

TROPICAL RESOURCES

The Bulletin of the Yale Tropical Resources Institute

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Please access the 2015 Bulletin at <http://environment.yale.edu/tri/publications/> in order to view maps, graphs, photographs, and figures in color.

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MISSION

About TRI

Mission

The Mission of the Tropical Resources Institute is to support interdisciplinary, problem oriented, and applied research on the most complex challenges confronting the management of tropical resources worldwide. Lasting solutions will be achieved through the integration of social and economic needs with ecological realities, the strengthening of local institutions in collaborative relationships with international networks, the transfer of knowledge and skills among local, national, and international actors, and the training and education of a cadre of future environmental leaders.

The problems surrounding the management of tropical resources are rapidly increasing in complexity, while demands on those resources are expanding exponentially. Emerging structures of global environmental governance and local conflicts over land use require new strategies and leaders who are able to function across a diversity of disciplines and sectors and at multiple scales. The Tropical Resources Institute seeks to train students to be leaders in this new era, leveraging resources, knowledge, and expertise among governments, scientists, NGOs, and communities to provide the information and tools this new generation will require to equitably address the challenges ahead.

TRI News

New Gift to TRI Endowment

We are excited to gratefully acknowledge the receipt of a further contribution to the TRI endowment from J.J. Earhart. This donation will enable TRI to support more Fellows and ensure that they are fully engaged in the support and experience that working with TRI has to offer.

TRI Program Officer: Erin Beasley

Erin Beasley joins TRI as Program Officer, following her own TRI fellowship in 2013. Erin Beasley received her Bachelor of Science degree with honors in Environmental and Renewable Resource Economics from Penn State University. She graduated with a Master of Environmental Management with a focus on social ecology from the Yale School of Forestry and Environmental Studies. Her work focuses on tropical agriculture, climate change, and the non-profit sector in Latin America, particularly in Bolivia.

The Burch Prize 2015

The William R. Burch Prize is named in honor of the influential founding director of TRI. The \$1,000 prize, generously funded by TRI alumni, is awarded annually to the paper written by a TRI Fellow published in *Tropical Resources* that best reflects Bill's visionary interdisciplinary leadership of TRI, as well as the mission of TRI: to support interdisciplinary, problem-oriented student research on the most complex challenges confronting the conservation and management of tropical environments and natural resources worldwide.

Gina Rae N. La Cerva is awarded 2015 Burch Prize

The Yale Tropical Resources Institute is proud to announce that the 2015 Burch Prize is awarded to Gina Rae La Cerva for their paper *Devouring the Congo*. Her lyrically-written article addresses the important role of the urban market in the extraction of luxury goods from the natural environment. That an urban taste for bushmeat is driving its trade seems clear; there is another tantalizing argument about nostalgia for village life driving bushmeat's increasing urban value. Further, as in many parts of the world, our ancestors set up the elements for the destruction of habitat and wildlife. The role of F&ES and TRI is to seek solutions to these seemingly intractable problems.

A Word from the Director

I am very proud to have joined TRI at such an exciting moment in its history and development. The case for integrated and interdisciplinary studies that address complex problems such as climate change and widening economic and social inequality is stronger than ever. The work that TRI Fellows undertake is increasingly important, and as we reflect on the successes and destinations of previous TRI Fellows (Beasley et al. pp. 1–5) it is essential that TRI faces forward and tackles the issues of tomorrow. To this end, through the generosity of donors, TRI has been able to increase our endowment to permit greater funding of student research; we have established an award for the best paper in the *TRI Bulletin*. Along with the new faculty hires in F&ES and the Departments of Ecology & Evolutionary Biology and Anthropology, tropical research at Yale is in good health and well-placed to ensure the success of future TRI Fellows and their studies.

In this issue of *Tropical Resources* (Vol. 34), we present the research of 11 TRI Fellows who conducted fieldwork in 2014. As usual, research was conducted in a wide range of environments in all tropical continents, ranging from environmental psychology in Brazil to plant surveys of forest gardens in Sri Lanka. First, in continued recognition of TRI's 30th anniversary, Erin Beasley, Tamara Thomas, and Katelyn Liesner present a review of the current status of TRI alumni (1983–2013). Where are they now? What are they doing? The findings are inspiring and humbling – TRI Fellows are making a difference, not only working in academia but in various international NGOs, development banks, and private companies.

Following this summary of Fellows past, we feature the research articles of Fellows present. Research was carried out in 10 countries throughout the tropics. From the Americas, Luke Weiss studies the chemical-stimulant contents of a liana used by indigenous groups of the upper Amazon, with a view to cultivation. In Mexico, José Pons provides recommendations to thorny socio-economic problems that are afflicting the ecology of a prestigious national park. In Peru, David Gonzalez examines the pernicious influence of lead use in artisanal gold-mining on the health of local people, and in Brazil, Alexandra Alhadeff uses an innovative psychological experiment to determine whether people become accustomed to the decreasing quality of their local environment.

From Africa, Gina Rae La Cerva documents the movement of bushmeat from Salonga National Park in the DRC, to the capital Kinshasa and on to fashionable restaurants in Europe. In Zambia, Tianjun Hou examines the relative influence and local perception of Chinese investment in development projects; while in Madagascar, Karin Bucht addresses how fuelwood is being supplied by plantations. In South Africa, Linda Holcombe highlights the little-known conflict between penguins and fishermen over their fishy prey.

From Asia, Klaus Geiger provides some of the first data on the composition and diversity of forest gardens in Sri Lanka, and in Indonesia, Sarah Casson documents how local communities are united and strengthened by traditions and ceremonies in the face of climate change and administrative bureaucracy. Finally, in the first of a new series of Field Reports, Sarah Casson and Nicole Wooton describe their experience on the 2015 Neotropical Lepidoptera Course in Brazil.

As you read these articles, I hope that you are as excited as I am about the role of TRI, its Fellows and alumni, and the work they do.

Simon A. Queenborough, Ph.D.

Mrs John (Elizabeth W.) Musser Director, Yale Tropical Resources Institute

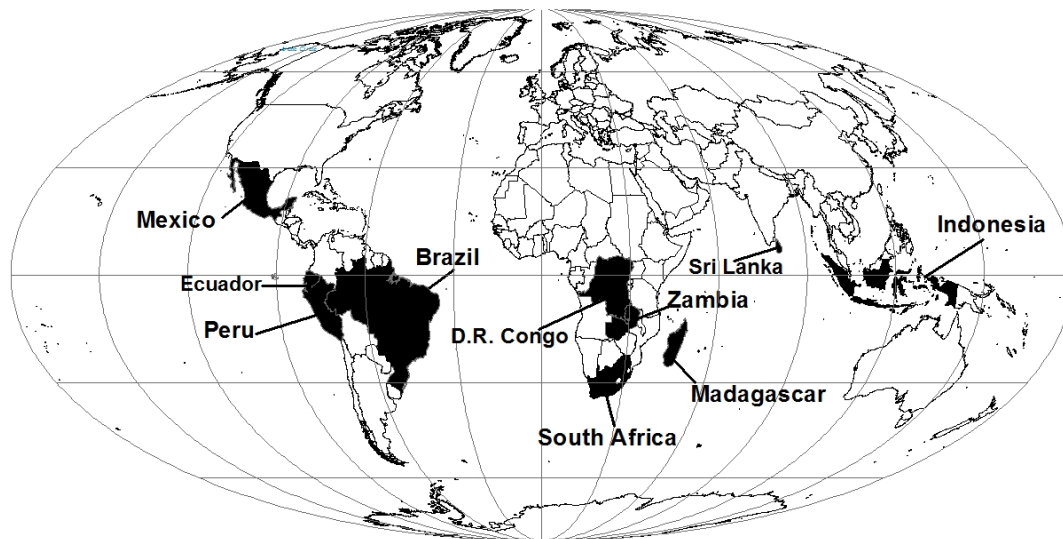
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TRI Fellows research sites represented in this issue



- Brazil:** Alexandra Alhadeff
D.R. Congo: Gina Rae La Cerva
Ecuador: Luke Weiss
Indonesia: Sarah Casson
Madagascar: Karin Bucht
Mexico: José Pons
Peru: David Gonzalez
Sri Lanka: Klaus Geiger
South Africa: Linda Holcombe
Zambia: Tianjun Hou

TRI Fellows: The first thirty years

Erin Beasley, TRI Program Officer, Tamara Thomas, MEM 2016 &
Katelyn Liesner, MEM 2016

Abstract

What can we learn from the Tropical Resources Institute (TRI) fellows of the past three decades? After their research proposals were written, the field work complete, and results analyzed and published, what was next for the hundreds of Yale School of Forestry & Environmental Studies (F&ES) researchers who explored natural resource challenges across the tropics? We examined the current work of TRI alumni to learn more about the diverse career paths that our fellows take after their summer research. We confirmed that TRI has a broad and growing network of alumni in academia as well as the non-profit, public, and private sectors. Our alumni address conservation and management from local to international scales, and work in dozens of countries around the world. For many F&ES students, summer research with the support of TRI was an early step in a career of inquiry across multiple environmental fields and issues. We believe that fostering investigative inquiry among early career researchers and environmental professionals encourages a deeper and more situated understanding to address critical challenges for conservation and management of tropical environments and natural resources worldwide.

Yale Tropical Resources Institute

Since its creation in 1983, the Tropical Resources Institute (TRI) has supported over 580 students to pursue interdisciplinary research on resource management and conservation issues in the tropics. The mission of TRI is to provide a forum to support and connect the initiatives of the Yale community in developing applied research, partnerships, and programs in the tropics. We support projects that aim to develop practical solutions to issues relating to conservation and management of tropical resources. TRI currently administers the TRI Endowment Fellowship, which supports Masters and Doctoral level research in the tropics each year, and, more recently, the Sri Lanka Forest Conservation Fund, which supports research at the Field Center for the Sri Lanka Program in Forest Conservation. From 1995 to 2011, TRI also administered the Compton International Fellowship through a generous grant from the Compton Foundation. Compton Fellowships supported research projects in Latin America and Sub-Saharan Africa

by international students from these regions.

The Tropical Resources Institute is led by the Director, and TRI staff include a Program Manager and several student Program Assistants, who contribute to an array of program activities, including the publication of *Tropical Resources*, the annual journal of student research carried out with the support of grants from TRI. TRI also has a Faculty Advisory Board, which provides guidance on policy matters and serves to evaluate student fellowship proposal submissions each year.

TRI recognizes that the problems surrounding the management of tropical resources are rapidly increasing in complexity, while demands on those resources are expanding. TRI seeks to train students as leaders in this dynamic era, leveraging resources, knowledge, and expertise among governments, scientists, NGOs, and communities to provide the information and tools required to equitably address the challenges ahead. Here, we illuminate the population of former TRI fellows to better understand this singular community and inform future fund-

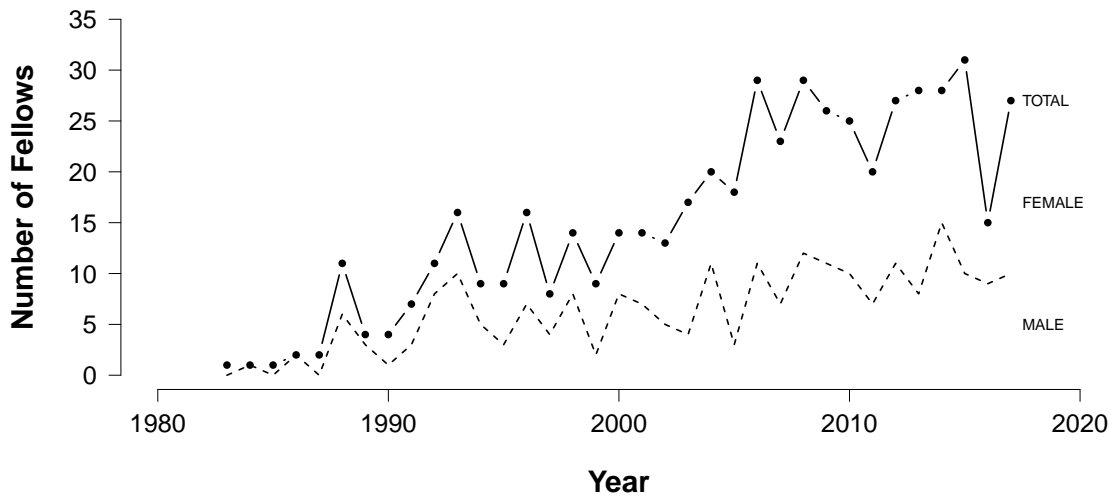


Fig. 1. The number of TRI fellows per year, identified by gender.

ing and training opportunities.

We considered fellows who received their master’s or PhD degree from F&ES between 1983 and 2014 (n = 565). Of those individuals, we gathered current information for 529 TRI alumni, including graduation year, gender, additional degrees earned, home country and country of current employment, job title, employer and employment sector.¹

Number of Fellows

The total number of fellows funded each year has increased from the handful preceding the creation of TRI to 20-30 students each year in the last decade (Fig. 1). This growth is most likely related to the overall rise in matriculating students at F&ES, concurrent with the increasing funding availability.

The overall gender ratio is female-biased (307 women, 222 men) following an increasing proportion of female researchers over the years (Table 1), reflecting the overall increase of female students at F&ES interested in research over the past two decades.

¹If you have recently changed jobs, moved, or completed a degree, we encourage you to email us at tri@yale.edu, so that we can stay up to date with your current work.

Year	Female:Male ratio	Female Quotient
1980-1992	36:42	0.86
1993-2002	84:59	1.42
2003-2014	187:121	1.54
Total	307:222	1.38

Table 1. The change in gender ratio of TRI Fellows from the 1980s to 2014.

Geographic Distribution

Not surprisingly, the interest that TRI fellows show in the tropics translates into work and careers around the world. Beyond the United States of America (US), TRI fellows work on all inhabited continents in a total of 48 countries (Figs. 2 and 3). The top five countries where our fellows currently work are the US (n = 355), United Kingdom (10), Thailand (9), Indonesia (8) and Brazil (7).

The majority of TRI Fellows originally hail from the US, and 10% of those alumni currently work outside of their home country (n = 33). The

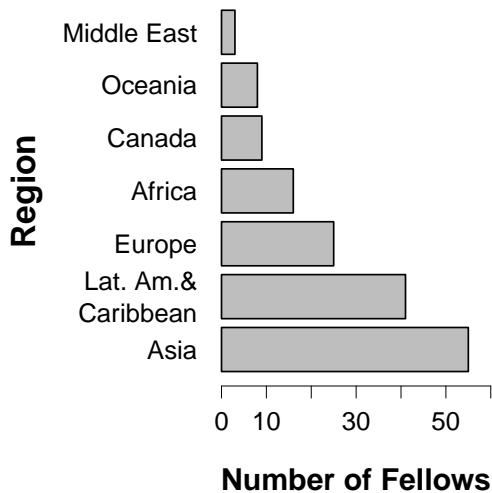


Fig. 2. Current (2015) location of place of business of TRI Fellows from 1980-2014. (n = 460; the US has 355 alumni and 17 are unknown – some fellows did not have a current country of business).

international TRI Fellows who listed a home country outside of the US are even more likely to be working “abroad”: 28% are currently working outside of their home country, with about half employed in the US and half elsewhere. These numbers underrepresent the truly global nature of the issues TRI fellows address, because many TRI fellows continue to work on international issues wherever they are located.

Employment sector

We hope that the TRI experience catalyzes student interest in conducting field research in the tropics, and TRI succeeds in attracting student fellows from both the academic (MESc/MFS) and professional (MEM/MF, albeit in lower numbers) career paths. Given the emphasis on research, it is not surprising that the largest employment sector for TRI fellows is academia. However, the variety of other sectors illustrates the diverse interests and career paths

²This number is lower than might be expected given the number of fellows in academia; however, many students were fellows during their PhD program at Yale F&ES.

possible to students after completing their research under the fellowship (Fig. 4) – over 60% are working outside of academia in a variety of non-profit, private, and public positions. A smaller subset of fellows currently work for UN programs and international financial institutions.

The changing nature of employment among those working to address problems in conservation and management is highlighted by the shift in sectors employing alumni. Students who graduated after 2004 are more likely to be working in the non-profit sector, and less likely to be working in the private, public, and academic sectors. This may point to the growing role that the non-profit sector plays in the kind of work that TRI alumni do.

The top employers of TRI alumni are Yale F&ES itself, followed by the World Bank (n = 9), the Nature Conservancy (8), the US Forest Service (8), USAID (7), WWF (6), and UNDP (5). While consultants and executive directors were two top job titles outside of academia, the most frequent job titles among our fellows occur within academia: Doctoral candidate is the most common (n = 55); other alumni in academia are working as post-doctoral researchers and faculty.

Academia

Of the 200 fellows in academia, the majority are still doctoral students (n = 55), while others now have post-doctoral (14), research fellow (21), or tenure-track (47) or tenured faculty (17) positions, non-tenure track (22) or are otherwise employed in university administration (20), or other activities (4).

After completing their education at Yale F&ES, 20% of TRI Fellows, went on to attain an additional degree (n = 106)², which likely prepared them for further research and studies. Within the two research-focused degrees in F&ES, almost half continued in this field: 45 of the 109 TRI fellows from the MFS program and 90 of the 229 from the MESc program currently list a job in academia.

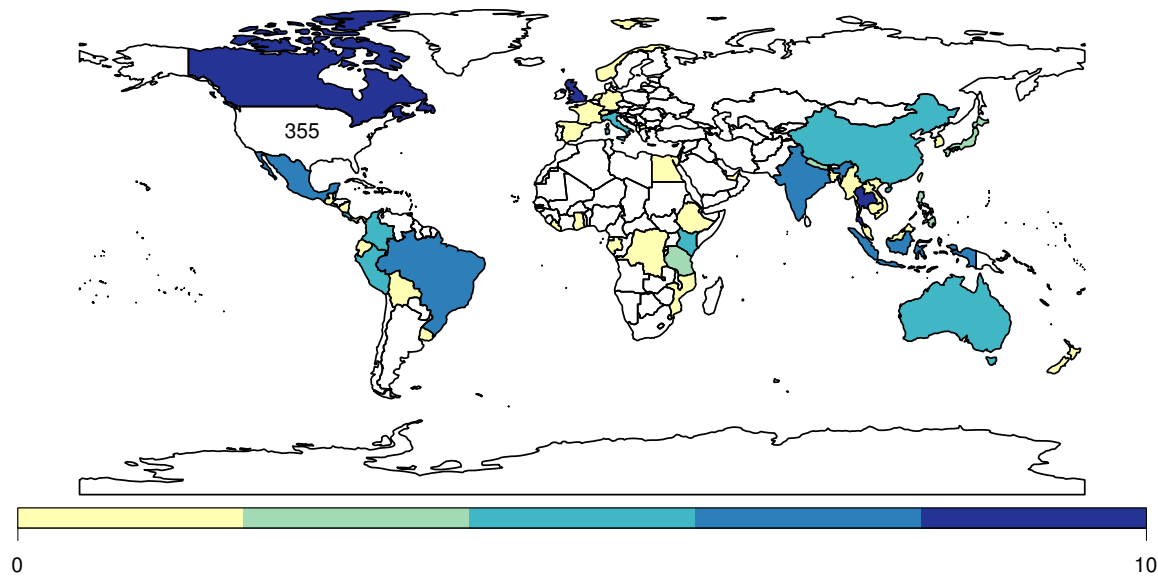


Fig. 3. Map of TRI Fellows work locations by country. Number of fellows varies from 1 to 10, with the US having 355.

The employing academic institutions range across the globe, from Columbia University (US), the London School of Economics (UK), Universidad de los Andes (Colombia), and University of Chittagong (Bangladesh), to the Melbourne Law School (Australia), and the Tokyo Institute of Technology (Japan). Columbia, Duke, UC Berkeley and UC Davis, and the University of Hawaii are top academic destinations for our fellows. Many Fellows remain at F&ES in various roles ($n = 26$).

Non-profit

The non-profit sector is the second-largest employer of TRI alumni ($n = 121$), and includes a wide variety of organizations ranging from the African Wildlife Foundation (Kenya) to La Suiza Co-op Coffee Growers (Guatemala). The top five employers are The World Wildlife Fund (6), The Nature Conservancy (8), Gordon and Betty Moore Foundation (3), and the Wildlife Conservation Society (2) and Pew Charitable Trust (2). Within this sector, alumni of TRI show their leadership as founders, executive directors and directors, senior

managers and program officers. Further, alumni in this sector are the most likely of all TRI alumni to be working on international issues – over half work for an organization or program specifically focused outside of the US.

Public and private sectors

TRI alumni in the private sector ($n = 82$) work primarily in energy (especially solar), consulting, communications, and natural resource investment companies. In addition, this sector also showed the most variation in employment, with work ranging from nutrition and wellness to engineering, mining, and tourism. Several of these enterprising alumni are CEOs, owners, partners, or principals of the business where they work (23).

In the public sector ($n = 72$), fellows provide their services primarily in the areas of forestry (20), international development (6), climate change (5) and energy (4). Other areas of work are conservation, regulation, and social science research. These alumni work at the local, state, and national level in 16 countries, although mostly in the United States

(75%). Top agencies include the US Forest Service (8), US Agency for International Development (7), US Environmental Protection Agency (4), US Department of Agriculture (4), and US Fish and Wildlife Service (3).

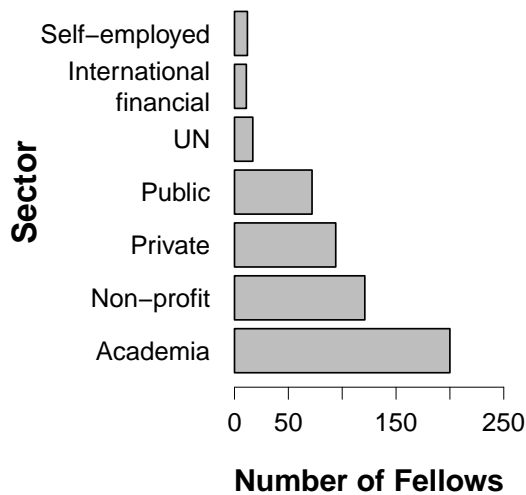


Fig. 4. Employment sector of TRI fellows.

Why is research with TRI important?

The increasing number of fellows, gender equity, and shift in employment sector reflect the expansion of the program and the international scope of work carried out by TRI fellows. The greater emphasis on direct impact via work in non-profits, as well as the traditional academic route, suggest that TRI alumni are making a difference more than ever before.

In the future, we expect to provide greater support to more fellows, with an increasing focus on interdisciplinary approaches to solving environmental problems. Because TRI fellows study closely with F&ES faculty, we expect fellows' research to better reflect recent and forthcoming hires in the School, as well as to take advantage of expertise from F&ES partner organisation within Yale and

further afield. Furthermore, we anticipate that alumni will have increasingly multi-faceted careers, working in several sectors for a variety of employers, either sequentially throughout their career or explicitly in multiple sectors from the beginning.

Why is it important to have people with research experience working in all of these fields? Whether in academia, policy, or practice, TRI alumni bring the deeper practical and academic knowledge of their research site to their careers in explicit and implicit ways. Giving students the chance to put an investigative lens on a complex resource issue allows them as professionals to consider problems and proposed solutions more critically, with a better appreciation for the ecological and societal relationships of the place. The environmental challenges of our time require building from previous knowledge, and the process of academic inquiry helps us to understand not only the root of these challenges but also creative solutions.

Addressing challenges cannot be done in isolation, and this review reveals the strength and opportunities across the TRI network. Past fellows working across many sectors means that our fellows take their research experience with them to universities, businesses, public policy, and social needs in the US and around the world. Our growing network is a testament to this population's underlying curiosity about the way the world works, across the tropics, and across disciplines. Our next step at TRI is to foster even better research and understanding of tropical resources among F&ES students, and build long-term research relationships that leverage the knowledge embedded across this diverse network of previous fellows. The skills of independent critical thinking, research design and execution, data analysis and writing that the TRI fellowships provide together create a firm foundation on which to build new leadership and knowledge to sustain and restore the long-term health of the biosphere and the well-being of its people.

Caffeine and theobromine analysis of *Paullinia yoco*, a vine harvested by indigenous peoples of the upper Amazon

Luke M. Weiss*, MF 2015 & James K. Kearns, PhD[†]

Abstract

Paullinia yoco R.E. Schult. & Killip (Sapindaceae) or 'yoco', is a liana (a woody vine) used traditionally by indigenous peoples of the upper Amazon region as a stimulating beverage, because it contains both caffeine and theobromine. However, as the wild plants become increasingly rare and hard to find because of permanent settlement within a much-reduced territory, there is growing interest among indigenous tribes to learn how to successfully cultivate it for community consumption and potentially as a cash crop. To date, there has been very little research conducted on the stimulant chemical composition of the liana and biochemical variation within- and between plants.

This paper provides the results of chemical (high-performance liquid chromatography) analysis of caffeine and theobromine concentrations of multiple samples of phloem and leaf material from 18 *Paullinia yoco* lianas. Caffeine values ranged from 0.1% to 3.6% with a significantly higher amount in the stem phloem material than the leaf material, and there was a positive linear correlation between stem diameter and caffeine concentration (% dry weight). Although the highest theobromine level was found in leaf material (1.8%), overall there was no significant difference between phloem and leaf material, and no correlation between stem diameter and theobromine concentration. Finally, we found a significant amount of variance of both caffeine and theobromine between individual plants. These results are important, first because they shed light on the apparently conflicting previous reports on *P. yoco* caffeine and theobromine content; and second, they provide important clues about the phytochemical architecture of *P. yoco* which in turn has important implications for the design of a cultivation strategy for local indigenous communities to potentially produce a yet-to-be domesticated plant of substantial market potential.

Paullinia yoco R. E. Schult. Y Killip (Sapindaceae) o 'yoco', es una liana (una enredadera leñosa) utilizado tradicionalmente por los pueblos indígenas de la región amazónica superior como una bebida estimulante, ya que contiene cafeína y teobromina. Sin embargo, como las plantas silvestres son cada vez más raros y difíciles de encontrar debido a asentamiento permanente en un territorio muy reducido, existe un creciente interés entre las tribus indígenas para aprender cómo cultivar con éxito para el consumo de la comunidad y, potencialmente, como cultivo comercial. Hasta la fecha, ha habido muy poca investigación realizada sobre la composición química estimulante de la liana y bioquímica intra-variación y entre plantas.

Este trabajo presenta los resultados del análisis química (cromatografía líquida de alta resolución) de las concentraciones de cafeína y teobromina de múltiples muestras de material floema y hoja de 18 lianas *Paullinia yoco*. Valores de cafeína variaron de 0,1% a 3,6% con una cantidad significativamente mayor en el material de floema

* Luke Weiss was born in British Columbia, and with most of his upbringing in Manchester, Michigan. He received a B.S. in biology from The Evergreen State College. Before coming to Yale F&ES, he spent 18 years living in the tropics of northeastern Ecuador working on numerous conservation and development projects with the Secoya indigenous nation. Currently he is an MF candidate, with interests in tropical restoration and sustainable land-use management. His research is focused on designing a sustainable cultivation system for a caffeine-rich liana traditionally consumed by the Secoya people which is becoming increasingly rare in the wild. Correspondence: lukemweiss@yahoo.com

[†] James Kearns is an Assistant Professor in the Department of Chemistry, Southern Connecticut State University.

vástago de que el material de hoja, y había una correlación lineal positiva entre el diámetro del tallo y la concentración de cafeína (% peso seco). Aunque el nivel teobromina más alta se encontró en el material de la hoja (1,8%), no hubo diferencia significativa entre el floema y el material de hoja, y no hay correlación entre el diámetro del tallo y la concentración de teobromina. Finalmente, se encontró una cantidad significativa de varianza de cafeína y teobromina, tanto entre los individuos. Estos resultados son importantes, primero porque arrojan luz sobre las aparentemente contradictorios informes anteriores sobre *P. yoco* cafeína y teobromina contenido; y segundo, que proporcionan importantes pistas sobre la arquitectura fitoquímica de *P. yoco* que a su vez tiene implicaciones importantes durante el diseño de una estrategia de cultivo para las comunidades indígenas locales para producir una planta todavía-a-ser domesticada del potencial de mercado importante.

Introduction

Stimulating beverages have been developed and are consumed by virtually all human cultures (Weinberg & Bealer 2001). Of the six caffeine-containing plant genera used as stimulants (*Coffea*, *Camellia*, *Theobroma*, *Cola*, *Ilex*, and *Paullinia*), *Paullinia*, a genera of woody vines or lianas in the Sapindaceae family, is the least studied (Weckerle et al. 2003). Two species within this genus have been found to contain purine Alkaloids (PuA): *Paullinia cupana* Kunth and *Paullinia yoco* R.E. Schult. & Killip. The seed of *Paullinia cupana*, more commonly known as guaraná, has received the most attention because of its economic importance as the key ingredient in commercial beverages (Henman 1982), that include internationally marketed brands such as Red Bull™, and Sobe™, as well as many lesser known national (Brazilian) brands. *Paullinia yoco*, on the other hand, remains one of the most important cultural plants of the indigenous tribes of the Amazonian regions of Ecuador, Colombia, and Peru (Miño et al. 1995). The fresh phloem layer of the vine is rasped and infused in cold water (Fig. 1 and 2) and drunk in early morning for its stimulating properties, attributed to its composition of caffeine and theobromine (Schultes 1987). Richard Evans Schultes (1987) reported *P. yoco* to be “amongst the Indians of Colombia and Ecuador, the most important non-alimentary plant in the economy.” *Paullinia yoco* is used by most of the tribes and communities affiliated with the western Tukanoan linguistic family (Schultes 1942, 1951), as well as their neighboring Cofán and Ingáno tribes that represent other language families (Zuluaga 2004). All

of these groups reside in the triple-border region of Ecuador, Peru, and Colombia, and all refer to this liana ubiquitously as ‘yoco’ (Belaunde & Echeverri 2001). In recent years however, a severe reduction in the extent of many indigenous territories from colonial encroachment, in tandem with other social and demographic changes, has led to a notable shortage of *P. yoco* in the wild. Traditional indigenous silvicultural management is no longer sufficient to maintain this plant within the current social and geographical context.

As a means of addressing this imminent shortage, the Secoya indigenous nation of the province of Sucumbios, Ecuador, is interested in learning how to more successfully cultivate *P. yoco* to meet



Fig. 1. A cross section of a *Paullinia yoco* cutting (4 cm diameter) showing the dark orange phloem layer and white resin. Credit: Luke Weiss.

the demands of the local community and also potentially to create a marketable product. To assess the economic potential of *P. yoco*, a better understanding of the plant's stimulant chemical concentration, the within-plant distribution of stimulant chemicals, and variance in chemistry between genetic provenances is critical. To date, very little research has been conducted on *P. yoco*, and worldwide only 40 herbarium specimens have been collected (Weckerle et al. 2003). The first reported chemical analysis was in 1926, where levels of caffeine were found to range between 2.0 and 2.7% (Michiels & Denis 1926). Another more recent study used previously collected herbarium specimens and found concentrations two orders of magnitude lower—median values for phloem material were 0.1% caffeine and 0.05% theobromine; and for leaf material were 0.03% caffeine and 0.03% theobromine. This contrast resulted in Weckerle et al. (2003) summarizing their findings by saying “clearly fresh stem material of various *P. yoco* provenances will be necessary to fully resolve the ‘yoco mystery.’”

This research, therefore, aims to elucidate the ‘mystery’ of this Amazonian liana through the analysis of fresh stem material of 18 *P. yoco* provenances, with sampling from multiple stem diameters and vegetative parts, collected under the guidance of indigenous experts. Specifically, the following hypotheses will be addressed: (1) caffeine and theobromine concentrations from fresh material are higher than those found in herbarium material by Weckerle et al. (2003), (2) caffeine and theobromine concentrations are higher in phloem than in leaves and positively correlated to stem diameter, and (3) there is considerable between-plant variation in caffeine and theobromine content.

Methods and materials

Field collection

Plant material from 18 *Paullinia yoco* lianas was collected under the guidance of local expert



Fig. 2. A Secoya elder, Delfin Payaguaje, during his morning ritual of rasping the phloem layer of *Paullinia yoco* into a gourd of cold water, which will be kneaded into a bitter beverage. Credit: Mitchell Anderson.

indigenous guides within the indigenous territory of the Secoya Nation (SIEKOPAI) located in the north-eastern province of Sucumbios, Ecuador (Fig. 3). This region is a lowland tropical rain forest on the eastern toe slopes of the Andes mountains at approximately 300 m elevation and with an average annual rainfall of 3,555 mm and mean average temperature of 24°C (Miño et al. 1995). The sampling sites were distributed over an area of approximately 10,000 hectares of *varzea* flood-plain and *terra firme* forest types, with an average distance of 6,947 m between sampled individuals. *Paullinia yoco* vines were positively identified by indigenous guides. The outer layer of bark was scraped away, and sampling of the phloem layer was conducted with a small knife. Sample sizes ranged between 0.25 and 1.0 grams, and were collected at the vine's base (approx. 50 cm from ground) and one to three other accessible regions. Liana diameter was recorded at each sampling point. Mature leaves were also collected when accessible. Plant samples were left to air dry during the course of the collec-

tion period; no preserving chemicals were applied to specimens.

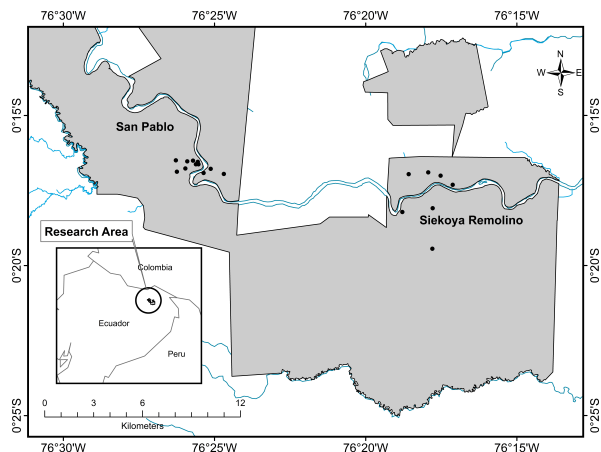


Fig. 3. Location of research site: Secoya Indigenous territory in the Province of Sucumbios, Ecuador.

Additionally, at each sampling site, the support tree identity (to genus level) and diameter at breast height (1.3m, DBH), forest type (varzea flood plain or terra firme) and GPS coordinates were recorded.

Plant sample preparation

Upon return to Yale University, plant samples were freeze-dried to constant mass and homogenized into a powder-sized particulate using a freezer mill. Plant sample analysis closely followed the methodology of Weckerle et al. (2003). Extraction of the samples was carried out with 5 ml 0.1N HCl in a snap-cap Falcon tube vial for 30 minutes at 50 degrees Celsius. An aliquot of 500 µl of the extract was applied onto a Merck Extrelut NT 1-100 column for initial solid phase separation. After 5 minutes, elution was carried out with 5 ml methylene chloride (CH₂Cl₂). The organic solvent (CH₂Cl₂) was removed by a stream of N₂ gas, and the residue dissolved in 500 µl 8% MeOH. Aliquots of 50 µl were analyzed by high performance liquid chromatography (HPLC).

HPLC analysis

Separation was performed on a Capcell Type UG 120 5µm column; size: 4.6mm x 150mm, and no pre-column, with eluents H₂O [A] and MeOH [B], both with 1% THF, at a total flow rate of 1 ml min⁻¹ and by the following gradient (%B over A): 0–10 min (8–25). Peaks were identified by using a UV detector set at the λ_{max} = 272 nm. The retention times were determined by running separate pure standards of caffeine and theobromine and were as follows (min): theobromine (4.0), caffeine (9.0). The detection limit was determined by preparing authentic standards at decreasing concentrations until no significantly observable peak could be identified.

Calibration curves were established by preparing mixed standards of equal concentrations (by mass) of caffeine-theobromine at various concentrations ranging between 0.2 ppm and 200 ppm. Individual *P. yoco* samples (% dry weight) of caffeine and theobromine were calculated by multiplying the peak area of the plant sample chromatograms by the calculated coefficient derived from the calibration curves.

Results

Calibration curves

The calibration curves were as follows (Fig. 4). For caffeine (R² = 0.998):

$$y = 0.0025x \quad (1)$$

and theobromine (R² = 0.9996):

$$y = 0.0031x \quad (2)$$

Chemical analysis of phloem and leaf material

A total of 36 samples of phloem material and 11 samples of leaf material representing 18 individual *P. yoco* lianas were collected (Table 1). Mean caffeine content (% dry weight) was 1.17±0.01% in phloem material (range = 0.01–3.68%) and 0.20±0.003% (range = 0.00–0.75%) for leaf material. Mean theobromine content was 0.18±0.002% (range = 0.01–

Material	Caffeine (% DW)	Theobromine (% DW)
Phloem (n = 36)	mean = 1.17 (range = 0.11 – 3.68)	0.18 (0.01–0.74)
Leaf (n = 11)	0.17 (0.00–0.75)	0.38 (0.01–1.63)

Table 1. Summary of caffeine and theobromine mean and range values of 36 phloem samples and 11 leaf samples.

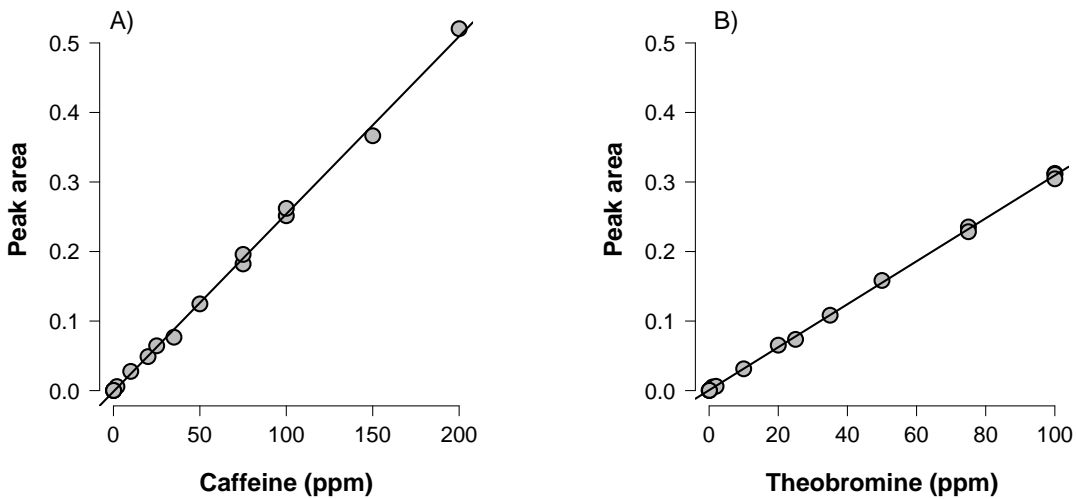


Fig. 4. A) Calibration curve for caffeine derived from prepared samples of caffeine (Sigma 99.9%) dissolved in 8% MeOH. Prepared standard concentrations were (ppm): 0.02, 0.05, 0.1, 0.2, 2.0, 10.0, 20.0, 25.0, 35.0, 50.0, 75.0, 100.0, 150.0, 200.0. B) Calibration curve for theobromine derived from prepared samples of theobromine (Sigma 99.9%) dissolved in 8% MeOH. Prepared standard concentrations were (ppm): 0.05, 0.02, 0.2, 0.1, 1.0, 2.0, 10.0, 20.0, 25.0, 35.0, 50.0, 75.0, 100.0.

0.74%) for phloem and $0.54 \pm 0.01\%$ (range = 0.01–1.63%) for leaf material (Table 2).

Within-plant variation in purine alkaloids

For all plant individuals pooled, there was significantly more caffeine in phloem than leaf material (Paired t-test, $t = 3.99$, $p = 0.0026$; Fig. 5A). There was no significant difference in theobromine concentration between phloem and leaf material (Paired t-test, $t = -1.599$, $p = 0.141$; Fig. 5B).

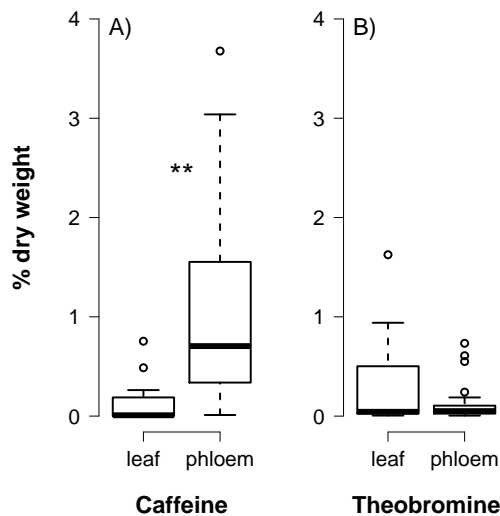


Fig. 5. Caffeine (A) and theobromine (B) content of phloem and leaf material from *Paullinia yoco* lianas from Amazonian Ecuador ($n = 18$). Significantly greater caffeine content was found in the phloem than leaf, but there was no difference in theobromine content.

Alkaloids versus stem diameter

As predicted, there was a significant positive relationship between phloem caffeine content and stem diameter, with around a 1% dry weight increase in caffeine for every 4cm increase in stem diameter (linear regression, $y = -0.18 + 0.34x$, $t = 7.541$, $p < 0.001$; Fig. 6A). However, the slight negative trend between phloem theobromine content and stem diameter was not significantly different from zero (linear regression, $t = -0.698$, $p = 0.490$; Fig.

6B), and there was no significant trade-off between percent dry weight caffeine and theobromine (linear regression, $t = -0.939$, $p = 0.353$).

Comparison with Weckerle et al. (2003)

A comparison of these results to the values found in the analysis of herbarium samples by Weckerle et al. (2003), revealed a significantly higher amount of both caffeine and theobromine values in the phloem material (Welch two sample t-test: Caffeine in phloem, $t = -6.111$, $p < 0.001$; Theobromine in phloem, $t = -2.7107$, $p = 0.0096$). However, our results did not differ significantly from those reported by Weckerle for caffeine or theobromine values in the leaf material (Welch two sample t-test: Caffeine in leaf, $t = 0.989$, $p = 0.336$; Theobromine in leaf, $t = -1.227$, $p = 0.245$).

Between-plant variation in purine alkaloids

Caffeine and theobromine content varied significantly between individuals, even controlling for stem diameter (ANOVA, caffeine: $F = 47.31$, $df = 1$, $p < 0.001$; theobromine: $F = 48.55$, $df = 1$, $p < 0.001$; Fig. 7A and 7B).

Support trees

The support trees of the *P. yoco* lianas included trees of 10 families and 15 genera (Table 3) in a wide range of successional guilds: from fast-growing pioneer species (*Cecropia* and *Solanum*), to long-lived pioneers (*Virola* and *Ficus* spp.), as well as late-successional species (*Nectandra* and *Ocotea*). Lauraceae was the most represented family with four individuals. The support trees ranged in diameter from 12 to 80 cm (mean = 37.2, $sd = 18.9$).

Discussion

New data on the 'yoco mystery'

Our results support the suggestion that fresh material of *Paullinia yoco* has much higher purine alkaloid content than herbarium material such as that reported by Weckerle et al. (2003). Specifically, Weckerle et al. (2003) analyzed 23 phloem sam-

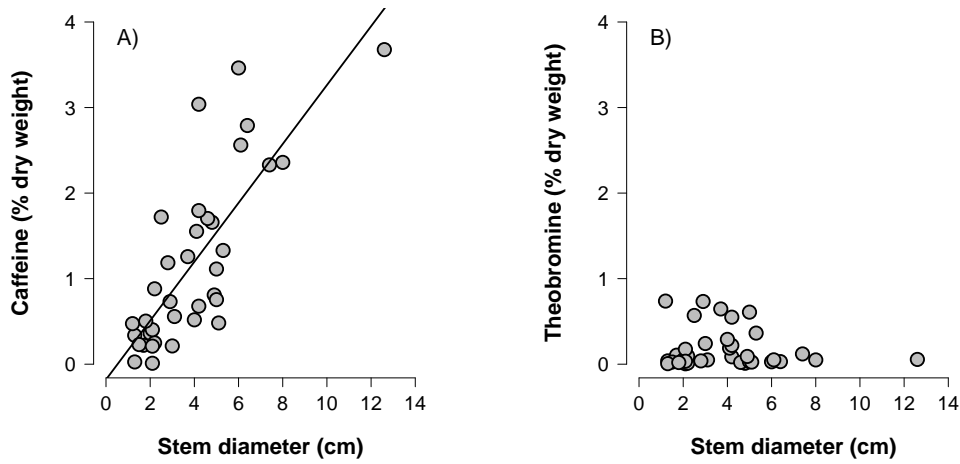


Fig. 6. Caffeine content (A) of *Paullinia yoco* lianas increased with increasing stem diameter, but theobromine content did not (B), for 18 lianas sampled from Amazonian Ecuador.

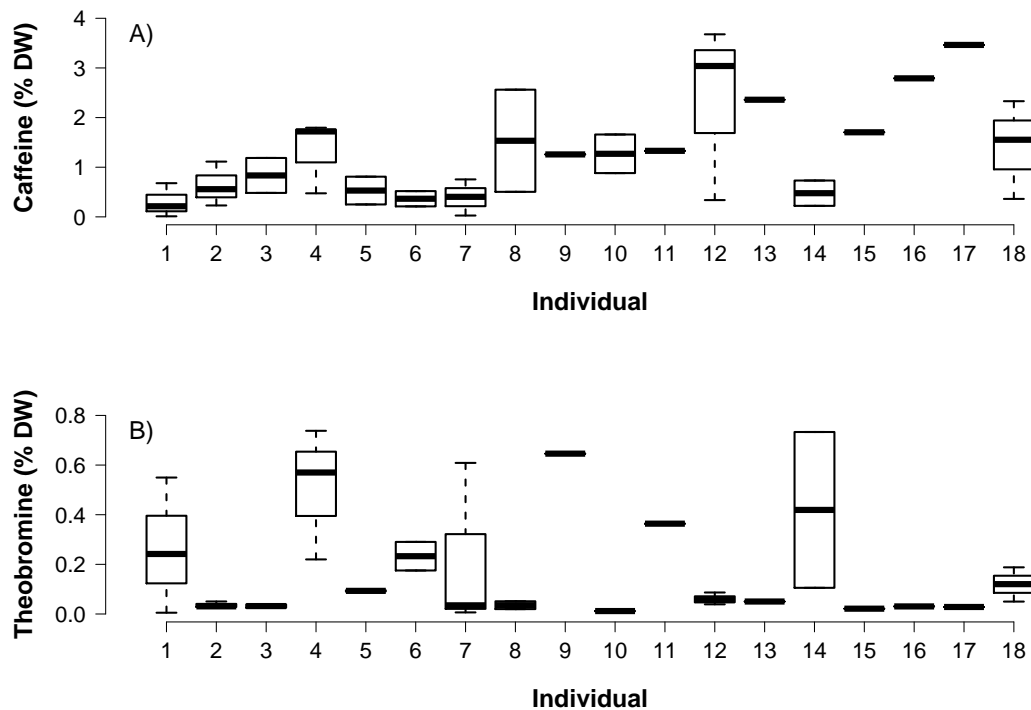


Fig. 7. There was significant variation in caffeine (A) and theobromine (B) content among individual *Paullinia yoco* lianas sampled from Amazonian Ecuador.

ples of *P. yoco* and found a median caffeine content of only 0.1% (range 0.00–0.525%) and median theobromine content of only 0.048% (range 0.005–0.185%). Our study reported much higher levels of both alkaloids in phloem, with mean caffeine levels of 1.18% and as high as 3.68%, and mean theobromine levels of 0.18% and as high as 0.74%, approximately four times higher than Weckerle et al. (2003).

However, this difference in alkaloid content between fresh and herbarium specimens was not apparent for leaf material. Weckerle et al. (2003) found a caffeine content range in leaf material of 0.00–1.3%, and theobromine of 0.00–0.438%, while our research found a caffeine range of 0.00–0.75% and theobromine range of 0.01–1.63%. In both studies, wide ranges of values were obtained, with a higher maximum value of caffeine found in Weckerle et al. (2003), but a higher theobromine maximum found in our study. Evidently, further studies are required to better understand the purine alkaloid distribution within the leaves.

One notable distinction between this research and the previous Weckerle et al. (2003) study is that we used a homogenized sample of 2–3 leaves from each liana, rather than analyzing specific regions of individual leaves. Perhaps closer attention to the particular region of the leaf and stage of leaf development during collection would further help to elucidate leaf phytochemical architecture. For example, caffeine content of tea leaves (*Camellia sinensis*) have been found to have higher caffeine levels along the edges and in younger leaves postulated as a defense against insects (Lin et al. 2003). Furthermore, the relative amount of shade and sun exposure may also contribute to varying amounts of purine alkaloid accumulation. In one study, shade-grown tea (*C. sinensis*) leaves were found to contain higher levels of caffeine than those grown in full sun (Hirai et al. 2008).

Within-plant variation in purine alkaloids

As predicted, there was significant within-plant variation in purine alkaloid content. Overall, phloem had a greater concentration of caffeine than leaves, but leaf material did not have a significantly higher amount of either purine alkaloid.

Furthermore, the results of this research revealed an important correlation between stem diameter and caffeine concentration (Fig. 6A), suggesting that larger and older plants accumulate caffeine as they grow. It may be this phytochemical architecture of *P. yoco* that can explain the relatively low caffeine content found by Weckerle et al. (2003). In their research, although stem diameters are not given, most of the phloem samples were removed from herbarium samples, which are traditionally taken from the upper, small branches where leaf and flower parts are present, and that according to our data will likely have much lower caffeine content than larger basal stems. Interestingly, this phytochemical architecture does not hold true for theobromine (Fig. 6B), and further research is certainly warranted to better understand the distribution of theobromine in *Paullinia*. In cocoa trees (*Theobroma cacao*) for example, the accumulation of theobromine is over 18 times higher in bean (33.20 mg g⁻¹) than in leaf (1.80 mg g⁻¹) material (Hammerstone et al. 1994).

Between-plant variation in purine alkaloids

Finally, the data from phloem samples highlight the striking differences in caffeine content between individual *Paullinia yoco* lianas. Not surprisingly, this variation between lianas is also recognized by the local people, where it is common practice to comment on the relative strength of a newly harvested ‘yoco’ liana (*pers. comm.*, July 2014). Without much more extensive sampling, it is hard to say whether this variance is most likely due to genetic differences or site differences. However, the caffeine content of *Paullinia cupana* also varies significantly between seeds of different provenance, ranging between 2.7 and 5.8% (Henman 1982).

Specimen	Family	Genus/species	DBH (cm)
yoco 1	Moraceae	<i>Helicostylis herrerensis</i>	26.0
yoco 2	Solanaceae	<i>Solanum</i> sp.	75.0
yoco 3	Mimosaceae	<i>Inga alata</i>	36.0
yoco 4	Melastomataceae	<i>Blakea</i> cf. <i>rosea</i>	24.0
yoco 5	Moraceae	<i>Ficus</i> sp.	80.0
yoco 6	Bombacaceae	<i>Matisia</i> sp.	48.0
yoco 7	Lauraceae	Lauraceae sp. 1	30.3
yoco 8	Mimosaceae	<i>Inga</i> sp.	31.8
yoco 9	Malvaceae	<i>Theobroma cacao</i>	12.0
yoco 10	Cecropiaceae	<i>Cecropia sciadophylla</i>	45.0
yoco 11	Unknown	Unknown sp. 1	21.0
yoco 12	Caesalpiniaceae	<i>Brownea grandiceps</i>	30.0
yoco 13	Myristicaceae	<i>Virola divergens</i>	47.0
yoco 14	Malvaceae	<i>Theobroma cacao</i>	14.0
yoco 15	Lauraceae	Lauraceae sp. 2	45.0
yoco 16	Lauraceae	<i>Nectandra paucinervia</i>	40.1
yoco 17	Lauraceae	<i>Ocotea</i> sp.	49.0
yoco 18	Unknown	Unknown sp. 2	15.0

Table 2. List of support trees identified at each *Paullinia yoco* sampling site.

Conclusion

Clearly, the popularity of *Paullinia yoco* as the preferred stimulant beverage among many indigenous tribes of the upper Amazon region is a testament to the liana's high caffeine and theobromine content. Although much remains to be understood in terms of its theobromine distribution, the within-plant distribution of caffeine is correlated to stem diameter, as well as considerable variance between individual 'yoco' lianas.

These results have important implications in the design of a cultivation strategy for this liana. First, it is crucial to cultivate the liana in such a manner to maximize its diameter, as well as the thickness of the phloem layer. For example, a single, larger vine would be preferable to more numerous but smaller, branching vines. Second, a closer examination of the canopy architecture of support trees is warranted to identify the most appropriate support-tree candidate for maximizing

the liana's leaf canopy index, which has been shown to positively influence phloem thickness in other tree species (Shrimpton & Thomson 1985). Third, the results reveal the potential importance of further genetic studies of various *P. yoco* provenances, perhaps over a much larger geographic range than the 10,000 hectares of this research, and to encompass provenances over the entire tri-country region. This genetic research would be needed in order to better understand the pathways of caffeine and theobromine production, and in selecting and cross-breeding to achieve a seed source with the greatest potential of producing the desired stimulant chemicals. Finally, it is worth adding that beyond the specific data collected in this research, this project illustrates the broader importance of combining indigenous knowledge and Western science during the creation of development projects for local communities that has both deep cultural implications and high economic potential.

Acknowledgments

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Mercury exposure and risk among women of childbearing age in Madre de Dios, Peru

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Abstract

The rapid growth of artisanal small-scale gold mining (ASGM) in Madre de Dios, Peru, has led to widespread mercury (Hg) use throughout this Amazonian state. Mercury that is released into the environment through ASGM is converted through natural processes to methylmercury (MeHg), a highly toxic and bioavailable form that accumulates in fish. People who eat fish contaminated with MeHg are at risk of mercury intoxication, which can damage the neurological system. Fetuses and infants are particularly susceptible, and mothers of childbearing age are considered a population of concern as they may pass Hg on to their children during pregnancy or through breastfeeding. Previous studies have found elevated mercury in residents of Madre de Dios, but there is a gap in understanding the Hg risk factors and level of knowledge of Hg risk among the population most affected by mercury contamination.

This study examines mercury exposure and risk factors among women of childbearing age (18–49 years old) living in three cities in Madre de Dios (n = 170). Study participants were selected randomly and asked for their informed verbal and written consent. Each study participant responded to a qualitative survey, which covered personal information and risk factors associated with Hg exposure. Hair samples were collected from each study participant and analyzed for total mercury content (THg). The study population had an average of 1.97 ppm THg (range: 0.01 ppm to 8.11 ppm), nearly two times the World Health Organization reference limit of 1 ppm. Some 78% of the study population had THg levels > 1 ppm. Elevated mercury levels were found outside of the mining zone in Iberia, where residents had an average of 2.37 ppm THg. Many study participants were worried about mercury contamination but had highly limited understanding of the health risks associated with mercury exposure. An immediate health response is needed to reduce the risk of Hg exposure in Madre de Dios, and an educational campaign could have immediate benefits.

El mercurio (Hg) es un contaminante global que tiene efectos dañinos para la salud humana y el medio ambiente. El crecimiento de la minería aurífera artesanal y a pequeña escala en Madre de Dios, Perú, ha subido el uso del mercurio (Hg) en este estado amazónico. Comunidades que viven en áreas afectadas de la minería, incluidas las comunidades de la cuenca Amazónica, tienen un nivel de riesgo elevado de exposición al mercurio. El mercurio contamina el medio ambiente y a través de procesos naturales para el metilmercurio (MeHg), una forma altamente tóxica y biodisponible que se acumula en los peces. Las personas que comen pescado contaminado con MeHg corren el riesgo de intoxicación por mercurio que puede dañar el sistema neurológico. Los fetos y los recién nacidos son particularmente susceptibles, y las madres pueden pasar el Hg a sus hijos durante el embarazo o la lactancia. Estudios previos han encontrado niveles elevados de Hg en los residentes de Madre de Dios, pero hay una brecha en la comprensión de los factores de riesgo de Hg y el nivel de conocimiento del riesgo Hg entre la población más afectada por la contaminación por mercurio.

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Este estudio examina la exposición al mercurio y factores de riesgo entre las mujeres en edad fértil (18-49 años) que viven en tres ciudades de Madre de Dios (n = 170). Los participantes del estudio fueron seleccionados al azar y les pide su consentimiento informado verbal y escrito. Cada participante del estudio respondieron a una encuesta cualitativa, que cubría la información y los factores de riesgo personales asociados a la exposición Hg. Las muestras de cabello fueron recogidos de cada participante del estudio y los contenidos de mercurio total (THg) fueron analizados. La población del estudio tuvo un promedio de 1.97 ppm THg (0,01 ppm a 8,11 ppm), dos veces más del límite de referencia Organización Mundial de la Salud (OMS) de 1 ppm. El 78% de la población estudiada tenía niveles de THg en exceso de 1 ppm. Se encontraron niveles elevados de mercurio fuera de la zona minera de Iberia, donde los residentes tenían un promedio de 2.37 ppm THg. Muchos participantes en el estudio están preocupados por la contaminación por mercurio, pero ellas tienen muy un nivel baja de comprensión de los riesgos que Hg presenta para la salud. Se necesita una respuesta de salud pública para reducir el riesgo de la exposición al Hg en Madre de Dios. Una campaña de educación podría tener beneficios inmediatos.

Introduction

Mercury (Hg) contamination in the Peruvian Amazon is a growing health and environmental concern (Driscoll et al. 2013, Swenson et al. 2011). The single most significant source of Hg contamination throughout the world is artisanal and small-scale gold mining (ASGM), which accounts for approximately 37% of total Hg released into the atmosphere each year (Gibb & O’Leary 2013). As the global demand for gold rose in the wake of the 2008 global financial crisis, there was increased pressure to exploit existing gold resources, such as those in the Peruvian Amazon (Swenson et al. 2011). Artisanal and small-scale gold miners have been active for decades in Madre de Dios, an Amazonian state in southeastern Peru (Gutleb et al. 1993, CAMEP 2013). However, there has been a drastic increase in ASGM activity in recent decades – between 1999 and 2012 the geographic extent of ASGM in Madre de Dios spread by 400% (Swenson et al. 2011, Asner et al. 2013).

Though alternative methods exist, workers in ASGM commonly use mercury to extract gold through the amalgamation process (Gibb & O’Leary 2013). Miners mix elemental mercury with a slurry that contains gold flecks to produce a gold-mercury amalgam. The amalgam is then heated to vaporize the mercury, which enables recovery of the gold. The tailings, which still contain mercury, are often dumped into waterways, and as much as 60% of mercury used in ASGM may be released into the environment (Diringer et al. 2015, Maurice-

Bourgoin et al. 1999).

There are generally two pathways that mercury released from ASGM can enter the human body. The first pathway is the inhalation of mercury vapors, which are produced when miners or gold shop proprietors heat the gold-mercury amalgam. Without proper safety measures in place, such as a retort, the mercury vapors may enter the lungs of workers and other people nearby (UNEP 2012). The second pathway is the consumption of food, usually fish, contaminated with mercury. Mercury released from in ASGM in makes its way into rivers and other waterways, where it is biochemically converted into methylmercury (MeHg), a highly toxic and bioavailable form (Barbosa et al. 1995). Once in waterways, MeHg accumulates in fish (Gibb & O’Leary 2013). People who eat contaminated fish can be exposed to potentially dangerous levels of MeHg (UNEP 2012). This is a population of special concern, as pregnant and nursing mothers can pass mercury to their infants during gestation or while breastfeeding (UNEP 2012). Serious birth defects may result when pregnant women are exposed to high levels of mercury. Mercury may also be passed from mother to child through breast milk, which can also impact neurological development.

Mercury is a toxic substance that, at high levels of exposure, can cause serious and irreversible damage to human health. The World Health Organization (WHO) sets the mercury acceptable limit for concentration in fish at 1 ppm (WHO 2008). Individuals exposed to levels of Hg above the this limit

are at risk of suffering from a range of health effects. At low levels of exposure, Hg can cause muscle damage, chronic headaches, mood swings, learning disabilities and sensory impairment (UNEP 2012). At high levels, Hg can cause birth defects, respiratory failure, kidney damage, coma, and death (UNEP 2012).

Mercury contamination appears to be a widespread and long-term issue in Madre de Dios. The most common way people become exposed to methylmercury is by eating contaminated fish (Clarkson et al. 2003). The U.S. Environmental Protection Agency sets the reference limit for the maximum at 0.3 ppm (U.S. EPA 2001). Studies dating back to the early 1990s have found fish contaminated with mercury in several Madre de Dios watersheds, some as far as 100 km away from the nearest gold mine (Gutleb et al. 1993, Gutleb et al. 1997).

There is limited understanding of the extent of Hg exposure in the human population of Madre de Dios, but the four studies that exist suggest that Hg presents a widespread risk (Yard et al. 2012, Ashe 2012, CAMEP 2013, Grandez-Urbina et al. 2014). Both Ashe (2012) and the Carnegie Amazon Mercury Ecosystem Project (CAMEP 2013) found elevated Hg levels in residents of Puerto Maldonado, the capital of Madre de Dios and its largest city. Between these two studies, hair samples from 430 adults were analyzed for THg concentration. Both studies report that the majority of the study population had THg levels above the WHO reference limit, with an average of 1.9 ppm reported by Ashe (2012) and 2.7 ppm reported by CAMEP (2013). Grandez-Urbina and colleagues (2014) studied Hg exposure in 60 women of childbearing age living in an indigenous community, also using hair as a biomarker. Most study participants were above the reference limit and the average exposure was 1.8 ppm THg. Residents of the mining communities have elevated Hg levels as well, as reported by Ashe (2012) and Yard et al. (2012). These initial exposure studies indicate that the human population of Madre de Dios is exposed to excess Hg wherever

studies have been conducted. However, in a region with a population of 130,000 and widespread mercury contamination, less than 600 individuals have been tested for Hg exposure. There is currently no local capacity to test human Hg exposure in Madre de Dios. Furthermore, there is limited understanding of the factors that increase the risk of Hg exposure in Madre de Dios.

This study focuses on adult women of child-bearing age, between 18 and 49 years old, living in urban communities of Madre de Dios, Peru. The aims of this study are threefold. First, I quantify the level of mercury exposure in women of child-bearing age residing in Madre de Dios by analyzing hair samples collected from each study participant. Second, I examine risk factors associated with mercury exposure, including personal background and behaviors, as ascertained through in-depth qualitative interviews with each study participant. Finally, I quantify the level of understanding of health risks associated with mercury exposure within the target population. Interview data was matched with levels of mercury exposure for each individual and with mercury levels reported in local wild-caught fish.

Methods

Study Site

Madre de Dios spans 85,300 km² in southeastern Peru and has a population of approximately 130,000 residents. Three urban areas were selected along a gradient of proximity to ASGM activity: Mazuco, which is in the zone where most mining occurs; Puerto Maldonado, which is downstream from the mining zone; and Iberia, which is outside the mining zone. Mazuco has approximately 3,000 residents and is located along the Huetpetuhe River, which has been a center of intensive ASGM activity where high levels of Hg were previously found in the human population (Yard et al. 2012). Puerto Maldonado is the capital of Madre de Dios and, with nearly 70,000 residents, its largest city (INEI 2012). Situated at the confluence of the Madre de

Dios and Tambopata Rivers, Puerto Maldonado is removed from ASGM activity but located in the same watershed. Iberia has approximately 4,000 residents and is located outside the mining zone in a watershed without ASGM activity.

Sampling

All study participants were women between the ages of 18 and 49 who had resided in their respective communities for at least six months. To select study participants, residences were selected at random and individuals living in each residence who met the selection criteria were asked whether they'd like to participate in the study. Written and oral informed consent was obtained for each study participant.

Each participant took part in a qualitative interview, which consisted of questions about basic personal information, including age, occupation, and level of education. Each participant was also asked about her level of concern of mercury contamination, level of knowledge of the health risk associated with mercury exposure, and symptoms that may be related to mercury exposure. A sample of hair was taken from each participant to assess mercury exposure.

Descriptor	N
N	170
Puerto Maldonado	120
Iberia	30
Mazuco	20
Sex	Female
Age Range	18–49 yrs
18–29 yrs	73 (43%)
30–39 yrs	52 (31%)
40–49 yrs	45 (26%)
Pregnant	12 (7%)
Breastfeeding	33 (19%)
Pregnant or breastfeeding	45 (26%)

Table 1. Descriptive data of the study population

Laboratory Analysis

Hair samples were analyzed for total mercury at the Environmental Science Center, Yale University, USA. Each hair sample was cut to 4 cm length for the portion of hair closest to the scalp. This approximates 4 months of mercury exposure, as hair grows an average of 1 cm mo⁻¹ (WHO 2008). The samples were then dried in an oven at 40°C. After dry weight was obtained, each sample was analyzed using the Direct Mercury Analyzer 80 device following EPA Method 1631. Mercury standards PACS and MESS₃ were used to ensure quality control.

Statistical Analysis

Analyses were conducted using the statistical software R (R Core Team 2015). Levels of mercury exposure were tested against the following risk factors: place of residence, age, level of education, and frequency of fish consumption. Single linear regression was computed for each factor.

Results

The majority of the study population in each of the three cities included in this study had high levels of mercury exposure. More than one in four (26%) women who took part in the study were either pregnant or breastfeeding, and thus at risk of passing mercury onto their children if they themselves have elevated levels of exposure (Table 1). The majority of study participants had limited understanding of the health risks associated with mercury exposure, and misconceptions were common.

Across the entire study population, the mean level of total mercury (THg) exposure was 1.97 ppm (range = 0.01–8.11 ppm). The majority (78%) of study participants had levels of mercury exposure above the 1 ppm WHO reference limit.

Mean total mercury exposure varied across the three study sites (Fig. 1). Study participants in Mazuco had a mean THg exposure of 1.90 ppm (0.38–4.78 ppm), and 70% had levels above 1 ppm. In Puerto Maldonado, study participants had a mean THg exposure of 1.89 ppm (0.01–5.22 ppm),

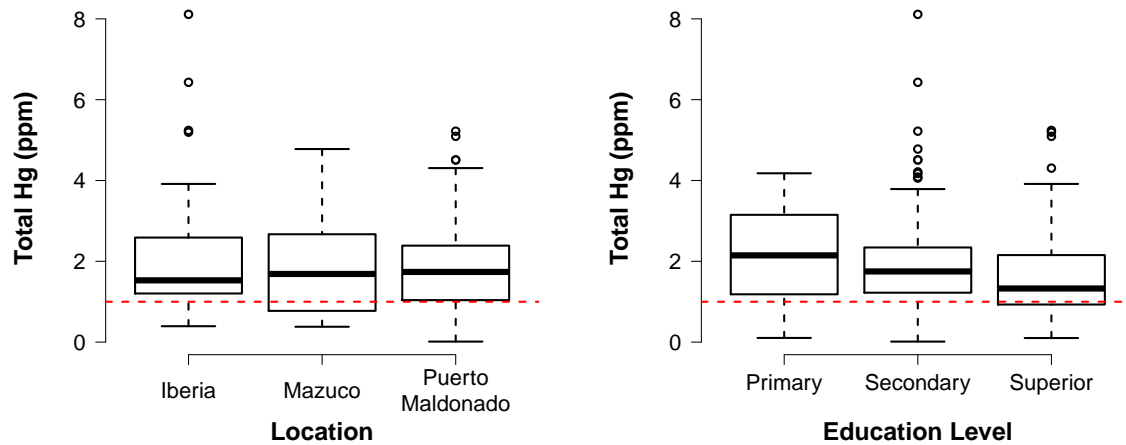


Fig. 1. Mercury exposure by place of residence (*left*) and maximum level of education (*right*). The WHO reference limit of 1 ppm is indicated by the horizontal dashed red line.

and 76% had levels above 1 ppm. In Iberia, study participants had a mean THg exposure of 2.37 ppm (0.39–8.11 ppm), and 93% of residents had levels above 1 ppm.

The frequency of fish consumption varied widely, from no fish consumption to daily fish consumption. The majority of study participants eat locally caught fish at least once per week. Higher frequency of fish consumption appears to be associated with higher levels of mercury exposure (Fig. 2).

Though the majority of the study population was concerned about mercury exposure, most respondents were misinformed or underinformed about health risks (Table 2). Nearly three in four study participants said they were worried or very worried about mercury contamination (73%). However, just slightly more than one in four study participants (26%) had some knowledge or were knowledgeable about the health risks associated with mercury exposure.

The flow of relevant public health information about mercury exposure is limited. Misperceptions about mercury were common among the study population. Some participants expressed concern that mercury exposure contributes to higher risk of can-

cer, though no such link has been established (EPA 2015). Many study participants had general knowledge of mercury-related health risks, for example, that mercury can damage the brain. However, very few study participants had an understanding of the symptoms of mercury exposure. Most of the study population had not seen the educational materials about mercury published by the Ministry of Health, universities, or NGOs. The most common way study participants learned about mercury and associated health risk was through popular media, including television, radio, and newspapers.

Category	N
Very Worried	19 (11%)
Worried	106 (62%)
Somewhat Worried	13 (8%)
Neutral	5 (3%)
Not Worried	17 (10%)
No Response	10 (6%)

Table 2. Responses to the question, “Are you worried about mercury contamination?”

Discussion

Women of childbearing age throughout Madre de Dios are exposed to high levels of mercury. Young children are at risk of mercury passed on from their mothers during pregnancy or breastfeeding.

Previous studies dating back to 1993 from Madre de Dios that have sought to quantify mercury contamination indicate that mercury contamination is widespread. The four previous studies of human exposure all report mercury levels in above the 1 ppm WHO reference limit (Fig. 3). The results from my study match previous findings, with similarly high levels of mercury exposure. Surprisingly, the highest levels of mercury exposure in my study were in Iberia, a community outside the mining zone. This is the first report from Madre de Dios of elevated mercury exposure in a community outside of the mining zone. Most women living in Iberia expressed little to no worry about mercury. Iberia is far removed from most ASGM activity by river, from major sources of Hg, suggests that Hg exposure may be a widespread problem throughout the region and the greater watershed. This area could stretch into Bolivia. The lack of awareness and concern regarding mercury exposure outside the mining zone may present an obstacle to health officials and researchers, who require public participation in order to conduct effective research and health interventions.

Mercury levels in my study were highest in Iberia, but earlier researchers found even higher averages in residents of Puerto Maldonado and the mining zone. This suggests that, though residents in Iberia are exposed to mercury, it likely is not the most contaminated city in the region. My result from Iberia indicates that populations outside the mining zone are also at risk of mercury exposure. More work is needed to quantify the levels of exposure outside the mining zone. Furthermore, public health officials may need to broaden their work to communities not previously thought to be at risk of mercury exposure.

There is a gap between how worried study par-

ticipants were about mercury and how much they knew about the actual health risks mercury poses. Though approximately 3 in 4 women expressed concern about mercury, only a 1 in 4 had at least some level of understanding of mercury's health risks. Women who are concerned about protecting their own health and that of their families do not have access to the information they need to make informed decisions about their health. Local health officials, as well as NGOs and universities, have produced educational posters and other materials designed to educate the local population about the risks of mercury exposure. Most of the participants in this study had not seen these materials. Local organizations interested in public health education around mercury may benefit from engagement with community groups that can distribute educational materials to members of the community.

Women of childbearing age are a population of concern, and most of the respondents were worried about mercury and were interested in taking measures to protect their and their family's health. A targeted educational intervention could have far-reaching benefits in protecting not only the health of these women, but also that of their children. Ashe (2012) found a correlation between high levels of fish consumption and higher levels of exposure to mercury. Health workers and others have called for reduced consumption of contaminated fish to reduce the risk of exposure. I collected data on the frequency of fish consumption, which species of fish study participants consume, and alternative sources of animal protein that are already a part of the local diet. Preliminary results indicated that though fish are an important component of the local diet, other protein sources including chicken and eggs also figure prominently. Concerns that women who reduce their intake of fish will not have adequate protein may be unfounded, but we need a more in-depth understanding of how habits of animal protein consumption vary seasonally.

We are still assembling the picture of where mercury contamination exists in Madre de Dios and what can be done to reduce or prevent it,

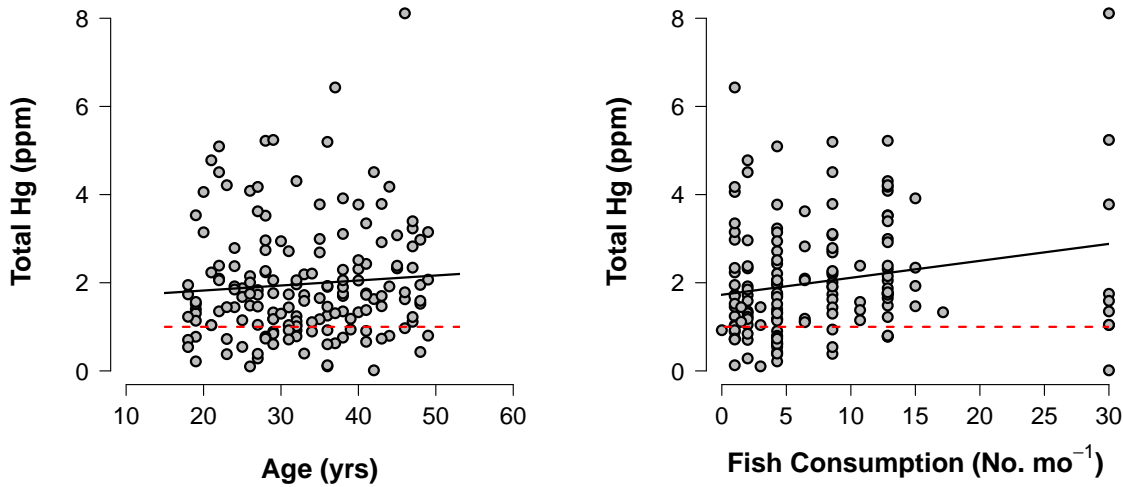


Fig. 2. Mercury exposure by age (*left*) and average number of fish consumed a month (*right*). The WHO reference limit of 1 ppm is indicated by the horizontal dashed red line.

or at least reduce or prevent one's exposure to it. What is known is that mercury contamination is widespread, and the more places we look for mercury, the more of it we find. Policymakers may do well to consider three routes to ensure that mercury intoxication does not become a major public health issue in Madre de Dios (and it is important to note that these routes are not mutually exclusive). First, at the national level, the Peruvian legislature is considering ratification of the Minamata Convention on Mercury, which would curb the import of mercury and restrict its use in ASGM. Preventing mercury from entering the country, or at least making it prohibitively difficult, would be beneficial. Second, the introduction of appropriate technologies that replace mercury in ASGM or that capture mercury before it is released into the environment can mitigate further harm. Third, a culturally appropriate educational campaign about mercury, its health risks, and how to reduce or prevent one's exposure to mercury can have an immediate benefit.

Though the scientific picture of mercury contamination in Madre de Dios is yet incomplete, there is no reason for government officials at the

national, state, and local levels not to take action to curb mercury contamination and exposure in the human population.

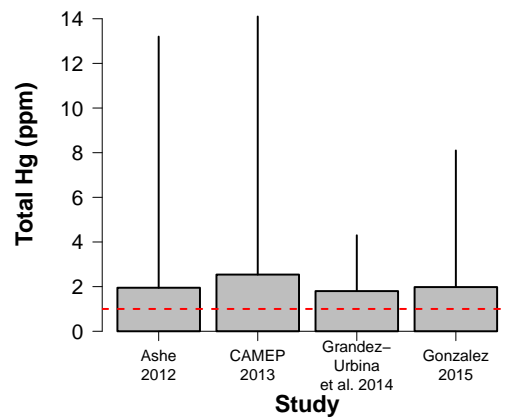


Fig. 3. A comparison of the level of mercury exposure from previously published studies from Madre de Dios. Vertical lines represent the maximum value for each study. The dashed red line represents the reference limit of 1 ppm.

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The social roots of ecological degradation in El Nevado de Toluca natural protected area, Mexico

José C. Pons, MEdSc 2015*

Abstract

Due to its rich cultural history, scenic beauty, and rich biodiversity El Nevado de Toluca is one of the most important natural protected areas in Mexico. But since the latter half of the twentieth century this natural protected area has undergone great ecological deterioration, which has mainly been caused by agricultural expansion by residents. This analysis shows that the roots of the ecological problem appear to be grounded in the historical exclusion of its residents from the natural resource management prescription. Thus, to halt the ecological deterioration of El Nevado de Toluca, local indigenous groups should be brought into the decision making process through a Biosphere Reserve scheme that is more inclusive and that provides residents with a means for socioeconomic development.

Debido a su historia cultural, la belleza de su paisaje, y su rica biodiversidad, El Nevado de Toluca es una de las áreas naturales protegidas más importantes de México. Desde la segunda mitad del siglo XX, esta área natural protegida ha sufrido un gran deterioro ecológico que principalmente ha sido causado por la expansión agrícola por los residentes. Este análisis muestra que las raíces del problema ecológico en El Nevado se deben a la exclusión histórica de sus residentes respecto al manejo de la tierra y de sus recursos naturales. Por lo tanto, para detener el deterioro ecológico de El Nevado de Toluca, grupos locales deben ser incluidos en el proceso de toma de decisiones. Una opción para esto la creación de una reserva de la biosfera que proveería mayor inclusión y desarrollo socioeconómico para sus residentes.

Introduction

With an area of 54,000 hectares in the central highlands of Mexico, El Nevado National Park was established in the 1930s with the goal to safeguard the scenic beauty, environmental services and unique biodiversity of the region. Since its creation, however, this natural protected area has undergone severe ecological degradation, which has negatively impacted stakeholders including people in neighboring cities who experience frequent water shortages, communal and private land owners within the protected area whose territory is increasingly polluted and degraded, and government authorities whose respect and legitimacy has decreased given

their failure to address environmental degradation. The expansion of the agricultural sector caused by rapidly increasing local populations appears to be one of the main drivers of El Nevado's ecological deterioration.

In this scenario, the policy problem is the social process to maintain the ecological integrity of El Nevado. The policy goal is to generate a process where the interests of the people in El Nevado are reconciled to prevent further ecological deterioration.

In this paper, I first describe the policy problem in terms of the social and decision processes that have driven ecological deterioration in El Nevado.

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Then I analyze the main trends and factors that have led to the problem, and discuss what is likely to happen if these factors are not addressed in the short term. In the last section, I make some recommendations to strengthen the ability of actors to cope with future challenges in natural resource policy and management in El Nevado.

Standpoint

My standpoint with respect to the policy problem is as an advocate and participant-observer. I was born and raised in Toluca, in the State of Mexico, a city only 20 km north of El Nevado. From school-organized events to friends and family field trips, I have been a regular visitor to El Nevado. This place has been very influential in both my heuristic development as a natural and social scientist, and my keen interest in resource management.

Beyond a source of motivation, El Nevado is also the landmark of my home town, the main water provider of the region, an important carbon sink, and a historical site that has traditionally been treasured for its spiritual values. As my grandmother pointed out to me, “El Nevado is the grandfather of the inhabitants of the State of Mexico”.

The main source of information used for this study is direct observation acquired since May 2011, when I became formally acquainted and involved in the policy problem in El Nevado. During this time, my interest in addressing the policy problem of El Nevado led me to form the non-governmental organization *Sumando Personas* (Bringing People Together). As a result, I have interacted with other stakeholders and I favor the ecological integrity of El Nevado over its degradation in part because I do not depend on its natural resources for subsistence.

Problem

Provisional statement

El Nevado is one of the most important natural protected areas in Mexico. At over 4,400 meters elevation, it is the fourth highest mountain in Mexico and home to the two highest lakes in the American

continent. El Nevado is home to 1,127 species, including 235 animals and 768 plants, many of which are endemic to the region (Ceballos 2011). Although the landscape is dominated by perennial forests, most of them pine trees, El Nevado also hosts grasslands and even tundra ecosystems near the top of the mountain.

Since pre-Columbian times, El Nevado was visited and venerated for the many environmental and spiritual services it provides. The Aztecs referred to El Nevado as *Xinantecatl*, or ‘nine springs’. For the Matlatzinca people, another pre-Columbian ethnic group, El Nevado was named *Nro’maani Nechhútata*, the ‘house of the god of water’. Today, the basins that drain from El Nevado provide 30% of the water used by the city of Toluca, the closest neighboring city, and 14% of the water used in the metropolitan area of Mexico City, where more than 20 million people reside (Gobierno del Estado de Mexico 2011).

The main problem in El Nevado is the ecological deterioration of the natural ecosystems caused by local residents through unregulated economic activities. This deterioration has been documented through the decrease in native land-cover, where only 17,000 ha of natural vegetation of the original 54,000 ha remains – a loss of almost 70% (Maass et al. 2006, Fig. 1). Furthermore, 60% of the remaining vegetation is now affected by invasive organisms and disease (Rios & Gutiérrez 2008, Vega 2008). The remarkable vegetation loss of the park appears to be caused by an array of illegal activities, including livestock grazing and the use of fire to enhance the agricultural output.

The loss of vegetation has consequently led to other forms of environmental degradation. According to Sanchez et al. (1990) 35–40% of the park area experiences severe forms of soil erosion, which in turn has affected water provision services in Toluca and the Valley of Mexico. Furthermore, landslides during the rainy seasons have resulted in a number of human deaths (Ceballos 2011).

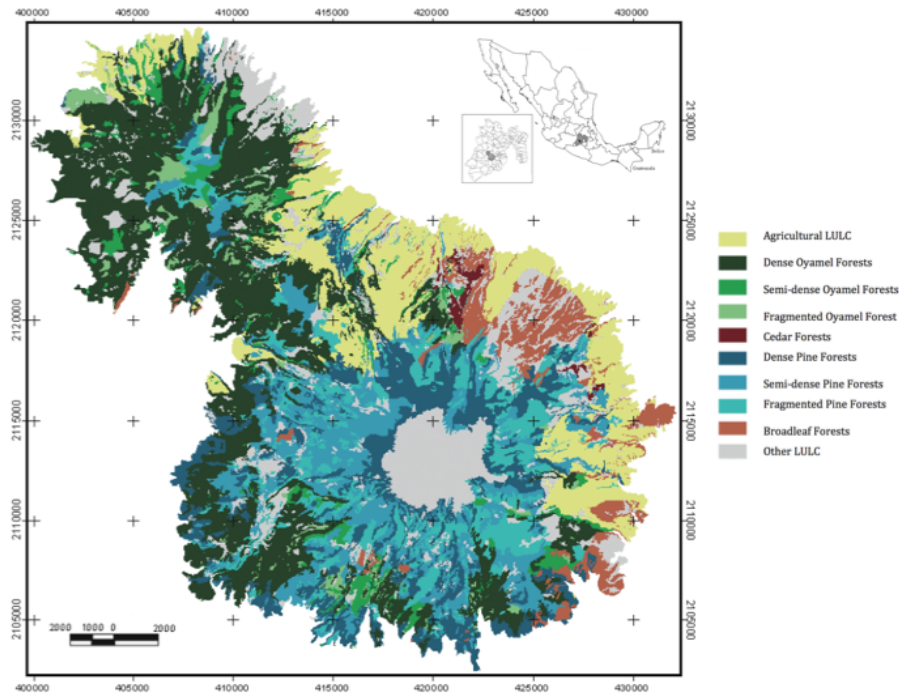


Fig. 1. Map of El Nevado de Toluca's vegetation cover in 2000 (from Maass et al. 2006).

Context

The problem in El Nevado can be clarified in terms of the seven functions that characterize decision processes: intelligence, promotion, prescription, invocation, application, termination, and appraisal (Clark et al. 2000, Lasswell & McDougal 1992). These processes illustrate the dynamic nature of the policy process.

1. Intelligence

The intelligence function refers to gathering, processing, and dissemination of information. Despite the high levels of environmental degradation in El Nevado and its' importance as a provider of environmental services, there has been little information generated on the main drivers of ecological degradation. Until 1998, the sole providers of information were academics from the Autonomous University of the State of Mexico (UAEM) and National Autonomous University

of Mexico (UNAM), and they remain the main sources of data. Another source are the federal, state, and local governments, whose researchers were also among the first to produce figures on soil erosion and water infiltration (Ceballos 2011).

It is important to note that local residents of El Nevado are not formally recognized as part of the intelligence function: They are not part of the decision-making process, nor do they provide feedback or information regarding ecological deterioration. If intelligence is not being collected from or by the people who are directly responsible for generating the problem, it is unlikely that government agencies can generate management prescriptions that work both for people and the environment.

2. Promotion

The promotion function refers to the way in which proscriptions are formulated and promoted. The federal government of Mexico is the main promoter

of the official course of action within El Nevado: the legal status of the area was assigned through an executive mandate in 1936. The status of El Nevado as a national park provides a set of regulations to prevent the environmental degradation of the place. The federal government seeks power and respect in the form of votes and public acceptance by maintaining the scenic beauty and environmental services that El Nevado provides to the nearby population of over 20 million people. In this light, the interest of the federal government to promote El Nevado's ecological integrity can be seen as a strategy to maintain its own institutional interests.

Aside from official courses of action, there are other groups promoting *non-official* courses of action, among the most important of these are local communities within the national park. One of the incentives for residents to promote the ecological preservation of El Nevado is the income and wellbeing they acquire from tourism. In the winter season (December to March), approximately 8,000 people visit the park daily, spending money on park entrance fees and local goods and services (Ceballos 2011).

However, local residents also promote other courses of action with respect to the problem that might conflict with the preservation of El Nevado. Residents often promote agricultural activities within the park, something that despite being illegal is widely practiced. Examples of these activities include the production of potato, corn, and livestock. The expansion of the agricultural frontier into the park is one of the main causes of the loss of native cover and vegetation. The problem is exacerbated because farmers use fire to enhance the productivity of the land. Fires frequently get out of control and are the primary driver of loss of perennial forest cover in the park (Ceballos 2011). In this scenario, the interests of local residents for agriculture conflict with those of the authorities who are responsible for maintaining the ecological integrity of the park.

3. Prescription

The prescription function refers to the formulation and enactment of policies and guidelines for action (Clark 2002). As discussed above, more than one course of action is promoted or incentivized in El Nevado. This situation is partly explained by the fact that the official prescription of the protected area does not successfully reconcile the interests of all actors towards a common goal.

The prescription to maintain the ecological integrity of El Nevado is given by its legal status as national park. This status was awarded in 1936 by the federal government without any scientific or technical justifications. A detailed map of the area comprising the park was published 50 years after the reserve was established. This situation has led to territorial conflicts between the main actors: the *ejidos* (communally-owned lands), private landowners, and public authorities. Some of these conflicts have not been resolved to this day, resulting in an array of unregulated activities in the park because the activities of local settlers are neither allowed nor sanctioned.

4. Invocation

The invocation function refers to the rules put into practice to enforce prescriptions. In the case of El Nevado, the authorities have not enforced the official designation of a national park because the prescription is based on a limited perspective, and its enforcement would require highly coercive strategies. As noted, neither human settlements nor the consumptive use of resources are allowed in national parks according to Mexican law. The enforcement of this mandate would require the evacuation of more than ten thousand people, the majority indigenous groups. Although beneficial for the ecological integrity of El Nevado, the invocation of this prescription would require extraordinary military efforts by the authorities, and would likely involve human rights violations.

Furthermore, other actors involved, including residents or tourists, do not obey rules for two main

reasons. First, proscriptions are often unclear or in-existent. Although the legal definition, and basic attributes of National Parks are specified in various bodies of Mexican laws such as the constitution and LGEEPA (General Law on Ecological Equilibrium and Environmental Protection), a clear and comprehensive plan to organize the actions of people involved in El Nevado not been defined to this date. Second, El Nevado lacks, and has never had, a management plan.

5 & 6. Application and termination

The application and termination functions refer to the mechanisms by which the main actors in El Nevado can resolve disagreements or disputes, and can stop or change the rules. These can be via official or non-official arenas. In Mexico, official conflict-resolution mechanisms within natural protected areas are attributed and specified in each area's management plan. However, given the lack of such a plan for El Nevado, actors resort to other arenas to resolve conflicts. One of the most important arenas is the federal courts, whereby local communities, academics, or other actors can have recourse against the federal government for establishing a legal scheme that affects their values and interests. However, one of the main problems with the courts is that substantial legal skills, time, and wealth are needed to pursue a case—resources which the local communities in El Nevado do not have: these communities have some of the highest rates of illiteracy and economic marginalization in Mexico.

Other venues to voice disagreements and change rules exist through non-official channels, and they depend on the actors involved. Academics, for instance, have expressed their discontent with the inefficiency of the national park scheme through academic publications and public hearings, such as conferences or lectures. Local communities have expressed their opposition through public protests and by breaking the rules imposed on them. The views of visitors and

other citizens concerned with El Nevado have been mainly expressed through social media, an outlet of social discontent whose reach and relevance has increased substantially in the last decade. The importance of application and termination functions is that they serve as conflict-resolution mechanisms. They are essential to maintain a working system in the long-term, as the interests of the people are constantly changing and shaping the policy in place.

The relation between official and non-official arenas is such that they can be complementary, but both require high levels of economic and political resources to be implemented. Official spheres such as federal or estate courts should be in theory open to all stakeholders, however, in practice they often demand perhaps more time and resources than unofficial channels. With the rise of the media, more, and more efficient, unofficial channels are growing in importance and popularity. Facebook and Twitter are now common ground for debate and social participation.

7. Appraisal

The appraisal function refers to the continuous assessments made to evaluate the successes or failures of the program in place. Appraisal is also important to determine accountability for actions. In a similar fashion to the application and termination functions, appraisal is often specified in the management plan, which is non-existent in El Nevado. Thus, El Nevado currently lacks appraisal mechanisms to evaluate its policies and outcomes.

Redefining the policy problem

Although the main problem of environmental degradation was defined initially as simply the product of the anthropogenic impacts in the area, from this analysis it is seen that the problem has been fundamentally propagated by the exclusion of local residents from the decision-making process. Because the legal status of the area prevents local residents from undertaking essentially any sanctioned economic endeavor, they resort to agricul-



Fig. 2. North face of *El Nevado de Toluca*, a national protected area in México. *Credit:* José Pons.

tural production as a subsistence strategy. The status of the area as a national park is inadequate because local residents were (and still are) excluded from the intelligence decision process. As noted, this prescription has caused fundamental problems with other decision functions, such as invocation, termination, and appraisal.

Analysis

The exclusive history of El Nevado National Park

The illegal exploitation of natural resources in Mexico peaked in 1934, as a result of the agrarian reform brought by the Mexican revolution in 1910. This situation was recognized and addressed by the authorities at the time, who responded by establishing a network of natural protected areas to prevent the further exhaustion of natural resources. The protected areas were established under the legal status of National Parks.

Most of these areas, however, were established within a few years, and without social consensus or technical justifications, as in the case of the El Nevado (Fig. 2). The one-paragraph decree authorized by the ruling president of Mexico in 1936, Lazaro Cardenas, justifies the park creation as an action to protect the forest cover and the hydrological services it provided to the cities nearby. The decree, however, did not specify the park's bound-

aries, zoning, rules or regulations, nor did it indicate the methodology or operation to manage the new protected area.

As in most other national parks in Mexico, there were (and still are) human settlements located inside the perimeter of El Nevado prior to its establishment. Despite this, the existence of human settlements was ignored, and the effects that the park foundation would have on the people and their lands were not evaluated.

Not surprisingly, the poor oversight of the executive government to assess the repercussions of the park establishment on land tenure hindered conservation efforts. The change in land jurisdiction created a series of adverse effects, including the dilution of the original tenant rights, and as a by-product, private land became vulnerable to invasion and colonization by foreigners. Overnight, the establishment of the national park provided free open access to common resources.

This situation translated into deforestation, overgrazing, pollution and other important drivers of ecological deterioration that are still prevalent in the park. This historical context is important to explain the environmental degradation in El Nevado today, as the modification of the legal status of the land caused unprecedented uncertainty with respect to property rights and natural resource use.

Since the park's establishment, there has been an ongoing feud between people who held land titles prior to the park establishment, and the people who have occupied such lands after the park was established. Paradoxically, according to Mexican law, both owners and settlers should have been compensated and removed eighty years ago.

The conflict over land ownership has historically hindered the capacity of the authorities and other stakeholders to agree on how natural resources in El Nevado should be managed. One of the clearest outcomes is that, as noted, the park lacks a management plan. Without a clear system of land organization and resource management, there is an incentive to maximize the resource accumulation and exploitation by users, which explains much of the environmental degradation that occurs in the park in the present.

Population growth in El Nevado 1990–2010

Population growth is an important factor to explain environmental degradation in El Nevado because it is closely related the expansion of agriculture and livestock production, the main drivers of land-cover change. According to the National Institute of Statistics and Geography in Mexico (INEGI 1990, INEGI 2010), as of 2010 there were 22 communities (in seven municipalities) in El Nevado with a total population of 10,255 people. Many of these communities were founded in the 1930s, the time when the park was founded. Moreover, the population is increasing at a remarkable rate, almost doubling in the last two decades (Fig. 3). The average growth rate was 147% (1990–2000) and 117% (2000–2010).

These growth trends reflect the increasing human pressure on the natural resource base of El Nevado. Population increase comes with a rise in the demand for subsistence resources, which accordingly translates into the expansion of arable lands, grazing livestock, and water extraction. Thus, population growth causes a greater dependence on the landscape, causing greater environ-

mental degradation if not well-managed.

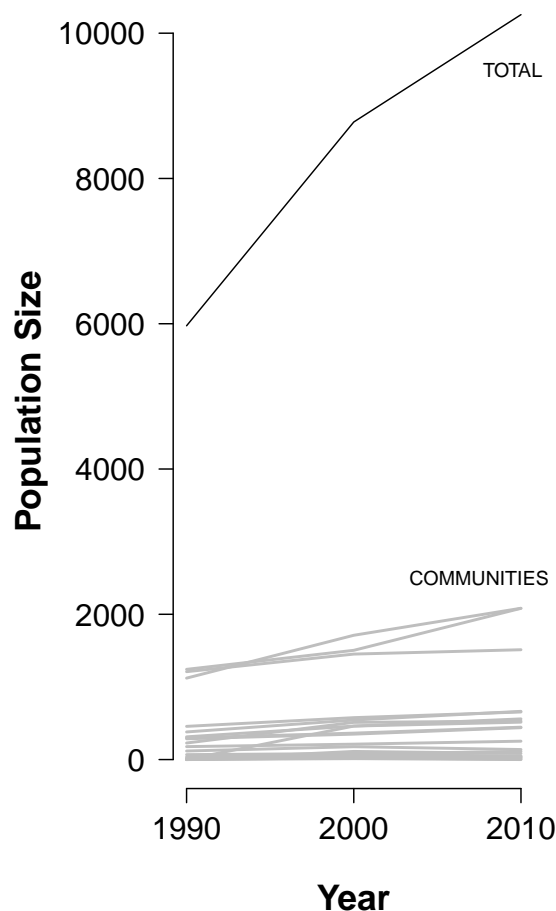


Fig. 3. Population growth by community in El Nevado (1990–2010). Grey lines indicate the population of each community in 1990, 2000, and 2010. The black line indicates the total population size, summing over all communities.

Socioeconomic factors

The precarious socioeconomic condition of the local communities in El Nevado is an important factor to account for exclusion, and increasing population growth. The National Census of 2010 presents the following figures. There are 1,299 households registered in El Nevado. Of these, only 577 (less

than 50%) have access to electricity, water provision and drainage. Furthermore, more than 30% of the population of 15 years of age or older did not finish primary education, none of the households in El Nevado have internet access, and the average illiteracy rate for each community is 17%, which stands in contrast to the national average of 6.9%. The National Council of Population rated 19 of the 22 El Nevado communities with 'high' levels of marginalization and the remaining 3 as 'very high' (INEGI 2010), based on seven variables: illiteracy, drainage, electricity, dirt floors, clean water provision, number of people per household, and income.

These assessments illustrate the precarious economic situations in which people in El Nevado live. Exclusion is clear from the fact that residents do not benefit socially or economically from the decision process. Residents are unable to challenge this situation through official legal channels, as they lack the financial resources to do so. Further, the high illiteracy rates and poor educational background likely drive the high population growth of the area. Family planning is hindered by a lack of information and means available, and religious institutions have a profound influence on the value systems of the people. Poor socioeconomic conditions further contribute to the non-regulated expansion of agriculture.

Future trends

If local residents are not provided with a clear and plausible alternative to improve their socioeconomic conditions, population growth and exclusion from the decision process is likely to continue. This situation would consequently foster the continuous expansion of non-regulated productive activities, resulting in further loss of native vegetation, soil erosion, and water provision services. In summary, the environmental degradation of El Nevado is likely to continue because the interests of the local residents are not included in the policy process.

Recommendations and evaluation

In light of the previous description and analysis of the policy problem in El Nevado, two prescriptions are proposed and evaluated, and one selection is justified.

1. *The original plan: compensation and relocation of residents*

One option to resolve the policy problem in El Nevado is to complete the plans that were originally prescribed: to financially compensate and relocate all the residents within the protected area. By reducing the population size, this solution would lessen the main anthropogenic impacts that cause environmental degradation. This option would require wealth, diplomacy, and most likely military efforts to be deployed by the federal government, as well as an alternative site, most likely urban, to relocate the people. The financial compensations for the land expropriated could allow people to invest into other productive activities, bettering their current unfavorable socioeconomic condition.

Evaluation of the original plan

Major drawbacks of this first option are the financial cost of compensating and relocating local residents as well as their willingness to leave or sell their land. Therefore, the federal government might have to move from a diplomatic to a military strategy to ensure compliance. This change could easily end in the infringement of the human rights of residents, as well as the high political cost to the government authorities in charge of relocation. In the case where the incumbent government is willing to take the political risk to use coercion to relocate the residents of El Nevado, the complexity comprised in the legal situation would present another significant challenge. The lack of clarity of land tenure means that it would be difficult for the authorities to know whom and how much to pay.

Furthermore, despite compensation, residents' socioeconomic condition is unlikely to improve. The high illiteracy rates and low levels of education

combined with relocation might prevent residents from engaging in other productive activities. Relocation could ultimately have pernicious effects for the socioeconomic welfare of those who move.

2. A new plan: inclusion of all stakeholders

A second prescription to address the policy problem in El Nevado is the creation and promotion of a new management plan, one that is based on the interests of the majority of the stakeholders. This plan should listen to local communities and include them in the decision process. An important element of the new management plan would be to strictly regulate the number of people and activities undertaken in the park.

A good alternative management scheme provided by the General Law on Ecological Equilibrium and Environmental Protection (LGEEPA) is that of a Biosphere Reserve. These designations allow human settlements and the consumptive use of natural resources within the protected area, thus aiding the socioeconomic development of El Nevado. However, biosphere reserves need detailed management plans and effective regulations to control and guide the anthropogenic impact on the protected areas. Therefore, preconditions of the success of such a reserve in El Nevado are (i) that local residents are included into the intelligence and promotion process, and (ii) ensuring that all land tenure conflicts are resolved by official means.

Evaluation of the new plan

The re-categorization of El Nevado as a Biosphere Reserve would also come with challenges. One of the most important is again, the conflict over land tenure. Without clear territorial jurisdiction, the zoning and organization of the protected area is a complex endeavor. Re-classification in itself will not solve the issues – the highest risk is that, like the current scenario, the new biosphere reserve scheme will lack a management plan, fostering an array of illegal and unregulated activities that would con-

tinue the environmental degradation of El Nevado.

Selection

From the two alternatives, I conclude that the re-definition of El Nevado as a Biosphere Reserve is the best option. From my analysis, the problem of El Nevado is rooted in the exclusion and marginalization of local people and is unlikely to be resolved through further exclusion and impoverishment. Assuming that the legal conflicts over land tenure can be resolved, and local inhabitants are included into the decision process, the biosphere reserve can provide the flexibility necessary to accommodate the common interests and protect the ecological integrity of El Nevado.

Thus, the following key actions are fundamental to enhance success of a biosphere reserve in El Nevado and should form central components of the management plan, effectively administered and enforced by the government:

1. Inclusion of local residents into all functions of the decision process, including the early conceptualization and planning of the biosphere reserve.
2. Provide the financial and legal means to resolve conflicts over land tenure in El Nevado in the short-term.
3. Legal recognition of human settlements in the area, investment on infrastructure to provide basic services (electricity, drainage, potable water, and internet).
4. Zoning of core and buffer areas, with a detailed description of the activities allowed in each area, and clear delimitation of urban zones.
5. Design and implementation of an educational program to increase the educational level of the local residents, particular focus should be placed on illiteracy rates. Components on the cultural, historic, and environmental importance of El Nevado should also be included.

6. Payment for ecosystem services, where the main benefactors are the local residents.
7. Forest management plan, with the local residents as operators and benefactors.
8. Develop eco-tourism in the protected area, where the local residents are the main administrators and benefactors.
9. Detailed plans to monitor environmental conditions of the park should be created. Academia, government, and local residents should be part of the monitoring system.
10. Create a management council with representatives of all major actors involved, and provide a detailed agenda to discuss conflicts, disputes, and modification to the rules and regulations of the protected area.

Conclusion

For its cultural history and the environmental services it provides, El Nevado de Toluca is one of the most important natural protected areas in Mexico. El Nevado is currently undergoing great ecological deterioration, primarily exemplified by the loss of native land cover, soil erosion, and water provision services. The main cause of environmental degradation is the agricultural expansion of local residents, who resort to these activities as a means of subsistence. The legal status of El Nevado does not recognize human settlements or economic activities within its jurisdiction, and leaves the actions of local residents unregulated. In this light, the roots of the problem appear to be grounded in the historical exclusion of local residents from the natural resource management prescription, increasing population growth and unfavorable socioeconomic conditions.

To resolve the policy problem in El Nevado requires the termination of the national park scheme and the establishment of a biosphere reserve. This

legal status would provide the flexibility to include local residents into the decision process, provide a means for socioeconomic development, and preserve the ecological integrity of El Nevado¹.

Acknowledgements

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¹After this article was finalized, and before it was published, the federal government of Mexico changed the legal scheme of El Nevado de Toluca from a National Park category to an Area for the Protection of Flora and Fauna (APFF). As it legally recognizes the presence and socioeconomic needs of the human populations found in El Nevado, the APFF scheme provides a stronger, if not panacean, alternative to resolve the ecological degradation of this remarkable natural protected area.

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Numb to the world: Degradation desensitization and environmentally responsible behavior

Alexandra C. Alhadeff, MEM 2015^{*}

Abstract

This study aims to explore the psychological effects of environmental degradation. The author proposes the concept of Degradation Desensitization (DD), which characterizes the loss of sensitivity to a previously aversive degradation stimulus, due to consistent exposure to that stimulus. The researcher predicts (i) that humans are averse to environmental degradation, and (ii) that consistent exposure to environmental degradation can lead to DD. Finally, the researcher hypothesizes that DD can lessen the likelihood that an individual will engage in environmentally responsible behaviors (ERBs).

A total of 147 middle and high school students were selected and randomly assigned to either a control or experimental group. In Parts I and III, 33 students participated in one-on-one and focus group semi-structured interviews. In Part II, over the course of four days, students in the experimental group were exposed to videos containing environmental degradation stimuli (EDS), while students in the control group watched videos that did not contain EDS. Students completed a survey before and after each viewing to assess their emotional and attitudinal changes and heart rate was monitored. Finally, students were given juice cartons following each viewing and their recycling behavior with respect to the empty cartons was observed. Results showed that students in the experimental group felt significantly more negative during and after the baseline video than students in the control. Further, younger participants felt more negative towards EDS than did older participants. Middle school students felt more negative with each subsequent video, but no similar effect was significant for high school students. Finally, on the third day, students in the experiment were significantly less likely to recycle than those in the control. Participants have a mental model of DD and were able to provide personal experiences, which align with the phenomenon, suggesting more legitimacy to the hypothesis.

It is hoped that this study will contribute to an understanding of the psychological effects of environmental degradation as well as the current literature on ERB.

Introduction

On August 1 1955, a telling photograph was featured in *Life* magazine. The photograph depicted cans, frozen foods containers, disposable diapers, garbage bags, and a paper tablecloth falling from the sky like rain onto a smiling couple who were raising their arms towards the tumbling sea of trash. The caption underneath the photo read, “Throw-away living: disposable items cut down household

chores.” The photograph reflected a paradigm shift away from the pre-World War II ‘waste not want not’ philosophy of living and toward a more wasteful zeitgeist.

A general rise in middle class income after World War II and the widespread availability of credit led to the age of consumerism and, consequently, the age of trash (Whiteley 1987). This increased consumption led to significantly higher levels of waste (Whiteley 1987). Waste is a criti-

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cal form of environmental degradation that can be directly perceived by humans. This degradation raises the question: Why would individuals like the couple in the *Life* magazine photo smile in the face of something that should naturally cause aversion?

Some environmentalists and researchers assume that those who possess adequate knowledge of the environment will take adequate measures to protect it (Kollmuss & Agyeman 2002). Yet, this assumption is not fully supported by the wealth of literature on environmentally responsible behavior. Specifically, the current literature does not sufficiently explore how consistent exposure to environmental degradation can affect one's attitudes towards the environment. Such exposure to environmental degradation may numb an individual's concern for environmental problems in general, a response known as desensitization. Ultimately, desensitization may reduce an individual's urge to engage in environmentally responsible behavior. The purpose of this study is to investigate whether exposure to environmental degradation leads to environmental desensitization and thus a decreased tendency to engage in environmentally responsible behavior.

Research question and objections

The purpose of this study was to examine biological, behavioral, and self-reported behavioral responses to environmental degradation. The guiding question in this research was: Does consistent exposure to environmental degradation lead to environmental desensitization and/or decreased likelihood of engaging in environmentally responsible behavior (ERB)? According to the Oxford English Dictionary, to degrade is "to lower in character or quality; to debase." Thus, degradation of the environment involves the reduction of the quality of any aspect of the environment (e.g., air, water, soil). Quality implies a comparison between an original state and the status quo and consequently, for quality to change, there must be a change in state. By environmentally responsible behavior, the research

refers to conscientious actions undertaken by individuals in order to mitigate negative impacts (by themselves, or others, or both) on the environment.

Specifically, the author addressed the following research questions:

1. Are people averse to environmental degradation?
2. Does consistent exposure of an individual to environmental degradation lead to degradation desensitization?
3. Does degradation desensitization decrease the likelihood that an individual will engage in environmentally responsive behavior?

Methods

Research context

The study was conducted in the International School of Curitiba, Curitiba, Brazil (ISC, -25.368693, -49.327079), an independent private co-educational college preparatory school. The school enrolls roughly 500 students from pre-toddler (3 years old) through grade 12 (18 years old). ISC was selected because of its extensive representation of global cultures, including students from over 30 countries. Students at ISC are involved in several programs and activities where they learn to appreciate and protect the environment.

Curitiba is the capital city of the southern state of Parana, Brazil, and is a global model for urban development. Its successful recycling program "Lixo que nao é Lixo" (Garbage that is not Garbage) was commended by United Nations Environment Programme (Benton-Short & Short 2013, p.253). The city-wide environmental education initiative has been successful in involving 70% of the community residents, who now separate household organic and inorganic waste. Moreover, two-thirds of the city's garbage is recycled (Rabinovitch 1992). Therefore, it can be assumed that the people of Curitiba are sensitive to, or at least aware of, the waste problem.

Participants

A group of students at ISC were invited to participate in the study ($n = 147$) via purposeful sampling. The sample was comprised of middle and high school students (11-17 years old). The students were primarily upper-middle to upper class. On a five-point scale, students were asked whether they had mostly lived in urban (1) or rural (5) environments, and the extent to which they generally engaged in ERB (1 = never, 5 = always), including recycling, water- and energy-saving measures.

Design

Participants were randomly assigned to degradation (treatment) vs. non-degradation (control) experimental groups. Participants were informed that a study regarding waste perceptions would be conducted, but they were not aware of the desensitization aspect of the research. The study had three objectives: first to determine whether students showed aversion to waste imagery; second if consistent exposure to waste imagery led to desensitization to that imagery; and third whether desensitization affected their likelihood of engaging in ERB.

Procedure

Data collection was performed in three distinct parts. In Part I, students were randomly assigned their treatment group, and one-on-one and focus group semi-structured interviews with fifteen students in each group were conducted. On day 1 of Part II, the experimental group completed a questionnaire regarding their background, current emotional state, and relationship with the natural world. Next, they were shown 5 minutes of video containing environmental degradation stimuli (EDS) from the film *Trashed* (2012), an award-winning documentary about waste, whereas the control group watched a 5-minute origami instructional video. Each participant's heart rate was monitored before, during, and after exposure. After watching the video, participants were asked a se-

ries of questions regarding their current emotional state on a five-point scale (1 = negative, 5 = positive), as well as their relationship with the environment and how various scenes of the video made them feel. Students were given a complimentary juice carton, which had been marked with a number associated with each student. Students watched 15 minutes from the documentary on days 2, 3, and 4, during which the same measurements as on day 1 were taken. In Part III, the researcher conducted semi-structured interviews with the same students selected for interviews in Part I.

Measures

Survey

On day 1, participants were asked a series of questions about their background, including their sex, age, and the countries in which they had lived. On days 1, 2, 3, and 4, students were also asked questions related to their perceptions of trash and environmental degradation. Questions from the Environmental Identity Scale (Clayton 2003) were included to measure the students' Nature Connectedness (NC), a proxy for environmental sensitivity. A total NC Score was calculated based on students' responses. Students were also asked to rate their emotional state and perception of power on a five-point scale (1 = negative, 5 = positive) before and after each video.

Behavioral observation

During the interview, students were given a complimentary juice carton, which had been marked with a number associated with each student. Participants were observed as they disposed of the cartons. While classes were in session, the researcher inspected all recycling containers and collected the disposed cartons.

Biometric

Students' heart rate was monitored prior to exposure, during, and after using a heart rate monitor

with chest strap (Pyle PHRM-22).

Interview

Semi-structured interviews were conducted with 33 students and were designed to assess environmental degradation perceptions of 11–17 year olds before and after the treatment. To ensure anonymity, students were identified using a random number during recording and transcripts. Initial interviews were 20–30 minutes in length and consisted of 15 questions to probe each student's Nature Connectedness, cultural background, ERB, and perception of power. An additional 15 questions in the final interviews were designed to identify changes post-experiment. The interviews were either one-on-one or focus groups consisting of two or three students. A thematic analysis approach (Boyatzis 1998) was applied, and for each interview the transcript was coded on the basis of the selected themes. After reviewing the transcripts, the following themes emerged:

1. Culture
2. Environmentally responsible behavior
3. Nature connectedness
4. Environmental degradation
5. Power
6. Degradation desensitization

Several sub-themes were identified within each of these themes, and these were used to further assess the interview data.

Results

Student background

A total of 147 students were invited to participate in the experiment, though not all students were present every day. On day 1, 114 students were present (62 male and 52 female). These students represented 36 countries, with over half having lived in two countries or more. Students' ages ranged from 11 to 17 years (mean = 14 yrs, standard deviation = 0.7). On a scale from 1 (urban) to 5

(rural), students had spent most time in urban environments ($M = 2.1$, $SD = 0.96$).

Students were asked to rate the extent to which they engaged in ERB (1 = never, to 5 = always). Students reported that they often recycled ($M = 3.8$, $SD = 0.9$), and engaged in water-saving ($M = 3.6$, $SD = 0.9$) and energy-saving behaviors ($M = 3.6$, $SD = 1.0$). A moderate positive correlation was found between an individual's nature connectedness score on day 1 and recycling (Pearson product-moment correlation, $r = 0.30$, $n = 111$, $p = 0.002$), water conservation ($r = 0.40$, $n = 111$, $p < 0.001$), and energy conservation behavior ($r = 0.33$, $n = 111$, $p < 0.001$).

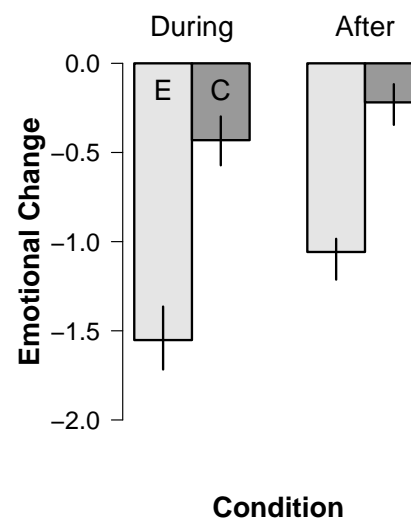


Fig. 1. Mean emotional change prior vs. during EDS exposure and prior vs. after EDS exposure in experimental (E) and control (C) condition.

Hypothesis 1: Are people averse to environmental degradation?

An independent-samples t-test was conducted to compare emotional change in participants who had been exposed to EDS during the first viewing ($n = 47$) and those who had not ($n = 52$). The emotional change variable was calculated by taking the difference between self-reported emotions before

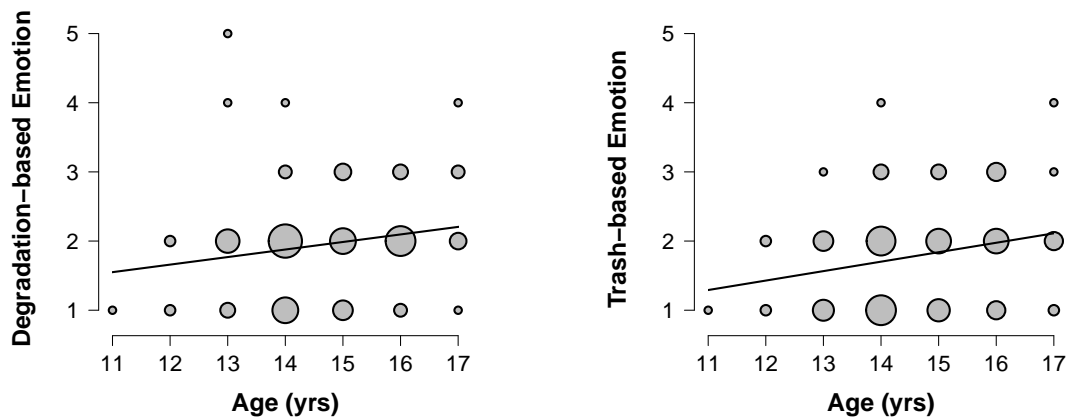


Fig. 2. Relationship between age and degradation-based emotion (*left*), and trash-based emotion (*right*) (1 = negative, 5 = positive). The size of each point is proportional to the number of students.

and during the video and before and after the video. There was a significant difference in the emotional change of the experimental ($M = -1.55$, $SD = 1.25$) and the control ($M = -0.44$, $SD = 1.03$) groups before the viewing and during the viewing ($t_{97} = 4.834$, $p < 0.001$). Additionally, there was a significant difference in the emotional change of the experimental ($M = -1.06$, $SD = 1.15$) and the control ($M = -0.23$, $SD = 0.83$) groups before and after the viewing ($t_{97} = 4.380$, $p < 0.001$). That is to say, there was a larger negative change in emotional state during and after exposure to EDS when compared to exposure to control imagery (Fig. 1).

A paired-samples t-test was conducted to compare emotional state prior to exposure to EDS and emotional state during the baseline exposure (day 1). There was a significant difference between the self-reported emotional state prior ($M = 3.95$, $SD = 0.87$) and during ($M = 2.55$, $SD = 0.899$) exposure to EDS imagery in the experimental group ($t_{54} = 8.47$, $p < 0.001$). Emotional state became more negative during exposure to EDS. Further, there was a significant difference between the self-reported emotional state prior to ($M = 3.95$, $SD = 0.870$) and after exposure ($M = 2.93$, $SD = 8.13$; $t_{54} = 7.35$, $p < 0.001$). Self-reported emotional state prior to

($M = 3.80$, $SD = 0.903$) and during ($M = 3.36$, $SD = 1.017$) exposure differed significantly in the control group ($t_{55} = 3.316$, $p = 0.002$). Similarly, a significant difference was also found between self-reported emotional state prior to ($M = 3.80$, $SD = 0.903$) and after exposure to control stimuli ($M = 3.55$, $SD = 0.952$, $t_{55} = 2.297$, $p = 0.025$).

Younger students were more likely to be concerned about the environment. Student age was positively correlated with both trash-dependent emotions (Pearson correlation: $r = 0.24$, $n = 114$, $p = 0.009$) and environmental degradation-based emotions ($r = 0.19$, $n = 114$, $p = 0.042$), on a 1–5 scale (Fig. 2). To further explore the effect of age, students' self-report data were divided into two groups: middle ($n = 69$) and high school ($n = 45$). An independent samples t-test was conducted to compare trash-based emotions between middle ($M = 1.67$, $SD = 0.76$) and high school students ($M = 1.98$, $SD = 0.69$). Middle school students felt significantly more negative towards trash ($t_{112} = -2.213$, $p = 0.029$; Fig. 3).

Further, students' nature connectedness score (1–5) on day 1 was positively correlated with their perceived power to improve environmental problems (Pearson correlation, $r = 0.41$, $n = 111$, $p <$

0.001), as well as their feelings towards nature ($r = 0.22$, $n = 111$, $p = 0.023$), but showed a negative correlation with their feelings towards environmental degradation ($r = -0.22$, $n = 111$, $p = 0.022$).

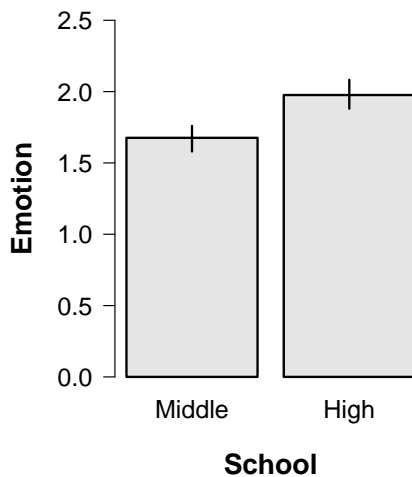


Fig. 3. Difference in trash-based emotion between middle and high school students.

Hypothesis 2: Does Degradation Desensitization exist? Students' ratings of emotion during the videos were analyzed using a mixed-design ANOVA with a within-subjects factor of exposure (day 1, day 2, day 3, day 4) and a between-subjects factor of group (control, experiment). Between subjects factors revealed a main effect of group (ANOVA, $F_{1,70} = 49.99$, $p < 0.001$), such that the mean emotion rating was more positive in the control than in the experiment. The predicted within-subjects effect of exposure was not significant ($F_{3,210} = 0.64$, $p = 0.591$). The interaction between exposure and group was also not significant ($F_{3,210} = 1.16$, $p = 0.325$; Fig. 5 left).

Similarly, students' ratings of emotion after the videos were analyzed using a mixed-design ANOVA with a within-subjects factor of exposure (day 1, day 2, day 3, day 4) and a between-subjects factor of group (control, experiment). Between

subjects factors revealed a main effect of group ($F_{1,70} = 52.19$, $p < 0.001$), such that the mean emotion rating was more positive in the control than in the experiment. The predicted within-subjects effect of exposure was not significant ($F_{3,210} = 0.91$, $p = 0.437$). The interaction between exposure and group was also not significant ($F_{3,210} = 0.46$, $p = 0.711$; Fig. 4 right).

Two DD variables were calculated through the difference between trash-based and degradation-based emotions prior to the first treatment and after the final treatment. Though no significant difference was found between the control and experimental groups, when high school students and middle school students were taken separately, significant relationships were revealed. Middle school students ($M = -0.33$, $SD = 0.83$) in the experiment reported a significantly greater change in the negative direction environmental degradation post-treatment than middle school students in the control ($M = 0.26$, $SD = 0.75$; $t_{59} = -2.945$, $p = 0.005$; Fig. 5 left). While high school students showed no significant change, middle school students became more sensitive to environmental degradation after the treatment, which contradicts the alternate hypothesis that students would become less sensitive.

Further, though there was no significant difference in Nature Connectedness between middle and high school students in the treatment group on day 1, by day 4, middle school students ($M = 31.19$, $SD = 4.45$) reported a significantly higher NC score than high school students ($M = 28.69$, $SD = 4.06$, $t_{55} = -2.197$, $p = 0.032$).

Students' heart-rate during the videos were analyzed using a mixed-design ANOVA with a within-subjects factor of exposure (day 1, day 2, day 3, day 4) and a between-subjects factor of group (control, experiment). The predicted within-subjects effect of exposure ($F_{3,123} = 1.769$, $p = 0.16$) and between-subjects effect of group ($F_{1,41} = 2.81$, $p = 0.101$), were not significant. The interaction between exposure and group was also not significant ($F_{3,123} = 0.895$, $p = 0.45$).

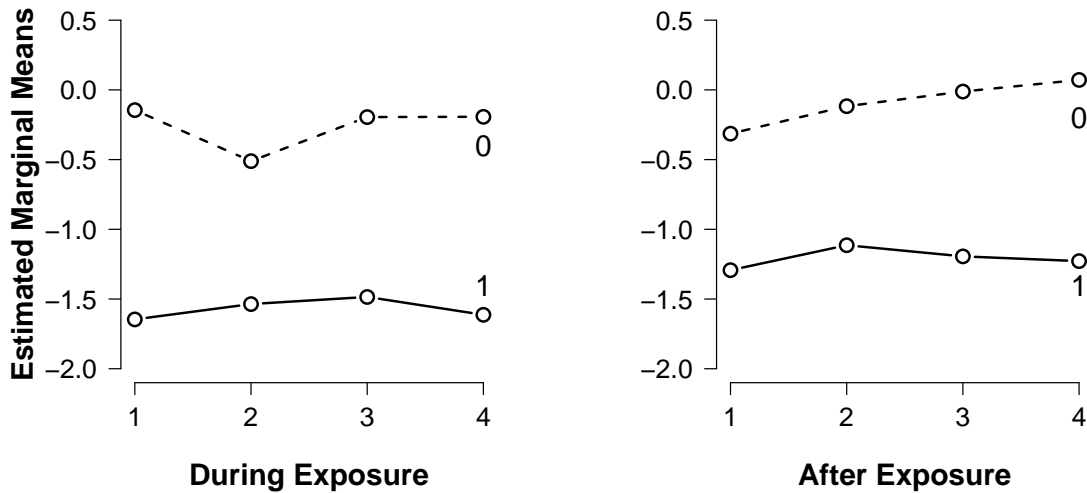


Fig. 4. Student’s emotions during (*left*) and after (*right*) watching either the experiment (*Trashed*) or control (origami) videos. Results shown are for mixed ANOVAs with a within-subjects factor of exposure (day 1, day 2, day 3, day 4) and a between-subjects factor of group (control, experiment).

Behavioral observation: Hypothesis 3: DD lessens the likelihood that an individual will engage in ERB.

A chi-square test of independence was performed to examine whether individuals in the experimental group were less likely to recycle than those in the control. Though no significant relationship was found on the first day ($X^2(1, N = 142) = 0.037, p = 1.00$), and second day ($X^2(1, N = 142) = 0.22, p = 0.694$), we do see a trend towards significance on the third and fourth days. A significant relationship was revealed on day 3 ($X^2(1, N = 142) = 5.04, p = 0.030$). Significance was not reached on day 4 ($X^2(1, N = 142) = 1.96, p = 0.186$; Fig. 5 middle).

Interview

Sixty-four children (ages 11–17) participated in in-depth semi-structured one-on-one and focus group interviews regarding their perceptions of environmental degradation. The interviews were analyzed using grounded theory (Maxwell 2012) and identified power as being the overarching theme supporting the theory of DD, reinforced by cultural

factors, and nature connectedness. More specifically, participants described a relationship between their assumed exposure to environmental degradation, perceived locus of control and how likely they were to engage in ERB. Participants also discussed how their cultural and familial upbringing informed their perceptions of the natural world.

Students were asked to rate on a five-point scale (1 = no power, and 5 = powerful) their locus of control (“Power to Change”) before and after the treatment. An independent-samples t-test was conducted to compare perceived locus of control between participants in the control group (n = 11) and the experiment (n = 21). There was a significant difference between perceived power before and after the treatment in the control (M = 0.546, SD = 0.282) and experimental (M = -0.429, SD = 1.363) conditions before the viewing and during the viewing ($t_{30} = 2.116, p = 0.043$; Fig. 5 right).

A single sample t-test was conducted to determine the degree of sensitivity of students in the experimental group (n = 21) to trash imagery. Stu-

dents were asked to rate their sensitivity on the first and last videos on a five-point scale (1 = not sensitive, and 5 = very sensitive). Students were significantly more sensitive to the images in the first video ($M = 2.90$, $SD = 1.04$) compared to the images in the last video ($M = 2.62$, $SD = 1.28$; $t_{20} = 2.905$, $p < 0.001$).

Discussion

Hypothesis 1: People are averse to environmental degradation

The findings from this experiment are consistent with the hypothesis that exposure to environmental degradation imagery (EDS) may have a detrimental effect on emotion. Participants reported a significant change in emotion in the negative direction when exposed to EDS. When participants were asked to rate their emotions after the video, their emotional states did not return to pre-exposure levels, which was consistent with the original hypothesis. This finding suggests that EDS may induce negative emotions at the time of exposure and that these negative emotions are sustained.

An aversive response to environmental degradation is consistent with the aesthetic judgment component of the Biophilia Hypothesis (Kellert & Wilson 1995). “If through evolution, certain natural landscapes have promoted human survival and reproductive success, then ... such landscapes nurture the human physiology and promote a sense of emotional well-being” (Kahn 1997). By extension, images of a degraded natural landscape may induce negative emotions. Harm to that landscape may be seen as harm to self. This experience can most aptly be described with the neologism *solastalgia*.

Solastalgia is “the distress that is produced by environmental change impacting on people while they are directly connected to their home environment” (Albrecht et al. 2007). A loss of ecosystem health can violate one’s sense of place and threaten well-being. Consistent with this theory, as predicted, the researcher found a significant relationship between a student’s connectedness to the nat-

ural world and her emotions stirred by environmental degradation. The higher the student scored in Nature Connectedness (NC), the more negative that student typically felt towards environmental degradation. It was clear through the interviews that students perceived the effects of environmental harm to transcend the environment itself and affect them personally. Some indicative quotes from student interviews include:

- (1) It [environmental degradation] hurts us, it hurts the environment. We should make our planet so we can live a better life in it. (student #133)
- (2) It affects us even indirectly. It is causing damage to us. (#122)
- (3) We are killing ourselves by cutting down trees. Bebendo o proprio veneno [Drinking our own poison]. (#31)
- (4) We do this to other people and to ourselves. (#34)
- (5) They [people] are contributing to degradation and making their life worse. (#130)
- (6) Earth doesn’t belong to us. We belong to the Earth. (#31)

All of the above students drew a connection between harm to the environment and harm to themselves. Though all the comments above demonstrate clear environmental concern, the reason behind the concern warrants further analysis.

Schultz (2001) outlines a tripartite classification of environmental concern: egoistic (care for self), altruistic (care for others), and biocentric (care for the biosphere). The form of environmental concern will depend on the individual’s interconnectedness with nature. The author proposes “objects (e.g., plants, animals, other people) are valued because of the degree to which they

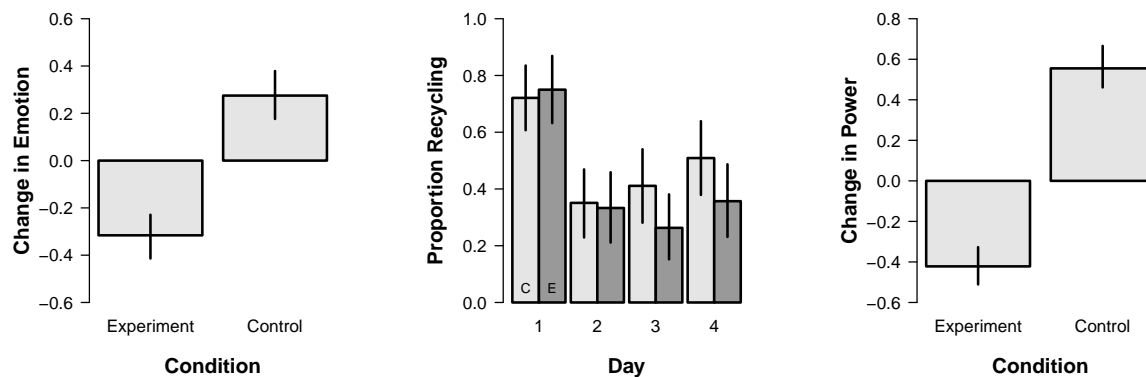


Fig. 5. Effect of degradation desensitization on student’s emotion and behavior. Mean degradation based emotion change pre- and post-four day treatment for middle school students (*left*). Proportion of students who recycled juice cartons after each treatment (*middle*; C = control, E = experiment). Change in power perception before and after treatment for control and experimental condition (*right*).

are included within an individual’s cognitive representation of self” (Schultz 2001). Those with higher perceptions of interconnectedness will display stronger biocentric concerns (Schultz 2001). Quotes 1 and 3 illustrate both egoistic concerns and biocentric concerns founded on the awareness of consequences for oneself or the communal or collective self, as signified by “us” or “ourselves” If the students are in fact referring to the communal “us,” this would indicate altruistic concern as well. Quote 4 clearly demonstrates both an egoistic and altruistic concern in that the student includes both others and himself in his construction, Quote 5, on the other hand, is altruistic only. Quote 6 appears to reflect only biocentric concern, with perhaps implicit egoistic and altruistic concerns insofar as what is good for the Earth would be good for everyone who belongs to the Earth.

Students’ concern for the environment, of whichever classification, was evident in the language they used to describe EDS. Students invariably used negative words such as bad, scared, sad, sickened, guilty, disgusted, and disappointed, to describe the EDS in the videos. Students 31 and 132 reported feeling physical pain or sickness in re-

sponse to EDS:

You think you own the world. I feel like my heart is squeezing... I feel grief mixed with anger. (#31)

I feel sickened. It [environmental degradation] is like using drugs... you shouldn’t do something you know is going to be bad for you long-term. (#132)

The description of Student 31’s “heart squeezing” indicates an actual physical pain in addition to emotional pain, as stated by his “grief mixed with anger.” Student 132’s drug simile, in addition to associating environmental degradation with physical sickness, reflects the long-term temporal impact of environmental harm. This acknowledgment is especially notable given that, most people, when considering whether to engage in ERB, postpone the environmental penalty for the immediate gain of convenience. Collectively, the quotes make it clear that environmental degradation affects people on an emotional level and may negatively affect their well-being in the short- or long-term.

The effect of culture

Though the researcher contends that aversion to environmental degradation is universal, there is great variability in the individual, group, and cultural characteristics of the participants. The present study's participants represent 36 countries, and over half have resided in at least two countries. Hence, these students have a unique and plural view of home as well as plural views of the environment. Understandably, their conceptions are not fixed, but malleable, shifting over geographical space and time. Many students could readily differentiate between environmental perceptions in the different places where they had lived. Below are several excerpts from interviews describing changes in ERB or environmental perception with the changing of home:

Student 81 was born in Curitiba but moved to France as a toddler where she lived for seven years. Student 81 then moved to Russia and back to France before returning to Curitiba in 2013. She stated:

Russia and France are very different. There was more pollution [in Russia], I can see it in the air: cars, factories [are causing the pollution]. I could smell and see the pollution. I never did that [recycling] in Russia. Mother stopped recycling in Russia. (#81)

Curitiba is better than in France. People put more effort into recycling and protecting the environment. I think it depends on the culture. (#81)

Though Student 81 did not know why her mother stopped recycling in Russia, she did acknowledge the power that culture has played on her conception of the environment. Indeed, consistent with the student's observations, Moscow currently has no recycling program and the practice is considered "very un-Russian" (McGrane 2014).

¹The "ecologic policy" referenced by the student is the Law for the Promotion of Sorted Collection and Recycling of Containers and Packaging, which has been in place in Japan since 1997 in an effort to reduce waste (Japanese Ministry of the Environment).

Prior to Brazil, Student 99 had lived in Germany, Russia, Portugal, and Switzerland.

In Switzerland people were very fond of waste. You always had to recycle, glass, plastic, all the trash had to be recycled even clothes. I didn't recycle in Portugal. Switzerland was where I learned to recycle. Switzerland was neater [than Brazil]. (#99)

Student 99's use of the word "fond" to describe waste is interesting. Clearly, she did not mean that the Swiss people liked waste, but that they put great emphasis or consideration on waste. Accordingly, she elaborated that the Swiss people managed waste more appropriately than in her current home of Curitiba. The same student later associates the word "trash" with sadness. She feels like her Brazilian peers are not as involved in ERB as she is.

Student 136 was born in Japan to Brazilian parents of Japanese descent. He lived in Japan for eleven years before coming to Curitiba in 2012. Below, Student 136 reflects on how his cultural background has affected his environmental concern:

People care about waste in Japan ... that can be because of ecologic policy¹ in Japan. I would say why people in Japan care about it. Personally, I don't care about the environment as Japanese do because I am in Brazil now and have Brazilian background. Even if I don't care much, in Japan I had to follow the rules of the community. (#136)

Student 136 asserts that his concern for the environment is not dependent on one's country of residence, but on one's cultural heritage. On the other hand, the extent of his ERB is entirely dependent

on the rules and regulations of his country of residence. For this reason, there is a disconnect between his belief and practice. His behavior is not dictated by ideology.

Hypothesis 2: Degradation Desensitization exists

The study demonstrated mixed results regarding the hypothesis that, to the extent DD exists, it is the loss of sensitivity to a previously aversive degradation stimulus due to consistent exposure to that stimulus. DD should not be confused with the concept of Nature Deficit (Louv 2006) and the more general 'nature disconnect'. Degradation Desensitization is different from other published concepts of nature disconnectedness for the following reasons proposed by the author:

1. Whereas "disconnect" theories explore how humans have become estranged to nature in general, DD explores the specific psychological effects of degradation.
2. Whereas disconnect can be assumed to be a general consequence of a multitude of catalysts described in the literature (Louv, 2006), desensitization is what allows the 'disconnect' to progress. In other words, desensitization is not fixed, but fluid, increasing over time. One can fall into deeper and deeper states of disconnect via progressive desensitization. Therefore, degradation and degradation desensitization have a reinforcing relationship. As degradation increases, so does desensitization, which allows degradation to continue.

DD may be linked to the personal amnesia component of Shifting Baseline Syndrome. Shifting Baseline Syndrome is "a cautionary tale referring to changing human perceptions of biological systems due to loss of experience about past conditions" (Papworth et al. 2009). This phenomenon can occur at the generational level, where knowledge is lost because younger generations are not "aware of past

biological conditions" and on the individual level, where people "forget their own experiences" (Papworth et al. 2009). Over time, there is an incremental decrease of environmental standards.

Because DD is a time-dependent phenomenon, it was predicted that younger individuals would be more sensitive to EDS than older individuals. This was supported by the modest positive correlation between both age and trash dependent emotions and environmental degradation emotions. Younger students were more averse to trash and environmental degradation than their older counterparts. In fact, middle school students in the experimental group became more sensitive to environmental degradation and trash over the course of the treatment, which contradicts Hypothesis 2. Because desensitization is progressive, older students may be less impressionable. Kaplan & Kaplan (2002) describe the adolescent "time-out," where adolescents had a lower preference for natural settings, compared to younger children: "adolescents appreciate natural settings, though apparently not as much as do younger children or adults. They favor places where they can be with their peers and activities that convey excitement and action" (Kaplan & Kaplan 2002).

Students were asked to envision a landfill and to describe how their emotions and senses would be affected after one day, one week, one month, and one year. On the first day, 97% of students expressed negative emotions associated with being in the landfill. After one week, 18% of students felt more negative, 39% felt the same, and 43% felt less negative. After one month, 21% of students more negative, 24% of students felt the same, and 55% felt less negative. After the first year, 94% of students felt like they would feel less negative or entirely accustomed. Some notable examples include:

[After one year] I would be numbed by the sight of so much trash. I wouldn't be annoyed anymore. (#104)

On the first month I would become

used to it ... after a year, I would become less human. (#35)

Aldo Leopold's adaptation of Descartes' famous dictum from "I think therefore I am" to "As a land-user thinketh, so is he" (Kellert & Wilson 1995) may provide some insight into Student 35's comment. While Descartes proposes an anthropocentric view of the human identity, Leopold's is biocentric. Both reflect that people's thoughts do not exist in a vacuum. The human identity is as much about selfhood as it is about the natural world. It follows that our connection to the natural world is an important part of what makes us human. Student 35 points out that she would be less human once she lost her sensitivity to the degradation about her.

The evidence seems to show that people believe in DD. However, the literature on affective forecasting (Wilson & Gilbert 2005) argues that people may wrongly predict the type, direction, intensity, and duration of future emotions. Therefore, students may have underestimated the degree to which they would be emotionally affected by the landfill. The inverse situation may also be true where students overestimated the impact of the landfill and underestimated the degree to which they would become desensitized. Interestingly, "people fail to anticipate how quickly they will cope psychologically with such events in ways that speed their recovery from them." (Wilson & Gilbert 2005). Because desensitization is a return to emotional neutrality post stimulus, this may be another reason why an individual may underestimate desensitization. Participants have a mental model of DD and were able to provide personal experiences, which align with the phenomenon, suggesting more legitimacy to the hypothesis.

Since I was little, my mother wanted to teach us the importance of recycling. She has this picture of a woman digging through a landfill ... a big poster sized image. She kept that in her bedroom to remind us of how fortunate

we were. As the years go on, we get less and less affected by the picture. (#56)

When I was a kid, the whole thing about animals getting caught in pieces of plastic really concerned me, but after a while it started to appear in every single animation, movie, documentary, and school, and by now, I'm not that concerned about it anymore. (#145)

Two students described similar stories where their aversion to air pollution in Curitiba lasted only a few months, because they became accustomed to it.

When I came here [Curitiba] from Japan, I think it [air pollution] really bad, but then I get used to it, so I don't even feel it is bad anymore. I think [I got used to it in] a couple of months. (#136)

Air pollution. When I was in Canada, I was fine and didn't have problems with asthma, but when I came back [to Curitiba], I have problems with asthma. It really annoys me because I don't have as much conditioning. It smells different here. But you just learn to live with it. It took me half a year [to get used to it]. (#132)

Beyond their theoretical conception of DD, students also appeared affected by DD after watching videos depicting EDS over the course of several days. For example, the researcher found that participants felt significantly less sensitive to EDS on day 4 when compared to day 1.

That's just what happens: after being exposed to information for too long, people adapt and get used to it. (#145)

Degradation desensitization and environmentally responsible behavior

You shut it out unconsciously because either you shut it out or you feel bad about yourself. (#132)

Our mind blocks out bad experiences so we don't feel bad. Form of defense of the human mind. (#34)

It impresses me that humans stop getting impressed. It is human nature to get used to things. We must adapt. Keeping people continuously impressed is difficult because they'll get used to it over time. (#116)

Based on their responses, the participants acknowledged DD both on a theoretical level and in their own apparent DD after watching videos depicting EDS.

Power

The results confirmed that the DD participants experienced was very much a function of locus of control. Generally, students felt "overwhelmed" by the scope of environmental problems and did not believe they had the power to improve environmental problems. A common trend was the feeling that one's power did not extend the boundary of one's own personal actions or immediate community.

[Regarding power to improve environmental problems] Not global problems, but in your community of course. You can always try to clean up the trash, find out if it's being taken care of problem. One person is not big enough to reach out to the world. Only if something extraordinary happens can someone affect the world. (#56)

We do have some power; if I have an idea I can spread it to family and other people and they can incorporate it in their lives. We have a small reach in our communities. (#143)

Further, students agreed that they had no power alone, but did have some power if they were part of a collective effort.

We have no power alone, but doing the work together we can help the environment. (#43)

They are just one person and there are so many other people; they see the trash even if you pick it up the next day it's going to be there again. It's never going to get better and unless anybody else helps. (#99)

Yet, participants acknowledged that when an individual feels like the scope of a problem is beyond her grasp and thus its resolution, in her mind, impossible. Any action in the face of such an impossibility is then deemed worthless. This problem—this perceived impossibility—in essence, is ignored.

A lot of times, there are big problems elsewhere in other countries that everyone tends to ignore because they can't do anything about it. Things that are too big that people can't take care of are things people tend to ignore. Things that go on in the news or things that go on in our communities that we can't control. (#56)

It's very complicated because these problems are so big. You are just one person, your actions are so small. You feel powerless; but if we don't do it who is going to? It is part of your duty to take care of it. (#142)

Can't do anything about it. Can take one thing [trash] out, but there is so much more. (#94)

The researcher found a strong positive correlation between NC and perception of power via the surveys. Students who scored higher on the

NC scale were more likely to feel that they had the power to improve environmental problems. Accordingly, the less sensitive a student was to environmental problems, the less likely they were to feel they have the power to make a difference. Such students described becoming accustomed to things they felt they had no power to change.

After the initial frustration, we realize we're useless. See it and get used to it. (#31)

At first I felt horrible. After some time I felt helpless and stopped paying attention. (#27)

If no one is recycling, no one wants to start because there are so many other people who don't do it, especially when they feel like it won't make a difference so they get used to it. They decide not to do something. They do not want to be the first person. (#99)

People say we can't make a difference so we don't get our hopes up. It is a noble dream, but no more than a dream. (#145)

Power affects my behavior. If I can make a difference, I will recycle. (#27)

Indeed, while students recognized the scope of the problem, some felt helpless while others felt empowered to at least address environmental problems on a personal level.

Hypothesis 3: Degradation Desensitization lessens the likelihood that an individual will engage in ERB.

We noticed a trend towards significance in the behavioral observation, with the experimental group recycling significantly less on the third day after watching three video clips of EDS. This indicates the existence of a lagged effect, in support of DD, whereby the effects of the IDS did not occur on the

subsequent day only but over the course of several days. This is further supported by the significant positive relationship found between NC score and ERB, showing a direct connection between environmental sensitivity and ERB. Hence, an individual that becomes increasingly less sensitive may be increasingly less likely to engage in ERB.

Though Phillips (1983) notes that heavyweight prize matches, a form of media violence, triggered "a brief, sharp increase in US homicides," there was a distinct lag in the effect, whereby peak violence was observed on the third day. One cannot presume the third day difference in the present study can be attributed to random variations because the difference was statistically significant. Interestingly, there was no longer a significant effect on the fourth day, which can be ascribed to random fluctuations. On the fourth day, students may have guessed that their behavior was being monitored and thus would have been more likely to recycle.

The decrease in recycling behavior is consistent with desensitization findings in the realm of violent media. Bushman & Anderson (2009) noted that participants who played a violent videogame took 450% longer to help a victim in a staged violent encounter, than those who had not played a violent videogame. Further, the moderate positive correlations found between NC and ERB indicate a relationship between environmental sensitivity and behavior. The researcher reasons that EDS, and perhaps more generally, exposure to environmental degradation, can affect one's likelihood to engage in ERB. As discussed in the prior section, this may be the result of the individual's perception of the scope of the problem and her locus of control.

There may be limitations with relation to the representativeness of the sample, which included 140 students from the International School of Curitiba. Thus, the sample may be disproportionately well educated. Future research should examine a larger and more diverse subset of the population.

Moreover, future studies may observe whether similar effects are seen when different forms of EDS are displayed. For example, one group could view a

film about deforestation and another on fishery collapse. After all, people will have differing opinions regarding which forms of environmental degradation are most important, and the degree to which they respond to the imagery may be dependent on such perceptions. It would also be interesting to determine the effects of environmental degradation in different forms, for example, imagery only, without accompanying sound, or in live viewing of degradation rather than video depictions. Indeed, the researcher would predict that walking on a landfill would impact participants more than a video in a classroom removed from the environment.

Conclusion

In this study, the author proposes a new construct, Degradation Desensitization (DD), which is the loss of sensitivity to a previously aversive degradation stimulus due to consistent exposure to that stimulus. The overall objective of this research is to further the current literature on the psychological effects of environmental degradation as well as the impacts of these effects on behavior. It is appreciated that the hypotheses put forth in this paper should be regarded as highly speculative at the present time. The author hopes that a deeper understanding of DD may allow for the development of a new framework to promote environmentally responsible behavior.

What is the practical use of knowing how people perceive degradation, waste and/or the environment? As our world undergoes anthropogenic changes, it is critical to examine how these changes affect our well-being and our relationship with the natural world. Only by understanding this relationship can we hope to achieve behavioral change. The experience of environmental degradation can leave people feeling defeated and powerless. Ultimately, these feelings may trigger certain defense mechanisms, which may act as a hindrance to ERB. Our ability to understand these dilemmas will directly inform our capacity to construct appropriate environmental engagement and communica-

tion frameworks. If DD does exist, we cannot hope to change behavior without first implementing a re-sensitization effort. This may come in the form of a marketing effort that emphasizes how people can personally be affected by environmental degradation. Showing the positive effects of ERB may counteract the feelings of hopelessness reflected in participants' responses regarding the scope of environmental degradation. In order to understand re-sensitization, a secondary study is needed. The research project should be interdisciplinary, conducted in cooperation with psychologists and conservationists.

Once again, the results illustrate a significant link between emotions and exposure to environmental degradation and support the validity of the Degradation Desensitization phenomenon. Accordingly, the findings of the present study may serve to further the discourse on environmental sensitivity and environmentally responsible behavior.

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Devouring the Congo

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Abstract

Bushmeat consumption in the Congo Basin has concerned conservationists for nearly four decades and has come to be seen as a somewhat intractable problem rife with military conflict and entangled with the small arms trade. In the Democratic Republic of Congo (DRC), bushmeat is currently undergoing a remarkable shift—from subsistence protein to luxury food. Through an ethnography of the value chain, this transformation is traced from production in Salonga National Park to sale in urban markets and eventual consumption in Kinshasa’s restaurants. This research opens up new sites of inquiry into the mystique and cultural value of a particularly important commodity, and examines the creation of economic value over both geographic and temporal distance. The work aims to reconceptualize an “ongoing crisis” as a process embedded in the normative social fabric of a dynamic country.

La consommation de viande de brousse dans le bassin du Congo préoccupe les défenseurs de l’environnement depuis près de quatre décennies et en est venu à être considéré comme un problème apparemment insoluble en lien avec des conflits militaires et avec le commerce des armes légères. En République démocratique du Congo (RDC), la viande de brousse est entraîné de passer d’alimentation de subsistance à nourriture de luxe. Grâce à une ethnographie de la chaîne de valeur, cette transformation est suivie, de la production dans le parc national de la Salonga à la vente dans les marchés urbains et la consommation éventuelle dans les restaurants de Kinshasa. Cette recherche ouvre de nouvelles perspectives sur la mystique et la valeur culturelle d’un produit particulièrement important, et examine la création de valeur économique à la fois sur la distance géographique et temporelle. Le travail vise à reconceptualiser une «crise permanente» comme un processus intégré dans le contexte social normatif d’un pays dynamique.

Devouring the Congo

If a white man kills a wild animal and eats it, it is called hunting game. Sometimes the animal is termed venison, other times it is identified and named—deer, elk, moose. If a black man kills a wild animal and eats it, it is called bushmeat poaching¹. The animals appear too numerous to name and so it is merely called flesh, protein. Still, if

we took a moment, we could indeed begin to name them. There is forest buffalo and striped Bongo antelope, monkey (oh the varieties!) and the red river hog. There are duikers of many colors—blue, bay, yellow-back, and numerous shades of red. There is slender nosed crocodile and cane rat, pet-sized mud turtles and pangolin with million dollar scales.

Eating game in the Democratic Republic of

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¹To avoid this, I will herein refer to “bushmeat” as game.

²DRC is often called “the richest, poorest country on earth.” It is one of the largest countries in Africa, covering just under one-fourth the area of the continental United States. It has incredible untapped wealth in the form of timber, oil, coal, diamonds, rare-earth minerals, cobalt, copper and ivory. Half of Africa’s forests are within its borders, which amount to 6% of the world’s total. Its rivers could produce half of Africa’s potential hydro-electric power, a total of 13% of the global capacity. The majority of this wealth is concentrated in the cities, and in a few hands. The per capita GDP is \$484 USD (World Bank 2014).

Congo (DRC) is an erudite affair.² It is eaten at Kinshasa's Grand Hotel at tables covered in white linen. Antelope steaks share the leather-bound menus with Filet de Capitan and Porc Chops au Jus. Today's special: Porcupine from Bas Congo, \$35, with vegetables and rice or fougou.³ Game is eaten at Mama Ekila Inzia where it has been eaten for 45 years. Under the kuba cloth ceilings, steaming plates of boa, crocodile, and turtle are served to local Kinois and foreign expats alike.

It is eaten buffet-style at Super Aubaine. Devoured to the tinkling sound of an indoor water feature. The walls are dressed in colorful paintings, the chairs are dressed in gaudy pink, the waiters are dressed in formal blacks and whites, and the food is dressed in unctuous sauce. And it is eaten at Chez Fideline, a cramped second-floor room accessed by a winding staircase. Here the patrons squeeze around four tables while the proprietress has her nails done by the entrance. The clanging and steam from the adjacent kitchen overpowers the sounds of the bursting street below. A whole monkey stews in the pot. Game is served with such mystique here that there is even a counterfeit version.⁴ At the German-owned Hotel Memling in downtown Kinshasa, visitors sit down for a curious "Traditional Congolese" meal without worry or guilt—their plates are piled with a sanitized smoked pork reminiscent of the original but delivered in a clean refrigerated truck.

These wild animals—once the feast of the poor and desolate—are becoming a luxury to be saved and savored. A special rich treat—like caviar—game is now reserved for celebration. Eat too much

and you might get gout. "We eat it because it makes us strong and intelligent," they tell me, "We eat it to remember and to teach our children what life used to be like." But nostalgia is a tricky beast and memory is an act of reimagining. With each bite, they remember childhoods in remote villages, straw huts with mud walls, and forests alive with noise. The songs of frogs at night were so loud they sounded electric. The air was cool and fresh then. The children ran around in rags with broad grins. The children laughed so easily it was almost sacrilegious. It was almost a sin. Most of all, they remembered those minutes, just before the sun rises, when the nocturnal animals have gone to sleep and the morning animals are yet to stir and the forest is momentarily silent.

The taste for smoky meat is an ancient relic of necessity. It was once the only way to preserve animals killed in the forest. Meat prepared this way is called *boucane*.⁵ The word itself derives from the Caribbean Arawak *buccan*, which describes a wooden frame for slow-cooking meat. On the island of Hispaniola, French sailors would break from attacking Spanish trade ships and hunt feral pigs. The smoked meat was kept in the bowels of their boats like treasure. Their food came to define them as *boucaniers*. English colonists in Jamaica knew these men as buccaneers, licensed under letters of marque to pillage and plunder. But London quickly realized that bandits were hard to control, and the term morphed into a one of indecency.

It is strangely resonate that the word in DRC for smoked meat is related to 17th century pirates. Considering how normal it is for Congolese to go

³A staple food, often made from cassava root flour. Alternately it is made from maize or semolina.

⁴Of the 14 restaurants I surveyed, only four did not serve game. Of these, one was a chicken-BBQ place. The other three were owned by non-Congolese. They said they didn't serve game because it was dangerous as they were unsure of quality and preservation techniques. In contrast, many Congolese I spoke to felt that domestic meat was unsafe because it was artificially preserved with dangerous chemicals. These varying conceptions are important in light of recent fears of Ebola transmission from bushmeat. The only people during my interviews who brought up the Ebola risk were Westerners. Exposure risk from bushmeat did not seem to be of concern for the Congolese. In fact, the opposite was true: rather than being a site of potential disease, bushmeat was a source of health.

⁵Little, B. 2007. *The Buccaneer's Realm: Pirate life on the Spanish Main, 1674–1688*. Potomac Books, Washington, DC, USA.

⁶For instance see: Nasi, R., Brown, D., Wilkie, D., Bennett, E., Tutin, C., van Tol, G. & Christophersen, T. 2008. *Conservation and Use of Wildlife-based Resources: The bushmeat crisis*. Secretariat of the Convention on Biological Diversity, Montreal, and Center

Devouring the Congo

out for boucane of buffalo or wild boar, the explosive concern in the West over “the bushmeat crisis” is rather strange.⁶ When I told one man from USAID that I was in DRC to research bushmeat, he replied gamely, “Oh I’m sick of hearing about bushmeat. It seems to be an impossible, perpetual problem. People have been measuring and discussing it for 30 years. What do you call a crisis that is ongoing? What are we actually going to do about it?” He smiled, his eyes disappearing into folds.



Fig. 1. The Democratic Republic of Congo and settlements associated with the transport of game from Salonga National Park to Kinshasa.

In contrast to its consumption, the creation of game is a wild affair. The majority is killed illegally, sourced from an isolated protected area 1,160 km northeast of Kinshasa (Fig. 1). Salonga National Park lies in the heart of the Congo Basin, the typified heart of darkness, the heart of Africa.

for International Forestry Research (CIFOR), Bogor. Technical Series. 33; Robinson, J. & Bennett, E. 2002. Will alleviating poverty solve the bushmeat crisis? *Oryx* 36, 332; Bennett, E. et al. 2006. Hunting for consensus: Reconciling bushmeat harvest, conservation, and development policy in West and Central Africa. *Conservation Biology* 21, 884-887; among many others.

⁷At 36,000 km² kilometers, Salonga is the largest tropical forest park in Africa and the second largest in the world. It is divided into two blocks (North and South), with a corridor of secondary forest and cleared land in the middle. It is entirely located within the sedimentary “cuvette centrale” of the Congo basin.

It spans an area larger than Belgium.⁷ Deep rain forests are veined with streams that merge to become rivers, mixing further with others to become arteries. These braided waterways turn the land to marsh and swamp. For some land animals, the streams are barriers to movement. For others, like us, the rivers become a transport network through overpowering foliage too thick and prickly for traversing on foot. I flew to this place in a tiny plane steeped in clouds. The pilot was a Protestant missionary from Minnesota named Garth. As we gained altitude, he told me of all the strange things he had transported in his Cessna: 14 bicycles, four motorcycles, seven goats, and innumerable vials of medicine. His eyebrows looked as if they wanted to migrate to his mouth. Below us, the rivers of Salonga bled through the forest in slow velvety meanders.

The animals of Salonga are near-mythical. There is the forest elephant so tormented for the wealth of its tusks. The bonobo, our lust-bound relatives whose flesh is rumored to taste like our own. The elusive Congo peacock. One beast, the swamp-haunting sitatunga antelope, has elongated flared hooves and a ragged, rufous, waterproof coat. Both are enlightened adaptations for a creature that spends its days prancing over flooded riverbanks. In the males, there is a white chevron between the eyes and above, two silver horns spiraled like emerging leaves and tipped in ivory. Clear scorpions that like to hide in shoes, and armies of polished driver ants that hunt in all three dimensions. There are irascible snakes so deadly even uttering their names sparks fear. “Black Mamba” is whispered to children, like ghost stories meant to provoke nightmares.

A species cannot exist in isolation—the boundaries between one and another are illusory—and so

it is not enough to name each animal, or portray the context in which it is eaten. We must describe the fabric in which each is rooted. The soils are sandy and shallow, overlaying primeval rocks, and swimming with microbes. The plants that grow on these soils produce chemicals called “secondary metabolites,” and eventually become fodder for many animals.⁸ When you eat game, then, you are not just tasting meat. You are tasting soil and sunlight, bacteria and metabolites. You are tasting a web of relations we cannot replicate. You are eating a landscape of magic. You are eating the past.

There is a long colonial history of how we talk about what Africans do and eat.⁹ The sentiment projected onto indigenous peoples by their conquerors is an angry admiration. In the same breath, man will denounce, criticize and call savage that which he also finds brave and pure and vital. The colonizer recognizes that while Western civilization has liberated him, it has also imprisoned him. He sees in Africa a wild, dark and empty jungle. He erases the peopled, domesticated forest that is actually there, and settles into the triumph of his own heroic odyssey.

To understand how hunting game became illegal, we must start with how land became owned. For forest-dwelling people, hunting was seen as an honorable activity. Customary land rights shifted over space and time to account for nomadic lifestyles and dictated who could hunt when and

where. Game was captured with hand-made snares or bow and arrow. The arrows were fashioned of slender dark wood. A heart-shaped leaf was slotted in the end to guide the flight. The tips were primed in poison. Hunting occurred yearlong, but it was the wet season when game was most plentiful. The rains flooded the lowlands, and the animals crowded the highlands. In the dry season, the rivers pulled back from their banks and the fish swarmed in the shallows, easy prey for sharp-tipped spears.

Because all life was communal then, eating was too. A forest buffalo could feed the entire village. Diets were protein-rich and carbohydrate-poor. Meat was the glue that bound society together. Certain game, like elephant, was reserved for men of high stature and believed to bestow a potent virility. Hunting itself was an ecological act.¹⁰ It tied the body to the forest in ways both physical and metaphysical. If you weren't careful, a witch doctor could cast your soul into an elephant, and you would be bound to it in both life and death.

Then Henry Morton Stanley wrought his violent path through these forests in 1874. He described them as an “endless ... suffocating wilderness”.¹¹ The forest presented white men like him with such difficult conditions that “the struggle for existence [was] on the whole severe”.¹² The expedition parties rejoiced at the site of grasslands.

In May of 1885, the “international” community

⁸For an interesting discussion of metabolites, see Waterman, P. 1996. Secondary Metabolites. In: Alexander, I.J., Swaine, M.D., & Watling, R. (Eds). *Essays on the Ecology of the Guinea-Congo Rain Forest*. The Royal Society of Edinburgh, Edinburgh, UK. pp 225-242. They can be affected by soil nutrients, variation in incident light, carbon/nutrient balance, specific trace elements, drought and salinity, damage caused by pathogens and herbivores, seasonality, plant habitat, plant form and stage of development. It is an incredibly complex system that we still don't fully understand.

⁹For an interesting overview see: Rau, B. 1991. *From Feast to Famine: Official cures and grassroots remedies to Africa's food crisis*. Zed Books Ltd. London and New Jersey, NJ, USA.

¹⁰Hunting can change animal behavior and plant dispersion. In cases of over-hunting, ecosystems may lose primary seed-dispersal agents, fundamentally altering the plant compositions. For instance, see: Yumoto, T., et al. 1995. Seed-dispersal by elephants in a tropical rain forest in Kahuzi-Biega National Park, Zaire. *Biotropica* 27, 526–530; Newing, H. 2001. Bushmeat hunting and management: implications of duiker ecology and interspecific competition. *Biodiversity and Conservation* 10, 99–118; Bodmer, R.E., 1995. Managing Amazonian wildlife: Biological correlates of game choice by detribalized hunters. *Ecological Applications* 5, 872–877.

¹¹Stanley, H.M. 1891. *In Darkest Africa* v.1. Charles Scribner's Sons, New York, USA. For more information about this period in DRC, including the slave trade that led up to it, see: Hochschild, A. 1999. *King Leopold's Ghost: A story of greed, terror, and heroism in colonial Africa*. Houghton Mifflin Harcourt, USA.

¹²*A Manual of Belgian Congo*. 1919. Naval Staff, Intelligence Dept. London, UK.

(the major European powers of England, France, Germany, Belgium and Italy) recognized King Leopold II of Belgium as having a sovereign claim over Congo. Five years later, these same countries created the first international conservation law: *The Convention for the Preservation of Animals, Birds and Fish in Africa*.¹³ The treaty had very little to do with the basis of intrinsic value of wildlife, and much to do with protecting African landscapes for European exploitation. They wanted a steady supply of game for their sporting activities. For those useful and rare animals, there was “Absolute prohibition on hunting or destruction” (vultures, secretary birds, wild asses) while others were deemed “Harmful animals desirable to be reduced in number within sufficient limits” (lions, leopards, pythons, otters).

The land and its people came to be viewed scientifically – a methodology driven in equal parts by neutral curiosity and in service of empire. Mustachioed men mounted expeditions on river steamers, calling these missions reconnaissance. They assessed waterway navigability and wrote extensive reports.¹⁴ Exotic species were collected, labeled, and pressed into type specimens. They spoke of everything in use-value and imposed rules, regimes, and statutes. Variable land rights were reassigned and legislated to suit colonial needs.

In 1898, a railway line was built between Matadi on the coast and Leopoldville (present-day Kinshasa), and the Belgian administration began

transforming the country into a model colony. A port was constructed and the extensive upstream river network co-opted to transport resources for export.¹⁵ Roads were hacked into the forests. The native men and women were told they could not use the forests as they once had. Brussels busied itself preparing agricultural bulletins. Villages, once dispersed around the riverbanks, were forced by brutal methods to cluster along the roadsides. Such compulsory resettlement became a tactic to facilitate control over a previously scattered rural population. The Congolese were pushed into the agricultural labor market through quotas, guarantees, “white gold” ivory tributes, and taxes. They were coerced to gather wild rubber¹⁶ under increasingly appalling conditions. Failure to pay led to the loss of hands.

As the colonial machine was laid across the land, Belgian Congo was envisioned as a new touristic playground for Westerners. Travelogues recast the forsaken Darkest Africa as a “Modern Central Africa”.¹⁷ The Belgians took to hunting on horseback. In Europe, hunting had been restricted to rich landowners for centuries. During the 16th century, only the privileged nobility were allowed to kill deer and harming royal game was punishable by death. So it was with little thought that such laws were implemented in Africa as well. With access to forests restricted, and La Colonie monitoring all domestic animals introduced into the country, meat became scarce. The authorities had a monopoly

¹³This treaty was the grandfather of the Convention on International Trade in Endangered Species (CITES), enacted seventy-one years later.

¹⁴For instance, see the *Bulletin de la Société Royale Belge de Géographie* 35 (1911), pages 229, 234, and 502; and *Revue de Géographie* 49 (1901). p. 369. Librairie Ch. Delgrave, Paris, France. Mentions of the Salonga River can be found in *A Manual of Belgian Congo* (1919), p. 242.

¹⁵Initially, colonial authority restricted migrant workers from making permanent homes or owning land in the city, but slowly rules were relaxed. A deeply segregated city grew, and by the 1940s and 50s there was extensive urbanization. Congolese were trained in administrative tasks, and as doctors and lawyers. This new middle class of évolués meant Congo had a wage labor force twice as large as any other African colony. For more on this process see: Freund, B. 1998. *The Making of Contemporary Africa: The development of African society since 1800* (2nd ed.). Palgrave-Macmillan, Basingstoke, UK.

¹⁶The wild rubber harvested in DRC was a species of liana (*Landolphia owariensis* P. Beauv.), not the tree variety typical of other locations. It was traditionally used as a medicinal plant.

¹⁷For example in Dugland, C. 1929. *Wanderings in Central Africa: The experiences & adventures of a lifetime of pioneering & exploration*. Seeley, London, UK, Campbell writes about *la route royale*, a newly built motorway north east of Mbandaka and the various opportunities for “luxurious travel” by rail and river that connected DRC to the Nile and the east coast of Africa.

Table 1. The value of bushmeat increases as it is moved from forest to restaurant.

Location	Value (\$) ^a	Distance from source (miles)	Transport method	Actors involved
Monkoto (Salonga NP)	10	0–50	On foot or bicycle	Hunters and market hunters
Mbandaka	11	200	Bicycle or pirogue	Market hunters and <i>Commercants</i>
Inflammable Port (Kinshasa)	18	~550	Large barge on Congo River	<i>Commercants</i> and wholesale vendors
Grand Marché (central Kinshasa)	27	~552 ^b	Vehicle or on foot	Primary or secondary vendors
Restaurant (Kinshasha)	21.50 ^c	~550	Airplane (cargo)	<i>Fornisseur</i>

^a whole monkey, USD

^b ~2 miles from port

^c per portion: 4–8 portions per monkey

on protein. Plantations replaced food crops, and the people relied on famine roots and tubers, native peanuts, imported starches and palm oil. Meat came to symbolize power and potency.

Like the threaded waterways of the Congo River Basin, the trade in wild meat is meandering. But like a river eventually empties into the sea, so too most meat eventually ends up in Kinshasa. Meat is still smoked for preservation because it may take months to move it from forest to city.¹⁸ With each step away from the forest, the price creeps higher. The hunter goes into the forest with bow and arrow, *calibre dooze* shotgun, or AK-47. He may follow animal trails through the thick cathedral or he may hack his own path.¹⁹ As he walks, he sets snares made from bicycle brake wire. He may shoot

down monkeys or be lucky enough to come across a massive bush pig the color of caramel.

When the animal has been killed, it is disemboweled. The skin is left on. Its body is splayed dorsally by a frame made of two crossed branches. It is warm-smoked for many hours. Because of the high humidity of the forest, the meat is re-dried over a small fire every few days. All this slow smoking means that when it is finally reconstituted in rich stews, the meat is delicate and tender. It falls to pieces in your mouth.

Groups of market poachers set up camps deep in the Salonga forest and amass many pounds of meat. It will take a week to hike it out to a more accessible part of the forest. The porters are each given one monkey for every five they carry out.

¹⁸Generally, road and river transport in DRC has worsened since the early 1990's. Yet Chinese-funded and built roads are rapidly changing this dynamic. For instance, see: Cheru, F. & Obi, C. (eds.) 2010. *The Rise of China & India in Africa* Zed Books, London & New York. p. 232. There are conflicting notions of what effect roads have on the bushmeat trade. For instance, Draulans and Van Krunkelsven (2002) argue "the collapse of the transport system increased the reliance on bushmeat to about 80% of protein consumed." Draulans, D. & Van Krunkelsven, E. 2002. The impact of war on forest areas in the Democratic Republic of Congo. *Oryx* 36, 35–40. Others argue that better transport increases the rate at which game can be moved from forest to urban areas. One study found that roads completely changed the direction of where meat went: Steel, L. et al. 2008. *The Scale and Dynamics of Wildlife Trade Originating in the South of the Salonga-Lukenie-Sankuru Landscape*. WWF-Democratic Republic of Congo. December 2008 (Draft – Not for Circulation). This was particularly the case for logging roads, which increased access to previously remote forest areas.

¹⁹Historically and contemporarily, hunters are always men.

The meat is then stacked into large baskets made from slender bent saplings and strapped to modified bicycles—saddle, chain, and peddle removed, strings tied from the handlebars to the baskets—and pushed for many more kilometers over rutted, single-track dirt lanes and across log bridges. Sometimes the trader will stop in villages and hang around for a few weeks, negotiating for more stockpiles of meat, bartering soap, salt, and bullets. Sometimes the people in these villages are his relatives and he is going home.

When a suitable tributary river is reached, the game is loaded onto a pirogue, a kind of slender dug-out canoe. Some days later it will reach the Congo River and the port town of Mbandaka. From here, the baskets of meat are placed on the decks of ancient wooden whaling boats where they join salted fish, burlap-wrapped bundles of charcoal, corn, and forest products that will bring enough profit to justify the month's cruise to the capital city.²⁰ These boats are floating villages. People onboard live and die, give birth and get married. They bring the country down to the city, then turn around and take the city back upstream—plastic tubs, razor blades, fake hair, clothes. It is an exchange of the natural for the industrial.

The geography of value

Finally in Kinshasa, these boats dock at gritty port markets.²¹ At *Marché Inflammable*, I met two sisters who ran a market bar that served as a headquarters for the illegal smuggling of game. It was made from recycled lumber with low ceilings.

²⁰Because of the long distance, and the many middle-men, products must be worth a certain price in Kinshasa to justify the long transport from Mbandaka. Game is a particularly high-value product as it does not degrade much over time and is relatively compact and lightweight. The price of meat in the city is four to five times the initial cost (Table 1). Live animals are also transported. Vegetables, on the other hand, are bulky and will rot.

²¹It is also interesting to note that you can tell the health of a forest by the kinds of animals found in a bushmeat market. For example, if there are a lot of red colobus monkeys for sale then the forest is likely still relatively intact, as they are the first to be hunted out. The smoked monkeys are identifiable by their paws.

²²For a good discussion of these politics see: Pryor, F. 1992. *The Red and the Green: The rise and fall of collectivized agriculture in Marxist regimes*. Princeton University Press, Princeton, NJ, USA. For more on periods of civil war see: Price, S. 2003. *War and Tropical Forests: Conservation in areas of armed conflict*. Food Products Press, Binghamton, NY, USA, and Hopson, M. 2011. The wilderness myth: How the failure of the American national park model threatens the survival of the Iyaelima tribe and the bonobo chimpanzee. *Environmental and Earth Law Journal* 1, 61–102.

“Sometimes we get chimp or elephant meat secretly wrapped in other kinds of meat, or hidden in maize or fougou,” they told me. “Sometimes ivory is hidden the same way.” When I asked if they were afraid of being caught, they said solemnly, “The soldiers cooperate with us, but we don’t trust them. They are not our friends.”

In 1960, colonial independence followed elections but the rapid retreat of the Belgians thrust the country into a brutal five-year civil war. When Mobutu Sese Seko took power in a US-backed coup in 1965, he gave a speech to his newly independent country. “You take some and you leave some,” he said, making it clear that if you weren’t taking what you could get, angling for every opportunity, you were weak and stupid. Corruption lost its tone of morality and became a strategic way of receiving what was deserved. By 1973, Mobutu’s power was all consuming. He brazenly executed anyone he suspected of being a rival. Because of Mobutu’s anti-communist stance, the US turned a blind eye to his grotesquely violent dictatorship.²² But despite his Western backers, he aimed to wipe the slate of any colonial marring and went about creating the official state ideology of *Authenticité*. He renamed the country Zaire, nationalized all foreign-owned industry and land. He called for the *évolués* to dress and speak and eat in an “authentic” Congolese manner.

DRC’s immense mineral wealth made it a country of geologic scandal, and Mobutu became one of the richest men in the world. With a leopard-skin hat and private European vacations, he was a

dictator with a bizarre aesthetic. Despite his proclaimed hatred of the West, he enacted many laws that looked strikingly similar to colonial methods, particularly when it came to wilderness conservation. In 1970, Mobutu expanded Salonga's park boundaries, motivated by a desire to create a protected zone larger than the Belgians had created.²³ He may very well have believed this was a revolutionary act—he was creating a symbolic gesture of Congo for the Congolese. But as with the Belgians, access was restricted to the corruption class, and it was now Mobutu who used Salonga as a private hunting ground.

By the 1980's, DRC was facing massive currency devaluation and increasing instability. In the early 1990s, war in neighboring Rwanda led to a massive influx of refugees and rebels into Congo's forests. Civil war broke out and Salonga buzzed with rebel soldiers, renegade locals and armed refugees. They took hostages to make sure local villagers delivered food. Game and ivory were stockpiled and traded for supplies and small arms. Widespread circulation of weapons became the norm. Crisis, starvation and desperation were rampant across the country. During this time, DRC was still predominantly a rural country. But with the instability of civil strife, the cities swelled with those desperate to escape the violent countryside.

The state invested heavily in urban and mining areas, while demanding high levies from cash crops, worsening disparity between metropolitan and village dwellers. Resources, economic growth and industry were concentrated, further facilitating a rural exodus. Newly salaried urbanites were willing to pay good money for traditional meats and demand for game shot upwards. Strong illicit networks developed to transport game from forest to city and ammunition from city to forest. Military

men in power were often at the center of this trade. They relied on poorly paid foot soldiers and park guards. Their wives became traffickers. Meanwhile hunting had become modern with the influx of AK-47s into the forest. A single person could now swiftly wipe out a troop of monkeys or a parade of elephants. In Kinshasa's markets, piles of elephant meat could be found for sale out in the open amongst the flies.

One evening, I sat above the Congo River in Mbandaka and watched the boats. The trade of products was so wrapped up in the act of daily living that it was difficult to separate the bodies engaged in work from those engaged in play. Somehow life and economy had seeped into each other and become entwined. Life was transactional. It wasn't always so difficult to transport goods in Congo. When the Congo was run by dictators—both colonial and African—there was a sense of things working, even if this order was imbued with violence. Smooth roads, national bus systems, and on-schedule river ferries reduced time and space. Today, there is a more vibrant, dysfunctional sense of time. Life takes as long as it takes. “God gave the white man a watch,” my Congolese coworker told me one night, “but he gave the Congolese time.”

Today, a heavy state military presence in Salonga has led to a decrease in rampant hunting. But the market forces driving urbanization and demand for game that began in the 90s did not disappear so easily. The military and poorly paid park guards are still involved in the trade, either directly or through the taking of bribes. Vast quantities of game turn rancid during transport through the many detours of this illicit network. The remote villages on the edge of Salonga are now colonized by conservation NGOs concerned about “empty forest syndrome”.²⁴ Their generators and motorcycles bring new noise to a forest they are worried

²³The Salonga National Park was initially established as the Tshuapa National Park in 1956 in order to preserve a large forest area from being harvested for timber. Mobutu's presidential decree ordinance 70-318 created “une reserve naturelle integrale” that was “intended to be a wildlife preserve specifically for the relocation of the nation's now endangered forest elephants, *Loxodonta africana cyclotis*.” (Hopson 2011, 81) It was registered as a UNESCO World Heritage Site in 1984.

²⁴For instance see: Redford, K.H. 1992. The empty forest. *Bioscience* 22, 412–422.

is becoming silent. Their presence not only brings material goods but also *creates the desire* for material goods—it's hard to know you want something until you see it. Media beamed down via their satellite internet brings images of pornography and consumption culture. The military captains spend their days at a mobile court prosecuting poachers under *Operation Bonobo* and their nights drinking warm Primus at the village's thatch-roofed nightclub. "Our money has become the message," one conservationist told me. In preservation lies the vision of all worldly benefits.

Today, Kinshasa is a chaotic city of 10 million people. The new president likes to drag-race down the Chinese-built roads in the center of town, alone in his fancy cars, his military attaché trying to keep up behind him, lights blaring, trigger fingers tense. Armored SUVs ply the streets, carrying foreign officials who pay exorbitant rents to live in the homes once owned by Mobutu's ministers. The rising middle-class in DRC wants a comfortable life. Billboards advertise the born-again saviors who promise ascendance from poverty and hardship, whitening cream, and Irish butter. In the poorer neighborhoods, live wires run along open sewer pits. Graffiti for the Autopsy gang.²⁵ adorns crumbling walls. While the West is plagued by the corruptions of material wealth, Congo has settled into the corruptions of material poverty. Both geographies exist in the modern world, but only one is considered primitive.

One chilly evening in Kinshasa, I ate antelope. It was stewed with tomatoes and spices. It was tender and smoky. It tasted neither wild or domesticated. It tasted like the sadness of the many millions killed in war, like the pulsating beats of Congolese music and the vivacious colors of the tailored fabrics. It tasted like the hard labor of many hands and of the polluted Kinshasa air. It tasted like the cool wet quiet of a threatened forest. It tasted embedded.

²⁵A local street gang

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Plantation projects in Madagascar: approaches, objectives and reflections for fuelwood production

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Abstract

As the majority of Madagascar's population continues to rely on wood and charcoal for cooking fuel, today, and as the production of charcoal to meet urban demand is linked to deforestation, plantation projects may offer an option to replace extraction from natural forests. This project aimed to gain insight into the status of plantation projects, in Madagascar, particularly in relation to fuelwood production. I conducted semi-structured interviews with representatives from four organizations that run active plantation projects in Madagascar, regarding project background, decision-making processes, management practices, sites, species, markets, and general thoughts about the role of plantations for fuelwood. Of these projects, two specialized in charcoal production specifically, although all of the organizations had implemented some type of intervention to improve fuelwood or supply chain efficiency. It seems that organizations may benefit from knowledge sharing regarding both approach to plantation as well as regarding technology such as improved-efficiency charcoal kilns. These projects still face numerous challenges as well, due to limitations from funding sources, lack of governmental support, and land tenure access. As most of these projects were recently launched, their impact and durability remain to be seen.

Comme la majorité de la population de Madagascar continue de utiliser le bois et le charbon de bois pour faire la cuisine aujourd'hui, et que la production de charbon de bois pour répondre à la demande urbaine est liée à la déforestation, des projets de plantation peuvent offrir une option pour remplacer l'extraction des forêts naturelles. Ce projet visait à mieux comprendre l'état des projets de plantation, à Madagascar, en particulier par rapport à la production de bois de chauffe. J'ai mené des entretiens semi-structurés avec des représentants de quatre organisations qui exécutent des projets de plantation actives à Madagascar, en ce qui concerne le contexte du projet, les processus décisionnels, les pratiques de gestion, les sites, les espèces, les marchés, et de réflexions générales sur le rôle des plantations de bois de chauffe. Parmi ces projets, deux étaient spécialisés dans la production de charbon spécifiquement, mais toutes les organisations avaient mis en œuvre un certain type d'intervention pour améliorer l'offre de bois de chauffe ou de l'efficacité de la chaîne de production. Il semble que les organisations peuvent bénéficier de partage des connaissances concernant à la fois l'approche de plantation ainsi que concernant la technologie tels que l'amélioration de l'efficacité d'un four à charbon. Ces projets se heurtent encore à de nombreux défis et, en raison des limitations de sources de financement, le manque de soutien gouvernemental, et l'accès à la propriété foncière. Comme la plupart de ces projets ont été récemment lancé, leur impact et la durabilité restent à voir.

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Introduction

Madagascar is globally recognized as a biodiversity “hotspot” with over 80% of its plants and animals endemic to the island (Medley 2004, Marcus 2001). As with much of the world, Madagascar’s forests, flora and fauna are threatened by a range of anthropogenic activities, one of which is land clearing for charcoal production (Bergeron 2002).

Utilization of charcoal or wood for cooking is still commonplace in Madagascar, with more than 90% of the population relying on one or the other (Global Alliance for Clean Cookstoves 2014, Gade & Perkins-Belgram 1986, Bergeron 2002). Charcoal is the principal energy option for cooking in urban areas particularly, due to its efficiency, cost, and transportability compared to wood, kerosene, or electric power (Seidel 2008). In addition to the ecological problems linked to charcoal demand (Meyers et al. 2006, Van der Plas 1995), urban markets tend to be volatile, and the price of cooking fuel is becoming increasingly cost prohibitive for Malagasy citizens. Today in Madagascar, people may spend up to 10% of their annual income on fuel alone (Bergeron 2002). Demand for charcoal has tripled over the last 30 years, with high increases in urban population, and this demand is cited as a major cause of deforestation across the country (Indian Ocean Times 2014, Meyers et al. 2006, Van der Plas 1995, Bergeron 2002). While these challenges are commonly recognized, most rhetoric in conservation dialogues tends to focus on limiting deforestation via protected areas, rather than looking at alternative ways of meeting the fuelwood demand of citizens (Consiglio et al. 2006, Clayton 2011, Raik 2007).

In the context of these challenges, this study aimed to gain an understanding of fuelwood plantations in Madagascar, via case studies of plantation projects. Historically, French colonial rule implemented eucalyptus plantations in the central highlands, whose remnants are still used today to meet fuelwood demand of the capital and surrounding cities (Gade & Perkins-Belgram 1986). To-

day, however, plantations for fuelwood tend to be limited to certain regions and projects and are not widespread. Clear statistics of plantation projects throughout the country do not exist, but a number of past, present, and future projects were identified in the scope of this study. Four projects: *Start!e*, *Bararata*, *Ecoformation*, and *GIZ PGM-E* were reviewed as case studies for this study (Fig. 1).

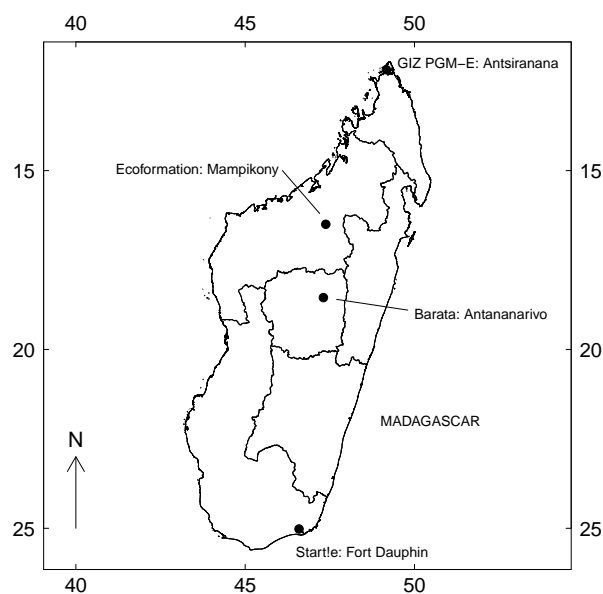


Fig. 1. Map of Madagascar, showing locations of the projects interviewed.

Beyond the four projects investigated, past initiatives in Madagascar have included: (1) USAID sponsored *Jariala*, which forested approximately 3,845 hectares in 6 communes surrounding Fort Dauphin, largely using varieties of *Eucalyptus*, in addition to *Pinus kesiya* and *Grevillia exul* (Sibomana & Burren 2006), (2) *CARMACODEC* (Carbonisation améliorée et contrôle forestier décentralisée à Madagascar) a project implemented in association with CITE and French Research Center CIRAD, for sustainable charcoal production for Mahajunga, in Northwest Madagascar (Montagne et al. 2010), and (3) World Wildlife Fund implemented fuelwood initiatives in the Southwest region, Toliara. Some examples of ongoing projects

that are now in early stages of operation include: (1) *Alamanga* is a French nonprofit, launched in 2010, with broad objective of reforestation, including species to be used for fuelwood among other uses (<http://www.alamanga.fr/alamanga/>), (2) *Honko*, a Belgian nonprofit, who launched a nursery for a fuelwood plantation project in 2012, in aims of reducing pressures on mangrove forests in the Southwest (Honko 2013), and (3) a broad scale project, “Program to support Agroforestry around Antananarivo,” is presently being launched by the European Union, aiming to implement 13,000 hectares of fuelwood plantation, among work with other interventions (aquaculture and agriculture), over a 5 year period (ASA 2014) . In addition, numerous nonprofits throughout the country, such as Association pour le Développement de l’Energie Solaire (ADES 2006), Zahana, and Azafady, among others, promote interventions such as improved-efficiency and solar cookstoves, in the aims of reducing charcoal consumption.

Methods

I conducted semi-structured interviews between May-June 2014 with four organizations that operate plantation projects. The organizations talked to were Start!e, a project based in Fort Dauphin using bamboo for charcoal production; Ecoformation, an organization implementing plantations for goals of reforestation in the Sofia Region; Bararata, focused on bamboo’s potential to replace traditional forest-dependent products, with projects in the central highlands surrounding Antananarivo; and plantations of the fuelwood production-focused branch of German-Malagasy Program for the Environment (GIZ PGM-E) in the Antsiranana region of Northern Madagascar (Fig. 1). I conducted interviews with individuals at the director or management level within each organization. I also visited selected nursery or plantation sites of Ecoformation, Bararata and GIZ PGM-E.

Interviews asked questions regarding project background, decision-making processes, manage-

ment practices, sites, species, markets for products, and general reflections of the individuals who represent such projects.

Results

Overall Goals

The organizations interviewed had varied objectives, and as a result, varied approaches in terms of their choices of plant species, project management, plantation products, and other activities beyond the plantations themselves. The organizations Start!e



Fig. 2. Charcoal produced by GIZ PGM-E.

and Bararata both focused specifically on using bamboo as a fast-growing alternative to trees, to reduce pressures on natural forests. Despite this similarity, Bararata aimed to focus on bamboo and bamboo products more generally, whereas Start!e held more interest in the ecological and social implications of current charcoal supply chains. GIZ PGM-E also aimed to produce charcoal to meet urban fuelwood demands and to reduce pressures on natural forests, although using more traditional plan-

Table 1. Summary of four plantation projects interviewed

	Start!e	Bararata	Ecoformation	GIZ PGM-E
Year established	2011	2011	2011	1995
Location	Fort Dauphin	Antananarivo; Tamatave	Mampikony	Antsiranana
Objective	Produce charcoal to meet needs and supply sustainably grown charcoal in the region, environmental and social reasons	Encourage and increase bamboo as a substitution for wood/trees – for economical and environmental benefits	Reforestation to help protect Madagascar's biodiversity, investment in carbon sequestration	Produce charcoal to meet demand & reduce energy dependence on natural forests
Products	Charcoal	Furniture, construction material, charcoal, artisanal products	Reforestation & carbon credits are primary; later on village cooperatives may choose to use wood	Charcoal
Current extent/Long-term planned extent	24 ha/1,000 ha	250 ha total	300 ha/ 5,000 ha	6,700 ha total
Species	<i>Bambusa balcooa</i> , <i>Oxytenanthera abyssinica</i>	<i>Dendrocalamus strictus</i> , <i>Dendrocalamus grandis</i> , experimenting with others	<i>Eucalyptus camaldulensis</i> , <i>Acacia auriculiformis</i> , <i>Tectona grandis</i> , <i>Khaya senegalensis</i> , <i>Terminalia mantaly</i>	<i>Eucalyptus camaldulensis</i>
Land	Small-scale lease from private landowner + compensation to locals who were using the land parcel before the project	Voluntary participation in plantations: land must be shown as secure by legal recognition of land ownership, contract rights for the land, or communal ownership	Land that was previously used for zebu grazing, in 7,200 ha area (with areas used for agriculture left out)	Voluntary participation in plantations: communities commit to put in plantations, and technicians verify their suitability
Other activities	Improved carbonisation, supply chain intervention	Product construction & commercialization, formation center	Technical training, improved cookstoves, product diversification (fruit, vegetables, hens)	Improved carbonization, supply chain intervention, improved cookstoves
Challenges	Land tenure & project scale	Independence of project operations from funders; lack of collaboration with government	Limited funds & equipment, poor planning, drought	Lack of supportive governmental framework for green fuelwood

tation species. Ecoformation had less of a focus on production, but a larger emphasis on reforestation and carbon sequestration. These organizations all held similar philosophies concerning the importance of Madagascar's natural forests and generating alternatives to them, but the more specific objectives have shaped how the various projects are approached.



Fig. 3. Some examples of the numerous bamboo-product.

Products produced

Closely linked to project objectives, the products produced by the different projects varied. Unsurprisingly, the main product from plantations that focused on fuelwood production was charcoal (Fig. 2). In the case of GIZ PGM-E, the majority of production was charcoal and only about 25% of wood grown on plantations was permitted for other uses, namely timber for local construction use. Start!e although still in early stages of the plantation production cycle, had a single expected product, bamboo charcoal.

Bararata another bamboo-oriented project focused more on a multitude of bamboo utilizations, rather than production of a single specific product. This organization aimed to make bamboo a commercially favorable product by working with artisans to encourage bamboo sourced furniture, buildings, construction materials, and artisanal products (Fig. 3). The organization was also exploring the potential of bamboo charcoal, but the bamboo species and size of plants produced by Bararata in the highlands does not produce large or hard

enough stems to make pure bamboo charcoal. Instead, they were mixing bamboo with charcoal from colonial-period eucalyptus plantations, to create a bamboo-supplemented “plantation-grown” charcoal product. Bararata also stated interest in potential of bamboo biomass for electricity, but this product remains an ideal at present.

On the other end of the spectrum compared to production-focused systems, Ecoformation’s approach was without specific products in mind. Instead, objectives of reforestation and carbon sequestration mean a lack of planned commercialization on the plantations that have been implemented. According to the interviewees at Ecoformation, once the plantations have been established for a greater period of time (they were established in 2013), their control and management would pass to the discretion of village-level cooperatives that could choose to utilize some wood for timber or fuelwood, as they see fit. Despite this option for local utilization, the organization expressed the opinion that the main objective was that of reforestation and vegetative cover, not specific products.

Land selection and local involvement

Two main approaches were adopted to access land for plantation projects. The first approach, used by Ecoformation and Start!e, employed preliminary studies to assess ideal sites for their projects, upon which they worked with village officials and documented land owners to obtain rights to land. Both Ecoformation and Start!e had central geographic areas of focus where the plantations were established and managed. In the case of Start!e, the current extent of the project is on land leased from an individual landowner with rights to the land. Local people had also been using the land for small-scale farming, so the organization offers compensation to them for lost profits. Start!e also involved the local community by receiving official blessing for the project from local officials and employing a number of local residents, aiming to employ the same number of men and women from the four

neighboring village hamlets on the plantation. Ecoformation similarly involved local-level officials for permission to move forward with the project, and has hired local workers for nurseries and plantation parcels. The organization also aimed to incorporate villagers through outreach such as sanitary education, training youth as future nursery managers, and training people to operate their own nurseries, utilizing a micro-finance approach. For these nurseries, Ecoformation buys materials, gives them to individuals and at the end of the production period they buy back the seedlings produced, deducting the cost of the initial materials that were provided. By offering financial incentives for villager participation, Ecoformation aims to promote the concept and practice of plantations and dis-incentivize brush fires that threaten tree growth, which is a challenge to such projects throughout the country.

The second approach to land access, the approach of Bararata and GIZ PGM-E, was more decentralized. With these programs, the project was promoted by the organization, but then left to villages to voluntarily choose to participate, and identify land areas of their own to use for plantation parcels. In addition to identifying land areas, communes and villages are expected to manage the resulting plantations themselves. A key concept behind this approach, as mentioned by GIZ PGM-E, is to move away from people’s expectations of “handouts” from nonprofit projects.



Fig. 4. Bararata’s *Dendrocalamus strictus* demonstration plantation (left) and nursery (right) in Antananarivo.

In this sense, these projects operate without giving direct compensation to villagers, instead they are supported in the beginning plantation stages (planting, terrain preparation, original parent plant stock), and at the level of the supply chain at the end of the growth cycle. As rural land ownership (in the traditional sense) means small parcel sizes and more individual management, the geographic extent of these projects reach wider throughout regions of operation, and production is more dispersed.

Species choice

The different objectives of the organizations interviewed had a strong impact on the species selected for the various projects. Bararata and Start!e both focus on bamboo, but with different specific aims, the species of bamboo are different. Start!e, focused on charcoal production, uses species based on their thick-walled anatomy, the non-native *Bambusa balcooa* and *Oxytenanthera abyssinica*, which can be successfully converted to charcoal. Start!e introduced both of these species, working with Madagascar's Department of Agriculture for importation and quarantine prior to their introduction. Additional considerations for Start!e's species choice were bamboo's fast growth, hardiness, and a lack of negative connotations from funders, where species such as *Eucalyptus* may be perceived as more invasive or negative environmentally. Bararata, while also concentrating on bamboo, has so far used species that had been previously introduced in the country, although it is also experimenting with other varieties of bamboo and the possible importation of species from China (Fig. 4).

Somewhat more "experimental" are the plantations of Ecoformation, which use principally *Eucalyptus calmadulensis*, and secondly *Khaya senegalensis* at present. The organization also listed *Acacia auriculiformis*, *Tectona grandis*, *Dalbergia* sp., and *Terminalia mantaly* among the species used and is experimenting with mixed-species parcels. While the species most used by Ecoformation presently (*Euc-*



Fig. 5. GIZ PGM-E *Eucalyptus camaldulensis* plantation (left) and test plots for previously used to help choose ideal species for the project (right).

alyptus and *Khaya*) are not native to Madagascar, the organization stated that they are aiming to find additional local species to use as well. With less production-focused objectives, this project seems to have more openness on species selection, although due to carbon credit funding, growth remained an important factor for financing the project. As a result it seems that fast-growing species have so far taken precedence over the "ideal" local ones.

Lastly, the longest established project, GIZ PGM-E, now mainly utilized *Eucalyptus calmadulensis* on their plantations. This project used experimental parcels in the beginning stages of the project, testing approximately 30 different species (Fig. 5). These experiments yielded *Eucalyptus calmadulensis* as the best choice, as most of the other species tested did not survive. Species of *Acacia* (*auriculiformis* and *mangium*) also survived, and was used in some of the project's plantations sites, but proved to be highly invasive so the organization discontinued their use.

Beyond the Plantation

Regardless of their goals, all of the organizations are committed to social intervention beyond the act of growing trees. In terms of fuelwood, in order for plantation-produced charcoal to be competitive with traditional charcoal from natural forests, which is produced at little cost from the perspective

of tree establishment, organizations are intervening in the market chain from plantation to urban market. According to one interview, in the supply chain going from village to urban consumers there is a series of middle-men charging a 100% mark-up for each resale, resulting in end-consumer prices that are up to six times the price of the sale at the village level. Additionally, charcoal prices fluctuate seasonally, going up in the rainy season compared to the dry season, although prices overall have increasingly risen over the years. In this, there is the opportunity for projects to organize collective transport of products to market, making plantation charcoal more financially competitive by cutting out middle-men. GIZ PGM-E has implemented “Rural Commercialization Centers of ‘Green’ Fuelwood,” to enable villagers to sell to centers rather than middle-men (Fig. 6). Charcoal is put into special bags demarcating their origin from GIZ PGM-E plantations, and shipped directly to urban areas where they are sold, cutting out some of the intermediaries found in the typical supply chain. The charcoal for GIZ PGM-E is marketed as “Green Charcoal,” and the specialized bags show that the charcoal’s plantation origin – that it has not destroyed natural forests. According to the interview, there is a considerable market for “green” fuelwood in urban areas, and they are sometimes not even able to meet demand. Bararata is planning to install specialized kiosks for selling a similar “green” fuelwood, which is derived from a mix of bamboo from their project, with plantation-eucalyptus charcoal. The organization Start!e has yet to implement commercialization of their products, but have plans to organize transport of charcoal from rural areas to town via wholesale transportation and sale, in order to keep prices low. Start!e also aims to combat the seasonal fluctuation of fuelwood prices by flooding the market with plantation-produced products at fixed prices when the rainy season starts, when prices typically go up.

For projects focused specifically on fuelwood production (GIZ PGM-E and Start!e), improved charcoal kilns were also used (or planned to be im-

plemented) to improve efficiency of charcoal production. In 2007, GIZ PGM-E started introducing methods of improved carbonization for making charcoal, by installing sealed cement kilns, to help prevent escape of methane that occurs in traditional methods, making carbonization more efficient. Implementation of the furnace has been a trial and error experience. The original rectangular-shaped kilns cracked due to expansion and contraction of heating processes (Fig. 6). The most recent model of kiln is dome-shaped, which has been more supple and so far withstood 38 firings. Start!e has plans for a mobile design, with an improved efficiency-kiln built on a shipping platform, enabling it to be brought to the raw material for conversion to charcoal.



Fig. 6. Fuelwood interventions beyond the plantation implemented by GIZ PGM-E: (Clockwise from top left): Rural “Green Charcoal” supply depot; an older rectangular model of improved charcoal kiln, which cracked after a few firings; and the most recent dome-shaped improved kiln, which has withstood firings so far.

On the other side of the producer-to-consumer supply chain, three of these projects also have improved cookstove interventions, to reduce net use of charcoal by consumers. Elements of these stoves can be narrower mouths than traditional metal stoves to reduce heat loss, or ceramic stoves that

hold and maintain heat better. GIZ PGM-E works with local artisans to produce improved-efficiency metal stoves. They are also looking to import ceramic stoves from the central highlands (where clay and ceramic production is common). Ecoformation does not emphasize fuelwood or charcoal production with their plantations, but to encourage less deforestation they promote fuel-efficient stoves and solar stoves (Fig. 7). Bararata has encountered challenges specific to bamboo charcoal, in that it burns too hot and risks breaking pots while cooking. As a result, the organization has a contract with an artisan to construct stoves that allow more space for bamboo combustion, although they are still in the experimental stages of the process.



Fig. 7. Improved efficiency ceramic cookstove and solar cookstove—a part of Ecoformation’s outreach to lower deforestation.

Reflections and Challenges

At the end of each interview, questions were posed regarding challenges the projects have faced, and the interviewee’s view on the role of plantations more broadly in Madagascar. The main challenges highlighted included limited funds, limitations due to funder expectations, lack of governmental framework supporting plantation projects, and challenges surrounding access to land and land tenure.

Opinions on the role of plantation projects more broadly in Madagascar might meet fuelwood demand were quite varied among the four projects. Ecoformation, whose objectives were focused more

on reforestation than product production, stated a greater importance in increasing vegetative cover in Madagascar, and that exploration of alternative sources of energy (solar ovens, biogas, improved efficiency stoves, etc.) is imperative. Bararata, also less focused on charcoal-specific production, stated that in the case of bamboo, the profitability of plantations is most important, and that charcoal-only production would not pay for the cost of bamboo production. Speaking most favorably of the potential of plantations for fuelwood in Madagascar, Start!e stated that “plantations are completely necessary”, as current forest and natural fuelwood sources are not going to meet demand in the next 20-50 years. Despite this, Start!e expressed caution against being overly optimistic due to challenges of successful community management of such projects and barriers, such as land tenure, that make these efforts on a broad scale much more difficult. GIZ PGM-E stated similar perspectives as Ecoformation, as to the importance of looking for alternative energy sources, but expressed the reality that wood-based charcoal will remain a major energy source for populations in Madagascar for the foreseeable future. GIZ PGM-E aims to streamline production from production to consumption to reduce overall demand, expressing that “we need to think in a combined manner to address the problem at hand”.

Discussion

Many active plantation projects in Madagascar are relatively new, and the sustainability and overall impact of these projects remain to be seen. Charcoal will likely to continue to be a major source of energy for cooking for a large part of the Malagasy population, and a cause of deforestation in Madagascar in the near future, making it all the more important to understand and learn from plantation projects. While the goals of projects can vary widely, there are areas where organizations can collaborate and learn from one another.

There was a common underlying theme of in-

terest in conserving natural forests, biodiversity, and addressing environmental concerns (such as erosion) among the projects interviewed. It seems that while organizations or individuals may value the use of local species, exotics such as eucalyptus or introduced bamboos have the faster growth rates needed to make managed plantations financially feasible and provide more rapid harvest and return. Two main approaches were taken in terms of local involvement and land acquisition. Two of the organizations had plantation parcels that are widely dispersed based on voluntary village-level participation in the projects, and the other approach was a more centralized one, with land concentrated in a given area. In the latter case, ownership of plantations remained with the organization, although there was some discussion of a transfer of management sometime in the future. It may be valuable for future studies to examine the different strategies of land acquisition and their impact on the long-term success of plantation projects.

The challenges faced by these organizations also yielded areas of common interest and possible collaboration. For example, the organization GIZ PGM-E has already achieved a “green” charcoal market, with significant demand in the Antsiranana region. This concept could be of interest to other organizations making plantation-produced charcoal; for instance Bararata expressed interest in marketing “green charcoal” products, but with fears that clients won’t be interested in the Antananarivo region. Similarly, Start!e’s planned approach to seasonal fluctuation of charcoal prices by flooding the market to even-out seasonal price surges could be an interesting application to other projects as well. Lastly, as all of these organizations aim to minimize deforestation and maximize fuel efficiency, coming together over improved technology such as high-efficiency cook stoves and improved carbonization may prove to be essential. For instance, GIZ PGM-E has undergone several trials of improved efficiency charcoal kilns before finding a sustainable model that withstood firings. Sharing knowledge and innovations among organizations aiming to im-

prove the efficiency of the charcoal supply chain from plantation to cookstove may help to reduce unnecessary trial-and-error and the costs associated with it.

In addition to improved communication among organizations, governmental-level and policy support for alternative fuelwood, silvicultural research and improved land tenure access are needed to address additional challenges faced by plantation projects. While the government has implemented a licensing system aiming to regulate charcoal trade in Madagascar, in reality few charcoal producers obtain the necessary permits, and unregulated charcoal trade is commonplace (Minten et al. 2013). Overall, the challenges and considerations in regards to all levels including production, trade, and regulations will likely need to be integrated in order to make sustainable fuelwood production in Madagascar a reality.

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Penguin politics: Human dynamics in the African penguin conservation debate

Linda Holcombe, MEdSc 2015*

Abstract

African penguins, the only species endemic to mainland Africa, have been steadily and consistently disappearing from the coasts of South Africa and Namibia. Many experts point to competition with small pelagic purse-seine fisheries as the most important current threat. Penguins and human fisheries both target schools of Cape anchovy and sardine which have historically congregated along the western coast.

This study sought to gather preliminary results on the perceptions of the fishing, conservation, and other communities in and around Cape Town, South Africa, related to African penguin conservation. Significant themes that emerged include a lack of awareness of the South African public about African penguin issues, disagreement among penguin conservation advocates regarding conservation approaches, ambivalence on the part of fishermen towards penguins as a species, and mixed opinions as to whether penguins and fishers have much direct interaction. The key issue, however, is one that likely confounds many conservation initiatives around the world – those responsible for making critical management decisions must choose which scientific recommendations to follow: navigating competing social, political, economic, and scientific interests and uncertainty in their efforts to do right by their country's inhabitants.

Introduction

African penguin (*Spheniscus demersus* L., Figs. 1 & 2) populations have declined by approximately 98% since the beginning of the 20th century: Once estimated at around 1–2 million pairs, the current population is down to approx. 26,000 pairs (Crawford et al. 2011). Naturally breeding in Namibia and South Africa, these penguins experienced heavy harvest of both eggs and guano, a primary driver for decline over several decades. Currently, both practices have been either outlawed or discontinued, but the now dramatically reduced populations face new threats such as habitat en-

croachment, climate change, oil pollution, and fishing competition. As of 2010, the IUCN Redlist has up-listed the African penguin to “endangered” status (IUCN 2014).

Articles written as early as 1976 suggested a preference to focus on more visible, less controversial topics in penguin conservation – such as the highly publicized oiled penguin rehabilitation stories. Frost et al. (1976) questioned the attention given to rescue and rehabilitation of African penguins, claiming that it distracted the public, donors, and politicians from the real problem facing penguin survival: overfishing. Such a preference

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would be understandable given the inspirational stories associated with oil rescue (e.g., deNapoli 2014), and the highly contested nature of fisheries in post-apartheid South Africa. Since 1994, the government and fishing industry continue to struggle in reallocating limited quotas and permit entry of thousands of previously disadvantaged fishers into commercial fisheries (e.g., Nielsen & Hara 2006). At stake is the potential collapse of vital commercial stocks, as happened recently in neighboring Namibia (Crawford et al. 1995). In the context of this struggle, there is reluctance to further restrict Western Cape fishing grounds by closing areas that surround penguin breeding islands (Coetzee 2010).

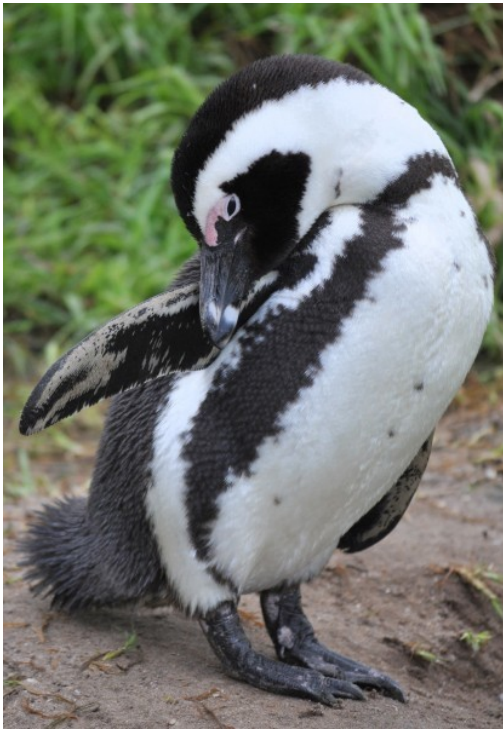


Fig. 1. Adult African penguin. *Credit:* L. Holcombe.

The literature demonstrates the conflicted nature of current penguin conservation: a vocal majority raises alarm at the continued decline of penguin populations and their apparent correlation with small pelagic schools of Sardines

(*Sardinops ocellatus* Pappe) and Cape Anchovy (*Engraulis capensis* Gilchrist) shifting from West to East. This well-documented shift (e.g., Crawford et al. 1995) takes the bulk of stock away from the vast majority of fishing capacity and effort in the Western Cape area of South Africa, where fish processing facilities, as well as virtually all penguin breeding colonies, are located. The prevailing academic theory is that heavy fishing effort in the West is leading to less fish in the water around breeding islands to sustain the significant food requirements for breeding birds (Whittington et al. 2005, Pichegru et al. 2012).

The opposition suggests that there is plenty of sardine and anchovy biomass in the water and other factors must be responsible for penguin decline. The current, controversial arrangement is a series of experimental closures of waters around penguin breeding islands that is expected to “prove or disprove” the effectiveness of marine protected areas in preventing penguin extinction. The skeptical group, mostly supported by the fishing industry, expects solid proof of penguin population increase before agreeing to maintain these closures. The conservation side calls for precautionary management, insisting that you cannot prove a long-term measure before you do it, and that a handful of years with shifting closures is not enough to indicate the success or failure of this measure.

In this study, I sought to understand the perspectives between the lines of the literature. As a penguin keeper in several aquariums, I was very familiar with the anatomy, biology, and general conservation principles related to African penguins. Given my work, I was also aware of my existing bias towards conservation. However, the goal was to explore perspectives of African penguin conservation on the ground in their native territory. The main target of this inquiry was the fishing community, given the already strained internal and conservation relationships, and their position as the accused primary driver of penguin population decline. I also hoped to better understand the dynamics within the penguin conservation community beyond the

Biodiversity Management Plan (Department of Environmental Affairs 2013). Overall, I wanted to understand what the human issues are in the attempt to prevent African penguin extinction. Participant observation, informal data gathering, and formal semi-structured interviews were used to seek answers to the following guiding questions:

1. What interactions do African penguins and Western Cape fishers have? Are they mostly positive, negative, or neutral?
2. What is the conservation/NGO perspective on the African penguin conservation debate?
3. What are the various interests/perspectives/motivations behind in the African penguin conservation plan (including the recent Biodiversity Management Plan) and related discussions?

Human issues in African penguin conservation

Key findings emerged under two main themes: (1) the expected fishing interactions (or lack thereof) with penguins, and (2) the politics of penguin conservation. The latter theme was the most surprising given African penguin conservation is very neutral and popular in zoos and aquariums (Holcombe, *personal observation*).

Penguin-fishing interactions

Accessing the fishing community was the biggest challenge of the project. Impediments such as language and fishing season were not the least of the barriers—I was also warned that the fishing community tended to be skeptical and suspicious of conservation researchers. However, among the participants interviewed, two competing narratives came forward. The first was the most prevalent and denied any overlap between African penguins and the fishing community. While artisanal fishing was not discussed in depth, commercial fishing was said to take place too far offshore to compete with penguins directly or even cause penguin by-catch mortality. Frequently I was told “fishermen never

see penguins”. Scientific observers monitor vessels such as trawlers and long-liners that target “line-fish” (e.g., hake and tuna), but they do not observe small pelagic purse-seine vessels which target sardines and anchovy—key prey for penguins. The lack of recorded penguin by-catch or gear interaction was often referred to as proof that the birds and vessels never overlapped. These reports, though, raised an interesting question: does a lack of data showing interactions exist because the interactions do not happen? Or is there no data because there is limited or no formal observation or reporting? According to the majority of those interviewed, including former and current government workers, academic conservationists, and associates of the fishing community, penguins are not directly impacted by the small pelagic industry because they do not overlap spatially and even if they did, the penguins are smart and fast enough to escape entanglement in the purse-seine nets.

Some other conversations revealed a different story. Conservationists and a former fishing industry worker suggested that penguins and commercial fishing not only overlapped while competing for small pelagics, but that penguins were sometimes killed in the process. One source even spoke of penguins and other local seabirds being ensnared on baited hooks or caught up and crushed in various nets. This participant emphasized the negative, but not necessarily deliberate, relationship between penguins and the fishing industry. He spoke of hasty and deadly removal of hooks from seabirds and the weight of netted catches squashing anything caught within them, penguins included. A conservation-minded individual himself, he asked colleagues why they didn’t take an extra second to remove hooks safely or shoo birds from the nets. The response was almost invariably “my friend, I am here to catch fish. I need to feed my family and the more fish I catch the more money I make. I do not have time for seabirds.” Another fisher responded to his efforts: “if you want to save seabirds, you can get your own boat. Me, I am here to fish.” Others questioned the assertion that

penguins did not overlap with small pelagic vessels given that penguins can swim many kilometers in each foraging event, and have been recorded on trips ranging from 10–15 hours (Petersen et al. 2006). Because penguins and the small pelagic industry target the same shoals of fish on the Western Cape, it is hard to imagine them not spatially overlapping. Further, it is worth noting again that the few fishery observation workers are stationed primarily on trawlers and long line vessels, not on small pelagic vessels. These observers do collect data on albatross and Cape Gannet sightings and interactions, two other endangered sea birds, but not on penguins. Penguin/fishery interaction data is solicited voluntarily, solicited since 2013, but nothing had been reported at the time of this inquiry (Conservation participant, *personal communication*).

A few references were made to deliberately harmful interactions between fishers and African penguins. A long-standing rivalry exists between the Cape Fur seal population and the fishing community on the Western Cape, and fishers have long lobbied for the rights to shoot problem animals who reportedly steal from catches. It appears this suspicion may extend to seabirds as well. I was directed to a 2000 news article that reported “chakka” (squid) fishers shooting at African penguins recently released by a rehabilitation center following the 2000 *Treasure* oil tanker spill (Horler 2000). The fishers did not know this was a batch of recently rescued birds being released and thought them thieves of their squid catch. As soon as they discovered that these penguins were part of a release, the shooting reportedly stopped (Horler 2000). It is unclear how many penguins were injured or killed by this particular incident as none washed ashore and the fishing vessels that were witness to the event were not forthcoming (Horler 2000). For context, although African penguins can eat squid, their preferred wild prey is almost exclusively anchovy and sardine. The participant that spoke of this article intimated that the story was not unique and it was possible events like this

continue to occur. The difficulty is that without observers on every vessel, an unrealistic expectation, there is no way to gauge how common this interaction is. There is also a strong code of silence among fishermen, briefly referred to in Horler’s article (2000), which would prevent authorities from accessing any details or even awareness of such incidents.

Overall, it does not appear that the small pelagic fishing industry or its members harbor negative associations with African penguins. Instead, penguins are often not even on the radar of this industry except when the potential for island closure to protect breeding birds threatens to restrict already limited access to fish. The reports of deliberate harm intended towards penguins are very few, while it remains unclear whether there is incidental harm as a result of fishing practices. The lack of strongly negative attitudes towards penguins, however, may be cause for optimism in future penguin conservation.

Beyond fishing

Other notable observations included the prevalent lack of awareness of African penguin’s endangered status among local South Africans. Even residents living near penguin colonies were surprised to hear that African penguins were listed as endangered. Without exception, every non-governmental or conservation-connected individual encountered was unaware of the African penguins’ predicament. This observation was mirrored by the experience of local conservation centers. Education and community outreach is a major component of current conservation planning, and my experience on the ground supports the need for such attention. Conservation facilities are focusing on the idea of empathy generation among South Africans towards seabirds in the hopes of inspiring both awareness and recognition of the intrinsic value of these species will help spur interest, support, and cooperation with current and future initiatives (two conservation participants, *personal*

communication).



Fig. 2. Adult African penguin and young. *Credit:* L. Holcombe.

Discussion

The story of African penguin conservation is infinitely more convoluted than visitors to an African penguin exhibit in a zoo or aquarium would imagine. The main barrier to effective interventions and conservation measures is dissonance and fracture among invested parties. The split is twofold: on the national level, the debate of precautionary versus strongly substantiated approaches results in impotence. There is also an apparent scarcity of solidarity among conservation groups which may hamper further progress under the new Biodiversity Management Plan (Department of Environmental Affairs 2013). The arguments remain in the realm of science and politics, especially since the public has little to no awareness of the problem.

Solving these problems would first require finding methods to bridge differences between the various conservation interests in order to create a uni-

fied voice in support of positive changes for penguins. Second, observers should be mandatory on all fishing vessels (not just trawlers and long-liners) and the data collected should include penguin sightings and interactions with vessels/fishing operations. Third, fishing industry-directed workshops on penguin conservation should be developed and implemented. There has been great success in this area with the same approach to albatrosses, even creating champions among fishermen for albatross conservation (multiple participants, personal communication).

Ideally, fishing pressure would be split evenly between the Eastern and the Western Capes, or preferably concentrated where fish stocks are now concentrated: on the East Coast. This approach would both alleviate tensions on local ecosystems trying to balance intense effort with waning stocks, and improve fishing efficiency by concentrating effort where catch is most available. Unfortunately, this scenario is unlikely because the West has historically been the hub of the nation's fishing industry and relocating processing facilities could be prohibitively costly and inconvenient. Hope for African penguin survival may instead rest on proactively addressing the spatial mismatch between fish, fisheries, and breeding islands, and fostering awareness of penguins as a species with intrinsic value whose disappearance will have unanticipated effects throughout this vital ecosystem.

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Are Chinese companies devastating the African environment? Exploring the role of a Chinese hydropower company in the Zambian environmental impact assessment process

*Tianjun Hou, MEM 2015**

Abstract

This article examines the role of Chinese companies in the environmental impact assessment (EIA) process, as exemplified by Sinohydro's involvement in the Kariba North Bank Extension project (KNBE) in Zambia. Since the launch of several large-scale Chinese hydropower projects in Africa, the international press and politicians have singled out the Chinese companies as the only stakeholders in those projects that violate environmental standards. Very little research has explored the detailed involvement of the Chinese and non-Chinese stakeholders in observing environmental norms. This article aims to fill in this gap. The present study examines the responsibility of the major stakeholders in the environmental impact assessment process. It concludes that both the Chinese and non-Chinese stakeholders are obligated to participate in this process. It is the interaction of the stakeholders instead of a single stakeholder that determines the environmental outcome. Therefore, a comprehensive understanding of the stakeholder network in so-called "Chinese" hydropower projects is important to identify possible intervention points that can guide the stakeholders to work together towards sustainability.

本文以中国水电的在非洲某水电站扩建项目作为案例，分析了在非洲的中国基建企业在环境影响评价体系中扮演的角色。自从中国在非洲承建了几个大型水电站之后，一些国际媒体和政治家纷纷指责中国公司违反当地的环境评估法律。但是，在一个大型基建项目中，往往会有几个公司，中国的和非中国的，共同参与到环境评估的流程中。所有参与的公司都有可能影响这个项目最终产生的环境影响。但很少有研究讨论中国企业和非中国的企业在执行环境评估时各自承担的责任和义务，或者中国企业是如何和非中国企业一起执行环境评估要求的。为了解答这个疑问，本文作者亲自到中国水电的某水电站项目实地研究一个月，重点考察中国水电和其他非中国企业在执行环境评估法律时的工作关系。研究表明一个大型基建项目的环境影响并不取决于一个企业的意志和执行力，而是所有相关企业互相协商共事的结果。因此，如果要确保一个有中国企业参与的基建项目符合当地环评法规，首先要先了解有哪些企业参与到这个过程，企业和企业之间是如何共事的。

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Introduction

China's investment in Africa has increased substantially in the past decade. The total volume of trade rose from \$10 billion in 2000 to an estimated \$200 billion in 2013 (Flynn 2013, Fig. 1). According to a World Bank Report, more than 30% of the investment goes to the power sector, of which hydropower projects have the biggest share (Foster et al. 2009). There are two categories of drivers that can explain China's inroad into Africa's hydropower market.

The first category is the market driver. The supply from China matches Africa's demand for electricity. The hydropower market in China is extremely saturated. The total hydroelectric generation capacity has grown from almost zero to 14,823 MW in 2007 (Fig. 1). Having built about 88,000 dams in China, Chinese hydropower companies have accumulated a great deal of construction experience and numerous hydro-electrical engineers (China Statistics Bureau 2012). Most machines used in previous hydro-electrical projects have yet to reach the end of their life cycle. Especially after the completion of the Three Gorge Dam, there are almost no large-scale hydropower projects left to work on in China.

Chinese hydropower companies are desperate to explore new hydropower markets in order to survive. On the other hand, Africa has huge hydropower potential that is yet to be developed. Africa has rich water resources. The total hydropower potential in Africa is estimated to be 35,000 TWh but only about 5% of Africa's hydropower potential, estimated to 1750 TWh, has been exploited (United Nations Industrial Development Organization 2009). While the world's average electrification rate is 82%, the rate in Sub-Saharan Africa is only 32% (International Energy Agency 2012). The rapidly growing population in Africa indicates the potential growth of demand for electricity. The world population will increase to between 9.6 and 12.3 billion in 2100 and much of the increase will be in Africa (Gerland et al. 2014).

The second category is the policy driver. The Chinese government launched the "Going Global" strategy in 2006. This strategy encourages Chinese state-owned as well as private companies to explore overseas markets and promote trade between China and the rest of the world (McDonald et al. 2009). To support this strategy, China's two policy banks, the China Export-Import Bank and China Development Bank, provide loans to host countries in Africa so that the African governments can afford to launch mega projects (Bräutigam 2011). Chinese companies are supposed to bid for the projects funded by the Chinese loans in host countries. In those Chinese-funded projects, the contracted companies (many of the contractors are construction companies from China) will get payment directly from the China's policy bank, which significantly decreases the financial risks of overseas projects for contractors. As a result, Chinese government-backed financial flow catalyzes the surplus flow of human capital and technology into the hydropower market in Africa.

While there seems to be great synergy between China and Africa, environmental criticisms have increased dramatically as Chinese hydropower projects flourish in Africa. The well-known political figures and advocates from international environmental NGOs singled out the Chinese companies in environmentally destructive dam projects and claimed that the Chinese dam builders ignored the international environmental standards. For example, on her visit to Tanzania in 2011, Hillary Clinton urged the African countries to hold Chinese investors to the same standards as they did Western countries and indicated that China was going to be a new colonizer on the continent (Quinn & Heinrich Jones 2011). International Rivers, a US-based environmental NGO, has been actively advocating against China's dam projects in the world. They estimated that Chinese companies are involved in at least 92 major dam projects all over the world (International Rivers 2012). In their published journal articles and policy briefs, they concluded that China's dam builders have yet to adopt interna-

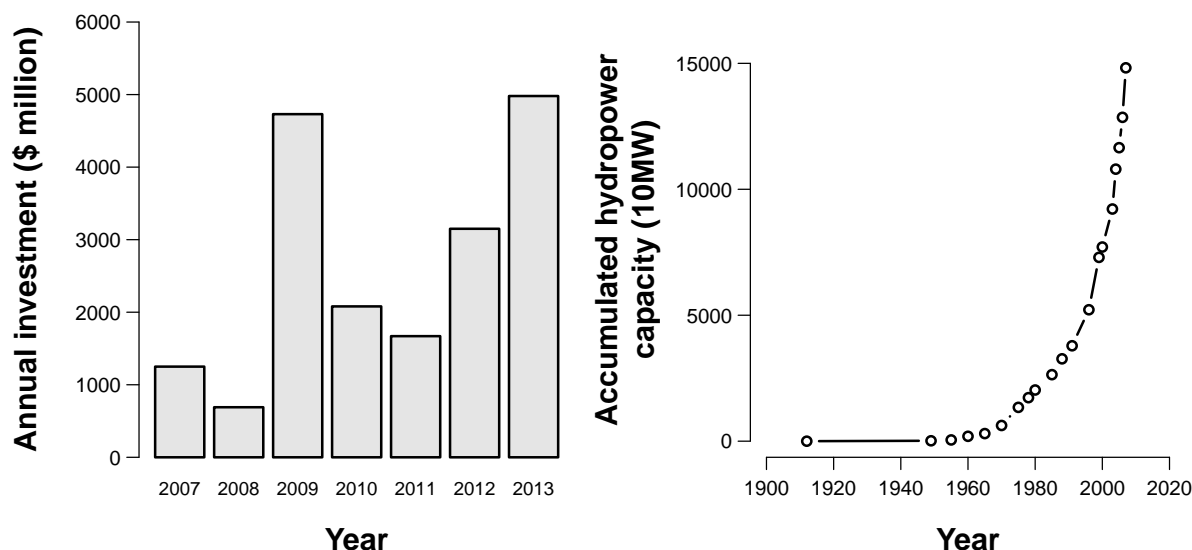


Fig. 1. *Left:* 2007–2013 China’s annual investment in hydropower Sub-Saharan Africa (USD million) *Data:* The Heritage Foundation (2013). *Right:* Accumulative hydropower capacity in China/10MW, 1910–present (Zhu 2010).

tional environmental standards (Bosshard 2009).

The environmental criticisms have created a misconception that Chinese companies are the only stakeholder in the project or at least the most powerful stakeholder that can steer the environmental outcome of a hydropower project. Very little literature has examined what a Chinese hydropower company should do to follow environmental norms in a project and how a Chinese company interacts with other non-Chinese stakeholders in complying with the environmental norms. This paper aims to fill in this gap and concentrates on the environmental impact assessment (EIA) process. The EIA process, first introduced in the USA, is an important effort to integrate environmental concerns into economic development. As an internationally adopted environmental legislation, EIA provides a structured framework to evaluate the negative impacts on the environment and systemic guidance for project owners to develop mitigation strategies. In Zambia, EIA approval is the prerequisite to

launch a project.

This article first reviews the procedure of environmental impact assessment (EIA) in Zambia and highlights the role of a hydropower contractor in that process. Then it contextualizes the EIA process in a Chinese hydropower extension project in Zambia. By analyzing the working relationship of major stakeholders in that project, this paper explores how they interact with each other in the EIA process.

Background of case study: Kariba North Bank Extension project

Hydropower provides 99.7% of electricity in Zambia (Government of the Republic of Zambia 2011). Zambia has vast hydropower potential that is yet to be developed. According to the International Energy Agency, the total hydropower potential of Zambia is 6000MW but its current installed capacity is only around 1900 MW and only 26% of the population has access to electricity (IEA 2012). Copper mines consume up to 68% of electricity,

and the mining industry contributes to 10% of GDP in Zambia (Government of the Republic of Zambia 2006).

The Zambian government has decided to continue focusing on developing hydropower in the next five years and Chinese hydropower companies have been actively involved in planning and constructing some of the hydropower projects. For example, Zambia plans three mega hydropower projects in the Zambezi River Basin: Kariba North Bank Extension (360MW), Kafue Gorge Lower (750MW), and Itzhi-tezhi (120MW). Sinohydro, a Chinese state-owned hydropower company, is the EPC contractor of all the three projects (EPC: engineering, procurement, and construction). The Kariba North Bank Extension Project (KNBE) is located on the border of Zambia and Zimbabwe, sitting at the north end of the Kariba Lake, the biggest man-made lake in the world. Once complete, the Kariba North Bank power station will meet the demand of electricity during peak hours and export the electricity to the neighboring countries.

The construction of the Kariba dam occurred between 1955 and 1959. The construction was stalled because it forced the resettlement of 48,000 local people, causing a huge political problem. Final construction was completed in 1977 by Mitchell Construction, a British company (Reeve 1960). On November 7th 2007, Sinohydro signed a contract with the Zambian Electricity Supply Company (ZESCO) to add two 180MW generators to the KNBE station. The contract became effective on October 1st 2008. This extension project officially ended on July 31st 2014.

The KNBE project was co-funded by loans from China Export-Import Bank (CEB) and the Development Bank of Southern Africa (DBSA). CEB is a state bank solely owned by the Chinese government and under the direct leadership of the State Council (Export-Import Bank of China 2015). It signed a Buyers Credit Loan Agreement with ZESCO amounting to US\$315.6 million for the project on November 13, 2009. ZESCO signed another loan agreement with DBSA on September

30, 2010. DBSA is a state-owned entity in South Africa. According to media reports, the amount from DBSA was US\$105 million (Reuters 2010).

Methods

I worked as an interpreter at the KNBE project for 33 days. In the Sinohydro office camp, I conducted semi-structured interviews with managers from the environment, health & safety department (EH&S), the contract department, and the human resources department. Each interview lasted for one hour. On the construction sites, I spoke with 11 Sinohydro Chinese junior engineers about their awareness of EIS. In Lusaka, the capital city, I conducted a semi-structured interview with a management team member in Sinohydro, one of six inspectors in the Zambian Environmental Management Agency (ZEMA) and the CEOs of two local environmental consulting companies. ZEMA, the Zambian equivalent of the Environmental Protection Agency (EPA) in the US, enforces the EIA legislation. The two environmental consulting firms are hired to prepare EIA reports for infrastructure projects in Zambia.

In addition to semi-structured interviews, I also did participant observation on the project site for one month. I lived at the Sinohydro camp and interpreted for Sinohydro engineers when they spoke with engineers from other stakeholder companies and the Zambian labor force on the construction site. I followed the same working schedule as the Sinohydro engineers, from 7:30am–12:00pm and 1:30pm–6:00pm from Monday to Sunday. The engineers I worked with were responsible for checking and repairing electronic devices. Since electronic devices are installed all over the project site, I worked in the underground powerhouse, the switchyard, and the step-up substation. I also interpreted for the chief technical engineer during his weekly meetings with the engineers from other stakeholder companies. Every meeting lasted for an average of four hours. In addition to interpretation, I participated in the weekly meeting within Sino-

Table 1. A list of semi-structured interviews at the Kariba North Bank Extension (KNBE) project.

Institution	Position	Interview length (hrs)
Sinohydro	KNBE project environmental health & safety manager	1
	KNBE project contract manager	1
	KNBE project human resources manager	1
	Company manager in Lusaka	2.5
Environmental Consulting Co.1	CEO	1
Environmental Consulting Co.2	CEO	1
ZEMA	EIA inspectorate	1
ZEMA	Registry Clerk	2

hydro where the project team checked the working progress. Moreover, I was actively involved in post-work activities to speak with more Sinohydro workers. I also had lunch and dinner with them in a small public canteen every day. After dinner, I would join the three department managers to walk for one hour near the Sinohydro camp. From them, I would learn the schedule of meetings and work for the proceeding days.

At the KNBE project site, I collected documents relevant to EIA from the Sinohydro project team. From the EH&S department, I collected the Environmental Project Brief (EPB), Environmental Management Plan (EMP), Environmental Control Plan (ECP), weekly safety inspection results, the company’s internal environmental standards and the 2009 environmental audit report. From the contract department, I received the general contract of the project. From the human resources department, I acquired the environmental permit issued by ZEMA.

Contextualizing the EIA process in the KNBE project

EIA is a formal process used to predict the environmental consequences, both positive and negative, of a project prior to the decision to move for-

ward with the construction. EIA now exists in over 100 countries worldwide. Before the project owner launches a project, he is required to prepare an EIA report. The EIA report assesses the negative environmental impacts of a project and lists the strategies to mitigate those negative impacts. In the process of preparing the report, the project owner is supposed to consult with all of the affected stakeholders including nearby communities to make sure that their concerns are properly addressed. If ZEMA approves the report, it will issue the project owner an environmental permit. Only after the project owner receives the permit can the project be launched. During the construction of the project, the project owner should regularly conduct environmental auditing to make sure that the contractor implements the mitigation strategies laid out in the EIA report. In addition, ZEMA can also conduct irregular environmental auditing of this project at any reasonable time (Fig. 2).

The EIA process shows that three stakeholders are involved in the process. The project owner refers to the company that borrows the money from development banks, pays for the construction of the project, and collects the revenue generated from the completed project. The project owner should prepare an EIA report before it launches the project.

The environmental government agency is responsible for reviewing the EIA report and deciding whether to issue the environmental permit. A contractor is hired by the project owner to materialize the project plan once the owner gets the environmental permit. In the KNBE project, the government agency is the ZEMA. The project owner is ZESCO, a Zambian state-owned company. The contractor is Sinohydro. An additional stakeholder in this project is Électricité de France (EDF), a French company. ZESCO hired EDF as the owner representative to assist ZESCO in supervising Sinohydro's construction work because EDF is an electrical engineering firm with a long history of engineering expertise (Fig. 3).

My field research shows that the KNBE project has the EIA document and the environmental permit from ZEMA. But the environmental audits of the EIA were not strictly carried out. According to the 2013 Zambian environmental management act, hydropower extension is within the category of the projects with insignificant environmental impacts.

So the project owner only needs to prepare a simplified version of an EIA report, which is called Environmental Project Brief (EPB). The EPB lists the environmental impacts of the project. Along with EPB, the project owner also prepares an Environmental Management Plan (EMP). The plan lists the mitigation strategies for the negative environmental impacts. In response to the EMP, Sinohydro has to prepare an Environmental Control Plan (ECP) in its bidding document. The ECP then provides core guidance to Sinohydro regarding how to implement the mitigation strategies proposed in the EMP (Sinohydro Corporation Limited 2014). The EH&S manager of the Sinohydro project team kept a copy of all the three documents (EPB, EMP, ECP) and I reviewed them.

But there was no existing copy of the annual environmental audit report from 2010 to 2014. The only available environmental audit report was from 2009. That report is 11 pages long and lists all the items that should be checked for this project. In this report 15 out of 60 items are not fully implemented.

I haven't found the follow-up documents that can show whether the suggestions for improvement in the 2009 report were implemented or not. ZESCO, EDF, and Sinohydro are supposed to conduct the audit together. The EH&S manager explained that Sinohydro, ZESCO, and EDF found that the auditing process was "not practical." Rather than conduct one three-hour long inspection solely for environment per month, they changed the inspections to much shorter weekly ones, for both safety and environment. Each weekly inspection produced a list of recommendations for improvement. I was told that those documents were destroyed because the project team adopted and implemented the recommendations immediately and there was no need to file the documents.

According to the company manager team member of Sinohydro, he has not heard about any environmental complaints about this project. For Sino-

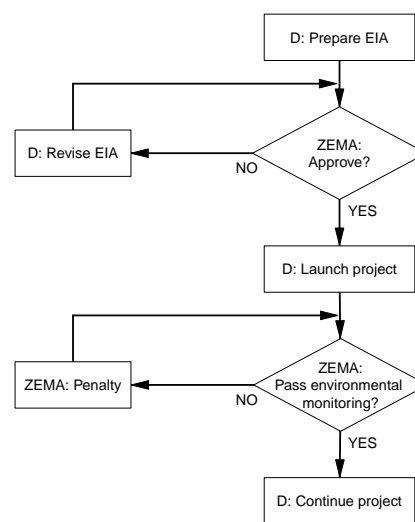


Fig. 2. Simplified Environmental Impact Assessment (EIA) process in Zambia (Southern African Development Community 2012). *Acronyms:* D = project developer, ZEMA = Zambia Environmental Management Agency.

hydro, environment is a technical issue. As long as their technology is good enough to control the negative impact levels under the standard, environment is not a problem. His comments on the EIA were

we are just following the standards set in the EIA. For example, if the EIA said the dam could not be higher than 100 meters, then we would make it lower than 100 meters. If our technology cannot reach that standard and someone complained to the government, then we will pay the fine.

Discussion

The monitoring of post-EIA implementation was not observed at the project site. Since there is no auditing report, it is not known whether the mitigation strategies were implemented or not. The stakeholder analysis of the project shows that the weak compliance with EIA auditing is more of an outcome of a stakeholder network instead of a single stakeholder in that network.

Sinohydro is tied in the stakeholder network so it cannot decide for itself whether or not it wants to mitigate the negative environmental impacts. First, it is required to draft an environmental control plan in its bidding process. In order to win the contract, Sinohydro has to review the EPB and EMP of the project and propose a plan to implement the mitigation strategy. Second, if Sinohydro is the only stakeholder who does not want to implement the mitigation strategy, it cannot survive the annual environmental auditing jointly conducted by ZESCO and EDF or the random inspection conducted by ZEMA. According to the contract terms and Zambian environmental management act, Sinohydro will be fined if it fails to implement the ECP. So in that case, it is not in Sinohydro's interest to destroy the environment.

One of the major criticisms of Chinese companies is that they either did not get EIA approvals or did not consult with the local residents about

the relocation when preparing the EIA report. But this research shows that the contractor companies are not involved in preparing the environmental impact assessment report. Concurring with Hensengerth (2012), the contractual arrangements define how large a role of a Chinese company can play in the EIA process. If the Chinese company is a contractor rather than a project owner, its role in environmental impact is more limited than that of a project owner. It is the project owner who should negotiate the compensation with the affected communities. If there is an environmental complaint about the project, the project owner should speak on behalf of this project to address the complaints of the public and communicate with ZEMA. Inside the project team, the project owner should investigate the complaints and figure out what the responsibilities are of each stakeholder in the project team.

The findings from this research can be applied to other hydropower projects where Chinese companies are contractors. An updated record of Chinese overseas projects shows that from 2005 to 2014, Chinese companies were involved as contractors in 152 out of 187 Chinese investment projects in Sub-Saharan Africa. In the KNBE project, ZESCO, the Zambian company happened to be the project owner and Sinohydro, the Chinese company, was the contractor. Empirical data implies that the role of contractors in other projects in the EIA process may be similar.

Conclusion

This paper has two core concerns: 1) to analyze the relationship between the Chinese and non-Chinese stakeholders and 2) to understand the role of each stakeholder in the EIA process. I argue that the role of a Chinese contractor company in an EIA process is limited. The procedure of EIA designates the project owner as the primary stakeholder to comply with the EIA legislations in the project. The project owner employs a contractor after the owner gets the EIA approval and launches the project. Therefore, the contractor is not involved in preparing the EIA report.

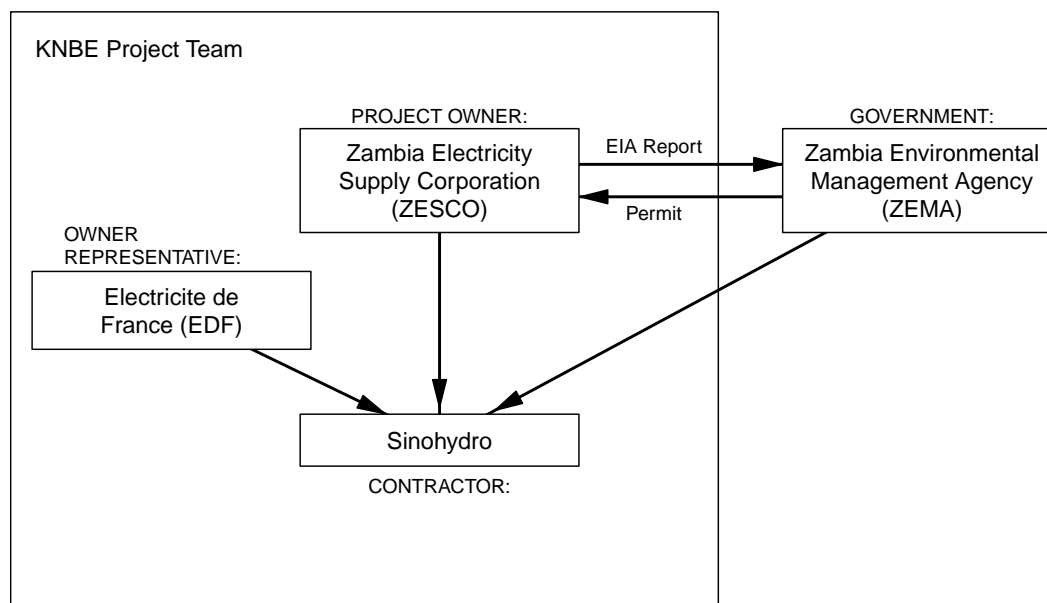


Fig. 3. Stakeholder involvement in the EIA process.

This research implies that the evaluation of Chinese companies' compliance with environmental norms needs to be more specific to the contractual terms of each project. As shown, the responsibility of a contractor is different from that of a project owner. When a project causes negative environmental impacts, the key stakeholder who can make change is more likely to be the project owner. In some projects, like KNBE, the owner is not a Chinese company. The understanding of each company's role in enforcing environmental norms will help to foster effective strategies to mitigate negative environmental impacts.

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Etic vs emic as adaptive measures to climate change: The rat as a misguided friend

Sarah Casson, MEM 2015*

Abstract

The rat ceremony performed by farmers in villages throughout East Flores, Indonesia, provides an example of an emic approach to climate change adaptation – one drawing insight from the perspective of the farmers themselves. The alternative, etic, approach, although heavily critiqued by practitioners and theorists, is often prioritized over emic ones, and typically employs quantitative measurements of livelihoods to understand how best to create resiliency in communities vulnerable to the challenges presented by climate change. The rat ceremony demonstrates a way in which community resiliency is strengthened by supporting an already existing community ceremony that emphasizes two essential tenets: community solidarity and coexistence with nature. Both tenets directly promote community resiliency. An explicit emphasis on emic approaches to climate change challenges could help re-define how adaptation is understood and supported within vulnerable communities such as rural villages.

Upacara Tikus yang diselenggarakan oleh para petani di sejumlah desa di Flores Timur, Indonesia, merupakan sebuah contoh pendekatan emic untuk adaptasi perubahan iklim – sebuah gambaran dari perspektif petani sendiri. Pendekatan alternatif, yaitu etic, meskipun sangat dikritisi oleh para praktisi dan ahli teori, sering menjadi prioritas ketimbang Pendekatan Emic, dan biasanya menggunakan pengukuran kuantitatif penghidupan dalam memahami cara terbaik untuk menciptakan ketahanan masyarakat yang rentan terhadap tantangan perubahan iklim. Upacara Tikus menunjukkan sebuah cara di mana ketahanan masyarakat diperkuat oleh upacara adat yang sudah ada yang menekankan dua prinsip penting: solidaritas masyarakat dan hidup berdampingan dengan alam. Kedua prinsip tersebut secara langsung mempromosikan ketahanan masyarakat. Penekanan yang tegas terhadap penggunaan pendekatan emic dalam menghadapi tantangan perubahan iklim dapat membantu perumusan kembali bagaimana adaptasi dipahami dan didukung oleh masyarakat yang rentan seperti masyarakat pedesaan.

Introduction

Much social science development theory addresses important tenets of climate change impacts on agricultural communities and how the international community might respond (Blaikie 1985, Escobar 1995). These theorists call for a questioning of the development discourse, for including the larger social economy within projects' analyses, and for current power relations to be questioned. Many

studies have examined the cultural, political, and economic connections between Indian society and monsoons (Fein & Stephens 1987). Yet, there is little research on similar relationships in Indonesia. Instead, within Indonesia, there is much on the history and social life of many cultures (Allerton 2003; Barnes 1974, Barnes & Barnes 1989, Bubandt 2004, Erb 1997, Forth 1993, Fox 1980, Fox 2011, Hägerdal 2010).

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Climate change adaptation approaches often prioritize etic perspectives over emic ones. Quantitative measurements of externally validated variables (i.e., an etic approach) are commonplace within adaptation projects. Yet, such approaches within development have been heavily criticized because of their lack of nuance. Much social science research that examines Indonesian communities' strategies to deal with climate change do so in an etic manner by measuring the successfulness of farmers' agricultural methods (Fujisaka et al. 1993; Keil et al. 2008, Stinter 2008). Other studies (Zimmerman 1987, Garay-Barayazarra & Puri 2011) approach the monsoon-community relationship in an emic manner, emphasizing local cultural knowledge, situating their research in cultural intangibles. Such research emphasizes the importance of understanding emic perceptions of the Australian-Indonesian monsoon in the creation of adaptation strategies to climate change.

The rat ceremony performed in villages throughout East Flores, Indonesia provides an example of re-analyzing nature-culture relationships within climate change adaptation. While the national-level Indonesian government has a vested interest in maintaining control of the rat population through pesticides and defining rats as pests, the rat ceremony proposes a worldview that sees rats as misguided friends, not enemies. This emic re-adjustment could drastically alter climate change adaptation policies for the better. An etic approach would be to continue heavy pesticide use; an emic approach would incorporate the rat ceremony and understand the multiple benefits it brings to the communities employing it.

Garay-Barayazarra and Puri (2011) researched how local cultural knowledge can be utilized in adaptation strategies for climate vulnerability. Garay-Barayazarra and Puri (2011) situated their research at the local level to understand indigenous Badeng communities' perceptions of the monsoon and cultural intangibles. In doing so, they focused on specific aspects of perceptions of monsoons (relationship to ayurvedic medicine and sen-

sory knowledge, respectively) within individual communities. Garay-Barayazarra and Puri (2011) encouraged the use of ethnographic and participant observation research methods to better understand how communities understand weather patterns in non-explicit ways. An adaptation strategy to climate vulnerabilities that only concerned itself with natural science weather forecasting but ignored the Badeng's conceptualization of their environment would fail. The authors state, for the Badeng, "direct bodily senses, rather than the inanimate instruments and computer models of modern scientific forecasting, are the avenues through which people come to experience and therefore know and predict manifestations of their local weather" (Garay-Barayazarra & Puri 2011:21). The Badeng view the world as deeply dynamic and connected to an individual agent's actions. They use that view to schedule daily agricultural activities as well as manage during times of extreme climate vulnerabilities, such as past mega-droughts. Such knowledge could provide a way forward to continued community resilience in light of climate change, especially when used to examine the concept of pests.

Criticism of etic approaches to climate change adaptation

Many research studies have proved the usefulness of such an approach. For example, Stigter et al. (2005) demonstrated the importance of including traditional methods and indigenous technology within resiliency projects focused on meteorological variability. Kehi and Palmer (2012) showed the importance of understanding cultural traditions concerning water. Ellen (2006) examined the relationship between the cultural significance of the sago palm and crop management systems. Similar studies have explained why states do not take such an emic-centric approach in their development practices. Just as anthropologists have studied village-level peasant conceptualizations of nature and culture, Dove (1986) showed that anthropologists can do the same to understand how

the state views itself in relation to the environment. In particular, the preservation of state-sanctioned environmental programs is often influenced by and has influence on state knowledge of non-crop unwanted plants – weeds. He argued that the preservation of state-sanctioned environmental programs is influenced and influences state knowledge of weeds.

The same argument Dove (1986) makes about weeds can be made about rats in eastern Indonesia. The Indonesian government's perception of rats misaligns with the local community's understanding of rats. Such a misalignment may reflect a larger rift. As Dove (1992) argues, in Pakistan the etymological transformation of the term “jungle” from “savannah” to “forest waste” reflects a larger shift in physical and cultural values that have resulted from a “dialectical relationship between nature and culture” (1992:231). The Indonesian government's defining of rats as pests is an intentional move towards separating nature and culture. As the Indonesian government strives for modernity, it desires Indonesian culture to represent the modernity of the inner islands, not the traditional heritage of the outer islands such as East Flores.

An example of an emic approach to climate change adaptation

It is the national Indonesian government, not the local agricultural department in the outer islands like Flores that promote the use of pesticides. While the local East Flores agricultural department offers farmers the option of pesticides (for free), officials prefer if farmers choose the so-called “cultural” option. This option entails a rat ceremony performed by the elders of an individual village.

As an agricultural department official stated, *“This special ceremony sends the rats back to where they belong – the sea – and is the most successful approach to clearing rats from agricultural fields. In my experience, the ceremony guarantees that rats will not return to a field for at least five years. If pesticides are used [instead of the ceremony], the rats will return next year with*

anger.” Another official clarified this quote by stating, *“The rat can be both enemy and friend. One must ask the rats nicely to return to their home in the sea by conducting the ceremony. One must be polite to the rats. Using pesticides is not polite to the rats.”* According to most farmers in East Flores, a long-standing relationship between farmers and rats exists and must be respected.

Why is this relationship so? Rats hold an important place within the culture of East Flores, Indonesia. Most believe that today's rats are descendants of ancient rats that aided the farmers' ancestors in a time of crisis. As one farmer explained, *“We cannot hurt the rats, even when they disturb our fields because they showed my ancestors the way to this land when they had to move from their original homeland many years ago. A big storm destroyed the original homeland, and so my ancestors' needed a new one. The rats were the navigators in the boats my ancestors took to come here because they are of the sea and know the sea.”* From an emic perspective, today's rats, therefore, do not represent random pests attacking agriculture but rather misguided old friends. Performing the rat ceremony allows farmers a favorable, restorative role – to navigate the rats back to their homelands just as rats once directed the farmers' ancestors to their homeland in East Flores. Berkes, Colding and Folke (2000) demonstrate similar uses of traditional ecological knowledge in climate change adaptation strategies.

To direct the rats a three-step ceremony is performed: sacrifice, procession, and forest mixture. A farmer explained the first step: *“The rat ceremony starts with the sacrifice of a pig. Other ceremonies can sacrifice different animals but for the rat ceremony, it must be a pig.”* The sacrifice must follow strict guidelines. Village elders from the four major clans must perform certain rites and position themselves around the pig as it is being sacrificed. These rites and positioning reflect the clans' role within the village. The second step of the ceremony involves a village member carving a rat statue about 6 inches in height and a canoe about a foot

in length. The rat statue is put inside the canoe. The elders, along with the entire village, accompany the canoe from the agricultural fields down to the sea in a long procession. At the sea, the elders recite prayers asking the rats not to return to the fields and the canoe with rat statue inside is left to drift out to sea. When the elders return to the village, they go into the forest to collect special leaves and roots only known to the elders. These forest goods are mixed with water and brought to the agricultural fields. There the elders recite prayers and spread the mixture onto all the fields using palm leaves to sprinkle the liquid. Such forest mixture provides food for the spirits of the fields, ensuring a healthy (and rat-free) agricultural plot.

Farmers must wait three to six days, depending on the elders' decree, before returning to their fields. As one farmer said, "We must not return at all to our fields during that time. I have used that time in the past to work around my house or to go fishing. When the elders say we farmers may return to the fields, there are no more rats. The rats are happily back in the sea and I am happily back in my field with crops still alive to feed my family with." All farmers reported the same thing, as did the local East Flores agriculture department officials: when done properly, the rat ceremony always works to rid fields of rats in way acceptable to both rats and farmers.

This ceremony is usually performed in February or March because as one farmer explained "Rats appear when the big rains have ended and there is no rain to deter the rats but lots of good corn and rice for them to eat." An agricultural department officer agrees: "The appearance of rats in fields directly relates to rainfall and the intensity of rainfall. Rats become especially present if there are periods of a lot of rain and severe periods of no rain." From these accounts, there appears to be a close relationship between the behavior of the monsoon and the performance of the rat ceremony.

Similar to the differing perceptions surrounding the rat ceremony in East Flores, the lack of clarity within the practice of augury (interpreting

omens from observing the flight of birds) in Borneo shows the ways in which nature and culture are understood and the relationship between the two are conceptualized. Dove (1996) argues that "augury is less a projection on to the environment of what society thinks about itself than a reflection (and operationalization) of what society has learned about its environment and about the relationship between itself and its environment" (559). Inner islanders view rats as pests; outer islanders see rats as something not to be eradicated but rather re-directed. They represent misguided friends, not pests. Rats are matter out of place. To the local community, rats belong in the sea, not the fields. The mistake rats make by living in fields (and thus eating all the crops) is something to be gently corrected through ritual, not a harsh chemical warfare through pesticide. In the end, what matters is a stronger inter-community relationship that views humanity and nature in coexistence.

Conclusion

Seeing the rat ceremony as a potential adaptation strategy to climate change proves a useful example of an emic understanding. When performed, the rat ceremony emphasizes two main principles: community solidarity and coexistence with nature. The rat ceremony is said to only work when the community is of "one mind and one heart." Community solidarity, instead of pest control, becomes the focus of the climate change adaptation. Rather than attacking nature through heavy pesticide use, the rat ceremony provides a different narrative to the human-nature relationship. Rats are friends of the farmers that must be guided back to their homeland in the sea through polite requests and prayers. Community solidarity helps to ensure a community's resiliency to the problems created by climate change.

An etic approach would likely ignore intricate social dynamics that are of rapidly shifting form and thus miss major tenets to a community's own adaptations to climate change and social change.

Incorporating local cultural conceptions of what constitutes solutions to problems created by climate change can be effective. An emic understanding of place provides in-depth context to a pest problem. An etic approach often just calls for increase in stronger pesticides, which presents possible health risks to a community and potentially removes an important reason to bring the community together on a regular basis.

Ensuring community resilience is an essential tenet of climate change adaptation (Adger et al. 2012, Berkes 2007, Folke et al. 2010, Folke et al. 2002). The coming shifts presented by climate change are unknown and unpredictable. What is known is that rural communities dependent upon small-scale agriculture are particularly vulnerable to disintegration of community cohesion. Community resiliency provides at least some stability in a time of great changes (Adger et al. 2012, Nelson, Adger & Brown 2007). Practices like the rat ceremony do just that. The ceremony provides an emphasis on working with other community members in harmony with nature that is essential to withstanding the challenges presented by climate change. The rat ceremony should stand as an example of other possible definitions of climate change adaptations. Instead of solely etic, top-down approaches, climate change adaptations could build upon existing social practices by explicitly taking an emic understanding of problems created by climate change and help communities to adapt from within.

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Characterizing the traditional tree-garden systems of southwest Sri Lanka

*Klaus Geiger, MF 2014**

Abstract

Land and habitat degradation, climate change, and local livelihoods are intimately related issues that continually evolve. Traditional agroforestry knowledge and practice are increasingly recognized as a sustainable land use. Agroforestry in Sri Lanka has existed for at least twenty-five centuries, but little research has quantitatively described the floristics and structures of these ‘tree garden’ systems and their relationships to human use and cultivation. This study examined the species composition and vegetative structure of tree garden systems typical of southwest Sri Lanka. Data shows as much as three times the species richness in the study site homegardens compared to other similar research in Sri Lanka. Additionally, homegardens in the study site, similar to those studied in the island’s central hill region, provide ecosystem services such as carbon sequestration that are valuable both economically and for conservation purposes. The productive activities at the site and proximity to the ecologically important Sinharaja forest reserve emphasize the crucial – but perhaps undervalued – role that local livelihoods and land management activities play in conservation.

Introduction

Environmental degradation is a serious problem with global implications (UN 2013), but the urgency of this issue is often masked by increasing human well-being (Raudsepp-Hearne et al. 2013). Current global greenhouse gas (GHG) emissions are 46% above their 1990 level (UN 2013). It is widely accepted that deforestation and forest fragmentation contribute significantly to these emissions, as well as producing “edge effects,” which include stronger winds and increased forest fire susceptibility that exacerbate the impacts of climate change (Laurance 2004, Golding & Betts 2008). Agriculture alone is estimated to drive ~80% of deforestation and directly accounts for 10-15% of total anthropogenic GHGs (Van der Werf et al. 2009,

Hulse et al. 2013, IPCC 2013), and this estimate is closer to 29% when including agriculture-related GHG emissions, such as transportation (Hulse et al. 2013). Timber products, palm oil, soybeans, and animal husbandry are significant drivers of deforestation, particularly in developing countries. Projections estimate that there could be a 40% reduction in global forest cover by the middle of this century, at which time the world population is estimated to exceed nine billion people (Soares-Filho 2006).

Unlike the variable effects of habitat fragmentation, habitat loss plays a clear and well-documented role in reducing biodiversity (Fahrig 2003). Protected area designations have succeeded in preventing deforestation, but often disrupted traditional livelihoods, in many cases only for the designated

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Traditional tree-garden systems of Sri Lanka

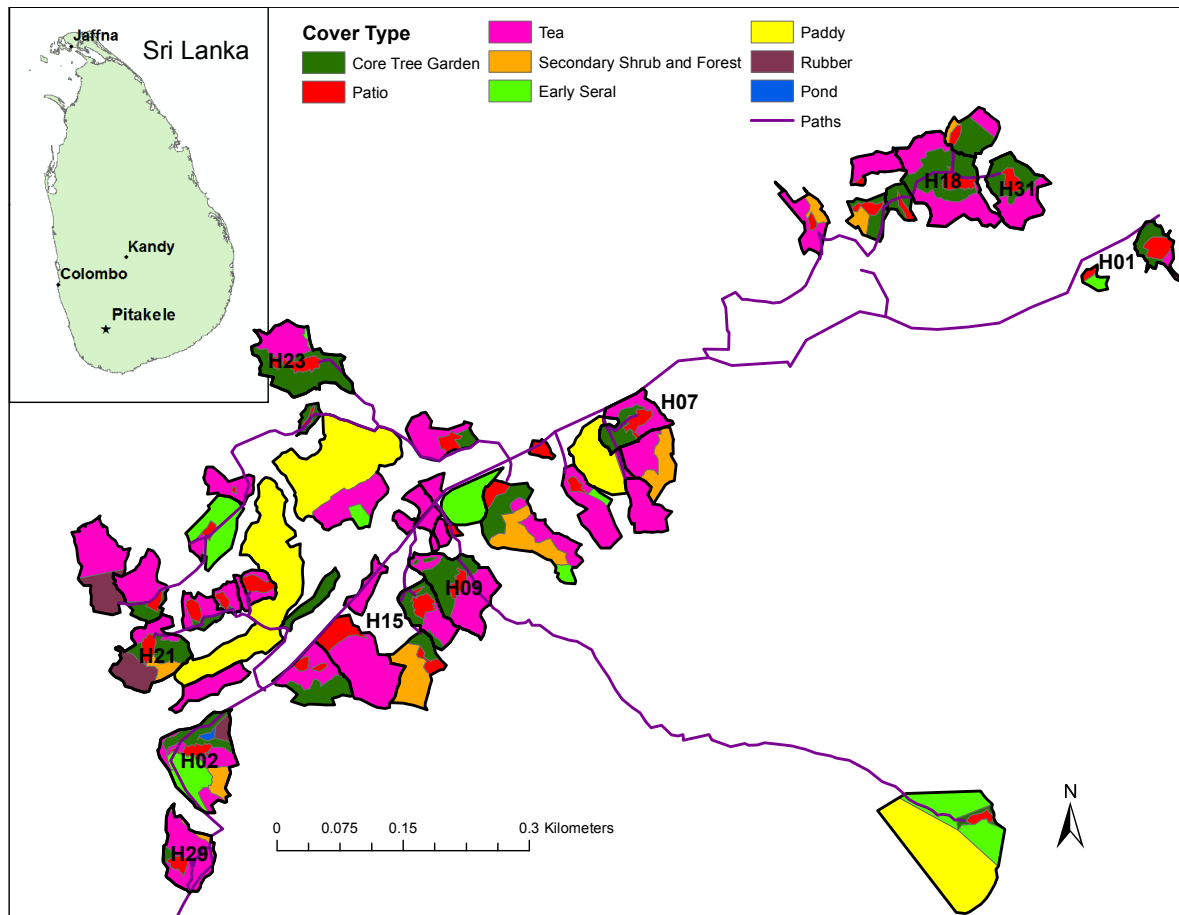


Fig. 1. Land cover types in the study site, Pitakele, Sri Lanka. Note that the bolded lines outline property boundaries and satellite farms; focal properties are indicated by numbers.

areas to be isolated by neighboring transformative agricultural and extractive land uses (Naughton-Treves et al. 2005). Agroforestry has been touted in recent years as a sustainable land-use alternative to combat climate change as well as the problem sometimes described as “rich forests, poor people” (Peluso 1992, Garrity 2004, Leakey et al. 2005, Verchot et al. 2007, Dawson et al. 2009).

Sri Lanka, a small island nation located off the coast of the Indian sub-continent, is biogeographically within the Indo-Malayan biome comprising a highly diverse range of fauna and flora of which 70% of the tree species in the southwest rain forest region are endemic (Myers 1990). About 44% of the island remained as native forest in 1956, the year of the first forest inventory (FAO 2007). Forest cover has declined by nearly 50% since then (Myers 1990, FAO 2002). This deforestation has significant implications for the future of species diversity—of which an estimated 25 to 30% is unique to the island—and forest-dependent local livelihoods (Erdelen 1988, Myers 1990). Rural communities have traditionally valued forests for a diversity of products and services, with timber serving a minor role. Perennial agroforestry systems called “tree gardens” result from traditional forest practices that protect biodiversity (Nair 1993): No-where is tree garden species diversity greatest than in tropical South Asia, and in particular southwest Sri Lanka (Braatz et al. 1992). While the Dravidian and Sinhala cultures of South India and Sri Lanka retained sophisticated and ancient traditions of plant use that date back over 5,000 years, the Indo-Aryans, the Mughals, and the European colonists brought new fruit species (Kosambi 1975). These introductions became incorporated into the tree gardens, which are now diverse mixtures of trees that provide fruit, medicines and spices that characterize the region but are especially diverse in the per-humid regions.

Scholars believe Sri Lanka’s tree gardens have been a cultivation practice for more than twenty-five centuries (Munasinghe 2003). In Sri Lanka, tree gardens have been studied in the central hill

region, an area that was the last refuge for the Kingdom of Kandy and which traded spices from these tree gardens with the Portuguese (De Silvas 1981). They are also known as “Kandyan forest gardens,” after the city of Kandy in central Sri Lanka. Though tree gardens account for 13-15% of the total land cover of the country and constitute 30-40% of the total cultivated area, the central hill region’s Kandyan tree gardens are the only tree garden systems that have been well described (Jacob & Alles 1987, Hoogerbrugge & Fresco 1993, Wickramasinghe 1995, Pushpakumara et al. 2012, Mattsson et al. 2013, Mohri et al. 2013). Some scholars argue that this resilient management regime arose as an alternative practice to resource depletion of the once-diverse rainforest (Wickramasinghe 1995). This tradition, a mixed forest-gardening system, has been described as a “highly diversified and economically viable form of land use” (Jacob & Alles 1987). Though centuries old, the home garden system has continued to evolve from one generation to the next in order to suit socio-economic, cultural, and ecological needs (Caron 1995, Pushpakumara et al. 2012).

Past studies have noted that the composition of tree gardens depends greatly on socio-economic conditions and strategies, but few architectural analyses have been employed to compare home garden characteristics with natural arrangements of flora species common in the area. In addition, there has been little evaluation of the functional diversity of Sri Lankan tree gardens (Pushpakumara et al. 2012). Lastly, highly heterogeneous research methods make it difficult to compare results and impossible to find patterns of social, economic, and ecological aspects, “on which system sustainability depends” (Pushpakumara et al. 2012). This study addresses these knowledge gaps in tree garden systems in southwestern Sri Lanka. Specifically, the following questions are asked:

1. How does species diversity in southwestern tree garden systems compare with previous studies in Sri Lanka?

2. Do the study site's tree gardens reinforce existing evidence concerning their functional diversity?

Methods

Study site

Pitakele, Sri Lanka, is a village in the southwestern lowlands comprised of thirty households (Fig. 1). The village is adjacent to the 89km² Sinharaja Man and the Biosphere (MAB) Reserve, a UNESCO World Heritage Site comprising the last remaining relatively undisturbed rain forest in Sri Lanka (Ishwaran 1990). The site's underlying geology is a metamorphic undulating topography overlain by weathered in-situ ultisols that are relatively poor in fertility (Cooray 1967, Mapa et al. 1999). Elevation in the village varies between 337 and 420 m above msl. Mean annual temperature is 26°C (Ashton et al. 2001). Average annual rainfall is 4000 mm, the majority of which falls in the two annual monsoon periods from May to July and September to December (Ashton et al. 1997).

Study interviews

Interviews were conducted and field data collected in June and July of 2014. A head from each of the 30 households was interviewed regarding their land-use history, current plant uses (e.g., non-timber forest products like tea, rubber, cinnamon, and medicinal herbs), and the specific techniques of cultivating and maintaining their tree gardens.

Field sampling

In the field, all 30 property boundaries and the borders of dominant cover types throughout the tree gardens were mapped (Garmin GPSMAP 64s GPS, Garmin International Inc., Kansas, USA). Dominant species mixtures (e.g., tea plantations) were the determining factor for denoting cover type (apart from the location-based 'patio'). Ten of the thirty houses were then selected as focal properties, based on the diversity of cover types represented and the size of the core tree garden area, in which

all plant stems were mapped.

The cover types were: core tree garden, secondary shrub and forest, early seral, patio, tea plantation, rubber plantation, and rice paddy. The *core tree garden* area is a key productive cover type that consists of an intimate mixture of seemingly disorganized perennial crops. The *secondary shrub and forest* cover type differs from the core tree garden area in that it is a less intensively managed arrangement of primarily woody plants arising from partial or total disturbance of a primary cover type. *Early seral* areas were covered principally by grasses, sedges, and forbs. The *patio* was the area immediately surrounding a house. Patios had spots where the mineral soil was exposed, but always contained vegetated strips both surrounding and within them. Because *tea plantations* have been extensively studied (Harler 1956, Eden 1958, Fuchs 1989, Dharmasena & Hitinayake 2012), stems were not mapped, counted, or measured in this cover type. *Rubber trees*, like tea, were typically found growing in plantations as the dominant woody species, and as such, were listed as a unique cover type. Most *rice paddies* in Pitakele were shared among village residents, with the rights to cultivation rotating among households. Thus, only those paddies cultivated by a landowner with sole rights were considered to belong to any given household. This rotation is due to the dynamic quantity of paddy land under cultivation during any given growing season (see Caron (1995) for an in-depth description of this transferable tenure system).

Every tree and shrub in each cover type (unless otherwise noted above) was mapped by GPS and identified. Structural data (e.g., height, diameter at breast height, canopy position, and horizontal area) were recorded to describe tree garden species arrangement, diversity, floristic patterns, and physical structure. Data were analyzed using ArcMap 10.2.2, Microsoft Excel 2013, and R (R Development Core Team 2014).

Results

Interviews

Interviews with the 30 household heads revealed several trends in home garden resource management. Pitakele's households and their respective farms were established within the last 50 years, bringing with them traditional tree garden production methods. All landowners listed natural medicine, sustenance, and income as important to their tree garden management. Interviews with landowners also revealed a decline in rubber production – reportedly due to excessive rain which impedes harvesting of latex – and cinnamon production, with a concurrent surge in tea production. Cinnamon, though present in some gardens, has all but disappeared as a means of income owing to the specialized skill required for harvest. Further, landowners reportedly favored tea as a cash crop due to heightened market access from wholesale buyers arriving daily.

Field Sampling

A total of 367 plant morphospecies in 198 genera and 86 families were found in the 30 tree gardens visited and/or reported by the landowners of Pitakele, Sri Lanka (Appendix 1). A total of 121 of the 367 distinct species documented are yet to be taxonomically identified. Thirty-five of the species reported by landowners in interviews were not observed directly by the author (Fig. 2). Four of the recorded species are known to be endangered, six are known to be near-threatened, and eight are known to be considered vulnerable (IUCN 2012). Nearly two-thirds of the recorded species had five or fewer individuals across the ten focal properties. The Simpson dominance index was 5%, meaning there was a 95% probability that two individuals randomly selected with replacement were from different species.

Species diversity within the 10 focal properties varied by cover type and growth habit (Fig. 2), with patio and core tree garden areas being the most diverse, and rubber areas being the least di-

verse. Within each strata or forest canopy layer trees and herbs accounted for the most species, whereas lianas and shrubs accounted for the least. (Fig. 5). Also, more than 80% of individual stems were under 10m tall in early seral, tree garden and patio areas. The most-recorded species across all cover types was betel nut (*Areca catechu* Arecaceae), which accounted for nearly 20% of all individuals. The second most-recorded species was gliricidia (*Gliricidia sepium*, Fabaceae) with 4.3% of all individuals; third was banana (*Musa* spp., Musaceae) with 3.8%; and coconut (*Cocos nucifera*, Arecaceae) fourth with 3.2% of individuals.

The thirty property sizes varied between 0.018 hectares to 1.34 hectares (mean = 0.34 ha, SD = 0.27). A few of the landowners cultivated additional land outside of the land immediately surrounding their household, boosting the mean landholding to 0.4 hectares. The ten focal properties ranged from 0.18 and 0.78 ha of contiguous land (mean = 0.47 ha, SD = 0.18, Fig. 3).

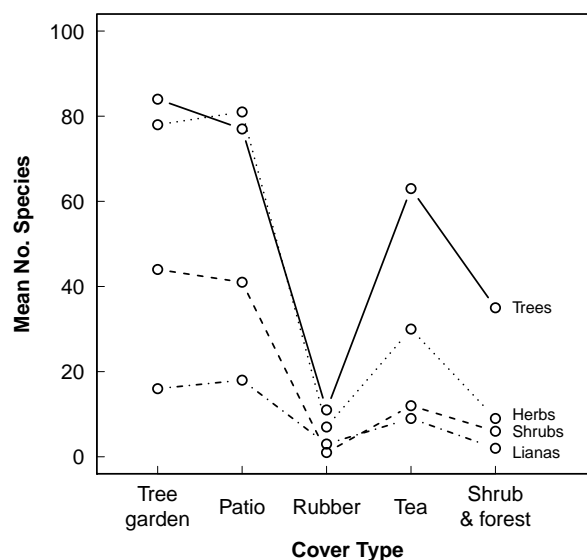


Fig. 2. Average species count by cover type and growth habit.

Patio had the smallest cover area amongst the intensively cultivated cover types (Fig. 3). The veg-

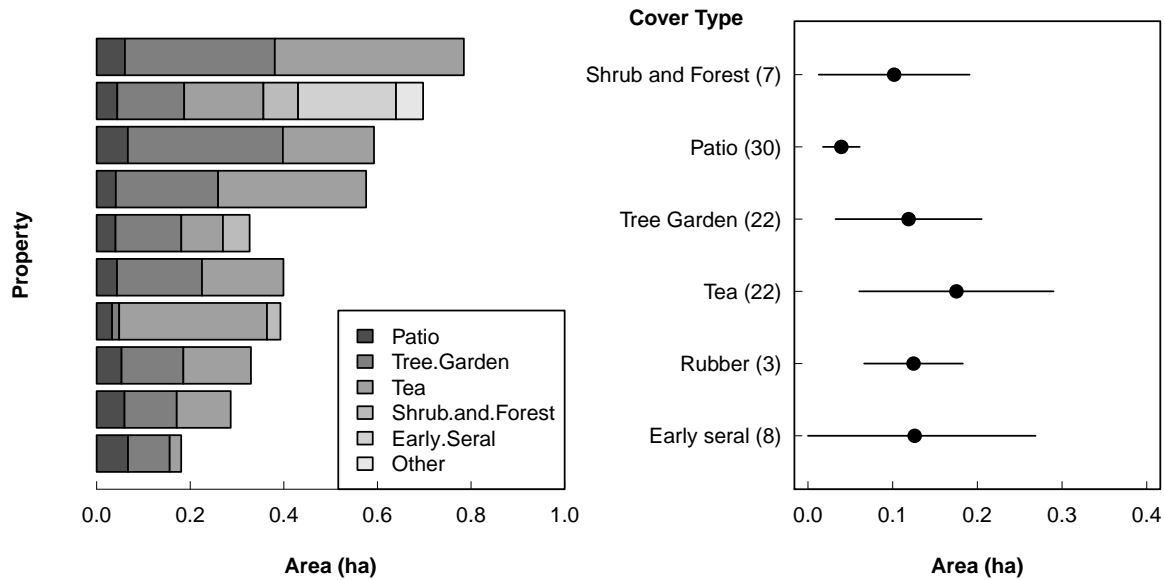


Fig. 3. *Left:* Pitakele focal property sizes by cover type (n = 10). *Right:* Mean area of each cover type for all 30 properties.

etation was principally herbaceous plants and small woody shrubs and so contributed little to a property's total basal area. These plants typically served non-timber purposes, such as medicinal and ornamental uses. Many ornamental species were individuals, found once in a single garden and growing in no other gardens. Patios and the core tree garden areas had the highest species richness (total number of species found in sample area) and Simpson's index (the probability of picking two different species at random) per unit area as compared with tea and rubber plantations.

Tea plantations were a nearly ubiquitous component of tree gardens in Pitakele, occurring on 27 of 30 properties, whether within the immediate garden or as a nearby satellite. Tea plantations and the core tree garden area made up for 76% each household's landholding (Fig. 4). Young leaves from tea bushes were reportedly picked about every nine days, continually maintaining the bushes' waist-high stature. The tea bushes formed the understory of each plantation, and depending on bush density, there would be little to no ground vegetation.

Coconut trees and areca nut palm trees were common overstory trees in the tea plantations, and in many cases served as ladders for bulat vines (*Piper betle*, Piperaceae) or black pepper vines (*Piper nigrum*, Piperaceae). The small multi-purpose leguminous tree *Gliricidia sepium* was abundant in some gardens' tea plantation, acting as a shade tree, a living fence and its leaves a natural nitrogen fertilizer. About 25% of *Gliricidia* individuals had bulat, black pepper vines, or another, frequently medicinal, liana species growing on them.

There were only two households with rubber plantations on the same contiguous land as the rest of their cultivated area. Existing rubber plantations did not have a cultivated understory, but they were thick with wild vegetation.

Discussion

The tree gardens of Pitakele, Sri Lanka, have a high species richness compared with previous studies on Sri Lankan and other similar agroforestry gardens. With a total of 367 recorded species, it appears that Pitakele's tree gardens hosted almost three times

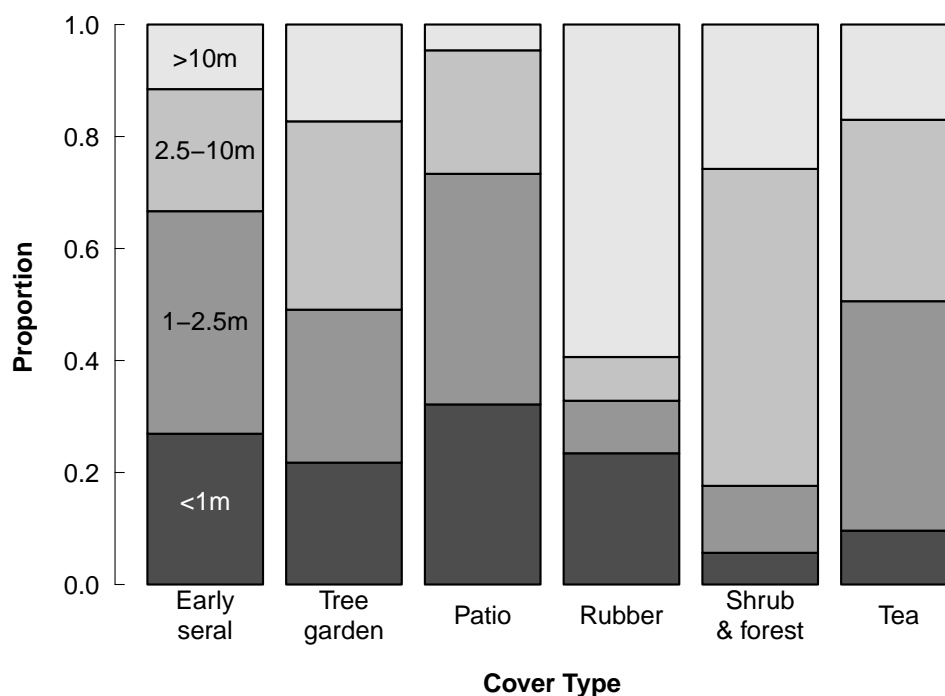


Fig. 4. Strata distribution by cover type.

more than the highest total number of plant species found in similar research from Sri Lanka (Perera & Rajapaske 1991, Ranasinghe & Newman 1993, Lindara et al. 2006). The ten focal gardens in Pitakele boast an average of 100 species per landholding, whereas these same studies confirm an average total species count for a given garden to be 46, 42, and 12, respectively.

A number of reasons might explain the high species diversity in Pitakele. Lower elevation, greater commercialization, low urbanization, and lower fragmentation were found to be the driving factors for high plant diversity in homegardens (Arifin et al. 1997, Kehlenbeck et al. 2007). Pitakele is both rural and located at lower elevation, though properties are not particularly large by comparison. Further, the village's proximity to the Sinharaja forest reserve may contribute to the greater species diversity via seed dispersal from the forest.

Though protected areas generally prevent de-

forestation and, thus, habitat loss, in many cases they are increasingly isolated geographically and genetically by surrounding land converted to non-forest cover (Naughton-Treves et al. 2005). However, various authors have suggested that Kandyan forest gardens' multi-strata vegetative structure, >70% canopy cover, and irregular horizontal distribution contribute to their resemblance to undisturbed forests (Perera 1991). As a system that has evolved over several centuries, it is probable that there is an established and proven logic behind site placement and spacing (Jacob & Alles 1987). Like other Sri Lankan homegardens, Pitakele's can be divided into 3-5 strata: a groundstory layer (<1m tall), a shrub layer (1-2.5 m), a mid-story layer (2.5-10 m), and an overstory layer (>10 m, which may be subdivided into two; Nair & Fernandes 1986, Perera & Rajapakse 1991, Fig. 4). Curiously, jak fruit (*Artocarpus heterophyllus*, Moraceae) was absent as a dominant overstory species, contradicting previous

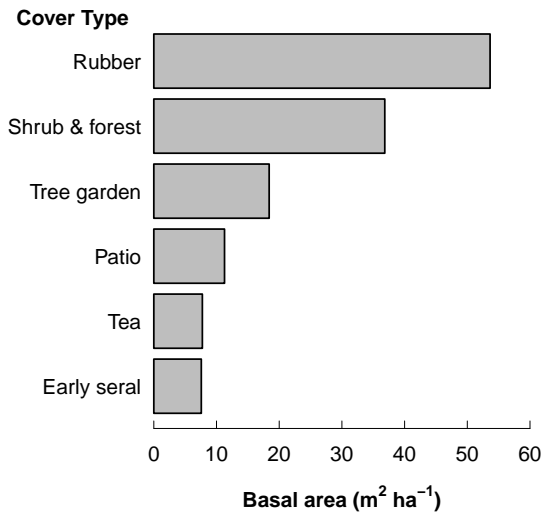


Fig. 5. Total basal area by cover type.

studies that describe jak fruit as a prominent feature in the Kandyan forest garden canopy (Perera & Rajapakse 1991). As expected, the cover types with a greater percentage of individuals in the mid- and overstory strata also had greater basal area of vegetation per hectare (Fig. 5). This physical similarity to natural forest underscores Pitakele’s Kandyan forest gardens’ importance in conservation, and their proximity to the Sinharaja forest reserve.

The Kandyan forest gardens’ physical similarity to natural forest permits it to provide many of the same ecosystem services that the natural forest provides (Kehlenbeck et al. 2007, Mohri 2013). The ecosystem services provided by homegardens, such as those in Pitakele, generally fall in to four categories: provision (e.g., food, medicine, fuel), regulation (e.g., climatic, carbon storage), cultural (e.g., religious purposes, such as the sacred ‘bo’ tree, *Ficus religiosa*), and support (e.g., nutrient cycling). Through provision, homegardens play a critically important role in conservation by mitigating “the fuelwood problem” – extraction of fuelwood from forests that is currently a primary cause for forest degradation on the island (Erdelen 1988). Additionally, tree gardens’ regulatory effect on lo-

cal climate are potentially significant, as the carbon stocks in a wet-zone garden like in Pitakele may amount to between 48 and 145 Mg C ha⁻¹ with a mean of 87 Mg C ha⁻¹ (Mattsson et al. 2013). Applying the average quantity of sequestered carbon in wet-zone tree gardens in Pitakele this amounts to a total of nearly 1,343 Mg C stored across all thirty properties and satellite farms.

With growing emphasis on tea production as the primary local income, the existence of tree gardens in Pitakele near the Sinharaja forest reserve may be undervalued for their conservation and economic importance. Nevertheless, although home-garden species diversity is cited as crucial to productive sustainability, some scholars argue that the benefits of biodiversity for local forest-dependent communities are exaggerated (Gunatilake 1998, Kehlenbeck 2007). What is overlooked is that land in developing countries is the most important productive asset and that there are differences in technology, preferences, and discount rates at different levels of development (Panayotou 1994). It follows that biodiversity conservation is a development issue. Thus, it is encouraging that Sri Lanka’s forest policy evolved from a preservationist reaction to colonial denudation in the decades following their 1948 independence to a more nuanced approach with greater stakeholder involvement in recent decades (De Zoysa 2001).

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Resting on the smallest wings: The flight of conservation^{*}

Sarah Casson, MEM 2015[†] & Nicole Wooton, MEM 2016[‡]

Abstract

Sarah Casson and Nicole Wooton attended the 2015 Neotropical Lepidoptera Course from March 6–15 at the Serra Bonita Reserve, in Camacan, Bahia, Brazil. The course is designed to provide students with a solid foundation in identification, classification, morphology, and biology of Lepidoptera associated with tropical habitats. It aims to promote future studies in the Neotropics and to develop contacts between internationally renowned scientists and students. Focused primarily on the ecology and systematics of Neotropical Lepidoptera, the course provides background and hands-on experience in the most important aspects of collecting, sorting, and preparing specimens; recognizing morphological characters in adults and larvae; and the identification of the most common moth families—tools that are useful for a wide array of Lepidoptera studies anywhere on the planet.

The Serra Bonita Reserve (SBR) is located in Brazil's famous Atlantic Forest, one of the most endangered and species-rich biomes on earth. Four primates occur there and Birdlife/SAVE Brazil has designated SBR as an Important Bird Area. Approximately 5,000 species of Lepidoptera have been identified at SBR, including a number of endangered species such as *Heliconius nattereri*, one of the rarest butterflies on earth. It is estimated that some 11,000 Lepidoptera species exist at the station (the same number found in the US and Canada combined).

Sarah Casson e Nicole Wooton participou da 2015 Neotropical Lepidoptera Curso de março 6–15 na Serra Bonita Reserve, em Camacan, Bahia, Brasil. O curso é projetado para fornecer aos alunos uma base sólida na identificação, classificação, morfologia e biologia de Lepidoptera associadas a habitats tropicais. Destina-se a promover estudos futuros na região Neotropical e desenvolver os contactos entre cientistas e estudantes de renome internacional. Focado principalmente na ecologia e sistemática de Neotropical Lepidoptera, o curso fornece apoio e hands-on experiência nos aspectos mais importantes da recolha, triagem e preparar espécimes; reconhecer caracteres morfológicos em adultos e larvas; e a identificação das famílias traça mais comuns—ferramentas que são úteis para uma ampla gama de estudos Lepidoptera em qualquer parte do planeta.

A Serra Bonita Reserve (SBR) está localizado na famosa Mata Atlântica do Brasil, um dos biomas mais ameaçados e ricos em espécies do planeta. Quatro primatas ocorrem lá e Birdlife/SAVE Brasil designou SBR como uma Important Bird Area. Aproximadamente 5.000 espécies de Lepidoptera foram identificados em SBR, incluindo um número de espécies ameaçadas de extinção, como Heliconius nattereri, uma das borboletas mais raras do mundo. Estima-se que cerca de 11.000 espécies de lepidópteros existir na estação (o mesmo número encontrado em os EUA eo Canadá combinado).

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Fig. 1. A selection of newly-pinned Lepidoptera. *Credit:* Bruno Miranda.

Field Report

“Learning how to successfully kill a butterfly is what we’re here to do,” said Dr. Andrew Brower, professor at Middle Tennessee State University and an expert on Nymphalid butterflies. He addressed a room full of students, researchers and naturalists at the Serra Bonita Reserve, located in the Atlantic Forest, or Mata Atlântica, of Bahía, Brazil. Over 70 percent of the room was under the age of 30, and they were all, in one form or another, there to study butterflies and moths. With only 8 percent of the original ecosystem remaining, the Atlantic Forest of Brazil urgently needs all the conservation help it can get. And the next generation of scientists is ready to help (Fig. 1).

Lepidopterists—studiers of scaly-winged, curling-hollow-tongued butterflies and moths (the Lepidoptera)—help provide fascinating science that naturally lends itself to conservation stories. A group of these researchers, including the authors, spent two weeks with the conservation team at the Serra Bonita Reserve to deliver crucial information about the health of the remaining Brazilian Atlantic Forest.

With its extremely high levels of biodiversity, much of which is endemic only to this rainforest, Serra Bonita Reserve has been globally recognized as a UNESCO Biosphere Reserve. The Brazilian At-

lantic Forest represents one of the most important and endangered ecosystems in the world.

“Some birders—from Bird Life International, I think it was—came by one day to see the birds,” said Vitor Becker, owner of the Serra Bonita Reserve. “Sitting on the porch,” he explained, “the researchers recorded 140 species of birds in a day. And they never even left the porch.” Serra Bonita Reserve, with a total of 400 bird species now recorded, is a family-run private reserve of 17,000 acres created to protect and study the remnants of this forest and its inhabitants.

The moth and butterfly collections created by the lepidopterist researchers during this trip, representing 40 different families (4,000 individuals)—and the many more specimens in Vitor’s private collection—play an essential role in the forest’s protection (Figs. 2 & 3).

Dr. Bower explained to the newer collectors: “You’re not decimating butterfly populations from collecting. You’re contributing to the body of knowledge that helps conserve them.” This body of scientific knowledge shows why a region should be conserved for its biodiversity and what species benefit from the conservation of an ecosystem.

To soothe anyone’s worries about indiscriminate insect execution, Dr. Bower referred to a 2001 study by McKenna et al., saying that “the number

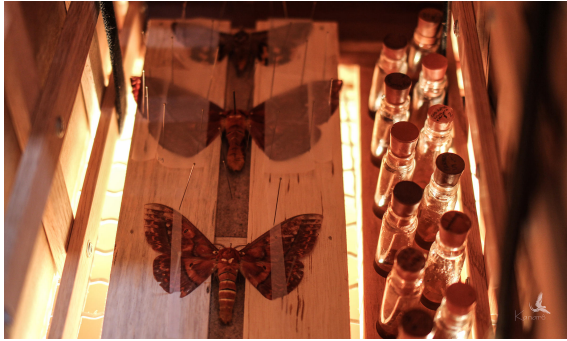


Fig. 2. Pinning and setting Lepidoptera. *Credit:* Bruno Miranda.

of Lepidoptera killed by cars and trucks along roadways for the entire state of Illinois for one week is 20,000,000 individuals.”

As Dr. Bower spoke about the techniques of a successful butterfly kill, smoke rose in the valley below us. The endangered forest was being burned to create new cow pastures: a reminder of the looming threats of habitat loss. And so each day we hiked into the rainforest armed with large, soft white nets and tiny envelopes to capture and hold the specimens. The intrigue of butterflies and moths is only useful to current conservation science efforts once an exhaustive database of specimens has been collected.

While we walked through dense jungle that extended over a hundred feet above our heads, the researchers discussed moth specimen presentation, specialized parasites of caterpillars, bat-butterfly ultrasound interactions, and the evolutionary branching of butterflies from the tropical savannah. Most researchers had a favorite Lepidoptera family for studying: Noctuidae, Limacodidae, Nymphalidae. (Or: “nocturnal moths”, “slug caterpillars”, “brushfooted butterflies”.)

A local Brazilian example of butterfly-centric conservation lies within one of the most thoroughly studied butterfly groups: the genus *Heliconius*, or longwings. One species of longwing, *Heliconius nattereri*, has been found to live only in a tiny slice of habitat within the Atlantic Forest.

“Everybody knows about *Heliconius nattereri* in

that region now,” said Dr. Jim Miller, course professor and research associate from the American Museum of Natural History. “Even the people who didn’t know about butterflies know it. Before, we could save the forests with flagship organisms like the golden lion tamarin or the harpy eagle. Now we can do that with *Heliconius nattereri*.”

But such conservation stories can only be told when based on sound scientific research. Any conservation story based on arbitrary or unsupported science hurts the larger conservation agenda.

“I only support storytelling [of conservation issues] if it has good, thorough science behind it,” said Dr. Lee Dyer, professor of Biology at the University of Nevada, Reno. The other lepidopterists agree: accurate, exhaustive, unbiased scientific research is required before stories can be shared.

Luckily for Serra Bonita Reserve conservationists, butterflies and moths lend themselves to both intriguing studies and fascinating stories, from big iridescent blue *Morpho* butterflies to spikey Saturniidae moth caterpillars. But Lepidoptera do not function like most iconic conservation species. Most species that are chosen to represent a landscape-scale conservation project, such as the North American Grizzly Bear, have an easily identified influence on the entire ecosystem. For butterflies and moths, the species spread and their environmental effects are less well known, but are still important to interconnected ecosystems.

The conservation of butterflies is the conservation of species interactions. Scientists estimate that 11,000 species of butterflies and moths live at Serra Bonita, the same number found in the US and Canada combined. Many of these Lepidoptera species are endemic to the higher elevations along the reserve’s mountain ridge, requiring specific conditions to survive. They have particular needs—it is common for their caterpillar stage to require a single species of plant to eat – and finding a mate involves complex biogeochemical interactions. To protect Lepidoptera is to protect a diversity of plant, bat, ant and parasite species, all of which depend on the presence of Lepidoptera and upon which Lepi-

doptera depend.

Thus far, the Serra Bonita Reserve is protecting the butterflies and moths in a small corner of the remaining Atlantic Forest, while also keeping the cow pastures at bay. It's no wonder that families and rising conservation leaders alike are increasingly focusing their efforts on private realm land protection. Though painstaking and complex in its execution, private conservation is the best option in many endangered landscapes and is gaining more attention today in the environmental realm globally. Even in the US, the Land Trust Alliance reports that private land trusts have protected 47 million acres of land, which is over half the entire acreage currently under the US National Park Service's protection. The trend is growing, too, with 10 million new acres of land since 2005. According to the Land Trust Alliance, private land trusts are the fastest growing segment of the conservation community in the US. The protection of these lands and similar areas across the globe often starts with the concerns of private citizens.

Vitor and Clemira Becker, owners of the private Serra Bonita Reserve, were living in Brasilia, 600 miles away from the Reserve, when they began to see the destruction of the Atlantic Forest. Each trip to the rainforest to gather specimens for their collection heightened their worries. Frustrated by the failure of national government-established protected areas, and alarmed by the damages, they took action themselves. The couple sold their home and gathered together their savings and retirement pension to buy a plot of relatively untouched forest on the slopes of the Serra Bonita mountain range, overlooking the old cacao farming municipality of Camacan.

"They even sold part of their moth collection," their daughter, Moema, said in a confiding tone. Thousands of hours go into collecting, pinning and cataloguing individual insects, and a serious collection represents both a scientific archive and a lifetime achievement. But the sacrifice of selling part of their Lepidoptera collection was crucial: the for-



Fig. 3. Pinned, set, and labelled Lepidoptera. *Credit:* Bruno Miranda.

est, one of the most biodiverse places in the world, was diminishing rapidly and national efforts were poor at best.

Today, urgent threats to the forest are never far from the Becker family's minds. In the past 10 years, the family and the reserve's corresponding NGO, the Uriaçu Institute, have protected 2,200 hectares. They hope their continued efforts of research and outreach will find pockets of like-minded partners who can help save the remaining 7,500 hectares of the Serra Bonita mountain range, critical habitat within the Brazilian Atlantic Forest.

As climate change worsens and poses a heightened threat to endangered ecosystems like the Brazilian Atlantic Rainforest, the continued conservation work of the Serra Bonita Reserve will prove essential in protecting a plethora of species from extinction.

"Losing a species is like losing a library full of books," said Dr. Dyer to the roomful of young researchers. Each species and its diverse interactions is a Shakespearian play, he continued, and threats ranging from habitat destruction to climate change are destroying a library that, in many cases, has never been read.

It is too late to save the entire Atlantic Forest library, but the work of next generation researchers and conservationists continues to bring to light new intriguing species, many never before known to science – new interactions, and new hope for

the remaining ecosystem—one butterfly book at a time.

Acknowledgements

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Fig. 4. Students on the course working in the laboratory and collecting out in the field. *Credits:* Bruno Miranda and Helber Adrian Arevalo Maldonado.

Announcing the 2015 TRI Fellows

TRI Endowment Fellowship: The TRI Endowment Fellowships are designed to support Masters and Doctoral students who conduct independent research in tropical countries. This year, 22 students received TRI Endowment Fellowships. The 2015 recipients and the locations of their research are listed below, and you can follow their exploits on the F&ES blog: <http://environment.yale.edu/blog/category/tri/>.

Fellow	Program	Location
Dana Baker	MESc	Tanzania
Jacob Bukoski	MFS	Thailand, Vietnam
Justine Cefalu	BA	Madagascar
Camille Delavaux	MESc	Ecuador
Audrey Denvir	MESc	Peru
Erika Drazen	MEM	Sri Lanka, Thailand
Eric Fine	MESc	Argentina
Carolina de M. Gueiros	MESc	Brazil
Delilah Griswold	MEM	Fiji
Nina Horstmann	MESc	Indonesia
Lan Jin	PhD	China
Ruth Metzler	MBA	Cuba
Robert Mwaniki	MEM	Kenya
Amrutasri Nori-Sarma	PhD	India
Juan Penagos Zuluaga	PhD	Panama
Rafael Roca Gonzales	MESc	Peru
Adrien Salazar	MEM	Philippines
Latha Swamy	MEM	Indonesia
Alexandra Todorovic-Jones	MFS	India
Elizabeth Tokarz	BA	Ecuador
Mariana Vedoveto	MEM	Brazil
Agnes Walton	MEM	Peru

Sri Lanka Forest Conservation Fund Fellowship: The Sri Lanka Forest Conservation Fund supports up to two students each year to conduct research at the Field Center for the Sri Lanka Program in Forest Conservation. The 2105 recipients are listed below.

Fellow	Program	Location
Vinh Lang	FS	Sri Lanka
Sophie Young	FS	Sri Lanka