Photos by Mary Rowe, Kathy Carusone, Tatsunosuke Iwaki, and Robyn Bath-Rosenfeld

Toucans, parrots, and other wildlife in Costa Rica's forests

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Annual Field Report

January-August 2018

Dear Volunteers:

What a year! As we reflect on this first year of our Earthwatch research program, we repeatedly return to our deep debt of gratitude to all of you and to your energy, passion, dedication, patience, and enthusiasm. We are here sharing the preliminary results of our initial field season with you and look forward to deepening our understanding of the relationships between people and wildlife in Coto Brus as we continue this project into the future. Perhaps we will see you again at Las Cruces on a future team!

The Coto Brus region is home to diverse wildlife, from emerald colored hummingbirds to white-faced capuchin monkeys. Las Cruces also houses the famous Wilson Botanical Garden, which has the second largest palm collection and many rare and endangered plants from Costa Rica and elsewhere.

Meanwhile, the region also hosts a diverse and growing human population and is defined as a multi-use working rural landscape. Across Coto Brus, cattle pastures are interspersed with tree plantations, coffee and cornfields, and remnant or secondary forest tracts. In this project, we have set out to understand how wildlife are using these working landscapes, focusing on interactions between fruits and fruit-eating, seed dispersing animals. At the same time, we are exploring human perceptions in the region to understand how land managers are making decisions about tree planting, land uses, and the retention of resources for wildlife on their land.

During this first year, we observed more than 100 wildlife species occupying the 16 observation sites incorporated in this study. We developed an initial estimate of diversity of fruit-eating species at each site, and are now relating those diversity metrics to characteristics of each site. We were able to compare and rank wildlife species by their frequency and importance as seed dispersers, and fruit types by their importance as resources for wildlife. We will be refining all of these values and rankings when we add a second year of data collection to the project.

Eventually, we will be translating our results for natural resources managers in Costa Rica, to contribute to wildlife habitat conservation and corridor planning. For now, are actively refining our approach for year 2 in light of the contributions you have all made in this first year, and we thank you once again, from the bottom of our hearts, for making this work possible.

Saludos,
Kerry Grimm, Clare Aslan, and Sarah Frey

SUMMARY

This was our first fielding year and therefore the primary outcome was setting up the project, establishing needed relationships and expectations with landowners at all study sites as well as with Las Cruces Biological Station, developing data entry and management protocols, and carrying out the first round of data collection in each season. Between January and August, 2018, a total of 222 hours of frugivory observations were performed across 16 study sites; 12 of these sites were located on working private lands including sites dedicated to pasture, cropland, timber production, and ecotourism, while the remaining four sites were located on the forest reserve grounds of the Las Cruces Biological Station. As an indicator of the importance of these lands for wildlife, we observed between 10 and 29 species of frugivorous animals consuming fruits at each site, with a total species diversity of 109 frugivores observed consuming fruits over the course of the year. The most commonly consumed fruit types included *Cecropia* sp. pods and purple berries. A total of 62 dedicated Earthwatch volunteers enabled us to map fruit/frugivore networks at each site and to compare network size and connectivity among land use types.

GOALS, OBJECTIVES, AND RESULTS

The ecological goal of this study is to understand whether fleshy-fruited trees (outside of agricultural plantations) in rural Costa Rican working landscapes serve as resources for wildlife (Sekercioglu et al. 2007; Pejchar et al. 2008). By providing food and stopover points for seed dispersers, such trees may serve as seed sources for forest regeneration following habitat fragmentation (Holl et al. 2000). We aim to determine how much frugivorous wildlife use working landscape parcels and thus to contribute a greater understanding of the importance of those parcels as habitat to ongoing efforts to assess wildlife corridors and habitat connectivity in the study region.

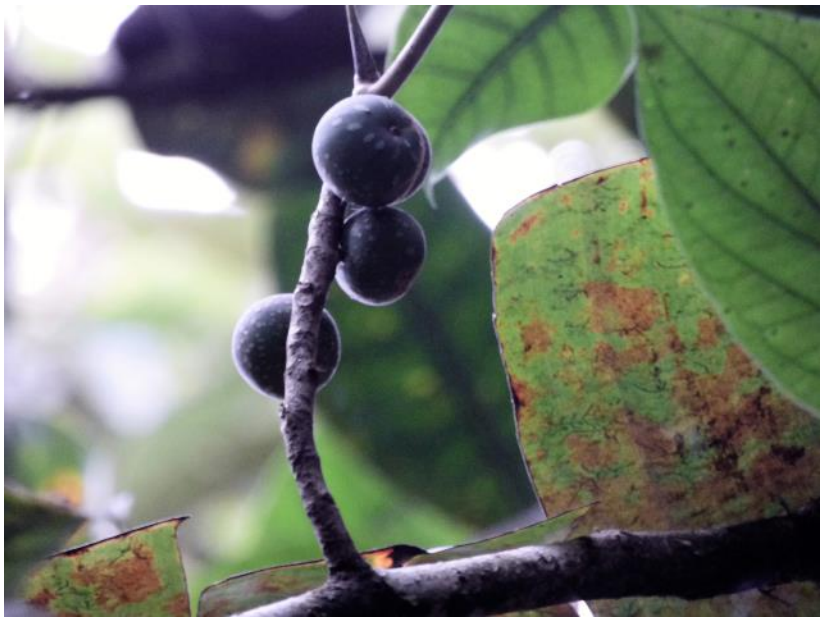

Photo by Mary Rowe

Meanwhile, the social science goal of our study is to investigate social drivers behind non-agricultural tree-planting practices in our focal region, and to understand whether these practices are driven by ecological awareness or desire to promote ecosystem services.

To achieve these goals, we address the following interdisciplinary questions:

1) What diversity of frugivorous species consume the fruits/seeds of planted trees across the working landscape of Coto Brus?

2) What are the most important frugivores consuming the fruits/seeds of planted trees, and how does such importance vary among land parcels differing in management practices, distance to intact forest, distance to surface water, and spatial distribution of fruiting trees?

3) What functional diversity of frugivores (i.e., small birds, large birds, monkeys, lizards, etc.) use the fruits of each tree functional type?

4) Why do rural land tenants in Coto Brus plant non-agricultural trees?

Photo by Kathy Carusone

Progress toward goals:

During this first year of data collection, we performed repeated systematic frugivory observations (Aslan 2011) at 16 Coto Brus study sites between January and August 2018. In the large majority of observations, teams were able to record visitors by species, with a few instances of poor visibility during which they were recorded by general size or functional group. Trees were classified by fruit functional type (generally, fruit color, fruit structure, and fruit size—for example, *small purple berry* or *citrus* or *cecropia*). This allowed volunteers without prior familiarity with tree species to conduct meaningful observations, and categorized fruits by characteristics relevant to frugivore choice and feeding behavior. Functional group approaches have been broadly adopted in citizen science and allow a balance between increased sampling efficiency and training requirements (Ward et al. 2014). Our use of fruit functional groups here aimed to measure frugivore visitation by fruit characteristics known to attract frugivores, thus observing fruits from a "bird's perspective" (Whelan and Willson 1994).) Most sites were visited by most Earthwatch teams, allowing us to compare wildlife use of fruits in the dry season (January-April) and the wet season (May-August). Total observation time at any given site ranged from 9.5 to 20.17 hours, for a total investment of 222 hours of observation time during the course of the year. This far exceeds the amount of observation time possible in most foraging studies and allows us to examine how the diversity of frugivores and fruiting tree types varied across sites as well as across seasons within this first year.

The data collected in this project will inform habitat connectivity assessments across the region, helping planners to understand how these working landscapes support frugivorous wildlife and may (or may not) be included in corridor mapping efforts. We are therefore examining the use of trees by wildlife with relevance to the spatial distribution of those trees and landscape context of each study site. For example, the large number of completed observations enable us to compare frugivore use of trees in forest, pasture, living fence, riverine corridor, and garden settings. They also enable us to compare diversity of wildlife among sites primarily used for pasture, crops, residences, and garden. We have constructed fruit-frugivore networks for each study site and are examining the network characteristics with relevance to land use, density and placement of trees, and distance to intact forest patches as well as the size of the nearest forest patch.

We also collected data to answer the social science questions of this research project. One of the graduate students, John Leary, interviewed ~10 landowners in an exploratory study in March. The answers to these questions allowed us to further refine the interview schedule. From May-August, he then conducted interviews with ~30 landowners in the Coto Brus area. Interviews focused on landowner past, present, and future land management practices and decision making; motivations, challenges, and opportunities they have experienced in planting and maintaining trees; ecological knowledge and observation about ecosystem services and wildlife on their property; and opinions on being involved in having their land a part of a biological corridor, as well as methods to which they would be amenable.

Results

Overall, 13 functional types of fruits were observed in the study sites (Fig. 1). Cecropia and purple berries were consumed most frequently by frugivores (accounting for 30% and 24% of overall fruit consumption, respectively), followed by green berries (10%), figs (7%), and palm (6%). Our methods enabled us to track the availability and consumption of each fruit functional group over time and to compare consumption between wet and dry seasons; for example, purple berries ranged in availability from a monthly average of 0 in January to over 3000 in July at study site 1, which is primarily managed for cattle pasture. Average availability of purple berries, across the full study season, was highest at site 7 (another cattle pasture site), but the average rate of consumption of purple berries by animals was much lower at site 7 than at some of the other sites. Red berries peaked in availability in the dry season in study site 13 (a garden site) and in the wet season in study site 5 (also a garden site). As these examples illustrate, a complex and shifting array of fruits can be tracked over the landscape by examining our data, demonstrating the range of resources available to wildlife over the year and over space. As we accumulate data over the next two years, we will evaluate how consistently wildlife foraging is associated with certain fruit types vs. certain land management types, to increase our understanding of the importance of this multi-use landscape for mobile wildlife.

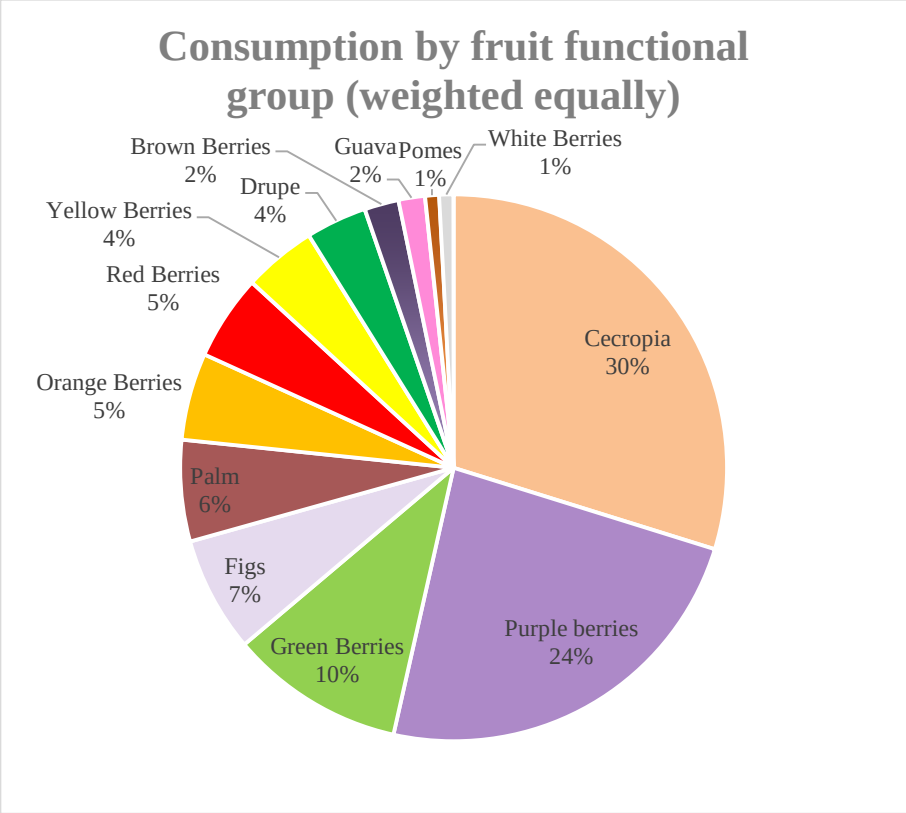

Figure 1. Fruit functional groups consumed by wildlife during systematic frugivory observations performed by Earthwatch volunteers in 2018. Observations were performed in 16 sites ranging in land use from cattle pasture to forest reserve.

By study site, total diversity of wildlife species observed interacting with trees over the course of the fielding year ranged from 18 (at site 16, a forest site) to 50 (at site 3, a cattle pasture). Total diversity of species consuming fruits ranged from 10 (at site 7, a cattle pasture) to 29 (at site 1, also primarily managed for cattle). Fruit consumption was recorded in trees located in forest (42%), pasture (18%), garden (18%), living fences (12%), and riverine corridors (10%).

It is known in that interactions between animals and plants can vary significantly year to year (Alarcón et al. 2008). We therefore consider the results presented here to be preliminary and look forward to analyzing multi-year results after seasons 2 and 3 of data collection. At this time, graduate student Robyn Bath-Rosenfeld is analyzing the first-year results using interaction network analysis to ascertain how network diversity and structure varied over study site land use type, availability of fruit functional groups, and proximity to water sources and intact forest patches. When these analyses are completed, their results will be shared with regional conservation professionals, including the staff at Las Cruces Biological Station, to inform their understanding of wildlife use of the multi-use rural landscape in the region.

Analysis of the interviews is also ongoing. Currently, John Leary has transcribed all the interviews and is in the process of coding them using NVIVO software, which allows data to be organized into categories for analysis and easy retrieval (NVivo 2014). This analysis has focused on data that will be used in John's M.S. thesis. Some major themes that have emerged so far include: lack of support from the government and a desire by landowners for greater support; increased transition to pasture from previous land uses, especially coffee production (major reasons included volatility of the market and prevalence of infestation by the coffee rust fungus); a perception among landowners that deforestation is decreasing and wildlife presence is increasing; ecosystem services from trees on the property were valued by landowners for ecosystem services and utilitarian value; and landowners are amenable to the idea of corridors as long as it does not impact their production. Given some of these initial results, one paper in John's thesis will focus on balancing ecosystem services and utilitarian values on landowner property; the goal is that this can inform future efforts on corridor establishment in the area.

PROJECT IMPACTS

1. Increasing Scientific Knowledge

a) Total citizen science research hours

During the first fielding years, volunteers spent approximately 8 hours per day on project-related activities. This typically involved at least one trip to an observation site, including between 45 minutes and 1.5 hours roundtrip of transportation and at least 3 hours of observation time in the field. For the remainder of the day, volunteers typically engaged in one or more of the following activities: additional frugivory observations, data entry, data collection for ongoing biological station needs (including pollination and herbivory observations), collecting, counting, cleaning, and planting seeds from frugivory events. (Note: most training was performed in a single full training day at the beginning of each team.)

b) Peer-reviewed publications:

Since this project is so new, we have no peer-reviewed publications to report at this time. However, we are working with the two graduate student field team leaders to process and analyze data from this past year, and we anticipate that both of them will lead the preparation of peer-reviewed publications, likely preparing such manuscripts for submission in 2019.

c) Non-peer reviewed publications:

At this time, we have no non-peer reviewed publications to report, although we have discussed developing an update white paper for the staff of Las Cruces Biological Station once the scientific results of the past year become clear.

d) Books and book chapters:

We have no books or book chapters to report.

e) Presentations:

Both of the graduate students who acted as field team leaders for this project are preparing to deliver public thesis defenses based on this work, and those presentations will take place in April 2019. Robyn Bath-Rosenfeld also plans to present about the project at the Citizen Science Association Conference in March, 2019.

2. Mentoring

a) Graduate students

List graduate students doing thesis work on the project and include student CVs and their research proposal on file with the university as an attachment (if possible) when you submit your annual report

Student Name	Graduate Degree	Project Title	Anticipated Year of Completion
Robyn Bath-Rosenfeld	MS	*Engaging citizen scientists to determine the importance of non-agricultural fruiting trees for seed-dispersing frugivores on working landscapes in southern Costa Rica*	May 2019
John Leary	MS	*Ecosystem services and utilitarian values of trees recognized by landowners in southern Costa Rica*	May 2019

b) Community outreach

Name of school, organization, or group	Education level	Participants local or non-local	Details on contributions/ activities
Mauricio Paniagua (individual)		Local	Mauricio (Mau) is a local Costa Rican research assistant who serves as a Field Team Leader for this project. He is extremely knowledgeable regarding the flora and fauna of the region, and is well-networked within the local community. It is through his networks that we were able to secure permission to work at each of the farms and private lands where data have been collected for this project. We could not do this work without Mau! We employ Mau to assist with leading each team as well as to perform preparation work in between teams. This helps him to cement his role as an accomplished research assistant in the project area (due to the large number of projects associated with the biological station, the regional need for Mau's skills is high).

3. Partnerships

Partner	Support Type(s)[1]	Years of Association (e.g. 2006-present)
Northern Arizona University School of Earth and Sustainability	Tuition and fee coverage as well as annual year salary for graduate students, thus permitting them to lead the field teams for this project during the summer	2017-present
Landscape Conservation Initiative	Funded field team leaders to join and plan teams	2017-present

[1] Support type options: funding, data, logistics, permits, technical support, collaboration, academic support, cultural support, other (define)

Photo by Mary Rowe

4. Contributions to management plans or policies

Plan/Policy Name	Type[2]	Level of Impact[3]	New or Existing?	Primary goal of plan/policy[4]	Stage of plan/policy[5]	Description of Contribution
Regional Coto Brus wildlife corridor planning	Management plan	National	New	To identify linkage routes for a wildlife corridor connecting La Amistad Park with other regions of Central America	Beginning: we have been informed that this effort is desired by managers at Las Cruces Biological Station and elsewhere, but have not heard that the effort is yet active	Using the data collected in this project, we plan to contribute an assessment of the use of rural working landscapes by wildlife. Following analysis of the data collected in this first year of our project, we will deliver our results as graduate theses + white papers to the Las Cruces director. Once we have completed three years of data collection, we plan to produce peer-reviewed manuscripts and will deliver those, as well as the raw data, so that this project can help inform the corridor mapping effort.

[2.] Type options: agenda, convention, development plan, management plan, policy, or other (define)

[3.] Level of impact options: local, regional, national, international

[4.] Primary goal options: cultural conservation, land conservation, species conservation, natural resource conservation, other

[5.] Stage of plan/policy options: proposed, in progress, adopted, other (define)

5. Conserving natural and sociocultural capital

a) Conservation of taxa

i. List any focal study species that you did not list in your most recent proposal

Species	Common name	IUCN Red List category	Local/regional conservation status	Local/regional conservation status source

ii. In the past year, has your project helped conserve or restore populations of species of conservation significance? If so, please describe below.

N/A: Our project has generated information relevant to the use of working landscapes by wildlife, and we will contribute results to the incipient corridor mapping effort in the region. However, that effort is still in its beginning stages, and no active conservation work has been undertaken relevant to corridors.

Photo by Robyn Bath-Rosenfeld

b) Conservation of ecosystems

In the past year, has your project helped conserve or restore habitats? If so, please describe below.

Habitat type	Habitat significance[7]	Description of contribution	Resulting effect[8]
Rural working landscapes	Corridors/migration paths	There has of yet been no implementation of conservation effort related to our work, but the data we are gathering will contribute to ongoing corridor mapping efforts and will result in the inclusion of at least some of the working lands we study in corridor proposals.	Eventual contribution will fall into the category of "extent maintained," since these working lands lands will be prioritized for maintenance based on their value for wildlife.

[7] Habitat significance options: nursery, breeding ground, feeding site, corridor, migration path, refuge, winter range, summer range, spring range, fall range or other (define)

[8] Resulting effect options: extent maintained, condition achieved, restored, expanded, improved connectivity or resilience

c) Ecosystem services

Indicate which ecosystem service categories you are directly studying in your Earthwatch research and provide further details in the box below.

☒**Food and water**

☐Flood and disease control

☐Spiritual, recreational, and cultural benefits

☐Nutrient cycling

☐Carbon sequestration

Details:

We are studying the use by wildlife of trees planted outside of forests and orchards, as well as multi-use rural agricultural areas in general, to better understand how working landscapes organized for human benefit can also support wildlife species. We specifically focus on wildlife foraging by examining consumption of fruits by birds, mammals, and reptiles.

d) Conservation of cultural heritage

Provide details on intangible or tangible cultural heritage components that your project has conserved or restored in the past year.

Cultural heritage component[9]	Description of contribution	Resulting effect
N/A		

[9] Cultural heritage component options: traditional agriculture, artifacts, building(s), hunting ground or kill site, traditional ecological knowledge and practices, monument(s), oral traditions and history, spiritual site, traditional subsistence living

RESEARCH PLAN UPDATES

Report any changes in your research since your last proposal/annual report. For any 'yes' answers, provide details on the change in the 'Details' box.

1) Have you added a new research site or has your research site location changed? ☐**Yes** ☒**No**
2) Has the protected area status of your research site changed? ☐**Yes** ☒**No**
3) Has the conservation status of a species you study changed? ☐**Yes** ☒**No**
4) Have there been any changes in project scientists or field crew? ☒**Yes** ☐**No**

Details – provide more information for any 'yes' answers

Our team of PIs as well as our local field team leader, Mauricio Paniagua, remain the same. However, our on-site field team leaders during most of 2018 included graduate students Robyn Bath-Rosenfeld and John Leary. Both of them are completing their MS degrees in spring 2019 and will no longer act as field team leaders for this project. We are recruiting another pair of students to spend the summer at Las Cruces Biological Station and lead the teams, under mentorship of the PI team. However, due to academic year calendar limitations, it will likely be mid-spring before we know the identity of these students.

ACKNOWLEDGEMENTS

THIS PROJECT WOULD NOT BE POSSIBLE WITHOUT THE TIRELESS SUPPORT OFFERED BY OUR TEAM AT EARTHWATCH. HEATHER PRUIKSMA AND DANA SALOMON HAVE BEEN SUPPORTIVE, RESPONSIVE, AND TIRELESS IN THEIR WILLINGNESS TO ANSWER QUESTIONS AND OFFER ENTHUSIASTIC ENCOURAGEMENT. ON THE GROUND IN COSTA RICA, MAURICIO PANIAGUA HAS BEEN A TREASURE—FULL OF KNOWLEDGE AND POSITIVITY AND PATIENCE. WE THANK THE STAFF AT LAS CRUCES BIOLOGICAL STATION FOR THEIR FLEXIBILITY AND CHEERFUL WELCOME THROUGHOUT THIS FIRST FIELDING YEAR. AND FINALLY, OUR DEEP THANKS TO EVERY VOLUNTEER—YOUR INSIGHTFUL QUESTIONS, OPTIMISM, DEDICATION, AND HOURS OF TIRELESS OBSERVATION, CRANING YOUR NECKS AND STRAINING YOUR EYES TO CATCH EVERY FLIT OF EVERY BIRD, HAVE MADE THIS PROJECT NOT ONLY A SUCCESS BUT A JOY.

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