## Final Evaluation Report

<table>
<thead>
<tr>
<th>Your Details</th>
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</thead>
<tbody>
<tr>
<td><strong>Full Name</strong></td>
<td>Liliana Cadavid Florez</td>
</tr>
<tr>
<td><strong>Project Title</strong></td>
<td>The role of isolated trees in conservation: effects of landscape structure on bird movements, seed rain and connectivity in lowland pastures of Veracruz, Mexico</td>
</tr>
<tr>
<td><strong>Application ID</strong></td>
<td>20173-1</td>
</tr>
<tr>
<td><strong>Grant Amount</strong></td>
<td>£5,000</td>
</tr>
<tr>
<td><strong>Email Address</strong></td>
<td><a href="mailto:lilocadavid@gmail.com">lilocadavid@gmail.com</a></td>
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<tr>
<td><strong>Date of this Report</strong></td>
<td>08 October 2018</td>
</tr>
</tbody>
</table>
1. Indicate the level of achievement of the project’s original objectives and include any relevant comments on factors affecting this.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Not achieved</th>
<th>Partially achieved</th>
<th>Fully achieved</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>To assess whether easily obtainable metrics of landscape composition and configuration, degree of isolation, and heterogeneity – as estimated through a land cover map derived from remote sensing data (high resolution aerial photos and LIDAR) – can be used to predict the attributes of the woody vegetation, around isolated trees, found in a pasture-dominated matrix in Veracruz, Mexico</td>
<td></td>
<td></td>
<td>fully achieved</td>
<td>We have done a complete woody vegetation survey of the study area. Likewise, we mapped all the forested fragments using high resolution aerial imagery and remote sensing data. With our results, we recommend that more complex and heterogeneous agricultural matrices could retain and enhance woody plant diversity while maintaining several ecosystem functions. Maintaining forest cover between rural and agricultural landscapes would improve vegetation diversity. It was a remarkable achievement that we can predict abundance and plant richness with readily available landscape metrics, such as forest cover metric and Shannon diversity index of land cover classes. In order to support woody plants assessment to inventory, we proposed a non-expensive and practical alternative. The combination of high resolution images with remote sensing data (LIDAR) works as a powerful tool to assess landscape heterogeneity. We promoted a solution to improve vegetation inventory, used for the design and execution of conservation plans in human-modified landscapes, combining SIG assessment with the local knowledge of community members.</td>
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<tr>
<td>To describe the structural and floristic attributes of the woody vegetation present within active pastures, and assess the magnitude of its spatial variation under different conditions</td>
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<td></td>
<td>Floristic composition and structure of woody vegetation of a pasture-dominated landscape was sampled and assessed. Local community members recognised the importance of maintaining native and cultivated trees in the region. We demonstrated</td>
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<td>Scenarios of deforestation (management intensity)</td>
<td>that different tree cover (such as isolated trees and live fences) enhanced vegetation richness in such highly fragmented landscapes. Moreover, we observed that the degree of deforestation was related to the spatial variation of woody plants composition. Local people started to plant native trees within their farms and livestock lands. Furthermore, activities such as the festival called “Day of the tree” will continue to ensure that local people spread this knowledge overtime.</td>
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<tr>
<td>To describe the spatial pattern of the fragmented landscape of an agro-system in central Veracruz, Mexico</td>
<td>The spatial pattern of this fragmented landscape still retains a high proportion of forested patches representing secondary and mature forests of central Veracruz, Mexico. Despite the considerable loss of forest and extensive habitat fragmentation, there are still arboreal cover patches of different sizes and canopy heights in the region. Besides, using a land cover map obtained by supervised classification of high resolution aerial photographs, the spatial pattern of the context of each isolated tree was analysed, at different scales. Also, landscape metrics at the landscape scale were estimated. The spatial data worked as predictors of seed dispersal, and frugivorous birds visit rates/richness.</td>
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<td>To determine the contribution that different types of tree cover (such as isolated trees) provide to structural connectivity in a human-modified landscape, and to characterise the spatial pattern of a fragmented landscape in Veracruz, Mexico</td>
<td>Using a land cover map, which shows all tree cover (or landscape elements) in a fine-grained resolution, overall structural connectivity of all forested patches was quantified. With this map, we conducted a landscape connectivity analysis in order to provide information about the contribution of each land cover class, of patches &lt; 1ha (such as isolated trees patches and small woody canopy patches), and of each forested patch in the maintenance of overall connectivity. The prioritisation exercise, in which</td>
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each patch was systematically removed from the landscape (one at a time) required of thorough GIS work, supported by extensive and rigorous fieldwork. Our results allow determining those individual patches and land cover classes that, if removed of the landscape, would decrease landscape structural connectivity for different hypothetical bird species. Tall canopy forested fragments and riparian belts are the most critical patches to maintain landscape connectivity, as well as medium canopy forested fragments (representing secondary vegetation or “acahuales”). However, patches < 1ha contribute with more than 30% to overall connectivity. Our recommendations, based on these results, enhance the potential value of trees outside the forest, in order to protect and restore them in human-modified landscapes. This type of actions guarantee the resilience of rural ecosystems and the conservation of biodiversity and ecosystems services.

To assess the value of isolated trees in seed dispersal function preservation within a pasture-dominated matrix in Veracruz, Mexico

A sampling of the seed rain, deposited under the canopy of isolated focal fig trees, was carried out over a whole year. Thirty-seven species of seeds arrived at the isolated trees, of which 80% are zochorous species, possibly dispersed by birds. The management intensity or degree of deforestation in this pasture-dominated landscape do not affect the arrival of seeds to the isolated trees. The identification of seed species was a long process; therefore, the data analysis is not finished yet. We want to assess if landscape structure (composition and configuration) around isolated trees (isolated trees context) have an impact on the seed dispersal function.
Also, to assess the scale effect at which this relationship is going on. Local farmers and cattle ranchers might implement our recommendations for design their productive land plots, in order to achieve that productive activities go hand to hand with ecological conservation. Currently, we are preparing a guide of the seed collection, and we will continue with the statistical analysis.

To describe the avifauna that visits isolated fig trees (Ficus cotinifolia) in a highly fragmented landscape of Veracruz, Mexico

Ninety-seven species of birds (including 31 migratory species, 32%) were found in the study area. During the bird survey, farmers of the local community went with us and learned to identify bird species by observation. To our surprise, we found a relatively high number of bird species in the active pastures of Jamapa, in comparison with the richness founded in other studies of tropical regions less fragmented. Of the total number of birds observed, the 31% are frugivorous species that would be potential seed dispersers. Veracruz is located through one of the migratory routes of birds migrating from temperate regions in America to tropical regions, in the winter season. Therefore, it is important to conserve tree cover of highly fragmented landscapes (i.e. Jamapa region), in order to maintain ecological connectivity that allows and guarantee the daily movements and migratory flux of birds. We are processing database and editing the bird list of the region, in order to complete a guide of the birds of Jamapa, Ver., Mexico, which we committed to ending.

To understand how bird species composition and visitation frequency to isolated trees change in response to the spatial arrangement and

The bird survey of 15 of the 16 original sampling units has been done currently. One of the isolated tree, in which the bird survey was carried out, was cut. In consequence, we reduced the sample size to 15 focal
landscape composition of surrounding vegetation | isolated trees. Due to logistical and security difficulties in the study area, we were not able to accomplish the bird survey at the time (i.e. during the season period that we had planned). Hence, the data processing and analysis is not yet complete. We aim to assess the impact of landscape context of isolated trees and landscape structure on the richness and movement of frugivorous birds to the focal tree.

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

Due to unexpected logistical problems with fieldwork, mainly related with adverse weather conditions, insecurity issues in Veracruz (i.e. not safe to travel to the study site in several occasions), I have not been able to carry out the third observation of birds at the time that I had planned. Currently, we are not finished with the data analysis to complete this goal. Besides, one of the isolated fig trees was cut during the survey, and some of the seeds traps were stolen; therefore, we had to wait until replacing them to have another month of seed sampling, in order to complete the whole year of sampling. Additionally, the processing, counting, and identification of the seeds took much more time than expected, because of the amount of sampled material of the 12 months and the few quantities of references seeds, at which I had access. To accelerate the process of identification, I asked for a student assistant who helped me. At present, we are carrying out the data analysis to complete this goal. There were also difficulties in planning the meetings and workshop to share the results, because of logistical issues with transportation at the INECOL. I used own resources to achieve those activities.

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

1. Our results show that even in highly fragmented landscapes used to raise cattle for decades, several tree and bird species of tropical forests are still present. If the arboreal elements present within pastures are properly managed, these species and their mutualistic interactions can persist for a long time within the landscape, being crucial for the maintenance of biodiversity and forest resilience. Community members and schoolchildren have increased the interest in conservation, and they are already aware of the care and management required in order to maintain agricultural productivity. Better management of arboreal elements and forest fragments as essential parts of the landscape, can both sustain their current activities for longer (i.e. cattle ranching) and maximise the future conservation of native species of trees and birds in this highly transformed and fragmented landscape.
2. Our study highlights the importance of arboreal elements within tropical pastures for the conservation of native flora in anthropic landscapes, as well as the potential of using structural landscape metrics—derived from image analysis and remote sensing data—to predict the spatial distribution of woody plant species richness and abundance in highly deforested landscapes dominated by cattle pastures. Our results are significant for the design and implementation of management tools within rural landscapes, aimed to promote biodiversity conservation without stopping livestock production.

3. Our project proves that a high density of tree cover (such as isolated trees) contribute significantly to landscape and ecological connectivity. Due to the prioritisation of forested patches, we recommend to preserve and maintain the two remnants fragments of old-growth vegetation in the area, such as the riparian forested belts and fragment with tall canopy forest. Likewise, maintain larger patches of secondary vegetation is also highly recommended. However, in such areas typically used for agriculture and livestock production, it is also valuable to preserve and restore land plots using landscape elements such as hedges, and isolated trees acting as stepping stones. Regarding the impact of our findings on the group (birds), the persistence of bird species that have been affected by deforestation may improve if there is an appropriate arboreal design in anthropogenic landscapes, which is the goal of our recommendations.

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

Local farmers have shown interest in knowing the birds that visit and use isolated trees. Also, they are now much more aware of the potential importance of isolated trees (and in general, of trees outside the forest) on the maintenance of a rich avifauna, which also translate into a much richer and dense seed dispersal of omiotochorous tree species, that people of the local community use currently and frequently. Selected community members were trained and were directly involved with vegetation, seed rain and birds field surveys. Throughout the time the fieldwork lasted, community members (both women and men) were hired and compensated with money stipends for their work during the vegetation and seed sampling, and the bird observation periods. Members who worked with us are consequently trained to recognise some of the trees and birds’ species, in case they want to organise themselves to carry out ecotourism plans. Furthermore, posters of birds and trees species of the region (Jamapa, Veracruz, Mexico) were given to the local primary school to teach the children how they look and to appropriate children about their surrounding animals and plants. Children of the Primary school in Jamapa actively participated in the education workshop that we gave. Additionally, some meetings and talks were held in order to socialise the results of the project to local community members, local farmers and cattle ranchers, and local authorities. Important to highlight is the initiative that community members of Jamapa (land farmers, cattle ranchers, homemakers and kids) have begun to make possible at the region. They became interested in the importance of trees outside the forests for the maintenance of biodiversity and ecological functions and services. They have understood that, as cattle ranchers and farmers, they are active actors in landscape transformation and its deterioration or conservation. For this reason, community
leaders started this initiative of proclaiming a “Day of the tree” (“Día del árbol”), and to celebrate this day (May 31st) each year with a festival (nowadays, there have been three festivals). The goal of this festival is to commemorate the importance of local trees in their region. The activity is organised in its totality by local community members, with the support of the municipality of Jamapa and Dra Patricia Moreno, who is the major leader or the ITTO Project. Adults and kids of kinder, primary, and secondary level all participate in the different activities related to the importance of trees for the environment. During the festival, a seedling of a native tree is given to the participants, in order to promote planting native trees in the region. (I am attaching to this report some pictures of these experiences).

5. Are there any plans to continue this work?

Yes, the team project will continue to work with the local community developing different approaches to study the role of trees outside the forests in this type of agro-ecosystems. Evaluations of the traditional use of some plant species that we identified in the study area are being carried out. Also, we have plans to continue doing workshops in other primary schools of the region, and a meeting with the cattle ranchers, in order to bring them the guide of Jamapa’s birds. As well, the team project will continue to support the activities of the “Day of the tree”, which is doing every year.

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

My data are already being incorporated in a broader project involving the municipality of Jamapa with other coastal municipalities of Veracruz, in which one of the main aims is to assess quantitatively the environmental services that are provided by arboreal elements (amongst them isolated trees in pastures) within anthropic landscapes. This project led by Dra Patricia Moreno (at INECOL) - and supported by ITTO, CONAFOR (National Forest Commission of Mexico), and INECC (National Institute of Ecology and Climate Change) - has focused mainly on the management benefits of trees within pastures and crop fields. Especially, on the use of trees outside the forest by local people, addressing also their potential benefits on carbon sequestration and the conservation of biodiversity. I was the only academic working on the role of isolated trees within pastures on the conservation of the avifauna as well as on the consequences of bird visits on seed dispersal of native forest plants dispersed by birds. The mentioned project led by Dra Moreno is a long-term project that has already ended. My data were very helpful in supporting the role of isolated trees in pastures for the maintenance of ecological functions and the potential of forest regeneration as another not always contemplated environmental services provided by these arboreal elements, that must also have been taken into account when addressing national and international schemes for the payment of environmental services. To date, the state authorities of Veracruz, as well as the federal ones are very interested in having quantitative and descriptive data on which and how many species will benefit by leaving or planting trees within pastures and crop fields. They are interested also in knowing what could be the ecological consequences of leaving these trees in the process of seed dispersal; my data will be helpful for them.
Moreover, we are preparing the publication of the results of the field surveys at Jamapa in the scientific literature (at least two papers in scientific journals), and we have already one book chapter published by ITTO on the matter. Both of this papers will be incorporated into my PhD thesis, at least as pre-prints and my thesis will include a general introduction and discussion in Spanish, in addition to handed in a hard copy of my thesis to the town of Jamapa, it will be available in PDF on the website of INECOL which is entirely open access. Additionally, I have presented part of my work in the “Congreso Mexicano de Ecología” (in August 2017), and in conferences given to my colleagues in the Functional Ecology Department of the INECOL.

Regarding divulgence material, we have shared the results with the community of Jamapa, in meetings and workshops using posters with photographs of trees and bird species taken during the fieldwork. Furthermore, within the expected outcomes of the project, I would like to highlight the future production and dissemination of a local bird identification guide based on the numerous photos I have taken on site. A short video (in Spanish) of the landscape perception by a local family was also carried out and shared at the Student Colloquium of INECOL.

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

The RSG fund was used to cover one sampling year of the final part of my project, from January 2017 to January 2018. It was a delay in started to use the funding for the final survey and the educational purposes, due to logistical complications and security difficulties. For this reason, my final report was not finished on time, since we did not have meaningful outcomes the last year.

8. Budget: 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. It is important that you retain the management accounts and all paid invoices relating to the project for at least 2 years as these may be required for inspection at our discretion.

<table>
<thead>
<tr>
<th>Item</th>
<th>Budgeted Amount</th>
<th>Actual Amount</th>
<th>Difference</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Food and accommodation (for research and field assistants)</td>
<td>1,320</td>
<td>1,467</td>
<td>147</td>
<td></td>
</tr>
<tr>
<td>Contract field assistant (3 workers)</td>
<td>3,426</td>
<td>3,126</td>
<td>-300</td>
<td>Because I had to pay the travel costs and material costs of the meetings and workshop, I saved some money that was destined for this item to pay these costs</td>
</tr>
<tr>
<td>Meetings and education</td>
<td>171</td>
<td></td>
<td></td>
<td>Additional expenses not</td>
</tr>
</tbody>
</table>
workshop costs (travel and accommodation) & considered in the previous budget \\
Travel costs (Fuel for vehicle, Xalapa - Jamapa) & 254 & 337 & 83.12 \\
Printing services for posters & 13 & _ & Additional expenses not considered in the previous budget \\
**Total** & **5,000** & **5,114** & **114** & **1 British Pound = 24.7 Mexican Peso**

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

i. To continue to provide regular training for the local community members, to develop leadership, so that in the future local people can act as strategy managers of their rural landscape.

ii. To send the recommendations outcomes to decision makers, government authorities, and local leader groups, in order to ensure the implementation of conservation strategies. The goal is that those strategies propose viable spatial arrangements and densities of forested cover in the landscape, in order to ensure sustainable farming, profitable forestry, and better quality of life for local people.

iii. Although this is not a monitoring study, it could be the basis at the future to generate a methodology for monitoring effective spatial arrangements of isolated trees context to preserve seed dispersal and bird connectivity.

iv. If it could be possible, it would be desirable to follow the validation of the statistical models that we have generated. For example, it could be proving the accuracy of the forest cover metric as a predictor of abundance and richness of woody vegetation in other study plots, different to our sampled plots. As well as, to assess the predictive power of the models for the estimation of seed diversity and visit frequency of birds towards isolated focal trees.

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

Yes, the RF logo has been used on all the oral conferences that I gave (at INECOL and Congress), and within my talks, I thanked the foundation for financing my project. Additionally, the RF logo was used in divulgation material, such as posters of birds and trees, and the short video. I will use the logo of RF in the bird guide we are preparing. Also, I thanked the Rufford Small Grant of the Rufford Foundation into the acknowledgements of the publication resulting of this project (one under review, and another one in prep.).

I have used The Rufford Foundation logo in the below materials that I mentioned above:
El contexto paisajístico de los árboles aislados: vegetación leñosa en potreros neotropicales del centro de Veracruz, México

Liliana Cadavid Flórez y Javier Laborde Dovalí
3 agosto 2017, VI Congreso Mexicano de Ecología

Gracias!!!

Contacto: llocadavid@gmail.com o llocadavid@posgrado.inecol.edu.mx
- Al Dr. Javier Laborde
- Al Dr. Sergio Guevara
- A la Dra. Patricia Moreno
- Al Dr. Zak Zahawi
- Al Dr. Victor Arroyo

How lonely are isolated shade trees in pastures? Structure and composition of woody vegetation around isolated trees

Liliana Cadavid Flórez
Javier Laborde Dovalí
13 junio 2017
11. Please provide a full list of all the members of your team and briefly what was their role in the project.

My team includes:

**Dr Javier Laborde Dovalí**: My PhD supervisor, he gave me all his experience and knowledge to complete all the stages of the project successfully. He, also, wrote with me the book chapter and the resulting publications.

** Dra. Patricia Moreno-Casasola**: Leader of the ITTO-Project, which my project is part of, and one of my PhD internal advisors. She helped us with the sample design.

** Dr Rakan (Zak) Zahawi**: My PhD external advisor. He gave us much advising for sample design and data analysis. He was also part of one of the scientific publications.

**Dr Sergio Guevara**: One of my PhD internal advisors. He helped us with the sample design.

**Marcial Gonzalez, Carmen Perez, Bartolo Tronco & Don Elio**: Local people were hired per day while doing field work as local guides and field assistants. They know very well the region and the owners of the plots to have the authorisation to enter into their lands. I am very grateful for the support of all members of the community of Jamapa.

**MSC Alfonso Aceves-Aparicio**: He worked as the field assistant and was part of the meetings and workshop carried out in Jamapa. Also, he was the photographer of the project.

**Biol. Margoth Perez**: an undergraduate student that help me as a volunteer in the lab processing seeds and capturing data of seed rain and birds. She was a student of the local University of Mexico that have the requirement to do social service to complete his graduation process.

**Student training assistants**: The turnover of staff in my project were high. Many students help me in the field and laboratory. Some of them were volunteers, but others were hired for their support and field assistance **(Alfonso Aceves-Aparicio, Helen Salazar, Víctor Castelazo, Jorge Cortinas, Luis Canillo, Amauri Samiento, Eva Aparicio, Beatriz A. Ortiz & Emmanuel Arriaga)**.

**Claudia Gallardo and Víctor Vásquez**: They work as technicians in the INECOL, and support me with plant identification.

12. Any other comments?

We are grateful to all the people that help us during fieldwork and data processing. Mainly, I am grateful with Marcial Gonzalez, Don Elio, Doña Carmen, and Bartolo Tronco for their logistical support and their kindness and hospitality throughout the evolution of the project. Without the help of so many people, it could not be possible to finish the project successfully.
I am thankful with The Rufford Foundation for financing my project with the Rufford Small Grant, and allow me to develop as a researcher in ecology and conservation biology.

I will present some figures that support and show the fieldwork, outcomes and divulgation of the project. The photographs will be send in an email as attachment files.

**Publications:**

1.1) Chapter of the book: “Servicios ecosistémicos de las selvas y bosques costeros de Veracruz” pp. 96-108
1.2) Publication under review in journal: Ecological Indicators. Image of the first page of the PDF sent by the Journal.

Indicators

Elsevier Editorial System™ for Ecological
Manuscript Draft

Manuscript Number:

Title: Using landscape composition and configuration metrics as predictors of woody vegetation attributes in tropical pastures

Article Type: Research paper

Keywords: Agricultural landscapes
Floristic composition
Landscape matrix
Remote sensing
Isolated trees
Silvopastoral systems

Corresponding Author: Dr. Javier Laborde, Ph.D.

Corresponding Author’s Institution: Instituto de Ecología, A.C.

First Author: Liliana Cadavid-Florez

Order of Authors: Liliana Cadavid-Florez; Javier Laborde, Ph.D.; Rakan A Zahavi

Abstract: Seasonally dry tropical forests in the Neotropics are typically transformed into pasture-dominated landscapes that represent a major threat to habitat biodiversity. Developing alternative management strategies that minimize the loss of native biota in agricultural landscapes is crucial. In a fragmented landscape in the lowlands of Veracruz, Mexico, we analyzed the community attributes of woody vegetation present in pastures in which different types of arboreal elements are common. We predicted that different landscape patterns, distinguishable using GIS land-cover maps, would be linked to woody plant diversity and its spatial variation. We created a detailed map of our study area distinguishing seven forest cover types. We sampled the woody vegetation within 16 circular plots each centered on an isolated fig tree and that varied in the amount of arboreal cover and proximity to remnant forest. We used a multimodel-inference approach to assess the relationship between different landscape metrics and woody vegetation response variables. Forest cover within each plot varied from 3% to 44%. A total of 1,777 woody plants (density = 35.4 plants ha⁻¹), belonging to 88 species were recorded. Landscape composition and configuration metrics, particularly the type and amount of arboreal cover, were strong predictors of woody plant richness and abundance, while landscape structural heterogeneity was strongly related to floristic composition; in contrast to the explanatory variables of isolation (i.e., proximity metrics). Tall canopy forest patches and isolated trees explained most of the variation in richness and abundance. Our results suggest that maintaining 20 to 40% woody cover within pastures and maximizing the heterogeneity of arboreal elements is necessary to promote the conservation of biodiversity in rural landscapes dedicated to livestock. Easily obtained landscape metrics can be used as a tool to enhance vegetation assessment and help in the development of more convenient
Photographs of the talk at the meeting with local communities shared the experiences of the work and the main outcomes and recommendations.

Talk at the meeting in Jamapa.

Photographs of the talk at the “Day of the tree” festival, shared our experiences, outcomes and recommendations.

Photographs of the Workshop in the Primary School of Jamapa.
Photographs of the fieldwork and field assistants.

Left: Field assistant Alfonso A. Right: Field assistant Helen.


Left: Field assistant Emmanuella. Right: Field assistants Alfonso, Jorge & Marcial.
Photographs of the bird field survey.

Left: Bird survey with Jorge. Right: Marcial doing the bird survey.

Bird survey with Marcial, Jorge & Azucena.
Photographs of the vegetation attributes assessment and the seed traps located under the canopy of focal trees.

Left: Vegetation attributes assessment. Right: Seed traps under focal fig trees.

Photographs of the seed rain sampling.

Seed rain sampling with Marcial & Bartolo.
Photos of some of the bird species founded in Jamapa

Left: Icterus gularis. Right: Piaya cayana.

Left: Dryocopus lineatus. Right: Melanerpes aurifrons.

Left: Thraupis episcopus. Right: T. abbas.
Left: Amazona autumnalis. Right: Turdus grayi.

Left: Turdus grayi. Right: Piranga rubra.

Pteroglossus torquatus.
Trogon melanoccephalus.

Photos of the seed species collected under isolated tree canopy cover.

Left: Achatocarpus nigricans. Right: Muntingia calabura.
Left: Ficus obtusifolia. Right: Sabal Mexicana.

Mucuna pruriens.