange capacity) compared to the intensive production plots (higher bulk density, lower soil organic matter, available nitrogen and cation exchange capacity) (Annex 5, at the end of the Report). Also when the soil macrofauna was related with these variables, mainly detritivores and earthworms were correlated more strongly with most of them, which explains the dependence of these organism with indicator conditions of soil quality. However, the individuals not detritivores and ants usually showed weak correlations. These groups have greater ecological plasticity and tolerance to a wide range of soil conditions, which may justify lower association with the soil variables evaluated (Annex 6, at the end of the Report).

   From the evaluation of all obtained results is proposed the ratification of the soil macrofauna indicators described in the 1st Rufford Small Grant Final Report and in practical manual

(Detritivores/No detritivores and Earthworms/Ants Indexes) to assess for it selves the soil quality or fertility, although the polls show that there is a poor knowledge, especially among producers, on soil macroinvertebrates and its practical usefulness.

4. Briefly describe the involvement of local communities and how they have benefitted from the project (if relevant).

The soil macrofauna sampling was accomplished with the help of the producers of food in the different urban agricultural systems, which are part of the local communities (photos of soil sampling shown in the second partial report of the project). Workers in these urban systems were interested in the conditions of their soils to assess and adjust the management practices applied. Moreover, educational talks on soil macrofauna were made to producers, technicians and professionals of urban agricultural systems studied who showed curiosity and understood the potential use of this fauna, as a practical and faster way, to assess the management employed, the soil quality and sustainable land use without need of physical and chemical measurements. However, as already suggested, the polls and talks carried out showed the need for a further extension of this knowledge among decision makers, technicians and producers whose functions correspond to soil conservation.

5. Are there any plans to continue this work?

The continuation of this work is based primarily on disclosure. Knowledge of the composition, functional importance and use of soil macrofauna as a bioindicator to evaluate the soil quality will continue in the urban agriculture environment in Cuba and in all possible areas where the primary interest is the care and soil conservation; even among students of middle and upper level and careers related to the subject (in Cuba: technical career in agronomy and/or engineer in agronomy). For the extension of this knowledge will be used educational materials already developed as the practical manual (1st Rufford Small Grant outcome) and pamphlet (2nd Rufford Small Grant outcome), which synthesize the composition, the functional characteristics of different taxa of macrofauna, the application of the practical indexes and sampling protocol of this fauna. Another way of disclosure will be through educational conferences and talks. The educational and training work will also involve the development of new materials, as could be illustrative catalogs, including high-resolution photos and the most distinctive taxonomic characteristics to facilitate identification of different taxa of macrofauna at the time of field sampling.

This work will continue with the study of macrofauna in other soil types in Cuba that have not yet been evaluated, as could be the soils of the central or eastern region in the country, which will allow to extend the application of the macrofauna indexes and maintain its validation.

6. How do you plan to share the results of your work with others?

The project results were disseminated through educational activities such as postgraduate courses on soil ecology and talks developed in worked urban areas (photos of educational activities shown in the second partial report of the project). In these educational activities the elaborated pamphlet and CDs were distributed, containing the obtained results in urban systems and the information of practical manual and pamphlet. A report in print and digital forms were given to the responsible of training in worked urban areas, covering the results on the macrofauna and physical and chemical soil properties and thus the soil health status in these areas and the convenience of management practices applied to them. The obtained results in different urban agricultural systems were also

included in a work presented at VIII International Congress of Soil Science 2015, happened from June 3rd to 5th in Havana: The soil macroinvertebrates as bioindicators of land use intensity and soil quality in Western Cuba (Annex 7, out of the Final Report).
In turn, the collected material and the project results about soil macrofauna have been and continue to be used as reference material and case studies, in training and courses on the composition, function, uses as a bioindicator, study methodology and laboratory identification of soil fauna, directed to professional's capacitation that want to continue this research line in Cuba and its application in national projects.

7. Timescale: Over what period was The Rufford Foundation grant used? How does this compare to the anticipated or actual length of the project?

The project was initially planned to take place in 12 months, but was extended by 13 months, due to the above reasons.

8. Budget: Please provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used.

Item	Budgeted Amount	Actual Amount	Difference	Comments
Farm Instruments		200		
Formaldehyde solution		100		Used to preserve the collected fauna
Other Field Supplies		400		It includes collecting small bottles, brushes and soft tweezers for collecting macrofauna, large and small nylons to deposit and transport soil samples to the laboratory, and other field supplies
Field Equipment Subtotal	**800**	**700**	**-100**	
Transportation and Fuel		600		20 days employed in locating the urban agricultural systems and then the coordination and implementation of macrofauna and soil sampling
Food		400		12 sampling days for 6 urban systems (two replicates of each agricultural urban system) and 3 participants
Fieldwork Subtotal	**900**	**1000**	**+100**	
Service for physical and	**1000**	**1000**	**0**	

chemical soil analysis Subtotal				
Laptop		300		It also includes USB memory flash
Printer		500		Along with the printer was invested in printer cartridges and an additional ink system, adapted to the printer
Laptop and Printer Subtotal	**700**	**800**	**+100**	
Office Supplies Subtotal	**600**	**600**	**0**	This budget also includes the participation in a scientific event and the corresponding print poster
Preparation and Printing of educational materials Subtotal	**1000**	**795**	**-205**	
Total	**5000**	**4895**	**-105**	45.93: bank tax transferences

Exchange rate: 1.48 CUC per £1.00

9. Looking ahead, what do you feel are the important next steps?

- Publication of the paper entitled "Variation of soil macrofauna in a gradient of land use as an indicator of its impact," where the practical indicators of the soil macrofauna are suggested for first time for Cuba and the world. The paper was already sent to the *Pastos y Forrajes* Journal and is in the arbitration process for acceptance. *Pastos y Forrajes* is a bilingual Cuban Scientific Journal (Spanish and English), published by the Experimental Station of Pastures and Forages Indio Hatuey, Matanzas, Cuba. It is registered in the databases of Cubaciencia and the Catálogo de publicaciones seriadas científico-tecnológicas del Ministerio de Ciencia, Tecnología y Medio Ambiente de Cuba. It also has international visibility as it is indexed in various international bases, including SciELO, Latindex, Redalyc, CAB Abstracts, Web of Science™ Core Collection, and others.
- Extension of knowledge about the importance of soil fauna conservation and the use of practical indicators of macrofauna as a tool to indicate soil fertility, in events and scientific workshops, training, conferences and talks for professionals, decision makers, technicians and producers.
- Looking for new funds to expand studies of macrofauna as a bioindicator in other soil types in Cuba, different than ferralitic red soils, which have been primarily evaluated in the subject until now, and to extend the knowledge on the results of soil macrofauna in the country.

10. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the RSGF receive any publicity during the course of your work?

The Rufford Foundation logo appears in the made pamphlet and was also included in the power point presentation that supported the educational activities developed. The RSGF was promoted

among colleagues and specialists, as a possible way of financing to develop campaigns and works about biodiversity conservation.

Annexes below:

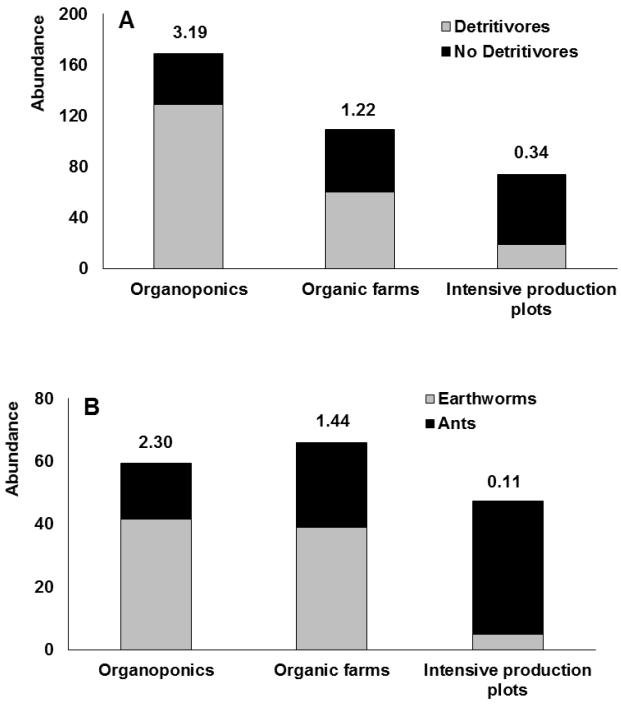
Annex 1. Taxonomic list of soil macroinvertebrates in urban soils from Habana del Este municipality, Cuba (Phylum[1], Class[2], Subclass[3], Order[4], Family[5], Genus[6], Species[7]).

Annelida[1]
Clitellata[2]. Oligochaeta[3]
Haplotaxida[4]
Glossoscolecidae[5]
Onychochaeta[6]
O. elegans[7]
O. windlei[7]
Periscolex[6]
P. brachycystis[7]
Pontoscolex[6]
P. cynthiae[7]
Megascolecidae[5]
Polypheretima[6]
P. elongata[7]
Octochaetidae[5]
Dichogaster[6]
Mollusca[1]
Gastropoda[2]
Stylommatophora[4]
Bradybaenidae[5]
Bradybaena[6]
B. similaris[7]
Oleacinidae[5]
Oleacina[6]
Polygyridae[5]
Praticolella[6]
P. griseola[7]
Subulinidae[5]
Leptinaria[6]
Subulina[6]
S.octona[7]
Streptaxidae[5]
Streptostele[6]
S. musaecola[7]
Arthropoda[1]
Malacostraca[2]
Isopoda[4]
Armadillidae[5]
Cubaris[6]
C.murina[7]
Venezillo[6]
Platyarthridae[5]
Trichorhina[6]
Trachelipidae[5]
Nagarus[6]
Porcellio[6]
P. laevis[7]
Diplopoda[2]
Polydesmida[4]
Paradoxosomatidae[5]
Condromorpha[6]
C. xanthotrica[7]
Ortomorpha[6]
O. coarctata[7]
Pyrgodesmidae[5]
Sphaeriodesmidae[5]
Spirobolida[4]
Spirobolellidae[5]
Trigoniulidae[5]
Leptogoniulus[6]
L.sorornus[7]
Trigoniulus[6]
T. corallinus[7]
Chiplopoda[2]
Geophilomorpha[4]
Geophilidae[5]
Pachymerium[6]
Lithobiomorpha[4]
Lithobiidae[5]
Scolopendromorpha[4]
Scolopocryptopidae[5]
Newportia[6]
N. stolli[7]
Chelicerata[2]. Archnida[3]
Araneae[4]
Araneidae[5]
Lycosidae[5]
Oonopidae[5]
Insecta[2]. Pterygota[3]
Coleoptera[4]
Anthicidae[5]
Carabidae[5]
Scarites[6]
S.cubanus[7]
Elateridae[5]
Scarabaeidae[5]
Ataenius[6]
Staphylinidae[5]
Tenebrionidae[5]
Dermaptera[4]

Porcellionidae[5]
Diptera[4]
Phoridae[5]
Hemiptera[4]
Cydnidae[5]
Cicadellidae[5]
Miridae[5]
Pycnoderes[6]
P. quadrimaculatus[7]
Pentatomidae[5]
Rhypanocromidae[5]
Hymenoptera[4]
Formicidae[5]
Nylanderia[6]
N.fulva[7]
Carcinophoridae[5]
Solenopsis[6]
S. geminata[7]
Wasmannia[6]
W. auropunctata[7]
Isoptera[4]
Termitidae[5]
Anoplotermes[6]
A.schwarzi[7]
Lepidoptera[4]
Erebidae[5]
Tineidae[5]
Orthoptera[4]
Gryllidae[5]
Acrididae[5]

Annex 2. Practical indicators of soil macrofauna in urban agricultural systems from Habana del Este municipality, Cuba. A: Detritivores/No Detritivores abundance index. B: Earthworms/Ants abundance index.

The values above the bars are indexes values obtained from the division of detritivores abundance vs no detritivores abundance and earthworms abundance vs ants abundance, found in every urban system studied.



Annex 3. Elaborated poll about the composition and function of macrofauna in the soil.

Responda la siguiente encuesta, la cual toma en cuenta el conocimiento de profesionales, técnicos y productores sobre la importancia funcional de determinados organismos en el mejoramiento y la conservación de la fertilidad del suelo.

Marque con una cruz las respuestas necesarias, correctas o más completas.

1. El suelo está formado por influencia fundamentalmente de:

1.1 Clima ☐

1.2 Clima + Material mineral de origen (roca madre, arcilla, arena) + Tipo de vegetación sobre el suelo ☐

1.3 Clima + Material mineral de origen + Tipo de vegetación sobre el suelo + Organismos vivos o biota del suelo ☐

1.4 Clima + Material mineral de origen + Tipo de vegetación sobre el suelo + Organismos vivos o biota del suelo + Tiempo ☐

2. Cuáles organismos viven en el interior del suelo o sobre su superficie y por ende son considerados biota del suelo? :

2.1 Lombrices de tierra ☐	2.6 Milpiés ☐	2.11 Escarabajos ☐
2.2 Ranas ☐	2.7 Arañas ☐	2.12 Cucarachas ☐
2.3 Cochinillas ☐	2.8 Hormigas ☐	2.13 Chinches ☐
2.4 Ciempiés ☐	2.9 Caracoles ☐	2.14 Orugas ☐
2.5 Ratones ☐	2.10 Babosas ☐	2.15 Grillos ☐

3. Coloque 1, 2 o 3 según el efecto que usted considera de cada organismo sobre la fertilidad del suelo, solo en aquellos que señaló arriba como biota del suelo. (1): Beneficioso, (2): Neutral, (3): Dañino:

3.1 Lombrices de tierra ☐	3.6 Milpiés ☐	3.11 Escarabajos ☐
3.2 Ranas ☐	3.7 Arañas ☐	3.12 Cucarachas ☐
3.3 Cochinillas ☐	3.8 Hormigas ☐	3.13 Chinches ☐
3.4 Ciempiés ☐	3.9 Caracoles ☐	3.14 Orugas ☐
3.5 Ratones ☐	3.10 Babosas ☐	3.15 Grillos ☐

4. Los componentes de la biota del suelo cumplen diversas funciones y provocan diferentes impactos en el suelo, los cuales podrían ser:

4.1 Abren canales en el suelo, lo cual favorece

a) su erosión ☐

b) su porosidad y la infiltración de agua y raíces ☐

4.2 Trituran y descomponen la materia orgánica, lo que

a) disminuye la reserva de nutrientes y la fertilidad del suelo ☐

b) aumenta la reserva de nutrientes y los libera como elementos esenciales para el crecimiento de las plantas ☐

4.3 Depositan sus heces fecales en el suelo, lo que contribuye a

a) la compactación del suelo ☐

b) mantener y aumentar el contenido de materia orgánica en el suelo ☐

4.4 Modifican y crean nuevos sitios o microhábitats, lo que influye sobre

a) una mayor actividad de animales y microorganismos descomponedores de la materia orgánica ☐

b) una mayor actividad de organismos plagas y consumidores de otros animales pequeños ☐

c) una mayor actividad de organismos que se alimentan de material vegetal y controlan el ingreso de este material al suelo ☐

5. Un suelo fértil o con calidad está asociado a:

5.1 Mayor cantidad de tipos de organismos con diferente función en el suelo (mayor diversidad) y de individuos por tipo (mayor abundancia) ☐

5.2 Menor cantidad de tipos de organismos con diferente función en el suelo (menor diversidad) y de individuos por tipo (menor abundancia) ☐

5.3 Mayor abundancia de organismos invasores y oportunistas como pueden ser las hormigas o de otros organismos que se alimentan de las partes vivas de las plantas y de diversos animales ☐

5.4 Mayor abundancia de organismos que descomponen la materia orgánica como las lombrices de tierra, las cochinillas, los milpiés, los caracoles y otros que cumplen igual función ☐

Annex 4.

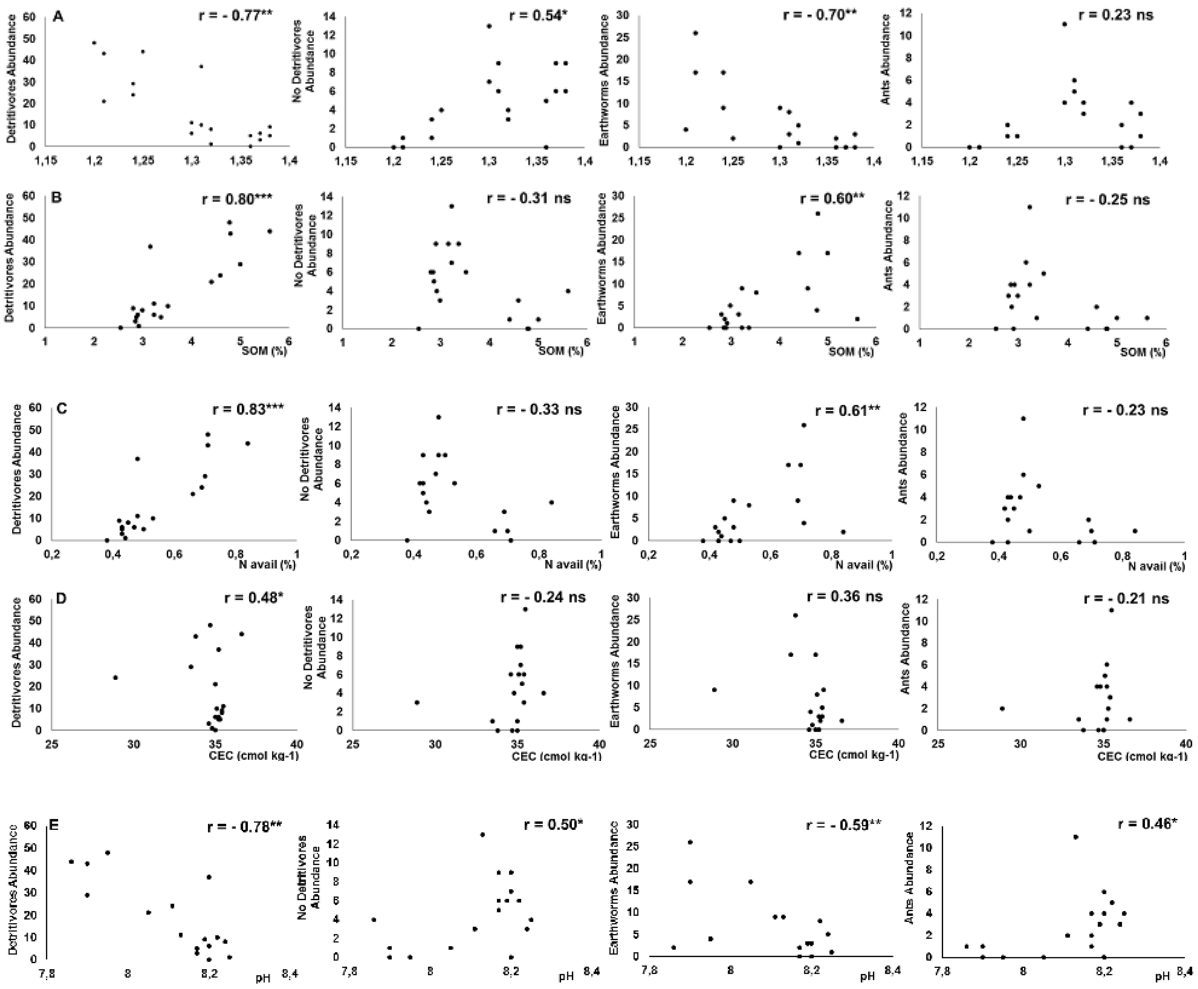
Annex 4. Pictures taken during the polls.

Annex 5. Biological, physical and chemical soil properties in urban agricultural systems from Habana del Este municipality, Cuba. Biological properties: Mean abundance of total soil macrofauna and its functional groups of detritivores, herbivores, omnivores and predators. Physical properties: Bulk density (BD). Chemical properties: Soil organic matter (SOM), Nitrogen available (N avail), Cation exchange capacity (CEC) y pH.

Biological, physical and chemical soil properties	**Organoponics**	**Organic farms**	**Intensive production plots**
Total macrofauna (individuals number)	169.0	109.3	74.0
Detritivores (individuals number)	128.7	60.3	19.0
Herbivores (individuals number)	0.75	4.0	8.3
Omnivores (individuals number)	31.0	39.0	42.3
Predators (individuals number)	8.5	6.0	4.3
BD (g cm^{-3})	1.25	1.31	1.37
SOM (%)	4.84	3.16	2.91
N avail (%)	0.72	0.48	0.43
CEC (cmol kg^{-1})	33.80	35.20	35.00
pH	7.90	8.21	8.21

Annex 6. Relationship between the abundance of Detritivores, No Detritivores, Earthworms, and Ants and the physical and chemical soil properties. A: Bulk density (BD), B: Soil organic matter (SOM), C: Nitrogen available (N avail), D: Cation exchange capacity (CEC), E: pH.

r: Correlation coefficient between both variables, with its significance level (ns: not significant, p>0.05; *: significant, p≤0.05; **: very significant, p≤0.01; ***: highly significant, p ≤0.001) and calculated using the statistical package PAST version 3.0 (Hammer, 1999-2013).



Annex 7.

Instituto de Suelos

2015 Año Internacional de los Suelos

CONGRESO SUELOS 2015

Por el manejo sostenible del suelo

Otorga el

CERTIFICADO

A: Grisel Cabrera Dávila.

Por su participación en el

CONGRESO SUELOS 2015

VIII Congreso de la Sociedad Cuba de la Ciencia del Suelo
"en saludos al 50 aniversario del Instituto de Suelos y
30 de la Sociedad Cubana de la Ciencia del Suelo"

Con la ponencia:

Título: LOS MACROINVERTEBRADOS EDÁFICOS COMO INDICADORES DEL IMPACTO DEL USO DE LA TIERRA Y DE LA CALIDAD DEL SUELO EN EL OCCIDENTE DE CUBA.

Autores: Grisel Cabrera Dávila y Y. I. Menéndez.

Palacio de Convenciones de La Habana, Cuba, 3 al 5 de junio de 2015

Annex 7. Certificate of participation in VIII International Congress of Soil Science, 2015.