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	Impact of land use intensity on soil macrofauna in Western Cuba. The macrofauna as bioindicator of soil fertility
RSG reference	13356-1
Reporting period	May 2013 - June 2014
Amount of grant	£ 5980
Your email address	grisel.caridad@yahoo.com
Date of this report	June 2014

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
Provide an updated inventory and ecological characterisation of soil macrofauna in four land uses in Western Cuba.			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).
Evaluate the effect of different practices or land uses on soil macrofauna diversity.			X	Initially the study was proposed to evaluate four land uses at Havana - Matanzas Plain in western Cuba (forests, pastures, crops and sugarcane fields), but after were committed another two land uses (pastures with trees or silvopastoral systems and agroecological farms).
Recognise and propose macrofauna indicators as signal of soil fertility or quality.			X	
Contribute to the knowledge of soil biodiversity, the functional significance of the macrofauna associated with soil fertility and management practices for the conservation of this biodiversity.			X	

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

There were difficulties in the location and selection of agroecological farms land use system in the Havana-Matanzas Plain region, because the livestock activity is more extended than the agricultural activity in the region. Nevertheless, data were provided from farms combining livestock and agricultural activities with the application of agroecological methods under Ferralitic Red Soils, as was committed in the project.

Also in the course of soil macrofauna collection, sometimes more days were employed in the sampling than the initially thought (2 days x land use system x seasonal period), due to the high incidence of rainfall that delayed the planned sampling.

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

1. The inventory of soil macroinvertebrates in all land use systems under Ferralitic Red Soils (according to Cuban Soil Classification) in the Havana-Matanzas Plain, showed a composition of three phyla, seven classes, 23 orders and 79 families, and could be named 73 families, 66 genera and 41 species. Considering the named taxa, were recorded for the first time in studies of soil macrofauna for the Havana-Matanzas Plain Region and processed systems: 22 families, 27 genera and 18 species (Annex 1, at the end of the report).
2. Land use systems with high stability management and more preserved (natural regeneration forests, pastures with leguminous trees/silvopastoral systems and agroecological farms) had the higher values of family richness and abundance of soil macroinvertebrates than the systems with greatest tillage intensity (pastures without trees, sugarcane and crops systems) (Annex 2, at the end of the report). The results illustrate that a stable soil management conserves and increases the biological fertility, which is important in the soils of the study region with intense agricultural and livestock activities and responsible for food production in western Cuba.
3. The results about Indicator Taxa Value or IndVal (Dufrene y Legendre, 1997) and Biological Soil Quality Index or IBQS based on soil macroinvertebrates communities (Ruiz *et al*., 2011), show that mainly earthworms and some detritivores macrofauna groups are characteristic or indicators of soils with high biological quality (Annex 3, at the end of the report). That allows to suggest as practical indicators of macrofauna to assess soil quality: the indexes of abundances of Detritivore/No Detritivore macrofauna and Earthworms/Ants. The domain of detritivores groups on no detritivores and earthworms on ants, indicate systems with greatest soil quality, stability and functionality.
4. A practical manual about soil macrofauna as a biological indicator of soil quality, according to results in Cuba was developed (manual attached). The manual refers information about composition and function of soil macrofauna, morphological - functional features and photos of the most important macrofauna groups in the transformation of soil fertility, practical indicators of macrofauna for evaluating the soil quality, the effect of various practices or land use systems on macrofauna and soil and management recommendations. Also in the manual is proposed a rapid protocol based on the macrofauna to assess soil quality and land management impacts, which is a first proposal of this type for Cuba. The manual information and mainly the rapid protocol are directed to increase the knowledge of the technical and professional staff dedicated to the soil care and to implement directly by technicians and producers (agricultural farmer, cattle farmer and forestry farmer).

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

During the process of soil macrofauna collection, mainly in the pastures without trees systems and silvopastoral systems, participated technical staff responsible for maintaining these ecosystems, which are part of the area communities. They learned on the sampling methodology of soil macrofauna, the functional significance of these macroinvertebrates and their indicative value of soil quality, through short talks while the fieldwork was conducted. This knowledge will enable them to continue the monitoring of soil biodiversity and its application as a soil quality bioindicator.

Moreover, in the X Provincial Meeting of the Cuban Association of Agricultural and Forestry Technicians where were involved professionals, technicians and farmers, also members of local

communities, were disseminated with educative approach aspects of macrofauna as instrument to indicate the soil quality and to conserve this resource. In that context the practical manual was promoted.

5. Are there any plans to continue this work?

From the results of the project and other previous results, practical indicators of macrofauna were proposed to assess soil quality and land management impacts. The next step will be to validate these bioindicators suggesting its application in various ecosystems, all with the purpose that it can be generalised and applied in a wide range of soil types and land uses. Another plan is to increase the divulgation of the practical manual developed and then to extend the knowledge of the functional role of macrofauna, as well as promoting the use of the indicators and the rapid protocol for evaluating soil macrofauna and soil quality.

The use of macrofauna as an instrument to indicate the soil quality and sustainable land use would be appropriate in the field of Urban and Suburban Agriculture, because of the importance of these spaces in local food production, which would be other action after this project.

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

The results were reported in two international events occurred in Cuba: IV International Congress of Tropical Animal Production 2013 happened from November 18th to 22nd (Cambios en la macrofauna de la hojarasca y del suelo en sistemas de pastizales y silvopastoriles en Mayabeque, Cuba. G. Cabrera-Dávila & Yojana I. Menéndez) and X Provincial Meeting of the Cuban Association of Agricultural and Forestry Technicians 2013 (ACTAF) within the Training and Agricultural Extension Topic, from November 22nd to 23rd (La fauna edáfica como instrumento para indicar la calidad del suelo y promover su conservación. G. Cabrera-Dávila, A.A. Socarrás, Y.I. Menéndez & G. Hernández).
The generated data are being processed for future publication in national and international scientific journals and will be part of a PhD thesis: “Comunidades de macroinvertebrados edáficos para evaluar la calidad del suelo en diferentes sistemas de uso de la tierra en las provincias Artemisa y Mayabeque, Cuba”. Furthermore, these results have been presented in courses on soil biology and ecology in master’s degree about soil, coordinated by the Universidad Agraria de La Habana.

The biological material collected, mainly of termites, has been deposited in the Isoptera Collection belonging to the Zoological Collection of the Cuban Academy of Sciences (CZACC). This material serves as a reference for future research and scientific and technical services in the country, and also to check by foreign specialists in their interest to know the Cuban termite’s biodiversity as part of the West Indies and the Neotropics.

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 carried out in 13 months and the funds from the Rufford Foundation were used in this time, from may/2013 to June/2014. The project was initially planned for 16 months but the work could be developed in 13.

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		300		
Entomological Kits		150		
Vials and formaldehyde solution		100		
Other Field Supplies		300		
Field and Laboratory Equipment Subtotal	**1000**	**850**	**- 150**	
Transportation and Fuel		816		28 sampling days for 6 land use systems in both seasonal periods
Lodging		320		16 days x 4 persons
Food		1200		28 days x 4 persons
Fieldwork Subtotal	**2000**	**2336**	**+ 336**	
Salary for Field Assistant Subtotal	**500**	**600**	**+100**	Two field assistants were needed
Personal Computer		540		A cheaper option was found in relation to the initially planned
Table for PC		68		
External Hard Disk		122		
USB Memory Flash		54		
External Modem		23		
Personal Computer and Accessories Subtotal	**1000**	**807**	**- 193**	
Printer cartridges		150		
Ink System		40		
Printing Sheets		100		
Printer Accessories Subtotal	**280**	**290**	**+ 10**	
Office Materials Subtotal	**200**	**144**	**- 56**	
Digital Camera		350		A cheaper option was found in relation to the initially planned
Batteries		105		
Charger		32		
Digital Card SD 2GB		13		
Digital Camera and Accessories Subtotal	**600**	**500**	**- 100**	
Participation in scientific events and print posters		100		
Digitisation and printing of educational material		300		
Scientific and Educational Materials Preparation Subtotal	**400**	**400**	**0**	
TOTAL	**5980**	**5927**	**-53**	Exchange rate: 1.48 CUC per £ 1.00

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

1. Publishing the results and making under consideration the macrofauna indicators proposed by the international scientific community.
2. Continuing the divulgation of the obtained results in different scientific and teaching activities.
3. Promoting the practical manual for the work with soil macrofauna, between decision makers and persons dedicated to the soil conservation, technicians and producers. This would also contribute to increase the environmental education activity with people in local communities.
4. Looking for new funds to continue the macrofauna research as biological indicator of soil quality and to validate its potential use, taking into account the local knowledge about the composition and function of the macrofauna, mainly in agroecosystems.

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 acknowledgments to RSGF were mentioned in the scientific events and talks, for the obtaining of the presented results. The logo and acknowledgments to RSGF appear in the practical manual as educative result of the project.

Annex 1. Soil macroinvertebrates composition at the different land use systems in Havana-Matanzas Plain.

F: Natural regeneration Forests, SP: Pastures with leguminous trees/silvopastoral system, P: Pastures without trees, AF: Agroecological farms, SC: Sugarcane systems, C: Crop systems/potatoes.

* New records in soil macrofauna studies for the Havana-Matanzas Plain Region and evaluated systems

Phylum Class	**Order Common Name Function**	**Family**	**Genus Specie**	**Management System or Land Use System**
Annelida Clitellata	Haplotaxida Earthworms Detritivores Soil engineers	Glossoscolecidae	*Onychochaeta O. elegans*	F, SP, P, AF
			O.windlei	F, SP, P
			Periscolex P. brachycystis**	SP
			Pontoscolex P. cynthiae**	F
		Octochaetidae	*Dichogaster*	SP, P, AF,SC, C
		Megascolecidae	*Polypheretima P. elongate*	F, SP,P, AF, SC, C
			Diplotrema	F, SP
		Moniligastridae	*Drawida D.barwelli*	F
		Undetermined		F, SP

Mollusca Gastropoda	Systellommatophora Slugs Detritivores	Veronicellidae	*Veronicella* *V.cubenses*	F, SP, P, AF, SC
	Stylommatophora Snails Detritivores Predators	Bradybaenidae	*Bradybaena* *B. similaris*	F, SP, P, AF
		Camaenidae	*Zachrysia** *Z. auricoma**	F
		Oleacinidae	*Oleacina* *O. solidula**	F
			O. subulata	SP, AF
		Polygyridae	*Praticolella** *P. griseola**	F, SP, C
		Subulinidae	*Subulina* *S.octona*	F, SP, P, AF
			*Rumina** *R. decollata**	F
		Helisinidae	*Emoda** *E. sagraiana**	F
			*Alcadia**	F
Phylum **Class**	**Order** **Common Name** **Function**	Family	Genus Specie	Management System or Land Use System
		Sagdidae	Hojeda* H. boothiana*	F
		Urocoptidae	Microcerasmus*	F
		Streptaxidae	Streptostele S. musaecola	SP, AF
Arthropoda Malacostraca	Isopoda Mealybugs Detritivores	Armadillidae	Cubaris C.murina	F, SP, P, AF, SC
			Venezillo	F, SP, P, AF
		Platyarthridae	Trichorhina	F, SP, P, AF
		Trachelipidae	Nagarus	B, SP, P, SC, C
		Porcellionidae	Porcellio P. laevis	AF
Arthropoda Diplopoda	Polydesmida Millipedes Detritivores	Paradoxosomatidae	Condromorpha C. xanthotrica	F, SP, P, AF
			Ortomorpha O. coarctata	F, SP, P, AF, C
		Pyrgodesmidae*	Lophodesmus* L. caraibianus*	F, SP
		Sphaeriodesmidae	Sphaeriodesmus	F
	Polizoniida Millipedes Detritivores	Siphonotidae*		F
	Polyxenida	Lophoproctidae	Lophoturus	F, SP, P, AF, SC

	Millipedes Detritivores			
	Spirobolida Millipedes Detritivores	Trigoniulidae	Leptogoniulus L.sororнus*	F, SP, P, AF, SC
			Trigoniulus T. corallinus*	SP, P
		Spirobolellidae	Spirobolellus	F, SP
		Rhinocricidae	Rhinocricus* R. duvernoyi*	F
	Stemmiulida Millipedes Detritivores	Stemmiulidae	Prostemmiulus	F
Arthropoda Chiplopoda	Geophilomorpha	Geophilidae	Pachymerium	F, P, AF, SC
	Centipedes Predators	Ballophilidae	Ityphilus	F
	Lithobiomorpha Centipedes Predators	Lithobiidae*		F, SP, C
Phylum Class	**Order Common Name Function**	Family	Genus Specie	Management System or Land Use System
	Scolopendromorpha Centipedes Predators	Scolopocryptopidae	Newportia N. stolli	F, SP, AF
		Cryptopidae	Otocryptops	SP
		Scolopendridae		SC
Arthropoda Arachnida	Araneae Spiders Predators	Anyphaenidae*		P
		Araneidae*		SP
		Gnaphosidae		SP, AF
		Lycosidae*		F, SP, P, AF, SC, C
		Ochyroceratidae*		SP
		Oonopidae*		SP
		Oxyopidae*		SP
		Undetermined		SP
	Opiliones Harvestmen Predators	Cosmetidae		F, SP
		Samoide*	Neoscotolemon *	F
	Pseudoscorpionida False scorpion Predators	Bochicidae		P
		Undetermined		SC
Arthropoda Insecta	Dictyoptera Cockroaches Detritivores Omnivores	Blaberidae	Pycnoscelus P.surinamensis	F, SP, P, AF
			Epilampra*	F
		Blattidae	Periplaneta	F, SP, AF
			Lamproblatta* L. albipalpus*	SC

		Blatellidae	Cariblatta*	F, SP, AF, SC
	Coleoptera Beetles larvae/adult Detritivores Herbivores Predators	Attelabidae	Cylas* C. formicarius*	C
		Carabidae		F, SP, SC, C
		Cerambycidae		C
		Chrysomelidae	Cerotoma* C.ruficornis*	P
			Maecolaspis* M.brunner*	P
			Typophorus*	AF, C
			Deloyala*	C
		Curculionidae	Pachnaeus P. litus	F, SP, SC, C
		Elateridae		F, SP, P, AF, SC, C
		Nitidulidae	Carpophilus C. humeralis	F, SP, P, AF, C
Phylum Class	**Order Common Name Function**	Family	Genus Specie	Management System or Land Use System
		Scarabaeidae	Ataenius	SP, P, AF
			Phyllophaga	F, SP, P, AF, SC, C
			Ontophagus*	SP, P
		Staphylinidae	Osorius*	F, SP, P, AF
			Coproporus*	F, SP
		(Aleocharinae)		SP
		(Staphylininae)		P, SC, C
		Tenebrionidae	Opatrinus O.pullus	F, SP, AF, SC, C
		Sylvanidae		SP
		Phalacridae*		SP
		Ceratocanthidae*		F, SP
		Undetermined 1		F, SP
		Undetermined 2		F, SP
	Dermaptera Earwigs Detritivores Predators	Carcinophoridae		F, SP, AF, C
		Labiidae*		SP
	Diptera Flies larvae/adult Detritivores	Phoridae*		F, SP, SC
	Hemiptera True bugs/Leafhoppers Herbivores	Cydnidae*		F, SP, AF, SC, C
		Cicadellidae*		SP, P
		Cicadidae*		SP
		Cixiidae*		P
		Psyllidae*		SP
		Coreidae*		SP
	Hymenoptera	Formicidae	Atta	SP, AF

		Ants Omnivores Predators Soil engineers	A.insularis	
			Nylanderia* N.fulva*	F, SP, P, AF, SC
			Solenopsis S. geminata	F, SP, AF, C
			Odontomachus O. insularis	F, SC
			Wasmannia W. auropunctata	F, SP, P, AF, C
		Vespidae Wasps adult Herbivores		F
Phylum Class	**Order Common Name Function**	Family	Genus Specie	Management System or Land Use System
	Isoptera Termites Detritivores Soil engineers	Termitidae	Anoplotermes A.schwarzi	SP, P, AF, SC, C
			Nasutitermes* N. corniger*	F, SP
	Lepidoptera Butterflies/Moths larvae/adult Herbivores	Erebidae*	Mocis*	F, SP, P, AF, SC, C
		Tineidae*	Acrolophus*	F, SP, P
		Undetermined		SP

Annex 2. Families' richness and total abundance of soil macrofauna at the different land use systems in Havana-Matanzas Plain.

Management System or Land Use System	**Families Richness**		**Total Abundance (Individuals number)**
	Observed	**Estimated (Bootstrap)**	
Natural regeneration Forests	52	55	950
Pastures with leguminous trees (silvopastoral system)	57	61	1072
Pastures without trees	28	32	123
Agroecological Farms	32	35	300
Sugarcane systems	24	26	220
Crop systems (potatoes)	22	25	78

Annex 3. Indicator taxa of soil macrofauna with their common name and function, IndVal and IBQS values at the different land use systems in Havana-Matanzas Plain.

Management System or Land Use System	Indicator taxa	Common name (Function)	Indicator taxa value or IndVal (%)	IBQS value
Natural regeneration Forests	*Onychochaeta elegans*	Earthworm (Detritivore and Soil engineer)	90	62 (high soil quality)
	Subulina octona	Snail (Detritivore)	89	
	Leptogoniulus sorornus	Millipede (Detritivore)	84	
	Pycnoscelus surinamensis	Cockroach (Detritivore)	80	
	Newportia stolli	Centipede (Predator)	71	
Pastures with leguminous trees (silvopastoral system)	*Nagarus* sp.	Mealybugs (Detritivore)	88	58 (high soil quality)
	Diplotrema sp.	Earthworm (Detritivore and Soil engineer)	78	
	Acrolophus sp.	Butterfly larvae (Herbivore)	66	
	Lophoturus sp.	Millipede (Detritivore)	61	
Pastures without trees	*Phyllophaga* sp.	Beetle larvae (Herbivore)	30	12 (low soil quality)
Agroecological Farms	*Dichogaster* sp.	Earthworm (Detritivore and Soil engineer)	59	28 (medium soil quality)
	Wasmannia auropunctata	Ants (Omnivore and Soil engineer)	53	
	Cydnidae	True bugs (Herbivore)	50	
Sugarcane systems	*Nylanderia fulva*	Ants (Omnivore and Soil engineer)	49	20 (medium soil quality)
	Periplaneta sp.	Cockroach (Omnivore)	47	
	Staphylinidae/Staphylininae	Beetle adult (Predator)	30	
Crop systems (potatoes)	*Solenopsis geminata*	Ants (Omnivore and Soil engineer)	26	8 (low soil quality)