TROPICAL RESOURCES

THE BULLETIN OF THE YALE TROPICAL RESOURCES INSTITUTE
2012 VOLUME 31

TROPICAL RESOURCES

The Bulletin of the Yale Tropical Resources Institute

Volume 31, 2012

In this issue

About TRI

Please access the 2012 Bulletin at environment.yale.edu/tri in order to view maps, graphs, photographs, and figures in color.

All figures used in these articles are the authors' own unless otherwise indicated.

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 Updates...

Carol Carpenter named new TRI Director

Carol Carpenter replaced Michael R. Dove as Director of TRI in January 2012. Dr. Carpenter (B.A., SUNY Binghamton; M.A., Ph.D., Cornell University) is Senior Lecturer and Associate Research Scholar in Natural Resource Social Science and Adjunct Lecturer in Anthropology. She sits on the advisory boards of the Council for Southeast Asian Studies and the Council of South Asian Studies. She is a fellow of Calhoun College.

Dr. Carpenter spent four years in Indonesia engaged in household and community-level research on rituals (including the ethnobotany of rituals) and social and economic networks. She then spent four years in Pakistan working as a development consultant on social forestry and women in development issues for USAID, the World Bank, and the Asia Foundation, among others. She has held teaching positions at Syracuse University, the University of Hawaii, and Hawaii-Pacific University, and a research position at the East-West Center.

She recently published Environmental Anthropology: An Historical Reader (co-edited with Michael Dove, Blackwell, 2007). Other recent publications include The 'Poison Tree' and the Changing Vision of the Indo-Malay Realm: Seventeenth to Twentieth Centuries (with Michael Dove, In: Histories of the Borneo Environment, KITLV Press, 2005), and The Role of Economic Invisibility in Development: Veiling Women's Work in Rural Pakistan (Natural Resources Forum vol. 25, 2001).

Dr. Carpenter's teaching and research interests focus on the history and theory of environmental anthropology, the social science of sustainable development and conservation, applications of economic anthropology to environmental issues, and the environmental implications of the invisibility of women's activities in agrarian households. She currently teaches an undergraduate seminar on Environmental Anthropology and four graduate seminars: the Social Science of Development and Conservation, the Anthropology of the Global Economy, the Black Box of Implementation (which concerns aspects of third world women, households, and communities invisible to project design and implementation), and Advanced Readings in the Social Science of Development and Conservation (which covers the theory behind the literature in these fields, e.g. governmentality).

Carol Carpenter, Ph.D.
Director, Tropical Resources Institute
Senior Lecturer and Associate Research Scientist in Natural Resource Social Science
Adjunct Lecturer in Anthropology
Yale School of Forestry & Environmental Studies
195 Prospect Street
New Haven, CT 06511-2189
Email: carol.carpenter@yale.edu

A Word from Director Carol Carpenter

The papers in this 31st volume of *Tropical Resources* represent a mere taste of the student research on the tropics supported by the Tropical Resources Institute (TRI), but that taste encapsulates our mission.

TRI (like the School of Forestry & Environmental Studies) is deeply interdisciplinary, represented in individual papers that bridge disciplines as well as the inclusion of papers from a variety of disciplines. These disciplines include political ecology (itself an amalgam of social sciences), ecology, and forestry.

The articles in this volume are organized into three sections, the first of which is “Identity, Perception, and Belief,” featuring articles by Rachel Kramer, Alaine Ball, and Daniela Marini. Kramer’s paper examines the conservation implications of social taboos against harvesting wild species in communities bordering a national park. Ball’s paper argues that government policies that favor what they imagine to be “traditional” resource use (in communities around a protected Ecological Station) create multiple, conceptual and real, ambiguities and ultimately conflict between Station and communities. Marini examines conflicting political and economic interests in fire management that result in arson—a real, and unmistakably negative, environmental impact.

The second section of this volume, “Energy, Carbon, and Ecosystem Services at the Local Scale,” features articles by Shereen D’Souza, Jing Ma, and Paulo Barriero Sanjines. D’Souza argues that narratives blaming the poor for environmental degradation, which underlie a soil carbon credit project, actually strengthen states—but do not succeed in reducing poverty or increasing conservation. Jing Ma documents negative effects of small-scale hydropower, which travel from irrigation impacts to increasing income gaps to social tension. Sanjines examines difficulties with engaging small farmers in Payments for Ecosystem Services schemes to support conservation.

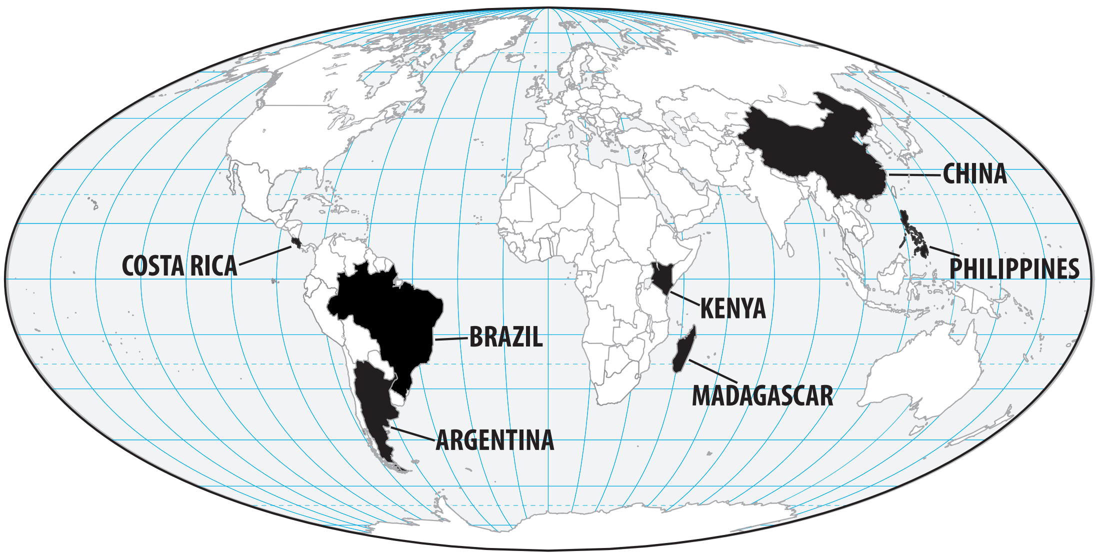
In the third and final section, “The Technical and Social Challenges of Reforestation,” Carla Chízmar analyzes the suitability of native tree species (for shade and drought tolerance) to be under-planted in rubber plantations for forest restoration. Tina Schneider and Erica Pohnan, in a co-authored article, assess both the conservation and socio-economic benefits of a new reforestation model called Rainforestation Farming.

These articles highlight the fact that the Tropical Resources Institute (and the School) is widely international; it aspires to nothing less than strengthening world research on tropical environments. This can be seen in the nationalities of the student researchers, as well as their research sites. For example, Ball’s research was located in Brazil’s Atlantic forest, and she is now a Fox Fellow at the University of São Paulo. Sanjines is Bolivian, carried out research in Costa Rica, and is now working in Brazil. Chízmar is from Panama and conducted her research in Brazil. Schneider grew up in Germany, carried out research for this paper in the Philippines, and is now carrying out Fulbright-funded research in Laos; Pohnan, her co-author, worked in Thailand, did this research in the Philippines, and is now on a fellowship in Indonesia.

In sum, we hope that these papers hint at the fundamentally multi-disciplinary and global reach of the outstanding students that TRI supports. It is a pleasure to teach, support, and advise these future leaders. They inspire us with the knowledge that progress is being made towards meeting the complex and daunting challenge of conserving tropical resources.

Best wishes,
Carol Carpenter

2011 TRI and Compton Fellows' research sites in this issue



Argentina:	Daniela Marini
Brazil:	Alaine Ball and Carla Chízmar
China:	Jing Ma
Costa Rica:	Paulo Barreiro Sanjines
Kenya:	Shereen D'Souza
Madagascar:	Rachel Kramer
Philippines:	Erica Pohnan and Tina Schneider

Note: The delineation of international borders on this map does not represent endorsement of any particular national boundary.

I. IDENTITY, PERCEPTION, AND BELIEF

Taboo in the Marojejy Massif: Characterization and Conservation Implications

Rachel Kramer, MESc 2012

ABSTRACT

The role of traditional knowledge has become increasingly recognized in environmental planning for landscapes of high conservation value. Informal institutions, such as taboos spurred from traditional ecological knowledge, have been associated with effective local resource management in communities heavily reliant on natural systems for subsistence, which have maintained relatively consistent group membership and have had extended residence on a landscape. In Madagascar, a global biodiversity hotspot, social taboos, or *fadys,* have been found to offer place-oriented conservation benefits for specific wild species, particularly when associated with self-enforced consumption prohibitions. This study documents specific-species fadys and associated narratives from households in four National Park-bordering communities established within the last century via homesteading in Madagascar's northeastern Marojejy Massif. Observed specific-species fadys are largely associated with consumption prohibitions inherited from the ancestors, yet their conservation implications are found to be ambiguous due to significant variation across households. Such variation is likely explained by community growth through immigration from diverse regions of the island with distinct place-based social institutions. Nonetheless, this study represents community demographics and relationships between households, wild species, and self-imposed resource use restrictions that may inform community-based conservation planning and education initiatives for the region, moving forward.

Introduction

Zanakin'ny do, vandana
The children of the boa have mottled skin
- Malagasy proverb, Mandena village informant

Rachel Kramer received a Masters in Environmental Science from the Yale School of Forestry & Environmental Studies (F&ES). Her research focuses on the social ecology of conservation and development. Raised in Africa, Rachel served three years as a Peace Corps Volunteer in rural Madagascar, partnered with the Wildlife Conservation Society. Prior to Yale, she worked with National Wildlife Federation on advocacy surrounding global commodity drivers of deforestation.

The ecological knowledge bases of communities often reflect dynamic systems by which local peoples have attributed meanings to and have adapted relationships with flora, fauna and ecosystem processes (Berkes and Folke 1998, Gadgil et al. 1993). Berkes, Colding and Folke (2000:1252) define traditional ecological knowledge as a "cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission…". This knowledge is often transmitted via informal institutions that govern behavior, such as ritual and taboo. Such institutions are most common in contexts of community property rights, where access to common pool resources is maintained by a collective of users (Begossi 1998). *Fady*, or taboo, is pervasive in Malagasy culture (Ruud 1960), and has garnered increasing interest among conservationists interested in understanding local resource use patterns and potential influences of informal institutions on human behavior and biodiversity (Jones et al. 2008).

In contexts of relatively recent occupation of a landscape, where households represent individuals from diverse regions of Madagascar with distinct place-associated social institutions, the conservation implications of retained fadys have yet to be widely studied. Lingard et al. (2003) identify immigration to be a significant factor contributing to the erosion of traditional fadys relating to radiated tortoises (*Geochelone radiata*) in southern Madagascar, where recently arrived community members with non-local ethnicities have no traditional objections to violating place-associated taboos. The extent to which specific species-oriented fadys are observed in communities established via homesteading in the Marojejy Massif of northeastern Madagascar and supplemented through immigration from diverse regions of the island, has yet to be considered. Community composition may or may not have implications for conserving endemic wildlife in this region.

This research intends to answer the following questions relating to study communities along the eastern and western peripheries of Marojejy National Park: (1) which specific-species taboos are respected by households bordering Marojejy National Park and what are their associated narratives; (2) how does the retention of local taboos vary within communities; and (3) what conservation implications can be drawn, if any, from these observed taboos?

Theoretical Literature

Na mahety ny fahiny, tsy hotry ny kolafany
Even fruits that are narrowly spaced, do not lose sight of their stem
- Malagasy proverb, Mandena village informant

Colding and Folke (2001) categorize "resource and habitat taboos," which serve as guides for local conduct in relation to the environment, into six typologies reflecting resource management functions. These include "segment taboos," which regulate resource withdrawal; "habitat taboos," which restrict natural resource use in time and space; "temporal taboos," which regulate resource access in time; "method taboos," which regulate methods for resource withdrawal; "life history taboos," which regulate removal during vulnerable life history stages; and "specific-species taboos," which afford protection to single species in time and space. Justifications for specific-species taboos in traditional societies include toxicity, physical appearance, or behavioral, medicinal, and ecological rationales (Begossi 1992).

Specific-species fadys documented from rural Madagascar commonly prohibit the killing, raising or consumption of certain plants and animals, or certain parts of plants and animals. Justifications commonly resemble Ruud's (1960:4) documentation of species associations with "homogeneous stories about a domestic animal, a wild beast, or a bird which has rescued people in a wonderful way". Such fadys are often associated with imprecations, or curses, including the conviction that violators will be sanctioned by the ancestors (Ruud 1960). These imprecations cultivate self-enforcement of specific-species fadys in many rural Malagasy communities.

With few exceptions[1], the observance of place-associated specific-species fadys has been credited with conservation benefits in Madagascar. These include multiple endemic lemur species classified as endangered and vulnerable by the International Union for the Conservation of Nature (IUCN) (Vargas et al. 2002, Britt et al. 1999, Thalmann et al. 1993, Hawkins 1999, Durbin et al. 2003, Loudon et al. 2006). Other mammals with documented fadys associated with localized conservation benefits include tenrec (Nicoll 2003) and bat species (MacKinnon et al. 2003). Marine (Lilette 2006) and terrestrial tortoises (Lingard et al. 2003, Nussbaum and Raxworthy 2000) have also been linked to fadys which protect local populations of these species in certain regions of Madagascar.

Local Context

Tany vanoko-lakana, tany naniriany no tsara
Land where trees yield dugouts, is land where all grows well
- Malagasy proverb, Mandena village informant

Madagascar is ranked a global biodiversity conservation priority area for its species endemism (Brooks et al. 2006). Estimated to retain less than 9.9% of its original vegetative cover, this island roughly the size of the state of Texas is thought to support 3.2% of global plant species and 2.8% of global vertebrates (Myers et al. 2000). The rainforested peaks of the island's northeastern Marojejy Massif, which in Tsimihety dialect denotes "place of many teeth," were first classified a Réserve Naturelle Intégrale (RNI) in 1952, following botanical inventories by Henri Humbert of the Natural History Museum of Paris. These inventories noted exceptional local endemism in the Marojejy region (Humbert 1927). The legal status of the Marojejy RNI was adapted in 1998 to a National Park, to open the region to ecotourism (Garreau and Manantsara 2003).

Tenuous socio-economic conditions and fragile local ecologies have historically compelled households in Madagascar to adapt strategies for maintaining livelihood security that include migration for natural resource access (Nawrotzki et al 2011). While a small number of ethnic Tsimihety homesteaders originating in the Androna region of Madagascar practiced shifting cultivation in this landscape prior to the twentieth century, in the 1920s, prospectors from the French colony of La Réunion discovered fertile soils and mild climate conditions that were favorable for vanilla production. This finding stimulated significant migration to the region's agricultural frontier (Garreau and Manantsara 2003). As increasing population densities have constrained production in lowland areas, densities have surged along the periphery of Marojejy National Park in communities largely reliant on shifting cultivation of rice,

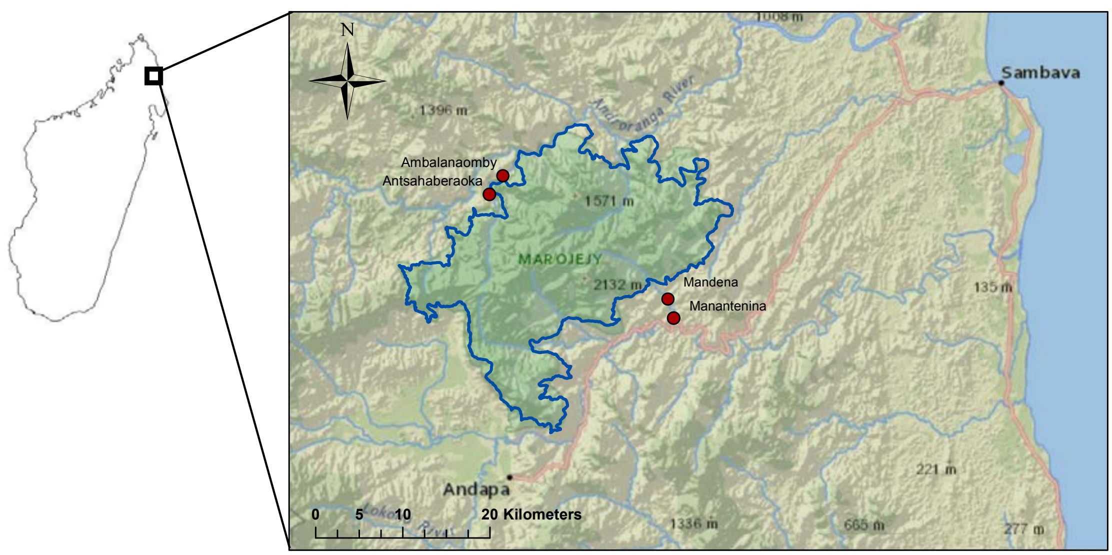


Figure 1. Map of Marojejy National Park in northeastern Madagascar with locations of the western Park periphery survey communities Antsahaberaoka and Ambalanaomby, and the eastern Park periphery survey communities Mandena and Manantenina.

other farmed staples, and coffee and vanilla cash crops.

Elders in one of two eastern Marojejy Massif study communities describe the arrival of founders of their village to this landscape in 1884, following northward migration from Mananara:

> And this is what brought them here [our ancestors], they sought an isolated place where there was plenty of available land that was fertile and humid… When they made our village here, there were a few who homesteaded in the southern flatlands, along the riverbank. There, to the south, they built low rice paddies… When BANAMAITSO [ancestor name, denoting "the black, toothless one"] first arrived, he and his kin cleared much of the forest… and then, bit by bit, others came to join him.

In addition to loss of habitat from the conversion of forested slopes to agricultural use, emerging threats to wild species populations have included market demand (pers. obs.) and local consumption of bushmeat in forest-bordering communities where domesticated animal alternatives may be insufficient, unavailable, or not preferred for meeting household protein requirements (Nielson and Patel 2008). While many socio-economic factors will inevitably influence the future of conservation in this region, as well as decisions on how to best engage forest-bordering communities in preserving resources within and along the periphery of Marojejy National Park, enhanced understanding of the observance of and justifications for specific-species household fadys may assist resource managers in integrating traditional knowledge into community-based resource management and education initiatives.

Methodology

Mandehana dieny malaina fa rehefa mazoto tsy afaka intsony
Those who are lazy receive nothing in plenty
- Malagasy proverb, Mandena village informant

This study documents specific-species fadys and associated narratives for households in four forest-bordering communities along the eastern and western peripheries of Marojejy National Park (Figure 1). 400 households were surveyed over the June-August 2011 period in the settlements of Antsahaberaoka (n=149) and Ambalanaomby (n= 51), situated on the remote western periphery of the Park, as well as in the settlements of Mandena (n=100) and Manantenina (n=100), situated along the eastern Park periphery, accessible by a national road but remote from urban centers. The communities selected for this study are located in areas of particular interest for future community-based conservation initiatives, due to constriction of forests along the Park periphery near the western settlements of Antsahaberaoka and Ambalanaomby (Schweter 2008), and the importance of local knowledge to perpetuate Marojejy National Park's ecotourism program in the eastern settlements of Mandena and Manantenina, which generate economic benefits for eastern households (pers. obs.).

This research was conducted as part of a larger socio-economic survey of agricultural yields, environmental attitudes, and the equity of to-date conservation and development investments in Park-bordering communities, following the initiation of a World Wildlife Fund (WWF) Integrated Conservation and Development Project in the region in 1994 (Garreau and Manantsara 2003). Surveys were administered in Tsimihety dialect Malagasy by the author, who is a fluent speaker, in collaboration with a research assistant from the École Normale Supérieure of Antananarivo and three

Photograph 1. A female community member and head of household responds to survey questions on a break from food preparation in her cooking hut along the western Park periphery.

local research assistants. Semi-structured interviews were conducted with community leaders prior to initiating household surveys in each settlement, and interviews were recorded using a handheld voice recorder and later transcribed and translated.

Survey agents lived in target communities for the duration of the study, with households in Antsahaberaoka and Ambalanaomby accessed two days on foot from the nearest road. Both male and female heads of household were surveyed according to availability. Households were selected opportunistically (method adapted from Sommerville et al. 2010) by walking through each hamlet during the morning, afternoon, and early evening hours and requesting to speak with heads of households. A minority of informants were interviewed in their agricultural plots, with careful avoidance of duplication. This study considers the open-ended questions: "how would you describe your ethnicity?", "what is fady in your family?", and "why are these things fady?".

Findings

Akanga maro tsy vakin-amboa
If the guineafowl are many, they will not be captured by the dog
- Malagasy proverb, Mandena village informant

The dominant ethnic identity reported from surveyed households in these four study communities is *Tsimihety* (Table 1), a group originating in the Androna region of Madagascar, whose members colonized the Marojejy Massif via northward migration from the Mananara region and eastward migration from the Mandritsara region to the west of the Massif. A second dominant ethnic group represented in eastern Marojejy study communities is *Betsimisaraka*, a people originating in coastal regions to the south of the Massif. Surveyed households in the remote western study com-

Figure 2. Species for which fadys prohibiting consumption were documented from households in the Marojejy region include the silky sifaka lemur (*Propithecus candidus)* (upper left), the crocodile *(Crocodylus niloticus)* (lower left), the Madagascar paradise flycatcher (*Terpsiphone mutata*) (upper right), the white-fronted brown lemur (*Eulemur albifrons)* (center), and freshwater eel (*Anguilla sp.)* (lower right).

munity of Antsahaberaoka represent a notable diversity of minority ethnicities, indicating settlement by individuals from distant regions of the island, such as *Hova* from Madagascar's central plateau and *Sihanaka* from the Lac Alaotra region. Households associated with each ethnic group generally have retained distinct ancestral fadys, including specific-species fadys that govern consumption of animals and plants that may or may not exist on the Marojejy landscape. This study finds that ancestral fadys continue to be observed in Marojejy households to reportedly self-govern resource use and behavior, with justifications that are occasionally reported as unknown, but generally involve fears of antagonizing the ancestors and provoking ill fortune.

Wild Mammals

Seven endemic non-primate mammals are reported to be fady to a minority of surveyed households in these four study communities (Table 2). A vulnerable (IUCN) lemur species specifically reported by a minority of households to be fady, is the white-fronted brown lemur (*Eulemur albifrons*) (reported by 16.5% of western households, yet 0% of eastern households). More broadly, 3% of western households and 9% of eastern households reported "all things that leap around" (clarified by informants to indicate all lemurs) to be taboo to kill or consume in their households. Reported justifications for lemur fadys include resemblance of these early primates to humans:

> Mostly, our fadys are inherited from the ancestors. But it is the fact that the brown lemurs and the silky sifakas look like human beings, that makes them fady for our family to eat them. (Antsahaberaoka village informant)

Table 1. Demographics and dominant ethnic associations for surveyed households in western and eastern Marojejy National Park periphery study communities.

	Western Marojejy National Park		Eastern Marojejy National Park	
Study community	**Antsahaberaoka**	**Ambalanaomby**	**Manantenina**	**Mandena**
Estimated population*	897	424	1552	2462
Number of households surveyed	149	51	100	100
Estimated total households	159	66	318	510
Percent total households surveyed	94%	77%	31%	20%
Mean household size	5.63±0.21	6.47±0.32	4.88±0.22	4.83±0.20
Ethnic identity of head of household	Tsimihety (70%)	Tsimihety (65%)	Tsimihety (77%)	Tsimihety (88%)
(% households surveyed)	Antotolana** (3%)	Betanimena (12%)	Betsimisaraka (10%)	Betsimisaraka (6%)
	Makoa (3%)	Antemorona (10%)	Antemorona (6%)	Makoa (3%)
	Antaisaka (2%)	Ambahy (4%)	Makoa (3%)	Antandroy (1%)
	Anjoatsy (1%)	Makoa (4%)	Antailampy (1%)	Antemorona (1%)
	Betsimisaraka (1%)	Antainosy (2%)	Antainosy (1%)	Sihanaka (1%)
	Madirano** (1%)	Antimaroa (2%)	Antandroy (1%)	
	Sihanaka (1%)	Betsimisaraka (2%)	Sakalava (1%)	
	Vohilava (1%)			
	Antemorona (<1%)			
	Antairomba** (<1%)			
	Antelampy** (<1%)			
	Antemadirano (<1%)			
	Antimahory** (<1%)			
	Antainosy (<1%)			
	Betanimena (<1%)			
	Bitsy (<1%)			
	Hova (<1%)			
	Marohala (<1%)			
	Silamo (<1%)			
	Tanandribe (<1%)			
	Zafikelimasina (<1%)			

*Source: Community leader reports of 2010 local census

**Distinct Tsimihety tribes

Wild Birds

Twenty endemic and feral bird species were reported fady by a minority of surveyed households. Most common fady species documented from this study are the blue coua (*Coua caerulea*) (reported by 28.5% of western households and 10.5% of eastern households), and the Madagascar blue pigeon (*Alectroenas madagascariensis)* (reported by 14% of western households and 13.5% of eastern households). Many households offered justifications similar to the following tale, which was modified by respondents to accommodate a variety of wild (native and non-native) bird species:

According to the stories, there was a time when there were many bandits. Our ancestors heard the bandits in the other part of the village. They fled, taking their children with them. Because they could not travel far, they hid themselves in the bush. One child with them began to cry at the same moment as a blue pigeon sang. One bandit said, "Ah, a person has cried over there." Half of the bandits believed it was not a person's cry, but a blue pigeon. And so, they went away from that place. The family was

Table 2. Wild species fadys reported from households in western and eastern Marojejy National Park-periphery study communities.

			Western Marojejy		Eastern Marojejy	
Reported wild species fady	Local name	IUCN Rank*	Antsahaberaoka households observing fady (n=149)	Ambalanaomby households observing fady (n=51)	Manantenina households observing fady (n=100)	Mandena households observing fady (n=100)
Lemurs						
all things that leap around**	zavatra mambokim-bokina	VU	**6**	**0**	**6**	**12**
bamboo lemur (*Hapalemur griseus*)	bokombolo	VU	**2**	**0**	**0**	**1**
silky sifaka (*Propithecus candidus*)	simpona	CR	**6**	**1**	**0**	**1**
white-fronted brown lemur (*Eulemur albifrons*)	komba	VU	**25**	**8**	**0**	**0**
Other mammals						
civet (*Fossa fossana*)	jabady	NT	**3**	**15**	**1**	**1**
fosa (*Cryptoprocta ferox*)	fosa	VU	**1**	**0**	**1**	**0**
greater hedgehog tenrec (*Setifer setosus*)	sokina	LC	**0**	**7**	**0**	**25**
Madagascar civet (*Viverricula indica*)	fanaloca	LC	**1**	**0**	**0**	**0**
Madagascar flying fox (*Pteropus rufus*)	fanihy	VU	**12**	**5**	**2**	**0**
streaked tenrec (*Hemicentetes sp.*)	tsora	LC	**1**	**0**	**1**	**0**
tailless tenrec (*Tenrec ecaudatus*)	sokiny	LC	**25**	**7**	**1**	**2**
Birds						
blue coua (*Coua caerulea)*	mariaha	LC	**42**	**15**	**11**	**10**
cattle egret (*Bubulcus ibis*)	kilandy	LC	**0**	**1**	**0**	**2**
crested drongo (*Dicrurus forficatus*)	lehidronga	LC	**4**	**2**	**2**	**6**
crested ibis (*Lophotibis cristata*)	lampirana	NT	**0**	**0**	**0**	**1**
feral pigeon (*Columba livia*)	dimohina	LC	**8**	**9**	**0**	**0**
green jery (*Neomixis viridis*)	tehintehina	LC	**4**	**0**	**0**	**0**
green pigeon (*Treron australis*)	adabo	LC	**4**	**2**	**5**	**17**
helmeted guinea fowl (*Numida meleagris*)	ankanga	LC	**5**	**2**	**1**	**3**
Madagascar blue pigeon (*Alectroenas madagascariensis*)	finengo	LC	**18**	**10**	**11**	**16**
Madagascar cisticola (*Cisticola cherina*)	monjo	LC	**4**	**1**	**0**	**0**
Madagascar coucal (*Centropus toulou*)	kelibanda/tidian a	LC	**3**	**2**	**5**	**6**
Madagascar mannikin (*Lonchura nana*)	antsangirity	LC	**5**	**0**	**0**	**0**
Madagascar paradise flycatcher (*Terpsiphone mutata*)	siketry lava ohy	LC	**1**	**0**	**0**	**0**
Madagascar partridge (*Margaroperdix madagascariensis)*	rakibo	LC	**2**	**0**	**3**	**1**

Table 2. Continued. Wild species fadys reported from households in western and eastern Marojejy National Park-periphery study communities.

			Western Marojejy		Eastern Marojejy	
Reported wild species fady	Local name	IUCN Rank*	Antsahaberaoka households observing fady (n=149)	Ambalanaomby households observing fady (n=51)	Manantenina households observing fady (n=100)	Mandena households observing fady (n=100)
Madagascar magpie robin (*Copsychus albospecularis*)	todiana	LC	**0**	**0**	**1**	**1**
Madagascar red fody (*Foudia madagascariensis)*	fody	LC	**0**	**0**	**0**	**1**
Madagascar white eye (*Zosterops maderaspatanus*)	sobery	LC	**0**	**0**	**0**	**1**
Rand's warbler (*Randia pseudozosterops)*	siketry	LC	**1**	**0**	**0**	**0**
souimanga sunbird *(Nectarinia souimanga*)	soy	LC	**1**	**0**	**3**	**0**
velvet asity (*Philepitta castanea*)	soisoy	LC	**0**	**0**	**1**	**0**
Reptiles and amphibians						
crocodile (*Crocodylus niloticus*)	voay	LC	**4**	**0**	**1**	**1**
radiated tortoise (*Geochelone radiata*)	sokatra	CR	**0**	**0**	**2**	**2**
Marine/freshwater species						
African longfin eel (*Anguilla mossambica*)	amalombandagna		**9**	**1**	**1**	**0**
crab	foza		**64**	**5**	**0**	**4**
crayfish	tsivakiny mena		**5**	**1**	**4**	**4**
gobi fishes (*Gobidae* family)	toho		**0**	**0**	**0**	**1**
Madagascar mottled eel (*Anguilla marmorata*)	amalona		**11**	**7**	**25**	**21**
native fish in brackish or coastal waters	amboriky		**0**	**1**	**0**	**0**
octopus	orita		**11**	**4**	**3**	**4**
sea turtle	fano		**0**	**1**	**2**	**2**
shrimp	orana		**0**	**2**	**2**	**5**
Arthropods						
water beetle	tsokobona		**1**	**0**	**0**	**0**
Plants						
edible fern	anansengoko		**4**	**4**	**3**	**1**
edible greens	anantarika		**1**	**0**	**0**	**0**
edible greens	anantsindra		**1**	**1**	**0**	**0**
edible greens (*Solinaceae sp.*)	anantailamba		**6**	**14**	**3**	**0**
Spanish needle (*Bidens pilosa*)	anantalambo		**6**	**0**	**1**	**0**
trema tree*** (*Trema orientalis*)	angezoko		**0**	**0**	**7**	**8**

*IUCN Red List classification: CR=Critically Endangered, VU=Vulnerable, NT=Near Threatened, LC=Least Concern

**Reference to all lemurs

***Use for firewood prohibited

> spared and decided it would be fady from that day forward to kill blue pigeons, since the bird had saved us all. And this is the reason we do not eat them…our grandmother cast the curse, "the children of my grandchildren, if they kill or eat feral pigeons, will be like ash wetted with water that diminishes day and night, becoming poorer and poorer, and wasting away." (Ambalanaomby village informant)

Other justifications reported for fadys prohibiting consumption of wild bird species, which are unlikely to be violated include stories associating certain bird species with ingesting human flesh:

> One of our ancestors died, and was not well buried in the ground. The flesh was then eaten by helmeted guinea fowl. And so, it is fady for us to eat guinea fowl. (Antsahaberaoka village informant)

Reptiles, Amphibians and Fish

Two reptiles and amphibians are reported from households to be fady to kill or consume. Included is the critically endangered (IUCN) radiated tortoise (*Astrochelys radiata*) (reported by 2% of surveyed households in eastern study communities but not reported from western study communities). Interestingly, radiated tortoise do not exist in the Marojejy Massif landscape, but rather occupy habitat in the dry southern region of Madagascar and is a traditional ethnic Antandroy fady. Eleven marine and freshwater species were also reported fady by a minority of households, the most prominent being the Madagascar mottled eel (*Anguilla marmorata*) (reported by 9% of western households and 23% of eastern households), and crab (reported by 34.5% of western households and 2% of eastern households).

Wild Plants

Seven plant species were reported fady by a minority of households, including edible varieties of *anana* greens, one edible fern and the trema tree (*Trema orientalis*), for which a specific use-prohibition prevents households from cutting the tree down for firewood. One medicinal plant, *Bidens pilosa*, was also reported fady in a minority of households:

> The *anantalambo* [(*Bidens pilosa*)] fady originates from those who came before us, who collected this and other magical plants to counter the bad effects of incest. Until today, we do not eat it because we want to keep this protection, and we have not yet found a substitute fady food. (Ambalanaomby village informant)

Interpretation

Raha noana ny kibo, mivezivezy ny fanahy
When the stomach is hungry,
the spirit wanders
- Malagasy proverb, Mandena village informant

Only 3% of surveyed households (n=200) on the remote western side of the Park reported observing no fadys whatsoever pertaining to the consumption of wild or domestic species, or otherwise prohibited behavior. A significantly higher 16% of all surveyed households (n=200) on the ecotourism zone-bordering eastern side of the Park reported observing no fadys pertaining to consumption of wild or domestic species. This finding suggests that while the majority of households acknowledge respecting some form of fady in this region, higher taboo abandonment has occurred in households proximate to a major road, compared with more remote households.

One interesting finding comes from remote western region households, where the landscape is distant from Madagascar's coasts, yet reported specific-species fadys include marine species such as *orita* (octopus), *fano* (sea turtle), and *drakatra* (mangrove crab). These taboos appear to be maintained, despite the fact that none of these species exists in the Marojejy Massif. The *sokatra* radiated tortoise fady *(Geochelone radiata)* reported from households in the eastern region of Marojejy indicates the persistence of ethnic-associated fadys, which were reported in this survey by heads of household who no longer associate Antandroy as their dominant ethnic identity.

Although fadys prohibiting consumption of three lemur species are reported from many surveyed households, informants reported that lemurs continue to be illegally hunted inside Marojejy National Park to accommodate market demand in regional cities such as Sambava, on the Indian Ocean coast. Traditional fadys, where retained, may offer local protections, but do not evidently influence behavior of non-residents engaging in illegal hunting activity within Marojejy National Park, to service demand for wild meats in distant communities.

In a study of the erosion of traditional taboos in Nigeria, Anoliefo et al. 2003 documented that disregard for environmental taboos is acute in rural communities that have transitioned away from traditional religious ideologies and adopted Christian belief systems. A minority of heads of household in western and eastern communities in this study reported that they no longer observe traditional fadys as an express result of their adopted religious beliefs:

> Ever since I was very young, I have gone to church, and so I do not respect the fadys of my ancestors. (Antsahaberaoka village informant)

However, Seventh Day Adventist households in these study communities reported specific-species fadys prohibiting the consumption of lemur, tenrec, civet, eel, pig, and shellfish that have been directly attributed to their religious beliefs. Adventism seems to have absorbed and perpetuated traditional taboos consistent with its ideologies in rural communities in this region. 2% of western households (n=200) and 5% of eastern households (n=200) surveyed in this study directly attributed specific species fadys to their Adventist beliefs, in responses to the question "why are these things fady?" A recent bushmeat study by Jenkins et al. (2011) found eel species to be the wild meat with highest expressed local taste preference for study communities in a study region in the east of Madagascar. This suggests that in Marojejy region communities, both Adventist and traditional fadys prohibiting eel consumption may offer important protection to *Anguilla spp*.

Conclusions

Hazo tokana tsimba ala,
tondro tokana tsy mahazo hao
One tree does not make a forest,
as one finger cannot catch a louse
- Tsimihety proverb, Mandena village informant

Madagascar's Parks and protected areas preserve natural resources that support the livelihoods of agrarian forest-bordering communities, while preserving habitat for endemic biodiversity in the Marojejy Massif. In contexts in which the imposition of sanctions against hunting and/or consumption of threatened species presents a challenge to resource managers, informal institutions such as household taboos may play a role in protecting populations of critically endangered, vulnerable, and other wild species. This study finds that specific-species taboos reported from households in eastern and western Park-bordering communities vary widely, and are reportedly respected by a minority of households. This research is limited, however, in that it does not document whether expressed consumption prohibitions are abided by, in practice. Reported fadys may offer ambiguous protections when extrapolated to the broader community level, and further research documenting behavior, including bushmeat hunting and consumption, would offer further insight into the degree to which wild species fadys reported from rural communities actually afford conservation benefits to specific species.

While external actors and influences have been found to challenge local informal institutions, documentation of retained traditional ecological knowledge pertaining to species directly present on the landscape, or species from elsewhere which are associated with local flora and fauna, offers insights into the relationships between certain households and the environment in this region of Madagascar. Understanding traditional specific-species consumption fadys existent in Park-bordering households may inform local environmental education agendas in and around the Marojejy Massif, which may involve classroom materials, radio programming and other media. Such educational programs would, however, need to overcome the absence of or abandonment of taboos on the majority household level, if they were to influence broader populations to adhere to species-specific fadys. If carefully constructed, such programs might aid in the reinforcement of traditional belief systems and their associated conservation benefits, as communities continue to expand and diversify.

Endnotes

1. One exception is the example of place-based fadys that directly associate a species with ill omens and prescribes the killing of encountered individuals, which applies to the near threatened (IUCN) aye aye lemur (*Daubentonia madagascariensis*) (Jones et al. 2008).

ACKNOWLEDGMENTS

Thank you to Madagascar National Parks including BAKARIZAFY Hervé and FOSTIN of the Andapa office, Dr. Erik Patel of SIMPONA, the Madagascar Institute for the Conservation of Tropical Environments, and the École Normale Superieure d'Antananarivo. Special thanks to my excellent research assistants RABARY Desiré, IAMBOTSARA Willy Donatien, RAZAFIMAHATRATRA Desiré, and ANDRIAMBOAVONJISOA Zoharisoa Antenaina. Thanks also to Dr. Amity Doolittle and Lisa Bassani for advising and support. This work was funded by the Doris Duke Conservation Fellowship, the Tropical Resources Institute at Yale, the Agrarian Studies Program at Yale, and by the Seneca Park Zoo Docents Society.

REFERENCES

Anoliefo, G.O., Isikhuemhen, O.S., and Ochije, N.R. (2003). Environmental Implications of the Erosion of Cultural Taboo Practices in Awka-South Local Government Area of Anambra State, Nigeria. Journal of Agricultural & Environmental Ethics 16:281–296.

Berkes, F., Colding, J., and Folke, C. (2000). Rediscovery of Traditional Ecological Knowledge as Adaptive Management. Ecological Applications. 10: 1251-62.

Berkes, F., and Folke, C. (1998). Linking Social and Ecological Systems: Institutional Learning for Resilience. Cambridge University Press, Cambridge, United Kingdom.

Begossi, A. (1992). Food Taboos at Buzios Island (Brazil): Their Significance and Relation to Folk Medicine. Journal of Ethnobiology. 12: 117-139.

Begossi, A. (1998). Resilience and Neotraditional Populations: The Caiçaras of the Atlantic Forest and Caboclos of the Amazon (Brazil). Pages 129–157 *in* F. Berkes and C. Folke, editors. Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge University Press, Cambridge, United Kingdom.

Britt, A., Axel, A., and Young, R. (1999). Brief Surveys of Two Classified Forests in Toamasina Province, Eastern Madagascar. Lemur News

4:25–27.

Brooks, T.M., Mittermeier, R.A., da Fonseca, G.A.B., Gerlach, J., Hoffmann, M., Lamoreux, J.F., Mittermeier, C.G., Pilgrim, J.D., and Rodrigues, A.S.L. (2006). Global Biodiversity Conservation Priorities. Science 313: 58 – 61.

Colding, J., and Folke, C. (1997). The Relation between Threatened Species, their Protection, and Taboos. Conservation Ecology 1:(1)6.

Colding, J. and Folke, C. (2001). Social Taboos: 'Invisible' Systems of Local Resource Management and Biological Conservation. Ecological Applications. 11: 584-600.

Durbin, J., Bernard, K., and Fenn, M. (2003). The Role of Socio-economic Factors in the Loss of Malagasy Biodiversity. Pages 142–146 in S. M. Goodman and J. P. Benstead, editors. The Natural History of Madagascar. University of Chicago Press, Chicago, Chicago, USA.

Gadgil, M., Berkes, F., and Folke, C. (1993). Indigenous Knowledge for Biodiversity Conservation. Ambio 22:151–156.

Garreau, J.M., and Manantsara, A. (2003). The Protected-area Complex of the Parc National de Marojejy and the Reserve Speciale d'Anjanaharibe-Sud. In: The Natural History of Madagascar, S.M. Goodman and J.P. Benstead (eds.), 1451-1458. University of Chicago Press, Chicago, USA.

Hawkins, F. (1999). The Primates of Isalo National Park, Madagascar. Lemur News 4:10–14.

Humbert, H. (1927). La destruction d'une flore insulaire par le feu. Principaux aspects de la végétation de Madagascar. Documents photographiques et notices, Mémoires de l'Académie Malgache. 5: 1–79 in: Humbert, H. et al. 1936/2002. Flore de Madagascar et des Comores. Muséum National d'Histoire Naturelle, Paris.

IUCN (World Conservation Union). (2011.2). IUCN Red List of threatened species. IUCN, Gland, Switzerland. Available from http://www.iucnredlist.org/ (accessed January 2012).

Jenkins R.K.B., Keane A., Rakotoarivelo A.R., Rakotomboavonjy V., Randrianandrianina F.H., et al. (2011). Analysis of Patterns of Bushmeat Consumption Reveals Extensive Exploitation of Protected Species in Eastern Madagascar. PLoS ONE 6(12): e27570.

Jones, J.P., Andriamarovolona, M.N., and Hockley, N. (2008). The Importance of Taboos and Social Norms to Conservation in Madagascar. Conservation Biology 22:4:976-986.

Lilette, V. (2006). Mixed Results: Conservation of the Marine Turtle and the Red-tailed Tropicbird by Vezo Semi-nomadic Fishers. Conservation and Society 4:262–286.

Lingard, M., Raharison, N., Rabakonandrianina, E., Rakotoarisoa, J., and Elmqvist, T. (2003). The Role of Local Taboos in Conservation and Management of Species: The Radiated Tortoise in Southern Madagascar. Conservation and Society 1:223-46.

Loudon, J.E., Sauther, M.L., Fish, K.D., Hunter-Ishikawa, M., and Ibrahim, Y.J. (2006). One Reserve, Three Primates. Ecological and Environmental Anthropology 2:54–74.

MacKinnon, J.L., Hawkins, C.E., and P.A. Racey. (2003). Pteropodidae, Fruit Bats, Fanihy, Angavo. Pages 1299–1302 in S. M. Goodman and J. P. Benstead, editors. The Natural History of Madagascar. The University of Chicago Press, Chicago, USA.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., and Kent, J. (2000). Biodiversity Hotspots for Conservation Priorities. Nature 403: 853–858.

Nawrotzki, R., Hunter, L.M., and Dickinson, T.W. (2011). Natural Resources and Rural Livelihoods: Differences between Migrants and Non-Migrants in Madagascar. Working Paper. Population Program. Institute of Behavioral Science. University of Colorado, Boulder.

Nicoll, M. E. (2003). *Tenrec ecaudatus*, tenrec, tandraka, trandraka. Pages 1283–1287 in S. M. Goodman and J.P. Benstead, editors. The natural history of Madagascar. University of Chicago Press, Chicago, USA.

Nielson, M., and Patel, E.R. (2008). The Role of Taste Preference and Wealth in Bushmeat

Hunting in Villages Adjacent to Marojejy National Park, Madagascar. XXII Congress of the International Primatological Society, Edinburgh, UK, 3-8 August 2008. Primate Eye (96) Special Issue: 222-223.

Nussbaum, R.A., and Raxworthy, C.J. (2000). Commentary on Conservation of "Sokatra," the Radiated Tortoise (*Geochelone radiata*) of Madagascar. Amphibian and Reptile Conservation 2:6– 14.

Patel, E.R. (2009). Silky Sifaka, *Propithecus candidus*, 1871. In: Primates in Peril: The World's 25 Most Endangered Primates 2008-2010. Mittermeier, R.A., Wallis, J., Rylands, A.B., Ganzhorn, J.U., Oates, J.F., Williamson, E.A., Palacios, E., Heymann, E.W., Kierulff, M.C.M., Long Yongcheng, Supriatna, J., Roos, C., Walker, S., Cortés-Ortiz, L., and Schwitzer, C. (eds.). 2009. Primates in Peril: The World's 25 Most Endangered Primates 2008–2010. IUCN/SSC Primate Specialist Group (PSG), International Primatological Society (IPS), and Conservation International (CI), Arlington, VA. 84pp.

Ruud, J. (1960). Taboo: a Study of Malagasy Customs and Beliefs. Allen & Unwin, London.

Schweter, M. (2008). Clarification de la limite du Parc National de Marojejy. Association pour la Gestion des Aires Protégées/KfW. Parc National de Marojejy.

Sommerville, et al. (2010). The Role of Fairness and Benefit Distribution in Community-based Payment for Environmental Services Interventions: A Case Study from Menabe, Madagascar. Environmental Economics 69: 1262-1271.

Thalmann, U., Geissmann, T., Simona, A., and Mutschler, T. (1993). The Indris of Anjanaharibe-Sud, northeastern Madagascar. International Journal of Primatology 14:357–381.

Vargas, A., Jimenez, I., Palomares, I., and Palacios, M. (2002). Distribution, Status and Conservation Needs of the Golden-crowned Sifaka *Propithecus tattersalli*. Biological Conservation 108:325–334.

"We Live More Like Indians than Indians": Traditional Identity, Swidden Agriculture, and Boundary-making in the Atlantic Forest of Brazil

Alaine A. Ball, MFS 2012

ABSTRACT

Focusing on swidden agriculture as a central phenomenon, this paper examines the relationship between protected area creation, traditional resource management, and identity. I consider how boundary creation constructs and produces traditional identity, how identity and agricultural practices in turn construct these boundaries, and how "traditionality" is employed to include, exclude, and make claims. Data from interviews and participant observation in and around the Ecological Station of Juréia-Itatins (EEJI), a protected area of coastal São Paulo, Brazil, indicates that spatial, temporal, and conceptual boundaries create a complex system of ongoing negotiation and contestation between residents of the EEJI, government, and non-governmental organizations (NGOs). This results in changes in agricultural systems, altered perceptions of cultural identity, and uncertain governance that permits the continued practice of closely-monitored swidden agriculture. Residents, EEJI administration, park guards, and environmentalists relate traditionality to correct and incorrect resource use, often focusing on commercial extraction versus swiddening; how these actors implement and internalize traditional identity informs the imagining, reimagining, and crossing of physical and cultural boundaries. Ultimately, both traditional identity and identity-based boundaries are unstable concepts, and protected area management policy based on restricting traditionality to government-defined visions will perpetuate conflict between administration and residents.

Introduction

> *People look at a map and say, oh, look at this beautiful reserve! No, look at the reality. They don't know what's going on here!*
>
> -Resident of the EEJI

In referencing a map of the Ecological Station of Juréia-Itatins (Estação Ecológica de Juréia-Itatins), this resident draws attention to a particular perception of the land on which he lives, and how that perception differs from his daily experience. His perspective is a situated, existential one, while the map's is representational. A border on the map designates him, and about 250 other families, as "inside," defining how they are permitted to interact with their environment.

Many residents of the EEJI are considered "traditional" or *caiçara*, ambiguous designations that nevertheless have important political and cultural implications. Traditionality constitutes another boundary whose borders undergo continual re-drawings, which happen in relation to re-drawings of protected area borders

Originally from Houston, TX, Alaine Ball holds a BA in environmental studies and painting from Sarah Lawrence College. She has a longstanding interest in the nature/culture interface and has focused her studies at F&ES on the social ecology of tropical conservation and development. A Master of Forest Science graduate, Alaine will continue to investigate the relationship between environmental policy and small farmers as a Fox Fellow at the University of São Paulo.

within which traditional people live. In addition to these spatial and conceptual boundaries, a temporal boundary was created in 1987 by the establishment of the EEJI and the subsequent ban on traditional resource management, including swidden agriculture.

My research sought to understand the experience of practicing swidden agriculture in a protected area. Based on my findings, I argue that actors—local residents, EEJI administration, EEJI park guards, and environmentalists—define traditional identity and boundaries from positions in relation to each other, and that they predicate the functionality of their definitions on the potential stability of these terms. However, traditional identity and boundaries are unstable concepts that act on each other, precluding the use of fixed forms operable within the framework of Brazilian environmental law. This process manifests in the practice of and negotiations over swidden agriculture, which in turn influence identity and boundaries. Due to its close association with traditional identity, swidden agriculture is both impacted by boundary creation while simultaneously continuing to inform it.

By presenting data that support a link between traditional identity and swidden agriculture, differing conceptions of "traditional," and how tradition and agriculture are bounded through illegalization and monitoring, I demonstrate how the use of spatial and temporal boundary terms—such as "reserve," "traditional," and "in the past"—combined with boundary actions—such as the drawing and redrawing of reserve borders, and monitoring of residents—drive the ongoing negotiation of terms and space.

Theoretical Context

Both "culture" and "identity" are uncertain concepts, resisting definition. Culture has been conceptualized as a context in which actions and symbols can be interpreted (Geertz 1973) and as emergent or as a process (Williams 1973), while identity—fluid, negotiable, and often wielded as a powerful political tool—is questioned as a working analytical category due

Photograph 1. A newly cut roça in Praia do Una. After drying, the area will be burned.

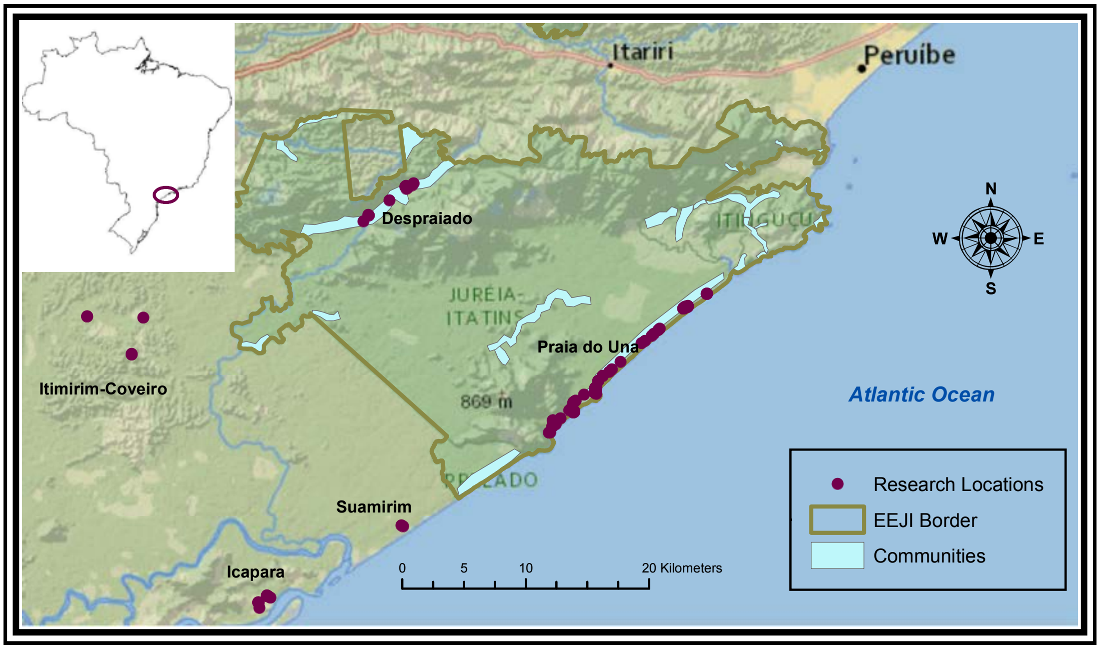


Figure 1. Research locations inside and outside of the EEJI. Sites indicated are current and former swiddens.

to its ambiguity (Brubaker and Cooper 2000). A closely related term is "authenticity": in seeking to describe the essential qualities of a culture or identity, both insider and outsider characterizations make claims about the authenticity of practices, beliefs, and knowledge. Criticized as referring to an idyllic past, authenticity and essentialism are devices used both to marginalize and to make claims about land and rights. They are also ways that local people seek to define themselves in a modern context, though the very existence of something called "traditional identity" is predicated on its contextualization within modernity (Hirtz 2003).

Much literature addresses the issue of people living in conservation areas, asking whether local peoples conserve biodiversity or contribute to the degradation of forests (Schwartzman et al. 2000; de Castro et al. 2006). Literature on the caiçaras and traditional peoples in Brazil has focused primarily on fishing practices, quantitative ethnobotany, agrobiodiversity, and the politics and problematic concept of "traditional" (Begossi 1998; Creado et al. 2008; Emperaire and Peroni 2007; Peroni and Hanazaki 2002). However, few studies have sought to understand the relationship between agricultural practice and identity, and between identity and protected areas, or have examined the on-the-ground negotiation of environmental policy and resource use.

Background

The Atlantic Forest and traditional people

As a threatened forest system of high endemism, the Atlantic Forest of South America has been the focus of conservation initiatives, especially the creation of protected areas (Myers et al. 2000). The caiçaras are a traditional people of mixed Portuguese, indigenous, and African heritage inhabiting the Atlantic Forest, and most caiçara communities are located within protected areas such as State Parks and Ecological Stations (Toffoli and Oliveira 1999).

Neither indigenous nor mainstream, traditional peoples in Brazil include *caiçaras*, *caboclos*, *quilombolas* (descendants of escaped slaves), and other groups formed over the course of colonial and post-colonial Brazilian history. The designation "traditional" has been used as a tool of marginalization (Schmink et al. 1992), to stake claims to land by traditional peoples, and, more recently, as a category of rights holders. Additionally, the discourse of "traditional"—the assumption that traditional populations are good stewards of their resources, or that they exist in a static state—has important political implications and can obfuscate heterogeneous characteristics of communities (Dove 2006). Describing a community as traditional or indigenous is as much a political as a cultural designation (de Castro et al. 2006; Li 2000).

For example, the traditional practice of swidden agriculture[1] has been paradoxically associated with both deep ecological knowledge of and adaptation to the forest *and* with degradation of the forest and maladaptation to modern land-use change (Diegues 1994; de Castro et al. 2006). This apparently conflicting characterization of traditional people is well demonstrated in the campaigns of the environmental NGO SOS Mata Atlântica, which, when politically convenient, uses caiçaras as an example of an ideal, balanced relationship between humans and nature while simultaneously advocating the removal of people from fully protected areas (SOS Mata Atlântica).[2]

Site Description and Methods

Located in the Ribeira Valley of coastal São Paulo, the EEJI contains the largest remaining contiguous tract of Atlantic Forest, encompassing 80,000 hectares of humid tropical slope forest and flood plain forests (de Carvalho and Schmitt 2010; Sanches 2001). As "fully protected" areas, Ecological Stations do not allow human residency; however, about twenty-two communities[3] remain within the EEJI, resulting in a paradoxical situation in which residents and their resource management are illegal.

Research was conducted between June and August 2011 in two communities within the EEJI, Praia do Una and Despraiado; with agriculturalists in several communities outside of the EEJI; with park guards and park administrators; and with representatives of environmental NGOs (Figure 1). These categories of actors sometimes overlap. In Praia do Una, all six families identify as traditional, while Despraiado is home to some 70 families, 26 of which have been determined traditional by the most recent anthropological study (de Carvalho and Schmitt 2010). I employed participant observation and semi- and unstructured interviews to gather data on perceptions, identity, and agricultural practices, operating from a phenomenological theoretical basis (Laverty 2003). In total, I conducted approximately fifty interviews, most of which spanned several days.

Findings and Analysis

Traditional swidden agriculture

In 1992, the EEJI administration began allowing swidden cultivation by permit, though EEJI residents complain that the permit process is so time consuming that it precludes any

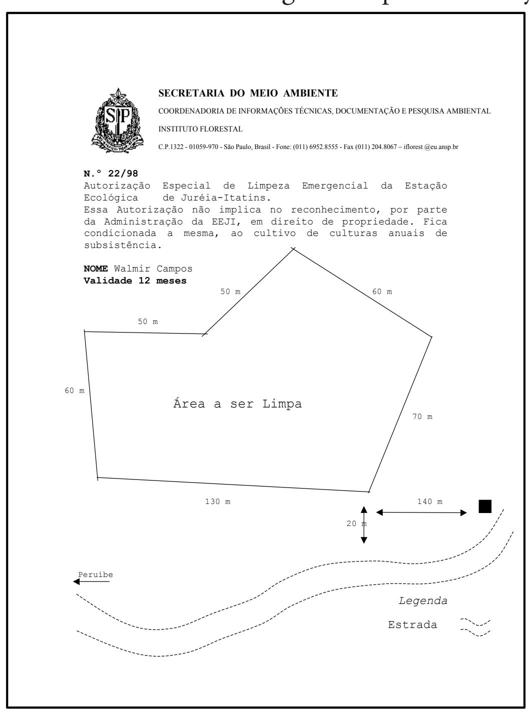


Figure 2. Example of an authorization to create a swidden plot of 0.12 hectares. Source: Instituto Florestal.

Table 1. Currently and formerly cultivated manioc varieties, within and outside the EEJI.

	Variety	Currently Cultivated	Lost or Out of Use
Bitter (*brava*)	Jurema/Preta	Praia do Una, outside EEJI	
	Três galhos/Branca	Praia do Una, Despraiado, outside EEJI	
	Amarelinha	Praia do Una, Despraiado, outside EEJI	
	Vermelha	Despraiado	Praia do Una
	Ibana	Despraiado	
	Quebra faca	outside EEJI	
	Imperial branca	outside EEJI	
	Mandipóia	outside EEJI	Praia do Una
	Cascuda	outside EEJI	Praia do Una
	Penaju		Praia do Una, outside EEJI
	Verde		Praia do Una
	Imperial		Praia do Una
	Canela durubu		Despraiado
Sweet (*doce, aipim*)	Manteiga	Praia do Una, Despraiado	
	Aipim amarelo	Despraiado	
	Roxa	Despraiado, outside EEJI	
	Roxinha	Despraiado, outside EEJI	
	Vassourinha	Despraiado, outside EEJI	
	Vassourinha roxa	Despraiado, outside EEJI	
	Vassourinha branca	Despraiado	
	Saracura	Despraiado	
	Paulista	outside EEJI	Despraiado
	Vitoria	outside EEJI	

functional farming. Most restrictive, in their eyes, are limitations concerning where and what they can cut to establish a new *roça*[4] based on the Brazilian Forest Code and federal environmental laws specific to the Atlantic Forest. In some areas, these restrictions have resulted in decreased fallow periods and production, as forest considered optimal for swidden locations is now off-limits, and degraded sites are farmed repeatedly. To authorize a swidden, a forestry technician accompanies a farmer to the site he wishes to cultivate, marking the location using a Global Positioning System (GPS) device, and issuing a permit showing clearly defined roça boundaries (Figure 2). In some cases, farmers are required to make roças away from roads, rendering them less visible to researchers and other outsiders.

When describing the landscape, EEJI residents stressed that "it was all roça," that "it was already conserved," and that "in the past, we were healthy and there was an abundance." Though a distinction between human areas and the forest is made, at the landscape level and across time, these boundaries are less apparent. Caiçara swiddens were formerly characterized by a high degree of crop diversity, with manioc (*Manihot esculenta*) as the staple crop, though agrobiodiversity is currently declining (Peroni and Hanazaki 2002). Farmers interviewed for this study currently cultivate a total of about thirteen manioc varieties—both sweet and bitter—which vary by community. However, all cultivation ceased in Praia do Una during the ban on swidden agriculture, and several manioc varieties were lost (Table 1). People often speak of their fear of fines and evictions. One family was fined before becoming aware of the ban on swiddening, illustrative of a general confusion that persists about the governing laws.[5] Today, it is unclear what is actually permitted under authorized swiddening. For example, although traditional agriculturalists consider burning the vegetation a necessity to ensure a good crop ("burning makes the earth much stronger"[6]), burning is highly discouraged by the EEJI administration and requires justification. Outside of the reserve, in areas designated as Environmental Protection Areas (APAs), burning is strictly prohibited, and large tracts of forest are rare.

What makes a traditional person "traditional"? Extraction versus swidden agriculture

When speaking of agriculture, several residents asserted that "the traditional person has to live from the roça," and that "we live more like Indians than Indians." This acknowledgement of the indigenous origins of their agriculture was stated both humorously and in resentful recognition of the more clearly defined rights of indigenous peoples in Brazil. Caiçaras find it ironic that they are the ones struggling for the right to practice swidden agriculture, while their indigenous neighbors have abandoned agricultural practices for the more lucrative endeavors of palm heart and orchid extraction. By law, indigenous peoples may extract a limited amount of certain forest products, a privilege denied caiçaras. These extractive privileges are illogical to caiçaras, as in their eyes they are the true practitioners of "sustainable" resource management, while indigenous peoples simply take from the forest without giving back:

> They don't care about anything, they will cut *juçara*[7] whenever, they don't wait for it to grow...to the correct size. They don't even make roças. Their culture is "extraction."[8]

Photograph 2. Sweet manioc.

In this light, swidden agriculture emerges as a central element in defining a "correct" way of living on the land, which provides, but also involves, community work and input. Conversely, the extraction and profit from wild forest products, when practiced without agriculture, are perceived by the caiçaras as depleting resources and involving no labor. Caiçaras speak scornfully of the "people from outside" who extract palm heart and hunt for profit, reinforcing the perception that bonds with the land are established through agriculture. Residents claim that illegal extraction and hunting worsened after the creation of the EEJI, as the transfer of their lands to the public domain has delegitimized their claims and former community boundaries. Rather than safeguard the EEJI from extractors, as intended, the boundary of the EEJI made another boundary—that of community territory—easier to cross.

However, many traditional residents now rely on palm heart extraction and commercial hunting to make a living, including those considered by the community and by the government as "purely" caiçara. As described in other cases, the illegalization of swidden agriculture can result in a huge increase in non-timber and other forest product harvests to compensate for lost income and agricultural production (Laird et al. 2010).

Problems of "traditional"

Although Brazilian legal definitions of traditional people address dependency on natural resources[9], caiçaras resent outside imposi-

Table 2. "Legislated identities" of the EEJI and associated tenurial situations.

Term	Refers to	Land Use Arrangement	Can request swidden authorization?
morador tradicional (traditional resident)	caiçaras or residents "native" to the area; considered traditional	*posseiro* (squatter, have ownership but no title) or *caseiro* (caretaker)	Yes
adventício antigo (old arrival)	caiçaras or non-caiçaras who arrived before the creation of the EEJI; may or may not be considered traditional	*posseiro* or *caseiros*	Yes
adventício recente (recent arrival)	non-caiçaras, non-"natives" who arrived after the creation of the EEJI; not considered traditional	*posseiro*, *caseiro*, or *meeiro* (sharecropper)	No

tions of identity as defined by bureaucrats or anthropologists. Smith (1999) refers to such impositions as "legislated identities," which do not place decision-making about identity and change in the hands of those being defined. Indeed, within the EEJI, legislated identities are operative on a daily basis, influencing decisions about resource use (Table 2).

Tania Li frames the process of relating identity with sustainable resource management as bounding people in a concept of community, "imagined as distinctive kinds of places, characterized by subsistence (poverty, limited market involvement, and limited wants)" (2001). These "distinctive kinds of places" then become what David Harvey (1996) calls "terrains of social control," in which marginalized groups remain marginalized, sometimes through a process involving their own imaging of themselves. Their "modern" characteristics also serve to their detriment, as revealed by a statement made by the executive director of a local environmental NGO: "they wear jeans and normal clothes, they aren't Indians. I am in favor of pulling them out [of the EEJI]."[10]

As one resident expressed, "We live differently, we respect nature and each other. We depend on the roça, on the forest, on the ocean. There never used to be fights around here."[11] Such statements can seem romantic, contributing to stereotypes of traditional people as existing in a timeless state of harmony with nature. Indeed, the framing of traditional identities in this manner, especially by anthropologists who do so in attempts to support the rights of traditional peoples to remain on their lands, has been criticized as further marginalizing them as "noble savages," as has the self-characterization by traditional peoples in this way as a kind of essentialization for political purposes (Adams 2003). Traditional people are caught in a delicate balance of presenting themselves as civilized but not too civilized, desiring development but only as long as it is "sustainable," noble in their traditionality but repressed enough to warrant the compassionate attention of potential allies.

In contrast to the optimistic proposals by some residents that imagine a revival of the traditional lifestyle, other residents of the EEJI believe that "the culture is over" because the "environmental movement killed the traditional person," and that therefore "there is no future in the roça." According to some the prohibition of the roça caused the death of the traditional person. Furthermore,

> We should do away with this traditional, not traditional [classification], and just be considered a community. We all depend on each other, this place depends a lot on what is not traditional. The communities don't make this distinction, the government does.[12]

Monitoring boundaries, complicating identity

The case of park guards, who supervise residents' resource management and monitor illegal palm heart extraction and hunting, further illustrates the ambiguities of illegality, identity, and the re-imagining of traditional practices by traditional people working in these capacities. Daily *fiscalização*, or enforcement, involves armed and uniformed visits to houses, inquiries, investigation of suspicious activities, treks through the forest to find animal traps, and attempts to intercept extractors and hunters as they leave the forest. Guards sometimes work with the Environmental Police, who use helicopters, Geographic Information Systems (GIS), and other technologies to improve surveillance of the EEJI.[13]

One resident described the hiring of local residents as park guards as an intentional strategy by the government to divide communities. Resentment and distrust towards those able to procure a job with the reserve is high, while with their newly conferred power, park guards become especially disconnected from the community. Another resident described the government's process for recruiting park guards as identifying the "worst *palmiteiros* (palm heart extractors)" to hire because they would know best how to think like palmiteiros and would have less incentive to continue their illegal activities if secured in steady employment.

Park guards are put in the clearly difficult position of monitoring their own communities, but often will avoid inspecting their immediate neighbors and own family if possible, making seemingly contradictory personal and official choices (Vasan 2002). During an interview with a park guard who considers himself traditional but who was characterized by other residents as one of those "worst palmiteiros," he described the commercialization of juçara palm heart as a formerly sustainable practice, because traditional people understood how to manage for continued production. Yet, in his present position, he fines people for these same activities and is highly disliked by the community. Daily, he straddles borders of illegality, identity, and

Photograph 3. A caiçara family in Praia do Una.

insider/outsider. All park guards interviewed accept “official definitions of reality” concerning the environment, e.g., natural areas exist where humans should not intervene, and conservation is necessary (Satterfield 2002). And although traditional people have not created the situation in which this paradigm has emerged, some of them adopt the perception that what they do—swidden agriculture—is also now part of the problem.

Conclusion

Employment of the concept of “traditional,” the association of identity with agricultural practices, and on-the-ground complexity of monitoring result in daily negotiations over resource use. Though insufficient enforcement of environmental laws due to lack of resources is commonly cited as the main obstacle to conservation efforts, park guards and the Environmental Police exert substantial energy monitoring traditional agriculturalists, which forces residents to continuously articulate their right to remain within the reserve. Because residents strongly link traditional identity with swidden agriculture, many contest the limitations currently imposed on traditional resource management. In the case of the Sustainable Development Reserve that briefly existed in Despraiado, the desire to continue practicing swidden agriculture drove the re-negotiation of boundaries. However, as demonstrated by this case and other decisions by the EEJI administration, the uncertain legal situation created by the establishment of the reserve prevents the utility of concepts such as “traditional” to define rights of resource use. Furthermore, traditional residents themselves, especially those who work for the government, may change their perceptions of traditional identity and sustainability of resource use.

Another map emphasizes the contrast between “inside” and “outside.” The manager of the EEJI showed me a satellite image of the Ecological Station that starkly reveals the contrast between the reserve and non-reserve: the coastlines on either side of the station’s borders are completely developed. Thus, although restrictions have undoubtedly contributed to loss of biocultural diversity, the imprecise governance within the Ecological Station and the distinction it makes between inside and outside may actually contribute to the preservation of traditional practices by providing the physical and quasi-legal space for the agriculture to occur. However, the government confines agriculture to authorized locations, limiting its practice to a form not considered “truly” traditional by residents, thus decoupling practice from identity. If the “environmental movement has killed the traditional person,” how can that movement and the borders it creates be supported by a traditionality that it illegalizes? Will it succeed in the creation of a new kind of confined traditionality operable within its framework, partially achieved by altering residents’ own views of their practices? While protected area boundaries and traditionality can be usefully dichotomizing by preventing large-scale commercialization and development, actor positionality and day-to-day negotiations result in the continual construction and reconstruction of these concepts, revealing their ambiguity and the differing perspectives of the land held by residents, government, and environmentalists. Despite the limitations imposed by environmental law, implementation within the EEJI provides the space to incorporate resident perspectives on swidden agriculture. Further incorporation of these perspectives, rather than attempts to define what they, and what a traditional person, should be, will reduce conflict between residents and administration.

Endnotes

1. Characterized by cutting and burning small patches of forest for short-term cultivation and by long fallow periods.
2. Employee of Instituto Socioambiental, personal communication, 17 August 2011.

3. *Comunidade*, or community, is the term used to describe settlements, comprised of clusters of a few to many families.
4. *Roça* can mean garden, farm, or fields, referring to the actual site of cultivation. However, when people speak of the roça, of making the roça, the word contains the entire process of swiddening and fallowing; as a non-permanent entity unfixed in space and time, roça necessarily involves the past, present, and future and thus describes a fundamental necessity for being, inseparable from self. Stories and memories of the roça are personal and community histories.
5. In Despraiado, farmers continued to swidden clandestinely during the ban, and the desire to continue practicing traditional agriculture partially drove the establishment in 2004 of a Sustainable Development Reserve (RDS), another category of protected area that allows "sustainable use." However, in 2009, the Secretary of the Environment of the state of São Paulo deemed the RDS unconstitutional, and the land was re-designated as an Ecological Station.
6. Resident of Despraiado, personal communication, 21 July 2011.
7. *Euterpe edulis*, the palm from which palm heart is harvested.
8. Resident of Praia do Una, personal communication, 2 July 2011.
9. Decree 6.040/07, article 3, paragraph 1 (Creado et al. 2008).
10. Executive Director of EcoJuréia, personal communication, 7 August 2011.
11. Resident of Praia do Una, personal communication, 25 June 2011.
12. Resident of Despraiado, personal communication, 13 July 2011.
13. Although it has not occurred recently, residents claim that guards would enter their houses unauthorized, steal pots and pans, and throw out their food under the pretext of searching for illegal game.

ACKNOWLEDGMENTS

I am very grateful to the small farmers of coastal São Paulo for their time, patience, and hospitality. Special thanks to Dauro Marcos do Prado for his assistance, and to EEJI managers Roberto Nicácio and André Martius. Sincere thanks to the Tropical Resources Institute, the Yale Program in Agrarian Studies, and the Carpenter-Sperry Research Fund for funding this project, and to advisors Michael Dove and Amity Doolittle for their guidance.

REFERENCES

Adams, C. (2003). Pitfalls of Synchronicity: A Case Study of the Caiçaras in the Atlantic Rainforest of South-eastern Brazil. In Ethnographies of Conservation: Environmentalism and the Distribution of Privilege, eds. Anderson, D.G. and E. Berglund, pp. 19-31. Bergahn Books, New York.

Begossi, A. (1998). Resilience and Neotraditional Populations: The *Caiçaras* of the Atlantic forest and *Caboclos* of the Amazon (Brazil). In Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience, eds. Berkes, F. and C. Folke, pp 129-157. Cambridge University Press, Cambridge.

Brubaker, R. and Cooper, F. (2000). Beyond "Identity." Theory and Society 29:1-47.

Creado, E.S.J., Mendes, A.B.V., Ferreira, L.d.C., and de Campos, S.V. (2008). Between "Traditional" and "Moderns": Negotiations of Rights in Two Protected Areas of the Brazilian Amazon. Ambiente e Sociedade 4.

de Carvalho, M.C.P. and Schmitt, A. (2010). Laudo Histórico e Antropológico (Historical and Anthropological Report). Technical Report for the Identification of Traditional Families in the Estação Ecológica de Juréia-Itatins, contracted by the Forestry Foundation, São Paulo, Brazil.

de Castro, F., Siqueira, A. D., Brondízio, E. S. and Ferreira, L.C. (2006). The Use and Misuse of the Concepts of Tradition and Property Rights in the Conservation of Natural Resources in the Atlantic Forest (Brazil). Ambiente e Sociedade 9:23-39.

Diegues, A. C. (1994). O Mito Moderno da Natureza Intocada (The Modern Myth of Untouched Nature). São Paulo: Núcleo de Apoio à Pesquisa sobre Populações Humanas e Áreas Úmidas Brasilerias-Universidade de São Paulo.

Dove, M.R. (2006). Indigenous Peoples and Environmental Politics. Annual Review of Anthropology 35:191-208.

Emperaire, L. and Peroni, N. (2007). Traditional Management of Agrobiodiversity in Brazil: A Case Study of Manioc. Human Ecology 35:761-768.

Geertz, C. (1973). The Interpretation of Cultures. Basic Books, New York.

Harvey, D. (1996). Justice, Nature, and the Geography of Difference. Blackwell Publishing, Malden, MA.

Hirtz, F. (2003). It Takes Modern Means to be Traditional: On Recognizing Indigenous Cultural Communities in the Philippines. Development and Change 34:887-914.

Laird, S.A., Wynberg, R.P., and McClain, R.J. (2010). The State of NTFP Policy and Law. In Wild Product Governance: Finding Policies that Work for Non-timber Forest products, eds. Laird, S.A., McClain, R.J. and R.P. Wynberg, pp 343-366. Earthscan, Washington, DC.

Laverty, S.M. (2003). Hermeneutic Phenomenology and Phenomenology: A Comparison of Historical and Methodological Considerations. International Journal of Qualitative Methods 2:Article 3.

Li, T. (2000). Articulating Indigenous Identity in Indonesia: Resource Politics and the Tribal Slot. Comparative Studies in Society and History 42:149-179.

Li, T. (2001). Boundary Work: Communities, Market, and State Reconsidered. In Communities and the Environment: Ethnicity, Gender, and the State in Community-based Conservation, eds. Agrawal, A. and C.C. Gibson, pp 157-179. Rutgers University Press, Piscataway, NJ.

Myers, N. Mittermeier, R. A., Mittermeier, C. G., et al. (2000). Biodiversity Hotspots for Conservation Priorities. Nature 403:853-858.

Peroni, N. and Hanazaki, N. (2002). Current and Lost Diversity of Cultivated Varieties, Especially Cassava, under Swidden Cultivation Systems in the Brazilian Atlantic Forest. Agriculture, Ecosystems, and Environment 92:171-183.

Sanches, R. A. (2001). Caiçara Communities of the Southeastern Coast of São Paulo State (Brazil): Traditional Activities and Conservation Policy for the Atlantic Rain Forest. Human Ecology Review 8:52-64.

Satterfield, T. (2002). Anatomy of a Conflict. University of British Columbia Press, Vancouver.

Schmink, M., Redford, K. H., and Padoch, C. (1992). Traditional Peoples and the Biosphere: Framing the Issues and Defining the Terms. In Conservation of Neotropical Forests: Working from Traditional Resource Use, ed. Redford, K. H. and C. Padoch, pp 3-10. Columbia University Press, New York.

Schwartzman, S., Moreira, A., and Nepstad, D. (2000). Rethinking Tropical Forest Conservation: Perils in Parks. Conservation Biology 14:1351-1357.

Smith, L.T. (1999). Decolonizing Methodologies: Research and Indigenous Peoples. Zed Books Ltd, London.

SOS Mata Atlântica, "Populações Tradicionais" ("Traditional Populations"). http://www.sosmatatlantica.org.br/index.php?section=info&action=populacoes.

Toffoli, D. di G. and de Oliveira, R. R. (1999). Caiçara Agroforestry Management. In Cultural and Spiritual Values of Biodiversity, ed. Posey, D. A., pp 302-305. United Nations Environmental Programme, London.

Vasan, S. (2002). Ethnography of the Forest Guard: Contrasting Discourses, Conflicting Roles and Policy Implementation. Economic and Political Weekly 37:4125-4133.

Williams, R. (1973). Base and Superstructure in Marxist Cultural Theory. New Left Review 82:3-1.

The Political Ecology of Fire in the Andean-Patagonian Region of Argentina

Daniela Marini, MFS 2012

ABSTRACT

The use of fire is still the basis for land management for millions of rural producers around the world. Although it is demonstrated that such traditional management practices are energy efficient and environmentally benign, fire has been long-maligned by colonial officers and modern-day development officials. Since the creation of provincial fire services in the 1960s, fire surveillance in Patagonia has become well established and fire use has been thoroughly legislated. However, fire governance in Patagonia has not yet been studied. The objective of my research is to elucidate the political character of fire management in order to provide recommendations to improve fire management strategies in Patagonia. From June to August 2011 I conducted 60 interviews with farmers, policy makers, scientists and managers in the Andean region of Chubut province. The most common themes in the interviews were the mismanagement of fire by rural inhabitants (22%), intentional fire setting as an expression of social tension (20%), pine plantations as fire hazards (18%), drier conditions promote more fires (18%), institutional corruption (10%), and fire setting for land acquisition (8%). I argue that conflicting interests among different actors result in arson, and that the Fire Service is deliberately obscuring the real causes of fire setting to secure national and provincial funds.

Introduction

Every summer, vast areas of Andean Patagonian forests turn to ash. Land use practices and policies are playing a critical role in the distribution and frequency of fire. The objective of my research is to analyze fire governance to provide recommendations for fire management strategies and a more efficient use of public funds devoted to manage natural resources in Patagonia.

Despite several studies demonstrating that traditional management practices based on the use of fire are energy efficient, environmentally benign and well-integrated into market systems (Peltzer 1978, Pyne 1990), fire has been long-maligned by colonial officers and later development officials (Robbins 2004, Mathews 2005). At present, policymakers in many developing countries are using fire suppression polices to perpetuate the colonial approach to fire management (Eriksen 2007). In light of official efforts to prevent fire, rural people continue to burn and resist regulations by making use of the physical character of fire: its easy anonymity, unpredictability and self-propagation (Kull 2004). Mathews (2005), in a study in rural Mexico, argues that the regulations against the traditional use of fire are part of an official discourse which justifies the Forest Service's authority by representing the forests as being at the mercy of destructive peasant farmers. Similarly, Kull (2004) documented the familiarity of Malagasy people in using fire, while government officials criminalize their burning practices through rhetoric and repression. Similar studies have concluded that conflicts between

Daniela Marini grew up in Córdoba, Argentina. She holds a B.A. in Biological Sciences from National University of Rio Cuarto in Argentina. Daniela studied plant ecology and conducted research on native forest restoration. During her Master of Forest Science at F&ES she focused on the political and social dimensions of forest use and conservation.

rural communities and official bodies over fire management always stem from global perspectives on environment and resource management having replaced local standpoints (Eriksen 2007).

In the Andean-Patagonian region of Argentina there is ethno-historical evidence of the use of fire by Tehuelche people who burned frequently for multiple purposes including the hunting of guanaco *(Lama guanicoe).* Beginning in the early 1900s, the central government of Chile developed a policy to use fire on a massive scale to convert forests to cattle pasture and favor settlement (Holtz and Veblen 2011), some of which spread east into Argentinean southern beach forests (*Nothofagus pumlio*) (Tortorelli 1947) (Photograph 1). Since the creation of provincial fire services in the '60s, fire surveillance in Patagonia has become well established and fire use has been thoroughly legislated. However, fire governance in Patagonia has not yet been studied.

My research aims to elucidate the political character of fire management in order to improve fire management strategies in Patagonia. The concepts of power and knowledge from Foucault (1991) and power and ignorance from Mathews (2005) are central to my analysis. I will draw on Foucault's idea that some notions of the world are formed through discourse and become true by certain social systems and practices. My argument is that conflicting interests among different actors result in arson, and that the Fire Service is deliberately obscuring the real causes of fire setting to borrow national and provincial funds. I will analyze the policies regulating fire practices in Patagonia, the official fire statistics and the perspectives and situations of all fire related actors.

Methods

Site Description

My research was carried out in two towns located at the base of the Andes in Chubut Province, Argentina: Trevelin and Esquel, the surrounding rural areas, and Alerces National

Photograph 1. Use of fire to convert forests into cattle pasture promoted by the Chilean government in 1900s. Picture taken in Futaleufu, Chile, at the border with Argentina.

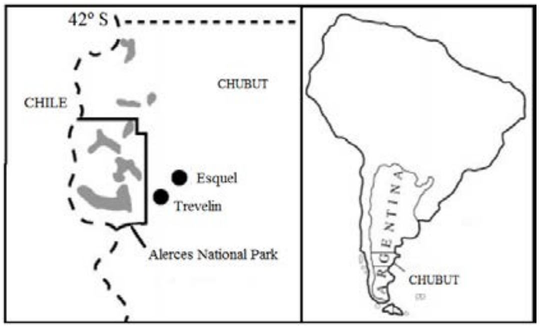


Figure 2. Map showing the location of Chubut Province, the Alerces National Park, Esquel and Trevelin cities.

Park (Figure 2). The climate of this region is defined by the rain shadow effect of the Andes which poses a barrier for humid air masses coming from the Pacific Ocean. The average annual precipitation drops abruptly from more than 3000 mm per year on the western side of the Andes to less than 800 mm per year at the forest/steppe ecotone (De Fina 1972). Forest composition changes along the precipitation gradient and also along the temperature gradient associated with increasing elevation (Veblen et al. 1992). Subalpine forests of the deciduous southern beach *Nothofagus pumilio* occur above 1000–1100 m in the entire area. In the west, the lowland rainforests are dominated by the evergreen *Nothofagus dombeyi.* In the eastern area, a native conifer (*Austrocedrus chilensis*) forms relatively open woodlands that grade into the steppe of low shrubs and bunchgrasses (Mermoz et al. 2005).

Sampling Design

From June to August 2011 I conducted 20 in-depth interviews with state officials from the Chubut Fire Service (SPMF), General Department of Forests and Parks (DGByP) and academic representatives from the Andean Patagonian Forest Research and Extension Center (CIEFAP) to examine state fire regulations. I obtained contact information from Thomas Veblen and his research group (University of Colorado, USA), who have previously conducted field work in the region. I inquired about the functioning of the institutions involved in fire management, collaborations among them, fire policy, and causes of fire.

To explore official fire surveillance I conducted archival research at the CIEFAP and SPMF libraries, and the Alerces National Park official fire records where I obtained information about all registered fire events since 1939. To analyze the social and institutional fire related system, I carried out 40 informal semi-structured interviews with farmers around rural areas. To approach farmers I first obtained burning notifications from the past 6 months, available at the Fire Service. I also interviewed landowners that did not notify of burning or that were located near recently burned areas. At the park, I interviewed park rangers working for the National Parks Administration (APN), personnel from the Department of Fire, Communications and Emergencies (ICE), and park dwellers living along the Provincial Route Nº 71 within the park. The questionnaires I used to guide the interviews were designed to gather data on land use practices with implications for the flammability of the landscape: post-fire cattle grazing, controlled burning to eliminate debris, fire suppression, pine plantations and morel mushroom production. I also inquired about the causes of fire and perception of fire risk.

Results

Fire Legislation

Fires became a matter of national importance for the Argentinean government in 1948 with the creation of the National Forest Defense Act which contained a chapter on prevention and fire fighting. Provincial legislation regarding fire began to appear in the late 1950s. In 1959 the Provincial Forest and Fire Authority of Chubut Province (DGByP) was created as the maximum authority in all aspects concerning forest fires, with the mission to "protect forest resources of the mountainous area

Table 1. Surface burnt (ha) and number of fire events by different fire causes as categorized by the Provincial Fire Service in the 2008, 2010 and 2011 fire seasons in Chubut province, Argentina (DGByP 2011).

Official Fire Statistics	2009		2010		2011	
	ha	N	ha	N	ha	N
Domestic waste burning	7	9	1	10	60	10
Forest waste burning	55	28	22	22	4	14
Crop waste burning	3	15	35	9	12	10
Burning	7	9	7	7	34	15
Unknown	7936	83	73	38	608	57
Intentional	310	46	36	92	1271	40
Grass re-growth	1	4	0	1	0	1
Child-set fires	46	19	7	9	44	21
Railroad	0	2	5	4	68	15
Bonfire	190	11	426	3	3	6
Machinery	0		0	2	0	1
Cigarette	4	1	0	1	1	2
Power line	3	1	0	3	0	1
Lightning	1227	3	20	3	90	2
Others	17	4	1	3	0	3
Total	9805		634		2194	
N	235		207		198	

of the province against forest and rural fires." In 1983 the DGByP established the Chubut Fire Management Provincial Service (SPMF) as the department specializing in fire issues. In 1988 the SPMF enacted the Chubut Province Fire Act. Through this act, with an emphasis on administrative aspects of fire management and budgeting, a fire suppression policy was implemented in all provincial territories. In 2004 the DGByP passed the Forest and Rural Fire Management Act to control fire setting in rural areas. It was adapted from the 1999 Forest Fire Law of the Community of Andalucía, Spain, with minor modifications by the former Director of DGByP, Omar Picco. "It is a very comprehensive law with lots of technical recommendations, but we are still far from achieving what is stated by this law due to the immaturity of our administrative and technical system," stated Picco[1]. Interestingly, a provision of this law allows salvage logging after a low intensity fire event. The adjacent provinces have forbidden the extraction of wood after a fire event to prevent purposefully setting fires to extract wood (Picco 2007), which is another cause of fire setting in Chubut. Another noteworthy fact is that in addition to annual budgets for fire fighting, there are emergency funds to cover the operational expenses of exceptionally large fire events, which creates an incentive for fire workers to set fires.

No official inspections are conducted to determine fire causes; they are established by discarding other possibilities (Picco 2007). During the winter, farmers must report to the fire authority the location, purpose for burning, and surface intended to burn. These notifications, "*permisos de quema*" (burn authorizations) are granted depending on weather conditions. During the summer, the use of fire is highly restricted to certain days in which the SPMF decides that the humidity and wind conditions allow for low-risk burning.

Within the Alerces National Park, the use of fire in the area has been curtailed since the park was created in 1937. At the same time, as is stated in the Argentinean Constitution, park inhabitants were given temporary occupancy permits that not only failed to protect them from a possible expulsion, but also represented a myriad of obstacles to use the land. People living inside the park have to pay for land

Table 2. Perspectives on fire and legal living situations of all the actors and institutions related to fire use, fire management and fire legislation in the Andean Patagonian region of Chubut Province, Argentina.

ACTOR	PERSPECTIVE ON FIRE
Chubut's General *Directorate* of *Forest* and *Parks (DGByP)*	Fire is a threat to be regulated. 80% of fires are anthropogenic. Mission: protect forest resources and promotion of plantations.
Provincial Fire Service (SPMF)	Fire is a natural element that has to be suppressed because the natural equilibrium has been broken. Mission: fire prevention, fighting, and education
Patagonian Andes Forest *Research* and Extension Center (*CIEFAP)*	Fire as a research topic: natural disturbance. Focus on natural fires (3%).
Universidad Nacional de la Patagonia San Juan Bosco (UNPSJB)	Fire plays a natural role but it has to be controlled. Mission: train professionals foresters.
National Parks Administration (APN)	Fire is a threat to conservation purposes. It is caused by park dwellers or carelessness tourists. 5% are natural fires. Mission: minimize the surface affected by fires.
Small land owners (<2500 Ha)	Fire is not a serious problem. It is used to burn crop waste and, in some cases, to open shrublands.
Big land owners (>2500 Ha)	Fire is a threat for private property. Own private firefighting equipment. Environmentally friendly attitudes.
City dwellers	Fire is damaging for nature. Ignorance about fire causes.
Alerces National Park inhabitants	Anonymous fire setting as a tool of resistance against APN. Extensive knowledge of forest fires and the topography of the park.
Real estate agents	Fire is caused by tourists and farmers.

use rights in the form of grazing fees for each animal they own. Now, to obtain a property title, grazing rights must be surrendered and, as a result, ranching is being abandoned for less profitable tourism initiatives. Park inhabitants are skeptical about tourism initiatives because they require capital and expertise that they don't have.

Official fire statistics

The earliest records of fire within the Alerces National Park date from 1940. From 1940 to 2009 there were a total of 180 outbreaks that affected an area of 48,500 ha. A record from 1944, described as *corta y quema* (slash and burn), affected 36,200 ha. Of the 180 outbreaks, 88% were no larger than 10 ha and the fires larger than 10 hectares burned 99.75% of the total surface of the park. Regarding fire causes within the park, 93.5% of the fire events were of anthropogenic origin, and 75% of the surface burnt due to forest clearance. The fire events originated by lightning (6.5%), burned 5.4% of the total area (Salina et al. 2010). Other causes reported are: "fire coming from Chile," "accidental," "negligence," "human causes," cigarette," and "intentional." After the creation of the Department of Fire, Communication and Emergencies (ICE) within the National Park Administration in 1995, firefighting activities as well as the recording and documentation of fire events were notably enhanced. From 1995 to 2009 there were 128 outbreaks (71% of the total number of fires recorded since 1940) and the total area affected was 176 ha. Only two events exceeded 10 ha and burned 74% of the total surface. Considering the location and timing of these fires, it can be inferred that they were set intentionally to damage the forest or property (Salina et al. 2010).

The Provincial Fire Service statistics recorded a total area of 126.327 ha burnt in the 2009, 2010 and 2011 fire seasons. The number of fire events varied between 198 in 2011 and 235 in 2008. The most frequently cited cause of fire is 'unknown'. In those cases where the causes were identified, 'lightning', 'bonfire' and 'intentional fire setting' are reported as the cause

Table 3. Most recurring themes cited from 60 interviews with farmers, park dwellers, city dwellers, fire service officials and researchers in Chubut Province, Argentina.

Most Recurrent Themes from Interviews	Percent (%) of interviews
Farmers' mismanagement of fire	22
Intentional fire setting as an expression of social tension	20
Pine plantations increase fire hazard	18
Drier conditions are promoting more fires	18
Conflicts among institutions regarding fire management	15
Institutional corruption ("the business of fire")	10
Official prevention and surveillance needed	10
Ignorance about fire effects and causes	8
Fire setting for land acquisition (real estate pressure)	8
Fires not a problem	5

of the largest fires in these three years. 'Forest waste burning' and 'child-set fires' are also frequent sources of ignition (Table 1). The categories used to describe the type of vegetation affected by fires varies from very broad ('grassland') to very specific ('*Stipa sp*.'), depending on the methods used to estimate the surface area (satellite images and/or visual estimates in the field). The category 'others' include forest waste, fruit trees, crops, infrastructure, etc. The two most affected cover types, as well as the most frequently burnt, are 'grassland' and 'scrubland'. A total of 257 ha of pine plantations and 1,148 ha of native forests were burned in the past three fire seasons.

Fire related actors and institutions

Fire is being used in many different ways for different purposes by different social groups. In the rural environment fire is used as a silvicultural technique to thin pine plantations, for weed and forest waste burning, and to open shrublands for pasture. Fire is used to clear pastureland of an exotic shrub (*Rosa ruviginosa*) that forms very thick stands that prevent cattle grazing and also to stop the expansion of willow (*Salix humboldtiana*) towards arable land along alluvial floodplains (Table 2).

In Alerces National Park, the park dwellers interviewed expressed an ongoing pressure from the park officials to leave the area. Interviewees reported constant downsizing of their old property lines and numerous eviction orders: "We are not treated as humans. European boars have more rights than us," Luis Soto declared.[2] It is common knowledge that park dwellers set fires intentionally to protest violations of their property rights and express discomfort for the treatment they receive from park officials. "I know exactly where and how to start a fire and they won't find proof," another park inhabitant declared.

In the urban environment, fire is seen as a damaging agent that can destroy the scenic beauty of the area and risk harm to the local tourism industry. The official discourse surrounding fire suppression has been represented so consistently in official statements and newspaper accounts that city dwellers in Chubut have largely accepted that fire is solely destructive and that it results from rural ignorance.

The CIEFAP is a public institution devoted to the implementation of sustainable use of forests and plantations. The center was created in 1988, financed by the German Agency for Technical Cooperation (GTZ). Researchers at CIEFAP provide technical assistance to DGByP and SPMF for strategies for forest protection from fire outbreaks. The research center shares a building with the School of Forestry at Juan Bosco National University of Patagonia. One goal of the school is to train professionals to work at the DGByP, SPMF and CIEFAP. The youngest graduates expressed their unconformity with the education received: "we basically learned how to plant and manage exotic conifer plantations."

Ideas and perceptions regarding fire

In response to questions surrounding the causes of forest and rural fires, the most common reason cited was the mismanagement of fire by farmers (22%) (Table 3). This was a widespread perception among city dwellers and fire service officials. However, all the farmers interviewed mentioned the importance of wind and fuel conditions as conditioning parameters for burning. Fire use by farmers in the rural areas is being inaccurately associated with forest burning among urban inhabitants. The second most recurring theme (20%) is intentional fire setting as an expression of social tension. Interviewees reported cases of fire setting as a result of personal conflicts among neighbors (debts, revenge) or fire setting by fired employees as retribution. Pine plantations, promoted by a national subsidy program to create a high-quality wood production center, are considered to increase fire hazard (18%) (Figure 3). However, although all costs are subsidized and thinning pine plantations is required by provincial law 5.232, in many cases silvicultural maintenance is not conducted, creating high vertical fuel connectivity. Favorable weather conditions for the spread of fire, such as dry winters with extremely low levels of solid precipitation and dry and windy springs, were mentioned by the interviewees (18%) as an explanation of large fire events in the last decade.

A quarter of the interviewees mentioned conflicts related to jurisdiction and funding between the Provincial Fire Service and the fire department within the National Park. This institutional tension prevented an effective operation to stop a fire event that started inside the park (presumably initiated by a park-dweller asserting property rights) and spread over 7,500 ha of provincial territory in 2008. The theme "institutional corruption" was mentioned in 10% of the interviews (and it may have been omitted by many other interviewees due to the confidential nature of the statements). An anonymous interviewee stated "workers receive instructions to burn, and if you walk around

Photograph 2. Pine plantations (*Pinus Ponderosa*) reported to increase fire hazard near Esquel city, Chubut Province, Argentina.

burned areas you can find the candles used for organized fire setting." The budget for firefighting is determined by the number of fires registered in the previous fire season; therefore, more fire events mean more funding for the fire service and income for the temporary fire fighters that are hired every season under short-term contracts. One low-level official who had graduated from the local forestry school referred to the fire problem as "the business of fire."

Another controversial cause of fire setting reported was related to an increasing real estate pressure for land for acquisition (8%). This trend has a historical basis. In his book *Patagonia Vendida* ("Patagonia Sold"), Sánchez (2006) describes how foreign elites got a "heavenly" piece of land in Patagonia during the 1990s. The ease with which land could be purchased was partly because the government spared no effort to attract foreign investors referring to Patagonia simply as "land that was left over." Now, nearly the entirety of Patagonia is privately owned, including natural resources such as oil, gas and water. The Benetton family is the owner of a million ha (currently in use as a sheep farm), while Douglas Tompkins, the owner of North Face, owns 900.000 ha devoted to nature conservation (Sánchez 2006).

The need for fire surveillance and fire prevention was mentioned by 10% of the interviewees, mainly those working at the Fire Service, city dwellers and students. This idea is related to the assumption that there is a generalized ignorance about the effects of fire on the ecosystem and about fire prevention strategies (8%). Other respondents argued that fire in the region is no longer a problem (6%) because there is not a continuous forest cover through which the fire could spread.

Discussion

The land-abundant context from Patagonia is far different than the densely populated slash-and-burn cultivation fields of Southeast Asia, Africa or Mexico, from where most of the research on the use of fire comes from (Dove 1983, Kull 2004, Mathews 2005). In Patagonia, farmers are not seen as poor peasants; they own valuable land and the means of production, and nearly the entire indigenous population was removed, except for a few segregated indigenous groups that still persist in the Andean region. The comparison among these different regions can shed light on the unexplored political ecology of fire in Patagonia, and, more generally, about state strategies to exert control over natural resources.

In the last decades of the nineteenth century, nature was disengaged from local ecologies and livelihoods, making Patagonian resources available for the state to offer as raw material for industry. The making of Patagonia as a "resource frontier" (Tsing 2005), determined the power structure of land distribution and resource access, shaping the political ecology of the region. Within this setting of vast uninhabited lands, the bureaucratic structure was built with solid foundations during the late 1950s. Ministries of the environment, forest services, fire services, and the administration of national parks were established to secure control over natural resources. Since then, the Fire Service in Chubut Province has maintained the stereotype of farmers as destructive, by imposing fire regulations specially directed towards them and targeting farmers for fire-use education campaigns.

To defend itself from competing departments, maintain its own definition of environmental problems, and proceed with its particular kind of intervention, a government department must therefore find ways to generate some kind of success (Li 1999). The General Department of Forests and Parks (DGByP) and the Fire Service have developed what I call *constructed ambiguity* to capture funds to perpetuate its bureaucratic procedures. Conflicting interests among different actors in Chubut province result in arson, and the DGByP is deliberately obscuring the real causes of fire setting to borrow public funds to justify its operations and maintain its credibility. Ambiguity allows the existence of many different meanings and many different criteria of success (Mosse 2004), and it also allows standardization and space for a circular logic in which failure is used to justify more intervention (Li 1999). Many elements, including indicators of degradation, definition of the fire problem as well as the jurisdiction of competing institutions, have been obscured by these institutions.

Official ignorance is playing an important role in the functioning of the Chubut Fire Service, but in a different sense than that stated by Mathews (2005). In the case of Chubut province, the causes of fire starting are unknown and no efforts are being made to elucidate them. The category of "intentional fire-setting" is the predominantly cited cause every fire season. Official ignorance about intentional fire setting prevents the state from solving the problem: if the causes of intentional fire setting were investigated in Chubut, and the roots of the problem were tackled, there might be not enough fires to justify the Fire Service budget.

Ambiguity and ignorance together produce institutional weakness and open the door to corruption. Most studies of the environmental effect of power are silent on the issue except as an annoying anomaly or as a case of statistical noise in an overall pattern (Robbins 2000). Organized fire setting by state officials working for the Fire Service, as stated by one of the interviewees, is the most blatant form of corruption in the natural resources management of the region. Corruption is reflecting the weaknesses of state institutions and is posing serious challenges for sustainable use of natural resources in Patagonia.

Management implications

The story of fire in Patagonia is a story of struggles over resources. Different interest groups use fire to get access to different kinds of resources: lands, funding, research topics, and jobs. Resource access can be legislated, negotiated, purchased, or just established through use.

It is in the interest of fire users to protect the forest cover and the aesthetic value of the region to attract more tourists and investors. They know how to burn for farming purposes at a minimum risk of fire spread. A key point to be addressed is the widespread attitude among fire officials of "the more fire there is, the more money we need." It is also necessary to improve the situation of temporary firefighters who are recruited only during the summer, and for some of whom have this as their only source of income during this period. Salvage logging after low intensity fire events should be banned to stop fire setting aimed at extracting wood while burning vast areas of forests. The implementation of maintenance silviculture in private and state owned pine plantations must be reinforced and monitored. There is a need to open a public debate on the causes of fires and to reflect on any interest that may lead to burn the forest. Finally, the 2004 Forest and Rural Fire Management Act (Ley 5.232) (adopted from Andalucía, Spain) should be revised to ensure coherence with the administrative and technical capabilities of Chubut Province. The ultimate goal should be to ensure that no one takes personal advantage of burning for other reasons than farming purposes.

Endnotes

1. Omar Picco, Personal comm., August 8th 2011.
2. Luis Soto, Personal comm., July 25th 2011.

ACKNOWLEDGMENTS

This research would not have been possible without the support of Compton Foundation and the Tropical Resources Institute at Yale. For support in developing the project, I owe thanks to Thomas Veblen and Juan Paritsis from University of Colorado at Boulder, Prof. Susan Clark, and Prof. Michael Dove. Also, thanks to Prof. Mark Ashton for feedback on various iterations of the research. I would also like to thank those who attended and offered feedback at a talk I gave on this project at the Latin American Student Interest Group SIG in November 2011. Finally, thank you to Jorge Rocha and Luis Schinelli for their invaluable help in the field.

REFERENCES

De Fina, A. L. 1972. El clima de la region de los bisques Andino-patagonicos Argentinos, p. 35-58. In M. J. Dimitri [ed.], La region de los bosques Andino-patagonicos. Sinopsis General, Vol.10. Coleccion Cientifica del Instituto Nacional de Tecnologia Agropecuaria, Buenos Aires.

Eriksen, C. 2007. "Why do they burn the 'bush'? Fire, rural livelihoods, and conservation in Zambia." The Geographical Journal 173(3): 242-256.

Foucault,M. 1991. Truth and Power. Power/Knowledge: Selected Interviews and Other Writings. 1980 [1972]. Harvester Press.

Holz, A. and T. Veblen. 2011. The amplifying effects of humans on fire regimes in temperate rainforests in Western Patagonia. Palaeogeography, Palaeoclimatology, Palaeoecology 31: 82–92

Kull, C. 2004. Isle of fire: the political ecology of landscape burning in Madagascar. Chicago, The University of Chicago Press.

Ley 5.232. 2004. Manejo del Fuego e Incendios Forestales o Rurales en Chubut. Honorable Legislatura de la Provincia de Chubut.

Li, T.M. 1999. Compromising Power: Development, Culture, and Rule in Indonesia. Cultural Anthropology 14(3): 295-322.

Mathews, A. S. 2005. Power/Knowledge, Power/Ignorance: Forest Fires and the State in Mexico Human Ecology 33(6).

Mermoz M., Kitzberger T. & Veblen T. T. 2005. Landscape influences on occurrence and spread of wildfires in Patagonian forests and shrublands. Ecology 86, 2705-2715.

Mosse, D. 2004. Is Good Policy Unimplementable? Reflections on the Ethnography of Aid Policy and Practice. Development and Change 35(4): 639-671.

Pelzer, K.J. 1978. Swidden cultivation in southeast Asia: historical, ecological, and economic perspectives. pp 271-286.

Picco, O. 2007. Marco Legal para el Manejod de Fuego en la Patagonia. CIEFAP. II Reunion Patagonica y III Reunion Nacional sobre Ecologia y Manejo del Fuego.

Pyne, S., Andrews, P.L., and Laven, R.D. 1996. Introduction to Wildland Fire. New York: Wiley.

Robbins, Paul. 2004. Political Ecology: A Critical Introduction. Blackwell, New York.

Robbins, P. 2000. The rotten institution: Corruption in natural resource management. Political Geography, 19, 423-443.

Salina, J., M. Cárdenas, et al. 2010. Plan de proteccion contra incendios forestales Parque Nacional los Llerces 2009-2010. A. d. P. Nacionales.

Sánchez, G. 2006. La Patagonia vendida: los nuevos dueños de la tierra, Buenos Aires: Ed. Marea.

Tortorelli, L. 1947. Los incendios de los bisques en la Argentina. Ministerio de Agricultura de la Nacion. Direccion Forestal. 283 pp.

Tsing, Anna L. 2005. Friction: An Ethnography of Global Connection. Princeton: Princeton University Press.

Veblen, T. T., T. Kitzberger, and A. Lara. 1992. Disturbance and forest dynamics along a transect from Andean rain forest to Patagonian shrubland. Journal of Vegetation Science 3:507–520.

II. ENERGY, CARBON, AND ECOSYSTEM SERVICES AT THE LOCAL SCALE

Blame and Misinformation in a Smallholder Carbon Market Project

Shereen D'Souza, MESc 2011

ABSTRACT

From Malthus's economic theories, to colonial-era conservation initiatives, to the age of aid interventions, the rural poor in the Global South are commonly blamed for environmental degradation. The 1987 Bruntland Commission Report, for example, one of the founding documents of the concept and practice of modern sustainable development reads, "Those who are poor and hungry will often destroy their immediate environment in order to survive: They will cut down forests; their livestock will overgraze grasslands; they will overuse marginal land" (WCOEA 1987). As some of the political ecology literature reveals, narratives of blame, regardless of veracity, have been quite effective at furthering implicit economic and political goals of states and development institutions even when explicit goals related to poverty reduction or conservation are unmet. This paper traces the reproduction of blame narratives in the first-ever project to generate soil carbon credits in a smallholder context, focusing on responsibility for deforestation and misinformation on the role of trees in hydrologic cycles.

Introduction

From Malthus's economic theories to colonial-era conservation initiatives, to the age of aid interventions, the rural poor in the Global South are commonly blamed for environmental degradation. And, as some of the political ecology literature reveals, discourses of blame, regardless of veracity, have been quite effective at furthering implicit economic and political goals of states and development institutions (see e.g. Ferguson 1994). In this paper, I review literature on blame and misinformation in colonial and post-colonial rural development and conservation interventions. Then, in presenting data on the Kenya Agricultural Carbon Project (KACP), I argue that smallholder responsibility for climate change because of deforestation is overemphasized by project staff, effectively obscuring the responsibility of other actors operating on a variety of temporal and geographic scales. I conclude the paper by offering reasons for why KACP reproduces a blame discourse and furthers misinformation about causes of and solutions to climate change. These factors include: pressure to meet high project enrollment goals, an unquestioned parroting of mainstream blame discourses, and limited access to information on the role of trees in hydrologic cycles. Acknowledging the need for further investigation, it remains to be

---

Shereen D'Souza graduated from Yale F&ES with an MESc degree. Her research focused on the intersections of international agricultural development and climate change. Prior to graduate school, Shereen worked on food justice and food policy issues in California. She holds a B.S. from the Georgetown School of Foreign Service.

seen whether KACP, in the long-term, will meet its explicit goals of reducing poverty, increasing food security and generating carbon credits given its use of blame narratives.

Literature

The rural poor are to blame for environmental degradation

In 1798, Thomas Malthus writes, "The labouring poor, to use a vulgar expression, seem always to live from hand to mouth. Their present wants employ their whole attention, and they seldom think of the future" (Malthus 1798). Gray (2005) argues that Malthus indirectly asserts the poverty-degradation link suggesting that the poor must, for example, deforest for firewood in order to feed themselves today, not considering the value of the tree for tomorrow. Moseley (2001) and Murphee (1993) argue that Malthus's views are codified in contemporary economics literature as "time preference": the poor have a higher rate of time preference than the wealthy who, because their present needs are adequately met, can consider the future and invest in protecting the environment.

Blaikie (1985), discusses the reproduction of blame for environmental degradation in the colonial model of environmental governance. A precursor to Hardin's *Tragedy of the Commons* (1968), the colonial model, Blaikie argues, asserts that soil erosion is caused by overpopulation of rural areas, as well as the ignorance and laziness of poor land users who are positioned, in the model, as the sole responsible parties for the degradation. Fairhead (1996) also identifies a colonial history of blaming poor, rural peoples for deforestation, even when deforestation does not exist. He argues that colonial administrators viewed the forest islands of Kissidougou, Guinea as remnants of a once-pristine forest progressively destroyed by locals, never considering the possibility and reality that the forest islands were created from savanna by the poor villagers because of the multiple-use value the forest islands offered.

As Lele (1991), Gray (2005), Duraiappah (1998), Broad (1994) and others note, the Brundtland Commission report, released by the UN in 1987, popularized the concept of sustainable development, and further solidified the blaming of poor, rural peoples for degradation with, "Those who are poor and hungry will often destroy their immediate environment in order to survive: They will cut down forests; their livestock will overgraze grasslands; they will overuse marginal land" (WCED 1987). This narrative is also widely evident in the rhetoric of mainstream development institutions (see e.g. World Bank [1996] in Gray (2005:9); and Pinstrup-Andersen 1995).

Photograph 1. This KACP participant demonstrates her success with intercropping, one of the strategies promoted by KACP.

What does blame accomplish?

There is plenty of evidence (e.g. Fairhead 1996; Gray 2005; Blaikie 1985; Thompson 1986) that the poverty-environmental deg-

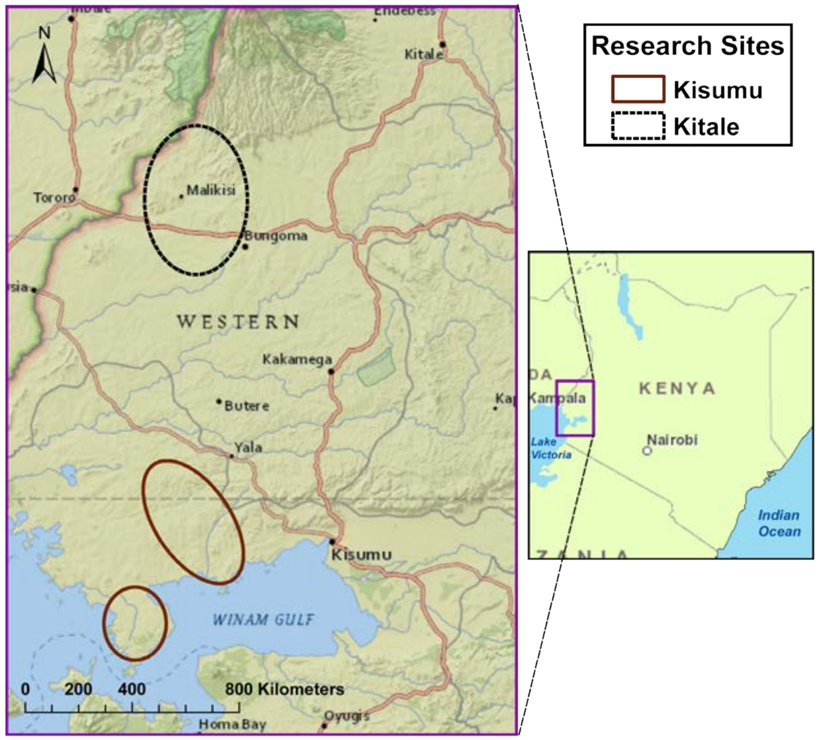


Figure 1. Map of study site.

radation link is not always true and is always far more complicated than proponents of such theories suggest. Why, then, is it reproduced and reinvented so continuously? The literature points to economic and political motivations. Leach (1994) argues that, in the case of Kissidougou, erroneously blaming local peoples for deforestation, and actively and passively ignoring evidence to the contrary, has been largely driven by economic considerations: colonial administrators were concerned with protecting high-value wild rubber "threatened" by local resource users. In the 1980s and 90s, the authors argue, aid and development funding became increasingly dependent on "green conditionality", i.e. the adoption of conservation measures (Leach 1994) predicated upon the need to conserve. Additionally, fines on locals for breaking laws related to timber extraction or wildlife use were an important revenue source for the forestry services for many years (Leach 1994). In a sense, the economic wellbeing of colonial, state, and local elite actors directly depended on the villagers of Kissidougou being guilty of deforestation.

Blaikie (1985) suggests that blaming poor land users enabled the obfuscation of the real cause, or one of them, of soil erosion: the colonial appropriation of the most productive lands, with the resultant marginalization of local peoples onto less productive lands. Colonial administrations responded to the problem of erosion by developing a "helpful stance" involving extension services that, again, allowed for increased control of local environmental decision making by state authorities.

Case Study – background and methods

The Kenya Agricultural Carbon Project (KACP) provides fertile ground for examining the reproduction of discourses of blame as they relate to a global, shared environment: the atmosphere. Started in January 2009, KACP is a collaborative effort of Swedish NGO, ViAgroforestry, and the World Bank BioCarbon Fund. The project explicitly aims to reduce poverty while generating carbon credits by incentivizing poor smallholders farming highly degraded land in Nyanza and Western Provinces to adopt sustainable agricultural land management (SALM) techniques, such as cover cropping, mulching, adoption of high yield varieties, and incorporation of short-term and long-terms agroforestry trees on cropland. These practices are thought to improve yields while generating carbon credits by directly or indirectly sequestering carbon in soils and biomass both above and below ground (VCS 2010). In addition to promoting SALM technologies, the project also aims to train participants on establishing village savings and loan associations and cooperative enterprises, as well as on increasing market-oriented production. According to ViAgroforestry staff, trainings on these topics indirectly support carbon sequestration activities by improving livelihood options and reducing poverty, which in turn helps to attract and retain project participants.

The project currently involves nearly 20,000 farmers, with the goal of eventually involving 60,000 smallholders farming on 45,000 hectares (Wekesa 2011). Participants are trained in groups by ViAgroforestry extension staff or by unpaid community facilitators who have been trained by extension staff. In general, all KACP staff come from the region where the project operates, with field extension staff often coming from the very villages in which the project operates. Most extension staff hold Certificates in Agronomy whereas administrative staff tend to hold college degrees.

Methods

Data were gathered in twelve villages near Kitale in Western Province and five villages near Kisumu in Nyanza Province through participant observation and interviews, as well as through reviewing project documents made available to me by ViAgroforestry staff. In total, I interviewed around 120 individuals from six main stakeholder groups: project staff, common-interest group leaders, project participants, non-participants, former participants and the poorest members of the communities.

Findings

Smallholders blamed for climate change

Interviews with project staff and observations at trainings for KACP participants revealed a dynamic in which staff blamed project participants for causing climate change. The following quote, from an extension staff person, comes from a training for KACP group leaders: "What do you think has caused the changes in the climate that you are seeing? Population pressure, cattle overstocking, deforestation and poor land management practices…The practices that you've done on your small parcels have caused climate change."[1] In this explanation of climate change, no attention was given to what other factors were also causing climate change, who was responsible for them, and the relative degree to which various factors and actors were responsible. In reaction to this explanation of causes of climate change, training attendees simply nodded or expressed agreement with the statements.

It is obvious that KACP has a focus on generating carbon credits, but the actual mission of the project is "to integrate sustainable agricultural land management practices into smallholdings and make it [sic] an engine of economic growth and a means to reduce poverty" (World Bank 2009). Yet, when asked why smallholders should participate in KACP, most staff members stressed the need for smallholders to mitigate climate change equally to other projected project benefits, such as increased food security, income and adaptive capacity. Typical responses included "this project explains to farmers that climate change is with us and they must mitigate and adapt,"[2] expressed by an extension staff person, and "farmers should participate in this project because they are emitting GHGs, but they will also get co-benefits like increased yields," expressed by a project administrator.[3]

Misinformation on how climate change could be addressed

Related to the blame narrative was misinformation presented to KACP participants about how they could reverse the effects of climate change. In addition to being told by KACP staff that they (the participants) had caused climate change by cutting down trees, most participants expressed the view that planting more trees, one of the main practices incentivized by the project, would "bring back the rains." When asked how they were adapting to the decreased rainfall that they were witnessing, nearly all interviewees responded that planting more trees on their land was an adaptation strategy. While some suggested that the trees compensated for lack of rain by protecting soil moisture and improving rain penetration (by loosening soils), many felt that the simple act of planting trees would attract rain clouds. Again, the source of knowledge on the supposed tree-rain connection was ViAgroforestry.

Analysis

In considering why blame is reproduced in KACP, two possibilities must be considered: the narrative helps extension officers meet high enrollment goals, and the staff are simply parroting a discourse to which they are not immune. As for why misinformation related to the ability of planting trees to regularize rain patterns persists, we must consider whether staff truly believe that planting trees will "bring back the rains," or whether they knowingly disseminate the misinformation because of the value associated with it.

Enrollment goals

In explaining climate change to a group of participants, the KACP extension officer, quoted above, says, "the practices that you've done on your small parcels have caused climate change." Next, he says, "If you and your neighbors act, you'll see changes."[4] Here, the assigning of blame for climate change is tied to wanting to give participants agency to change the situation, i.e. with guidance from ViAgroforestry, they can reverse the changes. Convincing farmers in KACP villages to act is critical in order for the project to survive. With the goal of eventually involving 60,000 farmers, in order to generate a meaningful amount of carbon credits, each extension officer has the responsibility to enroll 500 new farmers each year – no small task.

Enrollment goals have already proved problematic to achieve, with extension officers, as of mid-2011 having only a 75% success rate. If an officer is unable to meet the goal of 500 new participants within a year, any unmet portion of the goal is rolled-over to the next year. With unemployment rates around 40% in Kenya (CIA 2011), pressure to keep their jobs is high for KACP staff. As a result, not only is it necessary to convince farmers that they have a responsibility to act and that their actions will produce a desirable result, extension staff must convince participants to also convince their neighbors that they too must act. Isolated action, the rhetoric goes, will not be enough to overcome climate change. As stated by the same extension officer quoted above, "community-wide participation is necessary for success."

Staff influenced by mainstream blame discourse

Staff are not impervious to the global discourse that positions the rural poor as the cause of environmental degradation. The following quote on causes of climate change, from the Kenyan Minister of Agriculture, exemplifies why KACP staff might blame participants.

> "[We have contributed] in every way…At independence 14% of our land mass was forest. Today that has come down to 1% …That tells you human activity and agricultural settlement have significantly destroyed our natural resources especially forests. Therefore if we say that we have

> not contributed to climate change we will not be telling the truth" (Otieno 2010).

Perhaps because of the benefits, such as funding for mitigation efforts, associated with being "guilty" of climate change, the Kenyan minister pays no attention to the amount of deforestation carried out during British rule, what portion of the post-independence deforestation was caused by non-agricultural activity, what types of agricultural development have caused deforestation, and which processes might have indirectly caused deforestation by forcing poor smallholders onto forested lands. Interestingly, the Kenyan government official, instead of pointing a finger at the industrialized world for their historical responsibility for GHG emissions, points a finger at his own people. Here, as Leach (1994) might argue, showcasing the need to change environmentally destructive behaviors at home is more likely to draw international aid and development funding than convincing the developed world of its climate debt or even attempting to articulate a more nuanced argument about responsibility for climate change.

Misinformation related to tree planting

In considering how to address the pervasive misinformation on the role of trees in rain cycles, we must consider whether the misinformation is knowingly or unknowingly perpetuated. Staff may knowingly perpetuate the misinformation because more trees planted means more carbon credits generated. Or, because of the likelihood that smallholders will cut down the trees once they reach a point of maximum financial profitability, if not before, potentially undermining the viability of the carbon credits generated, staff may knowingly lie about the value of the trees in order to avoid this issue.

At the same time, it is quite possible that the myth of trees is disseminated because staff understanding of the relationship between trees and rain is incomplete, possibly because of issues of scale and temporality. While for-

Photograph 2. Members of a women farmers group near Kisumu participating in KACP.

ested areas do tend to experience higher rates of rainfall than non-forested areas because of evapo-transpiration from tree leaves, the size of the farm that KACP targets makes it virtually impossible for tree-planting efforts to markedly impact rainfall patterns. The typical KACP farmer owns less than one hectare on which (s)he plants subsistence crops and maintains a homestead, in addition to possibly planting trees. Reasons for this potential disconnect warrant further attention.

Conclusion

Drawing on a long history of blaming the rural poor for environmental degradation, the Kenya Agricultural Carbon Project blames smallholders for causing climate change through deforestation. Reasons for why this narrative is reproduced likely relate to enrollment-goal pressures or because the project exists within a mainstream development complex founded on unquestioned blame as a justification for intervention. In this paper, I also question why misinformation on the ability of on-farm tree-planting to reverse climate impacts is disseminated, and in response, I consider whether the misinformation is reproduced for ulterior motives or whether project staff are confused about the scale at which trees operate within a hydrologic cycle. These possibilities warrant further attention.

Regardless of the reasons why KACP reproduces blame and misinformation, it is clear that the project, in terms of equity, could be improved if these issues were addressed. The analysis presented here focuses on a single case study, but the phenomenon of linking poor, rural populations to the carbon markets or mitigation projects generally, through land use, land use change, and forestry practices, is growing rapidly. Any such project that reinforces a blame discourse would be problematic, especially because the environment supposedly being degraded is supralocal. According to the discourse, while it might be bad for the poor to degrade their own environment, if they are degrading our shared environment, intervention would be unquestionably justified. Additionally, any project that spreads incorrect information might run the risk of project failure. If, for example, it becomes clear that the persistent efforts of KACP participants to reverse the impacts of climate change through planting trees does not produce the expected effect, widespread project abandonment could occur. Whether or not these problematic aspects of KACP could be rectified remains to be seen.

Endnotes

1. It should be noted that project rhetoric paid no attention to the possibility that the "changes in the climate" were not in fact related to global climate change but rather to climate variability, often multi-year in length, common throughout Africa. For more on this, see Hulme (2005) and Balling (2005).
2. Interview with "extension staff l". July 20, 2011.
3. Interview with "administrative staff g". August 3, 2011.
4. Interview with "extension staff d", July 4, 2011.

ACKNOWLEDGMENTS

The research upon which this article is based was made possible by the generous support of the Tropical Resources Institute, Carpenter Sperry Fund, Program in Agrarian Studies and the Jubitz Family Fund. I am grateful for the advice and support offered by Professor Michael Dove and Professor Amity Doolittle. Finally, I would like to acknowledge and thank all the farmers and KACP staff members who participated in the research.

REFERENCES

Balling, Jr., R. (2005). Interactions of Desertification and Climate in Africa, in *Climate Change and Africa*. Ed. Pak Sum Low. Cambridge University Press, New York.

Blaikie, P. (1985). The Political Economy of Soil Erosion in Developing Countries. Longman Inc, New York.

Broad, R. (1994). The Poor and the Environment: Friends or Foes?. World Development 22(6): 811-822.

CIA(Central Intelligence Agency). World Factbook: Economy: Kenya. CIA. https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html (December 16, 2011).

Duraiappah, A. K. (1998). Poverty and Environmental Degradation: A Review and Analysis of the Nexus. World Development 26(12): 2169-2179.

Fairhead, J. and Leach, M. (1996). Misreading the African Landscape: Society and Ecology in a Forest Savannah Mosaic. Cambridge University Press, Cambridge.

Ferguson, J. (1994). The Anti-Politics Machine: Development, Depoliticization, and Bureaucratic Power in Lesotho. University of Minnesota Press, Minneapolis.

Gray, L. C. and Moseley, W. (2005). A Geographical Perspective on Poverty–environment Interactions. Geographical Journal 171(1): 9-23.

Hardin, G. (1968). The tragedy of the commons. Science 162: 1243-1248

Hulme, M. Doherty, R., Ngara, T., et al. (2005). Global Warming and African Climate Change, in *Climate Change and Africa* (2005). Ed. Pak Sum Low. Cambridge University Press, New York.

Leach, M., and Fairhead, J. (1994). Natural Resource Management: The Reproduction and Use of Environmental Misinformation in Guinea's Forest-savanna Transition Zone. IDS Bulletin 25(2): 81-87.

Lele, S. M. (1991). Sustainable Development: A Critical Review. World Development 19(6): 607-621.

Malthus, T. R. (1798). An Essay on the Principle of Population, W.Pickering, London, 1986.

Moseley, W. G. (2001). African Evidence on the Relation of Poverty, Time Preference and the Environment. Ecological Economics 38(3): 317-326.

Murphree, M.W. (1993). Communal Land Wildlife Resources and Rural District Council Revenues. Centre for Applied Social Sciences (CASS), University of Zimbabwe, Harare.

Otieno, S., Pauker, E. and Maina, P. (2010). Kenya Talks Climate. BBC World Services Trust. http://africatalksclimate.com/research/kenya-talks-climate (December 16, 2011).

Pinstrup-Andersen, P., and Pandya-Lorch, R. (1995). Poverty, Food Security and the Environment. International Food Policy Research Institute: Washington, DC. http://www.ifpri.org/sites/default/files/publications/vb29.pdf (March 8, 2012).

Thompson, M., Warburton, M., and Hatley. T. (1986). Uncertainty on a Himalayan Scale: An Institutional Theory of Environmental Perception and a Strategic Framework for the Sustainable Development of the Himalaya. Ethnographica, London.

VCS (Voluntary Carbon Standard). (2010). Western Kenya Smallholder Agriculture Carbon Finance Project: Project Description Draft. Unpublished document.

WCED (World Commission On Environment And Development). (1987). Our Common Future. (G. H. Brundtland, Ed.) Oxford paperbacks (Vol. Report of, p. 400). Oxford University Press. Retrieved from http://www.un-documents.net/wced-ocf.htm

Wekesa, A. (2011). Keynote on KACP. Unpublished Powerpoint Presentation.

World Bank. (2009). Carbon Finance Document for Land Use, Land-Use Change and Forestry (LULUCF) Projects. Unpublished document.

Small Hydropower for Sustainable Energy Development in Northwestern Rural China

Jing Ma, MESc 2012

ABSTRACT

A comprehensive analysis of Small Hydro Power (SHP) projects in a rural area of northwestern China was performed to test the role of SHP over the past two decades. This research is important because China is the largest energy consumer in the world, and 70% of the nation's energy is produced from carbon-intensive coal, although efforts are being made to replace coal with renewable energy choices. This research focuses on rural areas in China that are facing great energy shortage challenges, and are attempting to shift their energy reliance to less carbon-intensive renewable energies. Small-scale hydropower such as micro, mini, and small hydropower is one of the most promising alternative energy sources to achieve sustainable growth in these regions. Thus, it is important to test whether the SHPs are operating efficiently in terms of economic and environmental costs and benefits and social impacts. This assessment was conducted in the Linxia Hui Autonomous Prefecture in Gansu, China, through a series of interviews with local officials, SHP engineers, operators, owners, local communities, and a survey to the local population. The results of the on-site study show that SHPs contribute significantly to the local electrification process, as the stable and affordable energy provided by SHPs is widely acknowledged by the local people. However, the impacts to local irrigation caused by SHP operations, and the expanding income gap between SHP owners and low-income households, have caused social tensions. The research results also raised policy recommendations to create incentives for SHP investments. A comprehensive assessment was also performed to analyze the development of SHP over the next two decades, as well as its possible role in China's energy future.

Introduction

China is the largest energy consumer in the world, and more than 71% of its energy is produced from coal, which is highly carbon intensive (US EIA 2009). The emerging economy in China is associated with growing energy consumption. With a rapid economic growth rate of approximately 9.5% of GDP per year, China will account for 39% of the increase in global energy demand by 2035, according to the 2010 World Energy Outlook (IEA 2010). The Chinese government is aiming to switch from this problematic energy system to more renewable energy alternatives in order to support the country's long-term development goals (Wen 2012). Currently, hydropower accounts for the largest percentage (6%) of the relatively small portion of China's renewable energy consumption mix (US EIA 2009).

China has abundant water energy resources, yet only 39% of the available resources have been exploited. The exploitable hydroelectric resources in China stand at a potential 378 million kilowatts, equivalent to an annual power supply of 1.92 trillion KW·h. This scale of hydropower is the largest in the world, making up 16.7% of the world's total potential hydroelectric production capacity,

Jing Ma is from Lanzhou, Gansu, China and graduated from F&ES with a Master of Environmental Science in 2012. She studied environmental policy and economics, focusing on energy issues and sustainable development in underdeveloped regions in China.

Photograph 1. The author conducting a household survey with a local resident in Yinji Town, Linxia County, China.

which is equivalent to 50.7 billion tons of standard coal (Fang 2010). Among these exploitable water resources, large hydropower plants bases account for 67% of the nation's total hydroelectric capacity (Yang 2007).

The development of large hydropower plants remains controversial worldwide because of environmental, social, and security impacts (Yang 2007). Large hydropower plants might have negative effects on the local vegetation cover, hydrology, and aquatic species. In China, the implementation of almost every large hydropower plant involves large numbers of resettlements and migrants leaving their homelands (Zhao 2012). Large projects may significantly increase the risks of natural disasters, such as droughts or seismic activity (Vermeer 2011). Large hydropower plants also have strict technical and financial requirements that demand national-level government sponsored prospecting.

A promising alternative to large hydropower in rural economically underdeveloped areas is small hydropower (SHP). In rural areas of China, approximately 76 million people remain without access to electricity (Yüksel 2007). By definition, small hydro is the development of hydroelectric power on a scale serving a small community or industrial plant. The definition of a small hydro project varies, but a generating capacity of up to 50 megawatts (MW) is generally accepted as the upper limit of what can be termed small hydro in China. SHP schemes are mainly "run of the river," with little or no reservoir and civil construction work, using the flow of water within the river's natural range of seasonal flow so that the plants are more favorable for ecosystems, fish and river water storage (Yüksel 2007).

Statistics show that by the end of 2006, China had 40,000 small hydropower stations of under 50 MW in capacity. Combined, they represent 40 million kW, or greater than two Three Gorges Stations[1] combined (Yang 2007).

Small hydropower plants are more flexible and less strict in technology requirements and much lower in construction costs. They usually do not require relocation of local people, and thus have fewer social impacts. Because small hydropower plants are usually approved by local authorities, there are fewer requirements for their inspections, with more effective and shorter processes, though their environmental impacts are often underestimated.

A considerable amount of research has been conducted on hydropower as a significant source of renewable energy in developing countries. Electricity demand in emerging economies is rising rapidly and hydropower is an important contributor to the future world energy portfolio in developing countries (Yüksel 2010). Under the clean development mechanism (CDM) of the United Nations Framework Convention on Climate Change (UNFCCC), SHP projects could be of interest because they offset greenhouse gases (GHGs) with lower costs as well as contributing to the development of more sustainable energy production (Purohit 2008). Small hydropower can provide a positive social and economic contribution to the community through job creation and improved quality of life by contributing to an assured supply of electricity. When properly designed, SHPs can also incorporate features to ensure that the overall life-supporting capacity of the river ecosystems is safeguarded (Yüksek 2006).

Small hydropower is considered to be one of the most important forms of renewable energy because it is a sustainable, efficient, clean, secure, and technically feasible resource. However, small hydropower also has a number of shortcomings. Compared with a conventional energy project, small hydropower projects are of such a small scale that they are often unable to obtain support and attention, such as regulatory approval and preferential loans, from local authorities. The often remote locations of SHP projects also adds to the cost of delivery. Without proper technology, electricity output is unstable due to seasonal factors. In such cases, the grid company will typically lack interest in SHP and may even take some measures to prevent it from entering the grid (Zhou 2009). In addition, although SHP technology is mature, most of the existing SHP plants are old, the operation and management is often not professional (especially in developing countries), and the operation cannot be optimized due to lack of technical capacity. Therefore, it is difficult to achieve the predicted and designed levels of electricity (Zhou 2009).

China's SHP is currently playing an important role in local rural energy generation. The total installed capacity of China's SHP ranks as the biggest in the world. However, the SHP resources are unevenly distributed, and the exploitation level also varies between regions (Zhou 2009). The demand for energy production in rural China has increased in recent decades with several problems and difficulties. Major problems include an imbalance in rural energy development between regions, insufficient investment in the development of rural energy, and excessive dependence on forests for rural energy consumption (Li 2005). As a solution to these problems, SHPs are developing rapidly as a clean way for electricity generation, as the benefits of SHPs are widely accepted (Hicks 2004).

Study Site and Methods

Over the summer, I researched the SHP projects in northwestern Linxia Hui Autonomous Prefecture in Gansu, China, where I examined the economic costs and benefits of the SHPs during construction and operation, the environmental assessment of the projects, their impacts to the local environment, and local communities' opinions on the changes brought by SHP development over the past two decades.

This study selected Linxia Hui Autonomous Prefecture as the case study site. The site was selected based on environmental, economic, and social perspectives. Linxia is in the

Gansu Province that lies between the Tibetan and Huangtu plateaus, where the ecosystem is vulnerable and facing serious water loss and soil erosion problems. The province has a diversified terrain of grasslands, highlands, mountains, and loess hills. Therefore, such sites require a more rigorous analysis of SHP projects due to their greater vulnerability to human disturbance.

The other important factor is the Yellow River, the second longest in the country, which passes through the southern part of the province and gets its muddy yellow color from the loess in the river course. The prefecture is on the river course and has relatively abundant water resources that can be utilized and suitable for small hydropower projects. The use of the water resources in the region also require careful design and planning due the potential for large ecological impacts on the important upper stretches of the Yellow River.

I worked closely with the Department of Water Resources and Electric Power in Linxia County, the People's Government of Linxia Prefecture, and the villagers' committee of towns that are closely connected to SHPs in order to identify contacts in six local government areas that are supported by the electricity generated by SHPs. The SHPs are most densely distributed around the six towns where the research is conducted. To obtain more detailed information on energy consumption and SHP local impacts, 200 surveys were conducted in the study site by 4 researchers. The research included interviews with officials of the Government of Linxia Prefecture, engineers and experts of the Department of Water Resources and Electric Power in Linxia County, owners and operators of the SHPs, doctors in the local community hospital, local community religious leaders, and households.

Findings

Energy Structure Changes

More than 70% of the energy in Linxia Prefecture is generated from coal or firewood. Before SHPs were employed in many parts of the rural areas in the region, local people were mostly using very small-scale coal stoves for household energy demands. These old-style stoves are very energy inefficient and carbon intensive, and they are also unsafe and unstable when the coals are not sufficiently burnt. Local people without access to coals often cut down trees in nearby woods to burn for daily use. Forest degradation exists as a serious problem in the region, and the excessive use of firewood could highly affect the local land cover and local ecosystem. Thus, efficient and clean alternative energy resources might provide a mechanism to slow down forest degradation and protect remaining ecosystems. By utilizing the abundant water resources in the region, the power generation by the existing 21 small hydropower plants appears to be one of the most promising solutions.

By a comparison of the energy consumption structure before and after SHPs implementation in the year 2001, we can see a significant change in the pattern of energy use during the past two decades (Figure 1). Before SHPs implementation (2001), 51 households (27.7%) stated that they use electricity as one of the major sources of their daily energy consumption, while after SHPs implementation (2010), 106 of them said so (57.6%). This significant change in energy consumption patterns is partly influenced by the rural electrification process in Linxia.

Economic Status Improvement

Despite recent growth in Gansu and the booming economy in the rest of China, Gansu is still considered to be one of the poorest provinces in China. Its nominal GDP for 2009 was about 338.2 billion RMB (49.5 billion USD) and GDP per capita was only 12,836 RMB (1,879 USD), which is below the national average. Linxia also has lower income and GDP per capita than the Gansu province's average

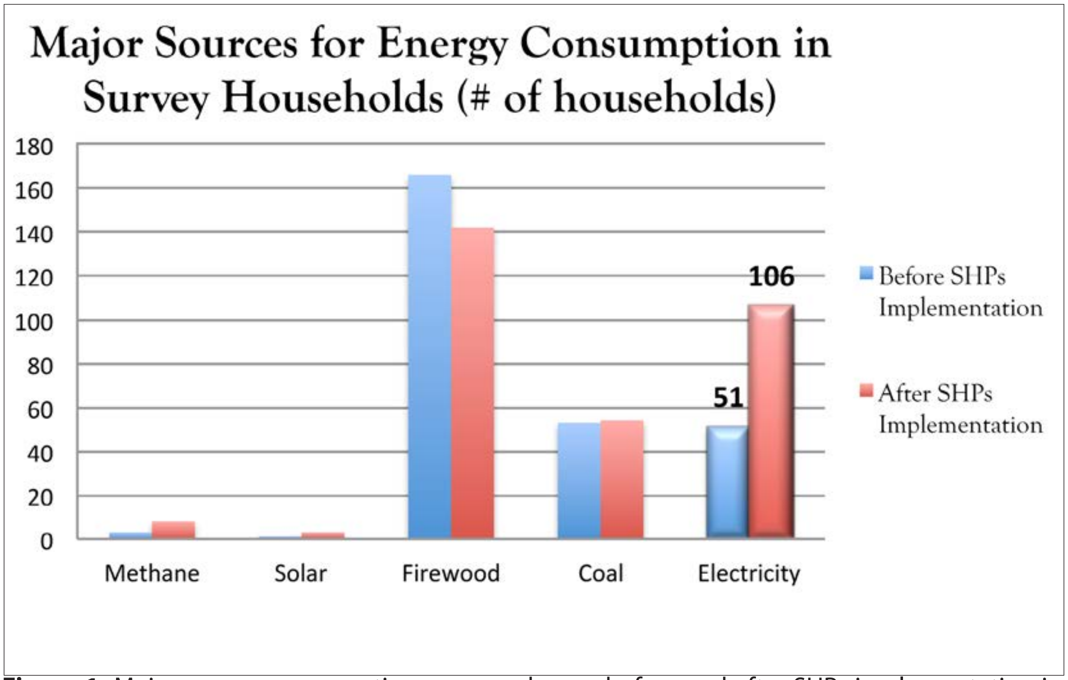
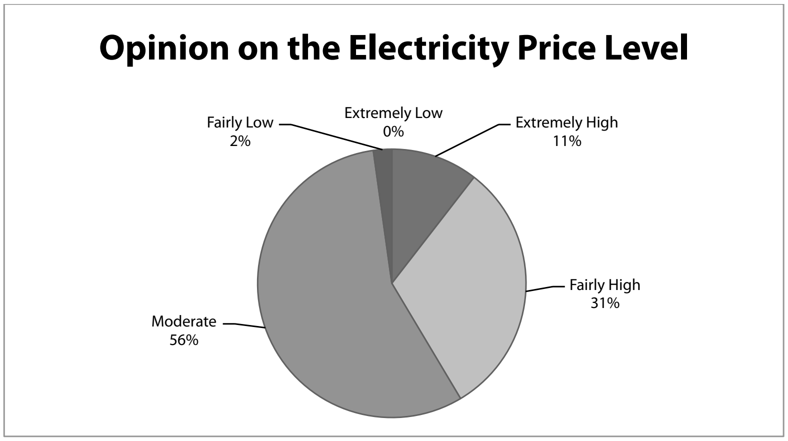


Figure 1. Major energy consumption sources change before and after SHPs implementation in year 2001 from survey results.

level. In this case, the alternative energy options have to be both renewable and, more importantly, affordable. The SHP projects are effectively providing renewable and low cost energy, thus solving the problem of energy shortages in the remote regions. Before SHPs were adopted, the electricity supply was not abundant in the region and the energy access was not stable. The most important economic benefit from SHPs is stable and low-cost electricity. The ownership of the SHPs has gradually changed from state-owned to private since 1991, which is very rare in inland underdeveloped China. These SHPs do not only provide their owners who are often local wealthy investors with comfortable profits, but they also pay the local government significant tax revenue. Even though these effects could not be directly measured, two aspects of the survey still show the positive impacts from SHPs for local economic improvement (Figure 2). The answers show that more than 75% of the respondents are able to afford the electricity expenditure, and most of them (more than 50%) feel the electricity price level is moderate.

Problem: Low tariff to the grid: low return on investment

With the extension of the large power grid by the central government of China since 2001, more SHP plants will be connected to the grid to compete with other types of energy. Though SHP accounts for a large portion of the renewable energy in rural China, its role as an energy supply source remains weak. Due to the abundance and low cost of coal (without incorporating the social externality), coal consumption still dominates China's electricity supply. In this case, SHP is not competitive with fossil fuels. In the study site in 2011, the average grid tariff is ￥0.231/kWh (i.e. $0.036/kWh), whereas the average tariffs for electricity from fossil generation are ￥0.36/kWh ($0.053/kWh), and the average tariffs from SHP are ￥0.27/kWh ($0.042/kWh) (Zhou 2009). This low feed-in tariff makes the economic return of SHP much less attractive. The current payback period of SHPs in Linxia is over 10 years, while the internal rate of return is often below or around 10%.



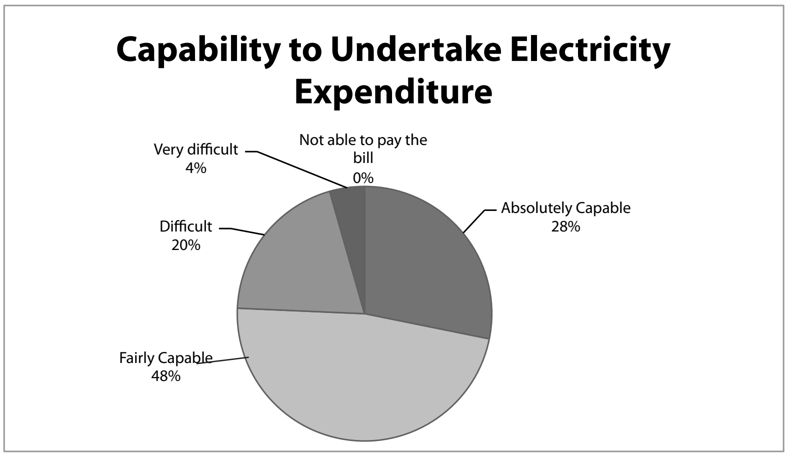


Figure 2. Respondents' capability of undertaking electricity expenditure and opinions on electricity price level from survey results.

Conclusions

China is facing significant energy demand challenges because of its rapid social and economic development in the foreseeable future. With abundant water resources and a large low-income rural population, SHP is one of the most reliable and cost-effective renewable energy sources with economic, environmental, and social advantages. Though the SHP potential seems to be promising, policy structure for its further development is vague, and institutional design for the electricity grid fails to incorporate social cost into the system.

It is almost certain that the exploitation cost of SHP will gradually increase due to the decrease of available hydro energy resources. Therefore, it is essential to carry out carefully designed policy supports to SHP that incorporate externalities in the market price to increase its economic viability and compete with other energy sources. This requires a long-term energy planning strategy that could sustain the market incentives with a stable return to investments.

Endnotes

1. Three Gorges Station is the world's largest power station in terms of generation capacity (22,500 MW).
2. Only 185 of these surveys were considered valid because 15 households misunderstood some of the questions; therefore, these questionnaires were discarded from analysis.

ACKNOWLEDGMENTS

I would like to thank my advisor Prof. Rob Bailis and Amity Doolittle for advising this study, and TRI Bulletin editors for their helpful comments on my drafts. I would also like to thank Yale Tropical Resources Institute (TRI) and F&ES Globalization Research Fund for the financial support to this study. I also greatly appreciate the support from local officials in Linxia County during my visit and the friendly people there!

REFERENCES

Energy Information Administration, U.S. E.I.A. (2009). China Energy Data, Statistics and Analysis – Oil, Gas, Electricity, Coal (pp. 13).

Fang Y., Wang M., Deng W., and Xu K. (2010) Exploitation Scale of Hydropower Based on Instream Flow Requirements: A Case from Southwest China. Renewable and Sustainable Energy Reviews 14: 2290-2297.

Hicks, C. (2004). Small Hydropower in China: A New Record in World Hydropower Development. Refocus 5(6): 36-40.

International Energy Agency, I.E.A. (2010). World Energy Outlook 2010 Executive Summary.

Li, Z., Tang, R., Xia, C., Luo, H., and Zhong, H. (2005). Towards Green Rural Energy in Yunnan, China. Renewable Energy 30(2): 99-108.

Lin, S., and Zhu, X. (2007). Private Enterprises and China's Economic Development. Psychology Press.

Liu, Y., Ye, L., Benoit, I., Liu, X., Cheng, Y., Morel, G., and Fu, C. (2003). Economic Performance Evaluation Method for Hydroelectric Generating Units. Energy Conversion and Management 44(6): 797-808.

Purohit, P. (2008). Small Hydropower Projects under Clean Development Mechanism in India: A Preliminary Assessment. Energy Policy 36(6): 2000-2015.

Vermeer, E.B. (2011). The Benefits and Costs of China's Hydropower: Development or Slowdown? China Information 25:3-32.

Wen, J. (2012). Speech at the World Future Energy Summit in Abu Dhabi, sourced from Xinhua News Agency. Retrieved Apr 29, 2012, http://www.gov.cn/ldhd/2012-01/16/content_2045746.htm

Yang, J. (2007). Hydropower: A Viable Solution for China's Energy Future? Retrieved Apr 29, 2012, http://www.energychinaforum.com/new/show.asp?id=1516&sort=4

Yüksek, Ö., and Kaygusuz, K. (2006). Small Hydropower Plants as a New and Renewable Energy Source. Energy Sources Part B: Economics, Planning & Policy 1(3): 279-290.

Yüksel, I. (2007). Development of Hydropower: A Case Study in Developing Countries. Energy Sources, Part B 2:113–121.

Yüksel, I. (2010). Hydropower for Sustainable Water and Energy Development. Renewable and Sustainable Energy Reviews 14(1): 462-469.

Zhao X., Lu L., Xiaomeng L., Jieyu W., and Pingkuo L. (2012). A Critical-analysis on the Development of China Hydropower. Renewable Energy 44:1-6.

Zhou, S., Zhang, X., & Liu, J. (2009). The Trend of Small Hydropower Development in China. Renewable Energy 34(4): 1078-1083.

Opportunity Analysis of Payment for Ecosystem Services: Policy Design and Implementation for Coffee Agroforestry Systems in Costa Rica

Paulo Barreiro Sanjines

Abstract

Incentive-based mechanisms, such as Payments for Ecosystem Services (PES), are widely used in the rural tropics to guide ecosystem restoration and conservation actions. The Costa Rican government developed a national PES scheme in 1996 to work towards forest restoration and conservation. In order to increase small landowner participation, a coffee agroforestry PES scheme was implemented. Nevertheless, a lack of institutional capacity and funding has made it ineffective in regions where it is most needed. A policy sciences problem-oriented framework is used to appraise a proposed coffee PES program's ability to meet the environmental and socio-economic needs of target populations. Results from the surveyed population show that 60% of coffee farmers are ready and willing to participate in the proposed program. Local institutional capacity has aided in developing environmental stewardship and promoted readiness towards sustainable practices. The final recommendations from the study shed light on new avenues to design PES-like schemes that will foster environmental stewardship, ecosystem service provision, and collaboration among stakeholders. Only through collaborative management and the development of strong support networks will coffee farmers and other small-scale agricultural landowners be effectively engaged in these mechanisms.

Introduction

Payment for Ecosystem Services (PES) is an environmental market-based policy tool (Asquith and Wunder 2008, Pagiola 2005), based on a voluntary and conditional agreement between the provider and the beneficiary of a well-defined ecosystem service (Wunder 2005). This policy tool is widely used in rural and agricultural settings of Latin American countries to assist landowners in their efforts to secure the provision of ecosystem services (Asquith and Wunder 2008, Seehusen and Guede 2011, 2010, Porras 2010). As ecosystem markets become more complex and competitive, and climate change increases agricultural yield instability, demand for PES increases. Research methods and reputable information sources are needed that are capable of informing decision-makers in a comprehensive and dependable manner (Kandji et al. 2008, Ghazhoul 2007, McAfee and Shapiro 2010, Lasswell 1950, 1956). New policy designs must be politically rational, practical, and sustainable.

Costa Rica is the first Latin American country to acknowledge the benefits and services the forest provides through the implementation of its Forest Law 7575 enacted in

Paulo Barreiro Sanjines is from Bolivia. At Yale F&ES, he focused on policy analysis and design of market-based mechanisms and tools to further access to rural sustainable livelihoods. Prior to Yale, he worked as the director of the Integral Management Protected Area (ANMI) Rio Grande-Valles Cruceños, which pioneered the implementation of municipal Payment for Ecosystem Services (PES) schemes. He is currently working in eastern Bahia, Brazil with Instituto Floresta Viva to develop rural PES projects focusing on water and carbon markets.

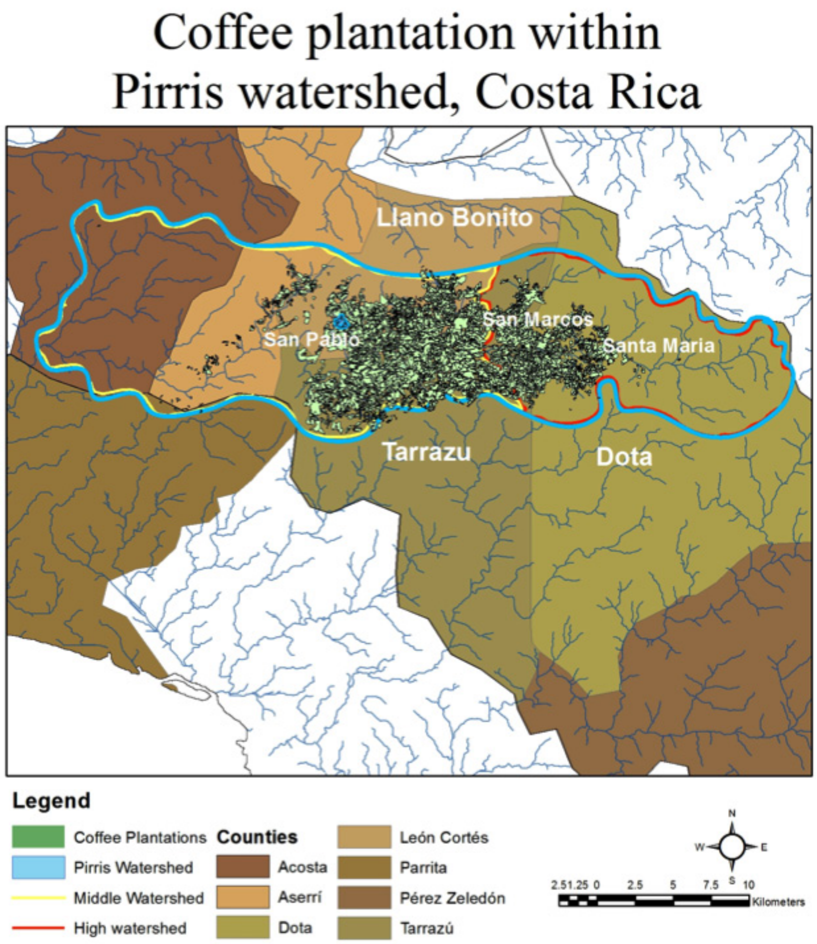


Figure 1. Map of the Pirris Watershed area (in light blue), with the division between high and middle watershed (red and yellow respectively), with the location of all coffee plantations (in green) (ICAFE, 2011).

1996. The country has developed a payment mechanism to compensate landowners for the protection and maintenance of four distinct services: biodiversity, carbon sequestration, scenic beauty, and water provision (MINAE 1996, MINAE 1997). PES funds are administered by the National Fund for Forest Finance (Fondo Nacional de Financiamiento Forestal, FONAFIFO) to pay small and medium landowners who practice sustainable forest management (MINAE 1996, FONAFIFO 2011).

Because of its high forest cover, shade-grown coffee supports a wide range of important ecosystem functions such as soil resilience, wildlife habitat, and hydrological stabilization (Polzot 2004, de Melo and Abarca 2008). From 2001 to 2008, a total of 3,898 hectares per year of Costa Rican coffee plantations were converted into pineapple farms, pastures, or urban development enterprises. A consortium formed by the Tropical Agricultural Research and Higher Education Center (CATIE), the Guanacaste and Montes de Oro Coffee Cooperatives (COOCAFE), and the Ministry of Agriculture (MAG) recommended a PES program for shade-grown coffee (de Melo et al. 2010). This recommendation is an effort to conserve the forest cover within areas of shade coffee cultivation and the provision of ecosystem services therein.

PES policy practitioners and decision-makers need tools that allow them to understand and participate in the process (Clark 2011). This study evaluates the adequacy of the proposed PES category by using the policy sciences as a framework to analyze data gathered in the field. The framework allows an analysis of participant interactions, shared values and goals, challenges of implementation, and ultimately to recommend alternative actions that influence policy effectiveness in a rational, practical, and justifiable manner (Lasswell and McDougal 1992, Clark 2011).

Methods and Materials

Site Description

My study was conducted in the mountainous valley of Los Santos within the Pirris watershed, located in the south central region of Costa Rica. The region is composed of the districts of Tarrazú, Dota, and León Cortés Castro all in the province of San José (See Figure 1).

This region was chosen because of its high density of small-scale coffee plantations (42% of the coffee plantations are 1-10 hectares in size) and its potential for PES, particularly carbon sequestration, hydrological stabilization, scenic beauty, and biodiversity. Los Santos has a total of 9,970 hectares of coffee plantations that extend across 44 different communities, representing 16.7% of the 59,746 hectares of the Pirris watershed (ICAFE and INEC 2007, Melendez and Quesada 2010).

The Pirris watershed varies in elevation from 1,000 to 2,000 meters above sea level. Coffee production occurs in two distinct elevations, comprising the (1) higher and (2) medium watersheds (Figure 1) (Meléndez and Quesada 2010). All altitudes in the watershed share clay soils prone to erosion. The irregular and steep topography of the region increases this risk. Landslides of mud and rock are observed along the road from Santa María to Providencia, Dota. Most soils in this region are Entisols, Andisols, or Inceptisols, distributed from the flood plain to the mountaintops (Melendez and Quesada 2010).

Sampling Design

First, I interviewed key informants of the primary institutions involved in the development of the coffee PES program (CATIE, COOCAFE, Ministry of Agriculture) (Briggs 1997). Based on the initial interviews, I conducted snowball sampling of additional groups and individuals (Waldorf and Biernacki 1981). I conducted a total of 15 interviews in 13 different organizations, which included governmental institutions, the private sector, and NGOs working at various locations in the shade-grown coffee production chain.

Next, I documented the interviewees' responses regarding their willingness to participate in the program, expectations, and challenges faced in implementation. In addition, I administered a total of 159 semi-structured surveys to smallholders within the watershed (Rubin and Babbie 2010, Fowler 1995). These surveys focused on the farmer's shade-coffee practices, costs involved and revenue generated over the last year, support networks, and preference among policy options.[1]

Finally, I conducted Focal Discussion Groups (FDGs) with seven farmers from each cooperative who had participated in Earthwatch "Leadership & Sustainable Farming" workshops. Based on their participation in the Earthwatch workshops, all participants were assumed to have an understanding of how agroforestry systems affected their coffee production. However, all participants were assumed to have no prior knowledge of the PES concept or the national PES law (Negri and Thomas 2003).

Results

I began my interview with the CATIE and MAG representatives, Dr. Elias de Melo and Sergio Abarca, by asking them about their vision with this policy. Dr. de Melo, researcher at CATIE, and co-leader of the PES coffee policy consortium, stated, "we believe that all productive sectors must assume responsibility for sustainable production…instead of strengthening intensive agricultural systems with high environmental impact and low social value, we must recognize and support integrated projects, [and be] mindful of the national goal towards sustainable development." The overarching goal of the consortium is to promote sustainable development in agricultural practices nationally.

On average, coffee farmers in the Los Santos region have been producing shade-grown coffee for 22 years. The households cultivate an average of seven hectares, with an average density of 150 trees per hectare. The preferred shade trees include *poró* (*Erythrina poeppigiana*), and avocados (*Persea americana*) (92%). All other planted trees vary greatly among farmers, often chosen for aesthetic purposes. All farmers surveyed use fertilizers and pesticides to treat pests and increase soil fertility. The farmers often obtain these agricultural inputs from local cooperatives, in addition to discretionary financing. The coffee cooperatives at Dota, Tarrazú, and Llano Bonito provide technical assistance to 75% of the surveyed population, while receiving an average of 29 *fanegas*[2] per hectare from each farmer annually. Of the 159 households surveyed, only 10 (6.2%) knew of FONAFIFO, had participated in PES, or were currently receiving payments for their contracts. The lobbying consortium formed by three representatives of CATIE, MAG, and COOCAFE was interested in the results of this study in order to shape the proposed coffee PES policy.

During a focal discussion group in Tarrazú, one farmer shared that. "one day if coffee production starts to decrease...we will all suffer. Most of the households that work with coffee, only work with coffee." Survey results show that 57% of all respondents obtain all their income from coffee farming (Table 1). This is a common concern raised at meetings of the executive board of the National Forest Office (ONF). Ignacio Fernández, executive board representative of the small and medium landowners at ONF, stated, "we [who work with PES] have failed to follow up with the farmer[s]. If our aim is to deliver benefits through the AFS [agroforestry systems] category, we must first

Table 1. Survey results, averaged to provide the context for coffee farming households in Tarrazu, Dota and Leon Cortez counties. Note: One *fanega* is equal to 46 kilograms of golden coffee beans.

		Averages from households
Family Size		4
Number of years in school	6 years	74%
	12 years	15%
	16 years	11%
Population economically dependent on coffee production (%)		57%
Receives technical assistance in their field (%)		75%
Production		29 *fanegas**
Years working with shade-grown coffee farming		22 years
Farm size (ha)		7 Ha
Tree density in the farm		150 trees/Ha
Number of tree species in the coffee farm	1 to 3	92%
	4 to 6	8%

understand what the farmer needs." Fernández emphasized that, as a representative of the small and medium landowners, he was very interested in the coffee PES scheme.

Agroforestry coffee systems

All farmers who participated in the surveys and the focal discussion groups stated they plant their coffee under the shade of other trees. Our conversations shed light on how farmers who practiced agroforestry perceived themselves in terms of environmental stewardship. At one workshop, a farmer stated that, "we alter the forest through the planting of fruit trees, shade trees, and trees on the edge of our farms. We aim to control factors that could affect the productivity of the coffee farm. In short, the coffee farm is an optimum site to manage micro-climates and maintain a comfortable temperature, serving as a habitat for animals, plants, and insects." Another farmer also communicated his concerns regarding climate instability and the desire to increase the amount of coffee grown under shade, expressing that "we have small farms that can easily be affected by an increase in shade. If shade is not properly managed, we can suffer from too much humidity, increase risk with pests and decrease in production. It would take extensive technical assistance to work without any complications in our production." From the survey, farmers in the region reported that they continue to work with shade because it provides a stable and healthy environment for the plant (48%), increases organic matter and nutrients to the soil (22.5%), and helps prevent diseases (12.5%) (Table 2).

Table 2. All responses were previously coded into six groups, and then calculated (n = 159).

Question: *Why do you work with shade in your coffee plantation?*	
Responses	**Percent**
Provides a stable and healthy environment for the coffee plant	48%
Increases organic matter & nutrients	22.5%
Helps prevent disease	12.5%
It saves you money on chemicals	5%
Improves production	4%
It is easier to manage	1%
No Response	6%

From his perspective of working with shade-grown coffee plantations, the coordinator of the Environmental Services division of FONAFIFO, Oscar Sánchez, responded that the intention is not to convert coffee farms to forests. Instead, FONAFIFO looks to CATIE and ICAFE for technical advice on the optimal amount of shade to use when growing coffee to ensure that PES does not affect the productivity of the coffee farmers.

When discussing this same issue, Dr. de Melo, also the CATIE-CAFNET-CIRAD project coordinator in Central America, and founding member of the Coffee PES consortium, stated, "…we are mindful that a critical element in coffee AFS is the amount of shade. CATIE has decades of experience working with these systems, and knows that an adequate harvest requires the maintenance of the balance of resources in terms of costs." To support and further clarify the goals and means of the consortium in implementing this program, the representative of the Ministry of Agriculture and founding member of the consortium for the Coffee PES proposal, Sergio Abarca acknowledged that, "due to its complexity, agronomists must work in AFS with an integrative and holistic perspective. We cannot desegregate its components to study the tree, or the crop, as a unit. These complex interactions are not considered in forest systems. The consortium seeks to evolve the current PES from a forest management focus towards an ecosystem management that takes into consideration the tree-crop interactions and the effect of the environment in the production of both goods and ecosystem services."

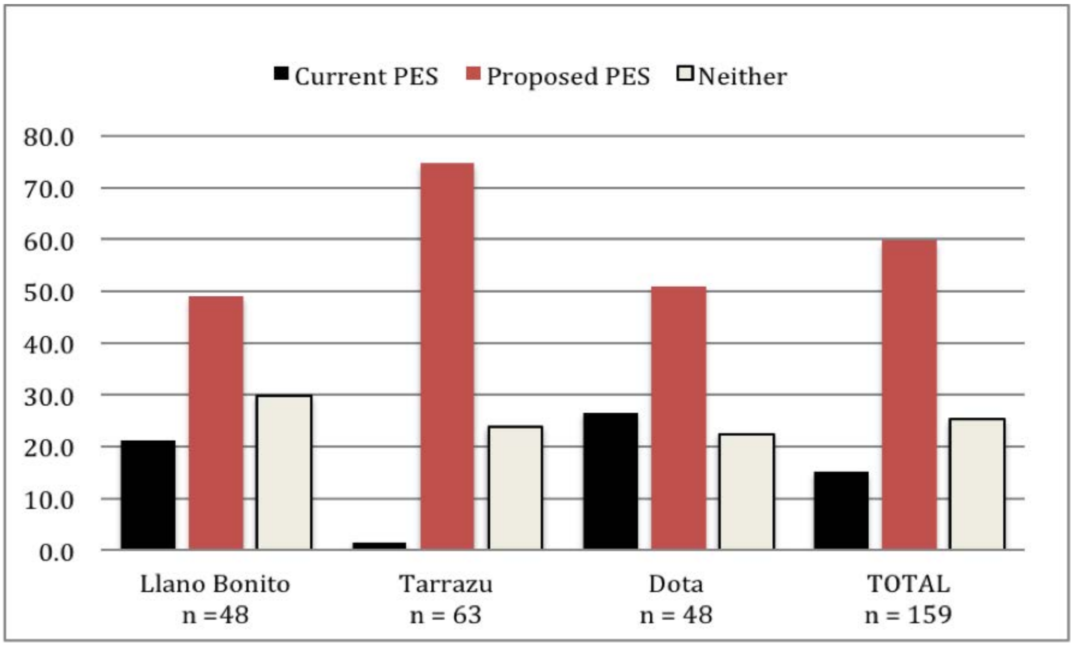


Figure 2. Survey results of PES Policy preferences in percentages by district and region.

An analysis of the social process of the actors under the proposed policy was performed based on the interviews. The resulting common goals and shared values identified for all participants are shown in Table 3, which will be used to analyze the policy process.

Policy process: Thoughts and demands

The decision process model is used to analyze the responses elicited from institutional interviews and coffee farmer surveys. Since coffee farmers had not participated in the proposed PES program at the time of the survey, this study is interested in their perceptions regarding the proposed PES policy (Figure 2 and Table 4) (Lasswell 1956).

Table 3. Common goals and shared values identified for the proposed PES policy mechanism using a problem-oriented approach.

Shared Values	Common Goals
Democratic leadership	Foster effective sustainable land use, and forest conservation
Well-being for partners and community members	Become a key player in the global ecosystem markets arena
Skill in natural resource management	Foster outcomes that integrate the diverse perspectives and skillsets of all relevant stakeholders
Respect freedom of choice and equality	

Survey results reveal that only 15% of the coffee farmers are interested in participating in the current PES. This result was discussed with Fernández from the ONF who opined that small and medium landowners do not have adequate technical support to participate in the program from, for example, "agronomists, and not forest engineers" to assist coffee farmers fill out requisite forms to FONAFIFO. Indeed, coffee farmers who were willing to participate in the proposed PES (59%) stated that their main concerns were the difficulty of managing the shade of free-growing trees (32%) and the likelihood of having a decrease in the coffee production due to excess shade (11%). This concern was present even though 75% of farmers said they received technical assistance in their farms (Table 1).

Analysis of the current PES policy framework and its decision process can shed light on the potential weaknesses and opportunities to consider prior to the prescription and implementation of the proposed PES. Specialized structures of the policy framework can be described through their functions (Lasswell

1956) and evaluated based on the common goals identified in the previous section, and established standards and criteria widely used in policy sciences (Clark 2011, Lasswell 1971). Three weaknesses identified include:

1. The rules and guidelines are not inclusive or prospective.
2. A positivistic and multidisciplinary approach is overemphasized.
3. The current system is not timely nor constructive.

Table 4. Summary of open-ended responses made by coffee farmers willing to participate in the proposed policy (n =95).

Summary of perceived strengths	%	Summary of perceived shortcomings	%
Freedom to manage tree shade	40	Free growing trees, difficult to manage	32
Stabilizes production, protects the soil	20	Decrease coffee production	11
Farm is ready to participate	15	Needs property title to participate	5
Biodiversity conservation	5	Not enough land to participate	5
Payment is fair, it would cover the costs	5	Policy does not work with avocado	14
Greater flexibility to participate as a small farmer	15	No Response	33

Finally, I weigh the compiled information and analysis to define a central problem that will be discussed in the following section. The problem is identified as: “the current system is positivistic and lacks integration of skillsets across participant stakeholders.” (Figure 3)

Discussion and policy implications

Problem orientation is a guiding framework that serves to clarify the goals of a group engaged in a policy process or program, describe the key events that guide the group towards their goals, analyze the factors, relationships, and conditions that create these trends, and describe project scenarios that would likely occur as the events, social process, and decision process proceed. Finally, one should evaluate whether these trends are moving towards the common stated goals (Clark 2011, Lasswell 1971, Lasswell 1956). The problem-oriented appraisal used in this study aims to provide an insightful reflection of the opportunities and weaknesses found in the existing and proposed PES policy.

Policy design must be practical and context-based; include social, biophysical and financial considerations; and clarify goals and responsibilities for all involved stakeholders (Lasswell 1956, Zbinden and Lee 2004, Clark, 2011). Results denote an overarching goal of well-

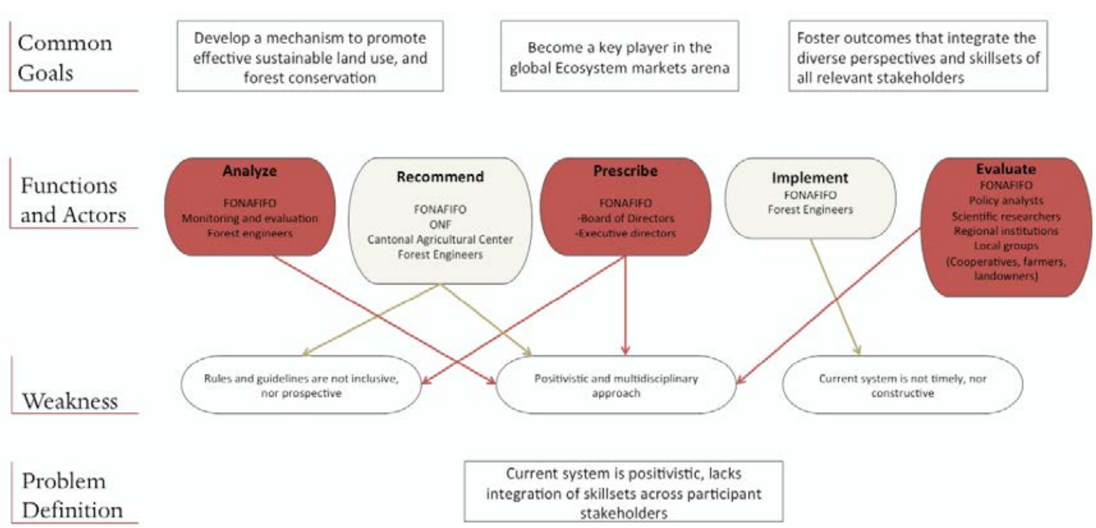


Figure 3. Evaluation of policy functions for the current PES based on the identified common goals.

being and democracy for landowners participating in the proposed policy and stakeholders responsible for its prescription and implementation. Three distinct but common goals emerge:

1. Develop a policy mechanism that effectively promotes sustainable land use and forest conservation.
2. Become a key player in the evolving ecosystem markets arena (i.e. watershed, biodiversity, and carbon markets).
3. Foster outcomes that integrate the diverse perspectives and skillsets of all relevant stakeholders.

These common goals are shared by other PES programs, and countries that are designing, or currently have in place, PES programs and incentive schemes (Shapiro 2010, Ghazoul 2007, Asquith and Wunder 2008). The Brazilian "Bolsa Floresta" program is an example of a program sharing these goals. Based on the Costa Rican experience, Bolsa Floresta has successfully engaged indigenous communities in conserving their forest in return for compensation and capacity building (Viana 2008). Current developments point to the institution of a state level PES policy that aims to increase the scope of compensation while providing clear monitoring and valuation mechanisms that add competitiveness on the global market for ecosystem services (Amazonas 2011).

In the case of Costa Rica, these goals have potential hurdles to overcome. I recommend the following alternatives be considered when the PES policy is designed:

Strengthen partnership and cooperation locally, nationally, and internationally

a. Geographically strategic partners would build awareness about the law to a wider range of groups. This would make implementation more inclusive and aware of context and expectations.
b. Furthermore, information gathered in this manner can further prepare the institution to comply with requirements to participate in international ecosystem services markets.

Collaborative management, including technical assistance programs, strong institutional interplay, and civil society participation would facilitate the positive reception of PES policy at the rural level (Calle et al. 2009, Corbera et al. 2009). Such framing can be achieved through understanding how farmers value ecosystem service maintenance and social capital (Calle et al. 2009, Ghazoul 2007). Designing and developing ecosystem service valuation studies with the coffee farmers, and allowing them to pursue alternative routes of compensation can fulfill this objective. This has been proven successful in some Latin American countries (Asquith and Wunder 2008, Shapiro 2010).

This may be achieved through the design of problem-oriented PES forum debates with coffee farmers to gather contextual information and obtain comprehensive recommendations that further PES policy functions and outcomes.

Promote holistic institutional learning

a. The complexity of the system requires both social and biophysical expertise. An interdisciplinary framework must be instituted under the new policy.
b. An interdisciplinary guide should be tailored to address the weakness of the decision-making process.

Securing ecosystem service provision through the implementation of PES programs calls for an interdisciplinary methodology that delivers comprehensive and innovative knowledge (Ghazoul 2007, Shapiro 2010, Asquith and Wunder 2008). Concerns expressed by institutional actors and coffee farmers show that current implementation lacks the participation of suitable actors. In addition, fair payment for ecosystem services and well-established markets require skills and expertise outside the scope of forest engineers or agronomists. Effective and constructive application of the law must be appraised and carried out by appropriate agents (Clark 2000, Lasswell 1956). Finally, stronger institutional interplay and participation of civil society can be achieved through recognition and knowledge of the base values and common goals shared amongst stakeholder groups (Lasswell 1956, Clark 2011). The road to this objective entails learning how to develop a holistic working framework for PES practitioners, both in the field and within institutions. A first step towards this could be the creation of positions tailored for professionals with working knowledge of interdisciplinary methods of research and analysis, along with a more broad set of practical skills.

Conclusion

Given the great array of perspectives and values each individual actor provides to the PES policy process, decisions and actions are made under uneven conditions. The lobbying consortium is unified in their goal to foster integrated production projects with agroforestry coffee systems at the national level. While coffee farmers are eager to participate, they are concerned about long-term impacts of these practices in their levels of production. A lack of comprehensive analysis of all four ecosystem services—biodiversity, carbon sequestration, scenic beauty, and water provision—could lead to the passage of laws that restrict FONAFIFO's ability to effectively work under the full scope of values within its legal framework and adequately respond to the needs and concerns of PES participants. The potential benefits from concerted collaboration between institutions and professionals must be well examined and discussed when designing proposed PES.

As a whole, the participants interviewed seek to foster sustainable land use and forest conservation through implementation of adequate programs for shade coffee farmers. Monitoring and evaluation of the programs must be achieved through an interdisciplinary approach that integrates social, economical and biophysical considerations. This design will increase the institution's ability to participate in global ecosystem service markets. Furthermore, working within an interdisciplinary structure will define clear entry points for apt professionals to collaborate with complex systems such as agroforestry coffee plantations.

Endnotes

1. I asked farmers to choose among three policy options: National PES Agroforestry (A), Proposed PES Coffee (B), or No PES (C). Each option had a card with an explanatory drawing and text explaining the requirements and contract details of each policy. All of this was verbally explained to the farmer before they made the choice.
2. One fanega is equal to 46 kilograms of golden coffee beans.

Acknowledgments

This work could not have been possible without the support and guidance of Dr. Elias de Melo from the CATIE; Carlos Jones from the COOCAFE; Sergio Abarca from the Ministry of Agriculture; and Oscar Sanchez Chavez, from the FONAFIFO. Their insights and recommendations were essential to my work. Furthermore, I would like to thank all of the wonderful organizations and individuals who also supported me in Costa Rica, including Earthwatch, Coffee Cooperatives from Dota, Llano Bonito, and Tarrazú, Bandera Ecológica, the Communication and Electricity Institute (ICE), all the members of my field team, to all the coffee farmers I surveyed and interviewed, and to all other friendly and encouraging support I found in Costa Rica. A special thank you to Helga Rodriguez, for her hospitality and continuous support.

Here in F&ES, I would like to thank my advisor, Dr. Susan Clark, for her patient guidance through the fascinating world of policy science. Many thanks aas well to my colleagues and friends at TRI, and others commenting on the presentation of my work. I trust that their insightful remarks and comments are reflected here.

References

Abarca, S., De Melo Virginio, E., Cabrera. J.. 2010. *Propuesta De Psa En Saf Café: Ampliando Prácticas Sostenibles Como Contribución a Alternativas De Cambios Globales*: INTA, CATIE, independiente.

Amazonas, Governo do Estado do. 2011. "Amazonas State Policy for Ecosystem Services and System of Ecosystem Service Management." *Project Law*. Ed. Amazonas, Governo de.

Asquith, N., and Wunder, S. 2008. *Payment for Watershed Services: The Bellagio Conversations*. Santa Cruz de la Sierra: Fundacion Natura Bolivia.

Briggs, C.L. 1997. *Learning How to Ask: A Sociolinguistic Appraisal of the Role of the Interview in Social Science Research*. Cambridge, UK: Cambridge University Press.

Calle, A., Montagnini, F., Zuluaga. A.F.. 2009. "Farmer's Perceptions of Silvopastoral System Promotion in Quindio, Colombia." *Bois et forêts des tropiques* 300(2).

Castro, R., Villanueva. A. 2008. "Mas De 30 Años De Exto En Pago Por Servicios Ambientales (Psa)." *Politicas De Recursos Naturales En Centroamerica: Lecciones, Posiciones Y Experiencias Para El Cambio*.

CATIE. 2009. *Sistemas Agroforestales Como Herramienta Para Recuperación De Paisajes Degradados En El Ámbito De La Concertación Interinstitucional Para El Desarrollo Sostenible*. Encontro Paulista de Biodiversidade. Centro Agronómico Tropical de Investigación y Enseñanza - CATIE.

Clark, T.W., Mazur, N., Cork, S.J., Dovers, S., Harding, R. 2000. "Koala Conservation Policy Process: Appraisal and Recommendation." *Conservation Biology* 14.3: 681-90.

Clark, T.W. 2011. *The Policy Process a Practical Guide or Natural Resource Professionals*. New Haven and London: Yale University.

COOCAFE, CATIE, ICAFE. 2010. *Seminario Taller Sobre Impacto Del Cambio Climatico En La Caficultura*. Hojancha: COOCAFE, CATIE, ICAFE, Oikocredit.

Corbera, E., Gonzales Soberanis, C., Brown. K. 2009. "Institutional Dimensions of Payment for Ecosystem Services: An Analysis of Mexico's Carbon Forestry Programme." *Ecological Economics* 68: 18.

De Melo, E., Abarca, S. 2011. Personal Interview. 21 June, 2011.

De Melo Virginio, E. Abarca Monge, S., 2008. "Cafetales Para Servicios Ecosistémicos, Con Énfasis En El Potencial De Sumideros De Carbono el Caso De Cooperativas Cafetaleras Afiliadas a Coocafe Costa Rica.» *CATIE-FUNCAFOR-COOCAFE-OIKOCREDIT*.Informe Final.

de Negri, B., Thomas, E. 2003. *Making Sense of Focus Group Findings*: Academy for Educational Development.

Fernandez, I. 2011. Personal interview. 5 August, 2011

FONAFIFO. 2011. "Fondo Nacional De Financiamiento Forestal." www.fonafifo.go.cr.

Fowler, F. J. 1995. "Improving Survey Questions: Design and Evaluation." *Applied Social Research Methods Series* 38.

Ghazoul, J. 2007. "Recognising the Complexities of Ecosystem Management and the Ecosystem Service Concept." *GAIA*: 7.

Gomez-Baggethun, E., de Groot, R., Lomas, P. L., Montes. C. 2010. "The History of Ecosystem Services in Economic Theory and Practice: From Early Notions to Markets and Payment Scheme." *Ecological Economics* 69.6: 1209 - 18.

Haggar, J. 2008. "Carbon Storage in Coffee Agroecosystems of Southern Costa Rica: Potential Applications for the Clean Development Mechanism." *CATIE*.

Instituto del Café de Costa Rica (ICAFE), Instituto Nacional de Estadistica y Censos (INEC). 2007. *Censo Cafetalero; Turrialba Y Coto Brus, Valle Central Y Valle Central Occidental, Y Perez Zeledon,uTarrazú Y Zona Norte* ICAFE, INEC.

Instituto del Café de Costa Rica (ICAFE), Monitoring

Unit. 2011. "Geospatial Data for Coffee Plantations in Los Santos." Ed. unit, ICAFE GIS. San José.

Kandji, S., Verchot, V.L. Mackensen, J. Tomich, T.P., Ong, C. 2008. *Opportunities for Linking Climate Change Adaptation and Mitigation through Agroforestry Systems*. Ed. Centre, World Agroforestry: The Earth Institute at Columbia University.

Lasswell, H.D., Kaplan. A. 1950. *Power and Society a Framework for Political Inquiry*. New Haven: Yale University Press.

Lasswell, H.D. 1956. *The Decision Process: Seven Categories of Functional Analysis*. Maryland: University of Maryland.

Lasswell, H.D. 1971. *A Pre-View of Policy Sciences*. New York: American Elsevier.

Lasswell, H.D., McDougal, M.S. 1992. *Jurisprudence for a Free Society: Studies in Law, Science and Policy*. 2 vols. New Haven, CT: New Haven Press.

Marin Melendez. L., Castillo Quesada, A. 2010. *Plan De Manejo De La Cuenca Del Río Pirrís*. San Pablo de Leon Cortes: Instituto Costarricense de Electricidad (ICE).

McAfee. K., Shapiro, E.N. 2010. "Payments for Ecosystem Services in Mexico: Nature, Neoliberalism, Social Movements, and the State." *Annals of the Association of American Geographers* 100.3.

MINAE. 1996. Ley Forestal 7575.

MINAE. 1997. Reglamento a La Ley Forestal.

Naranjo, F. 2011. Personal interview. 25 June, 2011

Pagiola, S., Arcenas, A., and Platais, G. 2005. "Can Payments for Environmental Services Help Reduce Poverty? An Exploration of the Issues and the Evidence to Date from Latin America." *World Development* 33.2: 237-53.

Polzot, C.L. 2004. "Carbon Storage in Coffee Agroecosystems of Southern Costa Rica: Potential Applications for the Clean Development Mechanism."

Porras, A. 2010. *Fair and Green? Social Impacts of Payment for Environmental Services in Costa Rica*. London: International Institute for Environment and Development (IIED).

Rojas, M., Aylward, B. 2003. *What Are We Learning from Experiences with Markets for Environmental Services in Costa Rica? A Review and Critique of the Literature*: International Institute for Environment and Development (IIED).

Rubin, A., and Babbie. E.R. 2010. *Essential Research Methods for Social Work*. Brooks/Cole.

Sanchez-Azofeifa, G.A., Pfaff, A., Robalino, J.A., Boomhower. J.P. 2007. "Costa Rica's Payment for Environmental Services Program: Intention, Implementation, and Impact." *Conservation Biology*.

Sanchez, O. 2011. Personal Interview. 22 June, 2011

Seehusen, S.E., Guede; F.B. 2011. *Pagamentos Por Serviços Ambientais Na Mata Atlântica: Lições Aprendidas e Desafios*. Brasilia: Instituto do Meio Ambiente e dos Recursos Naturais Renováveis.

Sesion Ordinaria 01-2010. *2010. Manual De Procedimientos*.

Solano, H.R. 1972. *El Cafe En Costa Rica*. San José: Oficina del Café.

Soto, M.A.C., 2003. *Gestion Local Y Participacion En Torno Al Pago Por Servicios Ambientales: Estudios De Caso En Costa Rica*: PRISMA.

van Oijen, M., Dauzar, J., Harmand, J.M., Lawson, G., Vaast, P. 2010. "Coffee Agroforestry Systems in Central America: A Review of Quantitative Information on Physiological and Ecological Processes." *Agroforestry Systems*.

Viana, V.M. 2008. "Bolsa Floresta: Um Instrumento Inovador Para a Promoção Da Saúde Em Comunidades Tradicionais Na Amazônia." *Estudos Avancados* 22.64.

Waldorf, P., Biernacki, D. 1981. "Snowball Sampling Problems and Techniques of Chain Referral Sampling." *Sociological Methods & Research* 10.2.

Workshop, Coffee farmer. 2011. Personal interview. 2 July, 2011

Wunder, S. 2007. "The Efficiency of Payments for Environmental Services in Tropical Conservation." *Society for Conservation Biology* 21.1: 48-58.

Zbinden, S., Lee. D.R., 2004. "Paying for Environmental Services: An Analysis of Participation in Costa Rica's Psa Program." *World Development* 33.2: 255-72.

III. THE TECHNICAL AND SOCIAL CHALLENGES OF REFORESTATION

Using Leaf Level Traits to Develop Tolerance Rankings of Native Tree Species for Restoration Under-planting of Rubber Plantations in Brazil

Carla Chízmar, MESc 2012

ABSTRACT

More than 300 years of forest exploitation and clearance for agriculture in the Atlantic forest region of Brazil has produced a landscape of relic forest patches estimated to be 10 to 15% of its original extent. Efforts to restore second growth Atlantic Forest could potentially take advantage of established rubber plantations, *Hevea brasiliensis*, by using under-plantings of native tree species to replace rubber. However, the lack of understanding of basic seedling leaf-level physiology and morphology is an impediment. I analyzed the initial growth of twenty native species growing under the partial shade of a rubber plantation at the Michelin Ecological Reserve, Brazil to compare leaf level traits of shade and drought tolerance. The experimental design was completely randomized using plantings of two-year old seedlings of 20 species of trees. Measurements were made of height and root collar diameter as indicators of growth performance. Leaf level measures of chlorophyll fluorescence, leaf mass, leaf area, and stomata density and size were taken to correlate to growth measures. Based on the relationship between height growth and chlorophyll fluorescence as an indicator of shade tolerance, species suitable for under-planting in shade conditions are *Parkia pendula, Caryocar brasiliense, Pseudoxandra bahiensis,* and *Tachigali densiflora*. Species ranked as shade intolerant and therefore not suitable for under-planting are *Marlierea eugenioides, Garcinia macrophylla, Sorocea guilleminiana,* and *Sloanea monosperma*. Based on stomatal density and size, species ranked as drought tolerant include *Sloanea monosperma, Marlierea eugenioides, Sorocea guilleminiana, and Helicostylis tomentosa.* In contrast, *Parkia pendula, Pouteria macrocarpa, Copaifera langsdorffii, and Psychotria cartagenensis* showed the lowest drought tolerance.

Carla Chízmar is from Panama. She holds a BS in Biology from the University of Panama, and a Master of Environmental Science from Yale University. Prior to F&ES, she worked for the Smithsonian Tropical Research Institute, the Environmental Leadership and Training Initiative, and the United Nations Environmental Program. She focused her research in applied ecophysiology working with restoration efforts in Brazil's Mata Atlantica region.

Introduction

Three centuries of forest exploitation and clearance for agriculture in the Atlantic Forest region of Brazil has produced a landscape of relic forest patches that now comprise 10 to 15% of the original forest area (Ribeiro et al., 2009; Tabarelli et al., 2005; Teixeira et al., 2009). Few large-scale attempts to restore deforested areas have been made in the Atlantic Forest region (de Souza and Batista, 2004; Teix-

Figure 1. Map of the Michelin Ecological Reserve showing the location of the plantation in 2009.

eira et al., 2009). Efforts to restore the Atlantic Forest could potentially take advantage of established rubber plantations, *Hevea brasiliensis*. Commercial forest plantations such as rubber have been termed "green deserts" (Viani et al., 2010). Nevertheless, several studies have reported that they can catalyze natural regeneration contributing to the establishment of a new second-growth forest (Lamb, 1998; Viani et al., 2010). Under-plantings of native tree species and voluntary establishment of natural regeneration beneath plantations has been reported as a strategy to re-establish second-growth forests (Parrotta et al., 1997; Schulze et al., 1994). Previous studies conducted in Brazil show that historical and environmental factors, such as canopy density and light availability, plantation age, forest species, distance from natural forests, silvicultural practices, and previous land use directly or indirectly affect natural regeneration richness, abundance and community structure under forest plantations (Viani et al., 2010).

Though restoration of rainforest through under-planting of native tree species beneath plantations is recognized to be an option, there is no information on basic seedling leaf-level physiology and morphology to gauge species drought and shade tolerance (Sansevero et al., 2009). Under-planting prescriptions require knowledge of what species to plant under what site and shade conditions. The amount of shade is suggested to be one of the most important limiting factors limiting growth and survival of tree seedlings beneath forest canopies (Chazdon et al., 1996). In general, less than 2% of photosynthetically active radiation above the canopy reaches a tropical rainforest floor (Ashton and Berlyn, 1992; Bazzaz and Pickett, 1980; Chazdon et al., 1996; Silveira Paulilo et al., 2007; Valladares et al., 2002). Species adaptation and plasticity of leaves is closely associated with shade tolerance and successional status of tropical trees species (Ashton and Berlyn, 1992; Straussdebenedetti and Bazzaz, 1991). Compared to other forest biomes, tree species of tropical wet forest show large variations in shade and drought tolerance, and nutrient-use efficiency which in turn influences their differential establishment, growth and survival (Ashton and Berlyn, 1992; Chazdon et al., 1996; Kitajima, 1994; Souza et al., 2004; Strauss-Debenedetti and Bazzaz, 1996).

Tropical tree species can be grouped into two coarse categories: early successional or pioneers and late successional or non-pioneers (Kursar and Coley, 1999; Strauss-Debenedetti and Bazzaz, 1996; Swaine and Whitmore, 1988). Early successional species require full sun conditions (i.e. gaps) to germinate and survive, have higher mortality rates, grow faster and are shade intolerant. Late successional species can germinate, survive and grow under shade conditions (Kursar and Coley, 1999; Swaine and Whitmore, 1988). The differences between these categories are reflected in their anatomical and physiological attributes, i.e. photosynthesis and transpiration rates, stomatal frequency, and leaf thickness (Ashton and Berlyn, 1992; Chazdon et al., 1996; Strauss-Debenedetti and Bazzaz, 1991). Late successional species are usually shade-tolerant with low photosynthetic rates, dark respiration rates, light compensation points, and light saturation points, but high apparent quantum yields (Bazzaz and Pickett, 1980; Kitajima, 1994; Oberbauer and Strain, 1986). Typically leaves of shade-adapted late successional species are thinner and less deeply lobed, exhibit larger surface per unit weight, thinner epidermis, less palisade, more intercellular space, and spongy parenchyma, less supportive and conductive tissue, and have fewer but larger stomata than comparable sun leaves of the same tree (Barnes, 1998; Givnish, 1988; Lichtenthaler et al., 1981).

Pioneers have higher leaf level anatomical and physiological plasticity than late successional tree species (Ashton and Berlyn, 1992; Gamage and Ashton, 2003; Kitajima, 1994; Straussdebenedetti and Bazzaz, 1991). Leaves of tropical pioneer trees show higher photosynthesis and respiration rates than late successional species (Bazzaz and Pickett, 1980; Davies, 1998; Givnish, 1988; Montgomery, 2004; Souza et al., 2004). Pioneers also have higher rates of transpiration and stomatal conductance, with higher density but smaller stomata that have more use efficient control of water loss (Al Afas et al., 2006; Ashton and Berlyn, 1992; Branco Camargo and Marenco, 2011; Craven et al., 2010; Woodward and Kelly, 1995).

Physiological and morphological measurements on seedling leaves grown under contrasting shade environments have been used to develop indices that are indicative of species shade and drought tolerance, regeneration traits, and successional status (Ishida et al., 1999). In my study, saplings of twenty native species from the Atlantic Forest of Bahia, Brazil planted beneath a rubber plantation were used to compare inter-species physiological and morphological leaf level traits. I sought to relate leaf level traits with the growth performance of the native tree species with the purpose of constructing a shade and drought tolerance ranking to be used in reforestation under-plantings in rubber plantations. I hypothesized that pioneers will exhibit slower growth rates, lower leaf areas, and lower levels of fluorescence (indicating lower rates of photosynthesis) than late successional species in the plantings. Differences among species regarding these traits will allow construction of a shade tolerance and water-use efficiency ranking that can be used for conversion of plantations to native forests using under-plantings.

Materials and Methods

Site description

The study was conducted at the Center for Biodiversity Studies at the Michelin Ecological Reserve (13° 50' S; 39° 10' W), located in the Municipality of Igrapiúna. The Michelin Reserve is 200 km south of the city of Salvador in the State of Bahia, Brazil (Figure 1). The Reserve comprises 4,000 ha of relic patches of early and late successional Atlantic Rainforest, and experimental rubber plantations. The topography of the region is mainly hilly, except for the coastal areas, ranging from 40 to 586 meters above sea level (PMB 2011). The geology

Table 1. Species tree height (H), root collar diameter (RC), wood volume index (WVI), chlorophyll fluorescence (C), stomatal density (SD), size (SS), and index (SI), mean ± standard deviation.

Species	Family	H (cm)	RC (cm)	WVI (cm^3)	C (Fv/Fm)	SD (mm^2)	SS (µm)	SI
Arapatiella psilophylla (Harms) R.S. Cowan	Fabaceae	159.25 ± 41.68	18.85 ± 3.72	0.90 ± 0.25	0.775 ± 0.047	380.89 ± 47.55	9.40 ± 1.81	3.48 ± 0.86
Calophyllum brasiliense Cambess.	Clusiaceae	224.50 ±59.90	22.76 ± 7.63	0.95 ± 0.53	0.797 ± 0.024	254.89 ± 24.06	11.77 ± 2.94	2.79 ± 0.69
Caryocar brasiliense Cambess.	Caryocaraceae	353.75 ± 136.30	54.04 ± 26.35	3.37 ± 2.12	0.804 ± 0.027	206.22 ± 30.61	9.66 ± 1.46	1.85 ± 0.54
Casearia bahiensis Sleumer	Salicaceae	188.00 ± 52.40	25.67 ± 7.03	1.41 ± 0.51	0.778 ± 0.031	417.56 ± 57.34	7.84 ± 1.27	2.81 ± 0.72
Cf. Andira sp.	Fabaceae	304.25 ± 88.70	34.70 ± 11.58	1.65 ± 0.92	0.829 ± 0.022	648.67 ± 90.58	9.94 ± 1.61	3.58 ± 1.88
Copaifera langsdorffii Desf.	Fabaceae	212.75 ± 74.50	27.62 ± 11.34	1.43 ± 0.71	0.760 ± 0.054	116.67 ± 14.73	14.32 ± 2.16	1.64 ± 0.42
Copaifera lucens Dwyer	Fabaceae	233.00 ± 77.40	27.39 ± 6.51	1.32 ± 0.42	0.785 ± 0.032	163.56 ± 34.06	11.67 ± 1.62	1.95 ± 0.37
Garcinia macrophylla Mart.	Clusiaceae	126.25 ± 42.82	19.68 ± 6.53	1.22 ± 0.45	0.731 ± 0.039	159.33 ± 19.60	11.96 ± 2.27	1.87 ± 0.42
Helicostylis tomentosa (Poepp. & Endl.) Rusby	Moraceae	181.50 ± 43.62	19.50 ± 4.06	0.84 ± 0.23	0.743 ± 0.038	477.11 ± 38.96	10.45 ± 1.62	4.51 ± 1.20
Hymenaea oblongifolia Huber	Fabaceae	141.00 ± 42.51	20.22 ± 5.07	1.17 ± 0.34	0.813 ± 0.028	176.44 ± 12.99	11.43 ± 1.45	2.19 ± 0.37
Marlierea eugenioides (Cambess.) D. Legrand	Myrtaceae	135.50 ± 33.83	19.15 ± 4.41	1.11 ± 0.45	0.759 ± 0.035	521.56 ± 53.20	6.21 ± 0.94	3.46 ± 0.59
Myrcia sp.	Myrtaceae	149.25 ± 33.88	18.94 ± 5.71	1.00 ± 0.55	0.753 ± 0.024	422.22 ± 56.19	5.72 ± 0.98	2.48 ± 0.62
Parkia pendula (Willd.) Benth. ex Walp.	Fabaceae	364.25 ± 100.40	60.75 ± 16.5	4.02 ± 1.22	0.810 ± 0.030	109.78 ± 16.32	11.79 ± 1.79	1.09 ± 0.27
Pouteria macrocarpa (Mart.) D. Dietr.	Sapotaceae	182.80 ± 56.10	21.15 ± 7.74	1.01 ± 0.58	0.778 ± 0.038	97.33 ± 15.68	15.60 ± 2.58	1.61 ± 0.20
Pseudoxandra bahiensis Maas	Annonaceae	285.50 ± 102.50	44.16 ± 16.87	2.80 ± 1.43	0.722 ± 0.095	151.33 ± 25.29	15.91 ± 2.40	2.18 ± 0.38
Psychotria carthagenensis Jacq.	Rubiaceae	217.00 ± 75.70	31.77 ± 11.34	1.89 ± 0.91	0.778 ± 0.035	161.78 ± 58.31	20.16 ± 3.49	2.44 ± 0.42
Sloanea monosperma Vell.	Elaeocarpaceae	148.00 ± 65.40	25.04 ± 9.77	1.73 ± 0.74	0.729 ± 0.072	822.22 ± 129.48	4.98 ± 0.99	3.72 ± 0.96
Sorocea guilleminiana Gaudich.	Moraceae	167.75 ± 65.80	20.08 ± 6.71	0.98 ± 0.36	0.724 ± 0.043	465.33 ± 54.75	8.66 ± 1.59	4.09 ± 0.65
Tabebuia stenocalyx Sprague & Stapf	Bignoniaceae	245.00 ± 83.00	31.07 ± 9.52	1.57 ± 0.49	0.803 ± 0.021	350.00 ± 86.13	11.25 ± 1.98	3.51 ± 0.83
Tachigali densiflora (Benth.) L.F. Gomes da Silva & H.C. Lima	Fabaceae	337.37 ± 119.90	34.31 ± 16.45	1.41 ± 0.93	0.808 ± 0.025	222.22 ± 31.88	16.78 ± 2.07	3.08 ± 0.81

is characterized by metamorphic gneissic rocks of magmatic origin and granitic rocks developed during tectonism (IBGE, 2011). According to the Brazilian Institute of Geography and Statistics Soil Map, the soils of Igrapiúna are latosols (IBGE, 2011). Mean annual precipitation in the reserve is ~2000 mm, temperature ranges from 21.7 to 30.8 °C, and humidity between 80 and 85% (Camargo et al., 2010).

The Michelin Ecological Reserve implemented a program from 2005 to 2011 to assist in the restoration of the Atlantic rainforests through the under-planting of native tree species beneath rubber plantations. During this seven year period the reserve staff planted approximately 15,000 seedlings per year. The site chosen for the study had ideal experimental conditions to compare species growth performance and develop tolerance rankings because of uniform site and shade conditions.

Experimental design

From June to August of 2011, I selected twenty native species and twenty random individuals per species for leaf physiological and morphological measurements at a 2-year old plantation. The species selection was based on availability at the plantation level (number of planted seedlings for a given species), local uses, ecological and economic importance, and field observations (i.e. herbivory damage).

Physiological and morphological measurements

To estimate growth rates, height was measured to the nearest centimeter for each plant using a 2.5 meter survey rod (Craven et al., 2010). Root collar diameter was measured using a caliper to the nearest millimeter.

For simple-leaved species, three leaves per individual plant were selected and for compound-leaved species, one leaf per individual plant. To calculate leaf area and dry mass, all leaves per tree were counted. For taller trees where counting all leaves was not possible, I estimated values using the average count of three randomly selected branches. Leaves were scanned using a flatbed scanner (Epson Stylus Office TX 300F) and surface area was calcu-

Table 2. Species total number of leaves (L), individual leaf/let area (ILA), individual leaf/let mass (ILM), individual leaf/let mass-area ratio (LMA), total leaf area per tree (TLA), total leaf mass per tree (TLM) mean ± standard deviation.

Species	Family	L (unit)	ILA (cm²)	ILM (g)	LMA(mg/cm²)	TLA (m²)	TLM (g)
Arapatiella psilophylla (Harms) R.S. Cowan	Fabaceae	19.3 ± 8.0	97.24 ± 35.80	0.96 ± 0.42	19.05 ± 2.78	130.8 ± 82.8	131.8 ± 92.9
Calophyllum brasiliense Cambess.	Clusiaceae	136.4 ± 101.5	79.20 ± 14.44	1.17 ± 0.24	6.03 ± 1.40	104.9 ± 71.0	158.4 ± 118.2
Caryocar brasiliense Cambess.	Caryocaraceae	202.5 ± 326.0	229.00 ± 80.65	1.58 ± 0.62	5.33 ± 0.90	1357.0 ± 2166.0	901.0 ± 1461.0
Casearia bahiensis Sleumer	Salicaceae	238.9 ± 123.5	90.46 ± 17.46	1.71 ± 0.33	6.06 ± 0.92	222.4 ± 115.0	433.1 ± 272.7
Cf. Andira sp.	Fabaceae	230.0 ± 245.6	18.64 ± 4.43	0.11 ± 0.04	13.01 ± 1.81	856.0 ± 921.0	539.0 ± 562.0
Copaifera langsdorffii Desf.	Fabaceae	317.7 ± 295.1	7.00 ± 1.50	0.04 ± 0.01	6.78 ± 1.00	228.7 ± 214.4	124.6 ± 122.4
Copaifera lucens Dwyer	Fabaceae	57.2 ± 42.7	33.28 ± 9.91	0.20 ± 0.08	8.34 ± 1.25	164.6 ± 166.1	105.0 ± 117.0
Garcinia macrophylla Mart.	Clusiaceae	98.3 ± 51.6	87.88 ± 21.82	1.16 ± 0.39	19.96 ± 1.89	86.0 ± 51.0	115.3 ± 74.9
Helicostylis tomentosa (Poepp. & Endl.) Rusby	Moraceae	102.2 ± 142.1	88.09 ± 28.65	0.59 ± 0.19	9.75 ± 0.97	104.1 ± 190.3	69.1 ± 123.6
Hymenaea oblongifolia Huber	Fabaceae	17.5 ± 8.6	217.42 ± 62.28	1.83 ± 0.60	6.11 ± 1.28	80.2 ± 48.2	69.4 ± 45.5
Marlierea eugenioides (Cambess.) D. Legrand	Myrtaceae	59.8 ± 28.9	119.61 ± 29.36	2.39 ± 0.66	12.43 ± 1.65	67.5 ± 29.4	133.0 ± 52.3
Myrcia sp.	Myrtaceae	499.0 ± 286.7	30.01 ± 5.29	0.29 ± 0.05	9.88 ± 1.23	145.7 ± 85.5	142.6 ± 85.9
Parkia pendula (Willd.) Benth. ex Walp.	Fabaceae	48.9 ± 15.2	41.16 ± 9.36	0.25 ± 0.09	25.04 ± 2.52	1340.0 ± 580.0	861.0 ± 515.0
Pouteria macrocarpa (Mart.) D. Dietr.	Sapotaceae	130.5 ± 99.5	144.34 ± 41.68	1.81 ± 0.61	0.79 ± 0.59	198.5 ± 168.1	254.2 ± 226.6
Pseudoxandra bahiensis Maas	Annonaceae	1087.0 ± 667.0	62.80 ± 14.80	0.63 ± 0.19	10.38 ± 1.66	719.0 ± 552.0	735.0 ± 611.0
Psychotria carthagenensis Jacq.	Rubiaceae	87.3 ± 81.8	286.07 ± 82.44	7.22 ± 2.44	21.93 ± 2.97	241.6 ± 216.4	576.0 ± 481.0
Sloanea monosperma Vell.	Elaeocarpaceae	896.0 ± 933.0	250.12 ± 39.44	0.20 ± 0.14	9.22 ± 1.43	2339.0 ± 2406.0	279.7 ± 399.7
Sorocea guilleminiana Gaudich.	Moraceae	119.1 ± 99.4	86.37 ± 26.31	0.89 ± 0.27	19.05 ± 2.78	114.0 ± 121.2	119.4 ± 124.7
Tabebuia stenocalyx Sprague & Stapf	Bignoniaceae	63.0 ± 33.7	248.01 ± 93.34	5.61 ± 2.63	6.03 ± 1.40	172.7 ± 134.5	395.4 ± 333.0
Tachigali densiflora (Benth.) L.F. Gomes da Silva & H.C. Lima	Fabaceae	42.3 ± 51.5	195.05 ± 70.16	1.89 ± 0.67	5.33 ± 0.90	1303.0 ± 1950.0	1192.0 ± 1714.0

lated using Image J software (http://rsbweb.nih.gov/ij/index.html). Leaves were weighed green using a digital scale, dried in an oven at 50°C until constant mass was reached and then weighed again to obtain dry mass.

Chlorophyll *a* fluorescence was measured on each of the same leaves used for area and mass using a Modulated Chlorophyll Fluorescencemeter (OptiSciences, US). Maximal (Fm) and basal (Fo) fluorescence yields were measured in dark-adapted (30 min) leaves (Maxwell and Johnson, 2000; Souza et al., 2010).

Stomatal densities and size were determined on nail polish imprints taken from the abaxial leaf surface (Branco Camargo and Marenco, 2011). Images of three single ocular views per leaf peel were taken to determine stomatal density and size using a binocular digital compound microscope (Motic BA400, US) on a field of view of 0.045 mm² at a magnification of 400x and a digital camera adapted to the microscope (Motic Cam 2300, US).

Statistical Analyses

Growth performance based on tree height, root collar diameter, chlorophyll fluorescence, leaf mass, and leaf area was used as a proxy to develop a shade tolerance ranking. Stomatal density and aperture size were used as a proxy for a drought tolerance ranking.

Additional parameters such as wood volume index and leaf mass-area ratio were calculated to compare growth rates among species. Wood volume index (WVI) per tree was calculated as (Montagnini et al., 1995; Wishnie et al., 2007):

$$WVI = \frac{0.5\pi D^2}{4H}$$

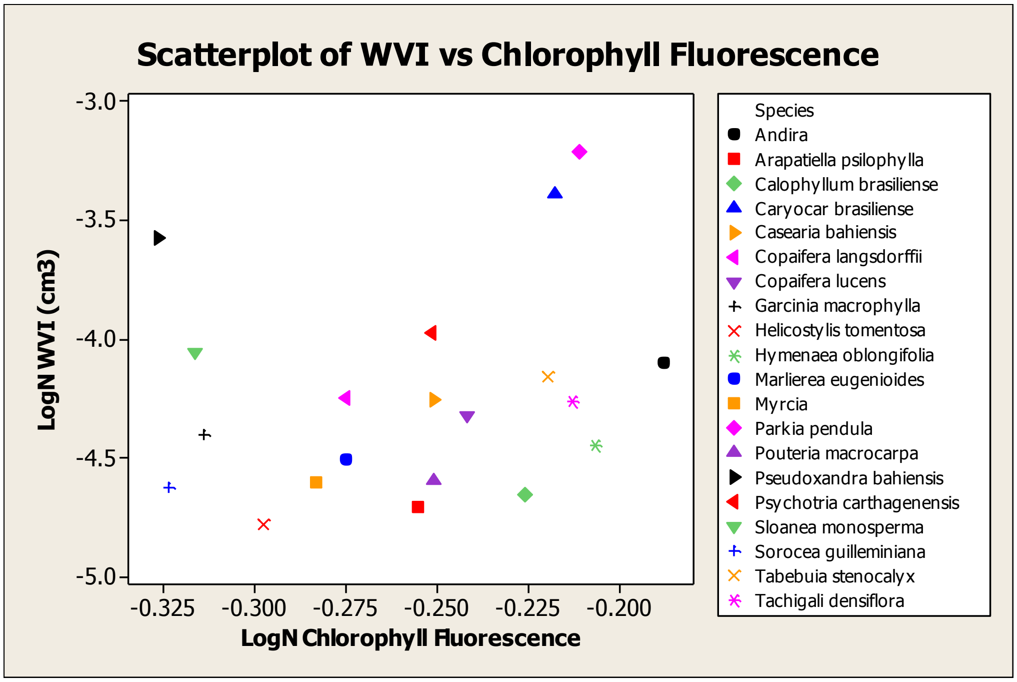


Figure 2. Scatter plots of WVI vs chlorophyll fluorescence per tree per species.

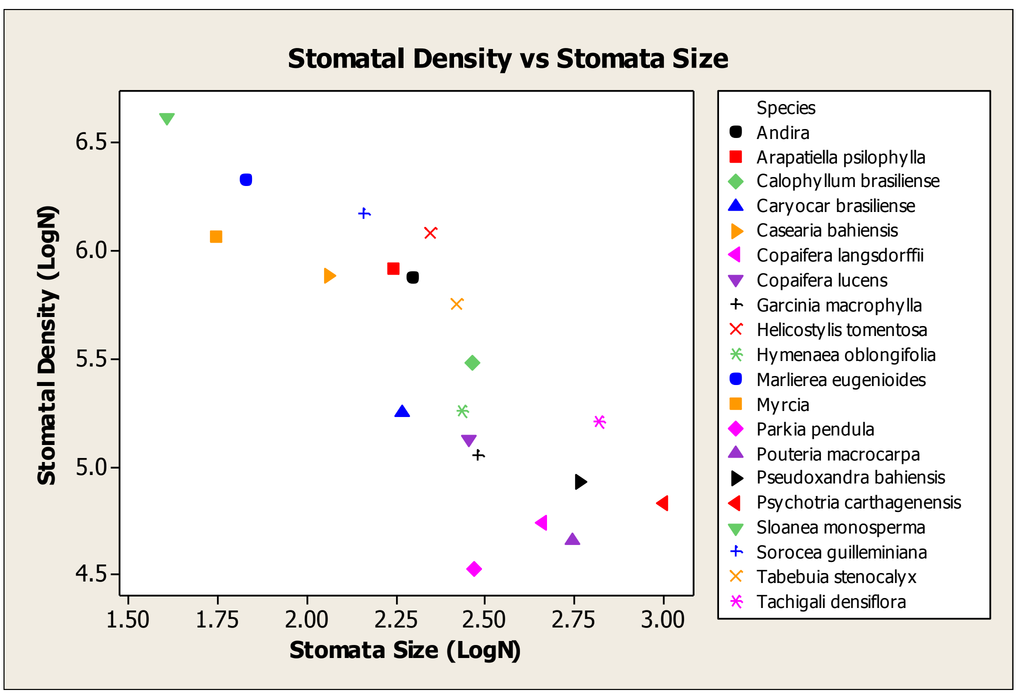


Figure 3. Scatter plots of stomatal density (per mm^2) vs stomata aperture size (µm) per species.

Leafmass-area ratio was calculated as:

$$LMA = \frac{Leaf\ Mass}{Leaf\ Area}$$

Scatter plots of all variables and species were used to group species into three coarse guilds: tolerant, intermediate, and intolerant for both shade and drought.

Results

Shade tolerance ranking

Among the variables measured, tree height and root collar diameter showed the highest significant Pearson correlation of 0.863 (p=0.00). WVI was highly correlated to leaf mass (0.766) and leaf area (0.753), p=0.000. From all variables analyzed in growth performance, chlorophyll fluorescence appeared to be the least significant. A regression analysis among tree height, root collar diameter, chlorophyll fluorescence, leaf area and mass was statistically significant (≤0.05) with an R^2 (adj) = 76.2%.

Table 3. Shade and drought tolerance ranking for all species from most tolerant to least tolerant.

Shade Tolerance	Drought Tolerance
HIGH	HIGH
Caryocar brasiliense	*Sloanea monosperma*
Parkia pendula	*Marlierea eugenioides*
Tachigali densiflora	*Myrcia sp.*
Cf. Andira sp.	*Casearia bahiensis*
Pseudoxandra bahiensis	*Sorocea guilleminiana*
Tabebuia stenocalyx	*Arapatiella psilophylla*
Psychotria carthagenensis	*Andira sp.*
Copaifera lucens	*Helicostylis tomentosa*
Copaifera langsdorfii	*Tabebuia stenocalyx*
Calophyllum brasiliense	*Caryocar brasiliense*
Casearia bahiensis	*Copaifera lucens*
Pouteria macrocarpa	*Hymenaea oblongifolia*
Sloanea monosperma	*Garcinia macrophylla*
Hymenaea oblongifolia	*Calophyllum brasiliense*
Sorocea guilleminiana	*Copaifera langsdorffii*
Helicostylis tomentosa	*Pouteria macrocarpa*
Arapatiella psilophylla	*Pseudoxandra bahiensis*
Myrcia sp.	*Psychotria carthagenensis*
Garcinia macrophylla	*Parkia pendula*
Marlierea eugenioides	*Tachigali densiflora*
LOW	LOW

Species means and standard deviations per variable analyzed are summarized in Table 1. Tree height and root collar diameter showed the highest variance both inter-species and intra-species. Chlorophyll fluorescence values showed some variance intra-species, but remained fairly constant inter-species. WVI variance remained fairly constant among species with the exception of *P. pendula* and *C. brasiliense*. Leaf area and total number of leaves per tree showed large variance both inter-species and intra-species. Leaf mass showed little variance both inter-species and intra-species when compared to other leaf related variables.

The mean value for chlorophyll fluorescence (Fv/Fm) among the twenty species analyzed was 0.774, which falls slightly under the maximum average value of Fv/Fm of vascular plants under normal conditions 0.79-0.84 (Maxwell and Johnson, 2000). Trees growing under partial shade are expected to be under certain light stress that can be reflected in the lower chlorophyll fluorescence values registered in the study.

Chlorophyll fluorescence measurements showed cf. *Andira sp.*, *H. oblongifolia* Huber, *P. pendula*, *T. densiflora*, and *C. brasiliense* as the species with the highest values. In contrast, *P. bahiensis*, *S. guilleminiana*, *S. monosperma*, and *G. macrophylla* showed the lowest values.

Total number of leaves per tree ranged from 7 to 3422 with a mean of 222.6 leaves. *P. bahiensis*, *S. monosperma*, and *Myrcia sp*. showed the highest number of leaves per tree, and greater variance within species than any other species analyzed. *H. oblongifolia*, *A. psilophylla*, and *T. densiflora* showed the lowest number of leaves per tree, and almost no variance within species. Tree species with highest number of leaves were single leaved species, and species with the lowest number of leaves per tree were species with compound leaves; simultaneously, individual leaf area and mass decreased when total number of leaves increased. Overall total leaf area and total leaf mass per tree increased with total number of leaves. A regression between total leaf area, total leaf mass, and total number of leaves per tree showed an R^2 (adj) = 70.3%.

Comparisons among species showed that *P. pendula*, *C. brasiliense*, *T. densiflora*, and cf. *Andira sp*. had the highest growth performance. *G. macrophylla*, *M. eugenioides*, *H. oblongifolia*, *H. tomentosa*, *S. guilleminiana*, *Myrcia sp.*, *A. psilophylla*, and *S. monosperma* showed the lowest growth performance.

A scatter plot of all species based on WVI and chlorophyll fluorescence values grouped species with similar growth performance into four guilds (Figure 2). A baseline for shade tolerance ranking using growth performance is constructed in Table 3.

Drought tolerance ranking

Stomatal density values showed the largest variance inter-species, but less so for intra-species. Scatter plot of all species based on stomatal density and size grouped them into three guilds: tolerant, intermediate and intolerant (Figure 3). A baseline for drought tolerance ranking using stomatal density and size aperture values is constructed in Table 3.

Stomatal density values per mm^2 ranged from 81 to 1000, with a mean of 316. *S. monosperma*, Cf. *Andira sp*., and *M. eugenioides* showed the highest stomatal density values, and *P. macrocarpa*, *P. pendula*, and *C. langsdorffii* showed the lowest. Stomatal density values showed little variance in most of the species with the exception of *S. monosperma*, cf. *Andira* and *T. stenocalyx*. Stomata aperture size values ranged from 3.733 to 28.100 µm, with a mean of 11.277 µm. *S. monosperma*, *Myrcia sp*. and *M. eugenioides* showed the smallest stomata aperture size, and *P. carthagenensis*, *P. bahiensis*, and *P. macrocarpa* showed the largest.

Discussion

All variables analyzed for this study were significant predictors of growth performance and water use efficiency. The vast majority of the species analyzed in this study performed well under the shade of rubber, indicating their high potential for reforestation purposes. However, the study showed a wide range of shade and drought tolerance species that present a challenge when trying to establish strict rankings.

As trees in the study were grown under partial shade conditions, species with high shade tolerance (late successional) were growing faster and more vigorously than those species with low shade tolerance (pioneers). In addition, a lower number of stomata is related to successional guilds as late successional species tend to have fewer and larger stomata. Nevertheless, it is important to consider that species stomatal density values may vary according to environmental factors, such as shade coverage. Pioneer species in the study might show lower stomatal density because they are growing under partial shade.

Some species showed a strong tendency towards extreme sides of the spectrum. In this sense, *Garcinia macrocarpa*, *Sloanea monosperma*, *Sorocea guilleminiana*, *Helicostylis tomentosa*, *Myrcia sp*., and *Marlierea eugenioides* could potentially be considered pioneer species because of their poor growth performance (shade intolerant), low chlorophyll fluorescence (i.e. low photosynthetic rate), and higher stomatal density. In contrast, *Parkia pendula, Caryocar brasiliense*, cf. *Andira sp*. and *Tachigali densiflora* could potentially be considered late successional species because of their excellent growth performance (shade tolerant), high chlorophyll fluorescence levels (i.e. high photosynthetic rate), and lower stomatal density. A larger portion of the species used in this study showed intermediate values for both shade and drought tolerance.

Caryocar brasiliense has been identified in other studies as heliophyte and xerophyte, both characteristic of pioneer species. However, in this study we found that *C. brasiliense* was one of the species with the highest growth performance in all variables measured, and showed intermediate values for drought tolerance.

Calophyllum brasiliense has been reported as a shade tolerant species (Calvo-Alvarado et al., 2007). We found high values of chlorophyll fluorescence, which confirms its ability to perform photosynthesis well under partial shade environments, but a lower WVI when compared to other late successional species in the study suggesting a slow growth rate.

Pseudoxandra bahiensis showed low drought tolerance and high WVI, yet its chlorophyll fluorescence values were significantly lower than species with similar growth rates. In contrast, *Hymenaea oblongifolia* showed intermediate to low drought tolerance, high chlorophyll fluorescence values, and very low WVI. This suggests that both species could potentially be late successional species with very contrasting growth rates.

Species that showed faster growth rates (i.e. higher shade tolerance), and lower drought tolerance in this study are more suitable for under-planting environments. In contrast, species that showed slower growth rates (i.e. lower shade tolerance) and higher drought tolerance are more suitable for the restoration of open or degraded areas, rather than under-planting environments. Depending on the specific reforestation objectives, species that showed intermediate shade and drought tolerance can be used for reforestation under-plantings with a slower growth rate.

The results presented in this study show the broad range of ecophysiological needs and growth patterns when utilizing native species in under-planting environments. Further studies comparing the same species in open environments will shed light on the plasticity and adaptation of the species to different light and moisture environments, as well as their successional status with more accuracy. Nonetheless, this study presents valuable information on the selection of species for under-planting in rubber plantations, and their potential application to other attempts to convert large scale monocultures into native species forests in the region.

ACKNOWLEDGMENTS

This study was funded by the Compton Foundation (USA). For their collaboration and support, I thank the Michelin Biological Reserve personnel and especially Kevin Fletcher, director of the Center for Biodiversity Studies. This study would not be possible without the valuable help of my field research assistant Mauricio Hoyos Gracia. I would also like to thank Mark Ashton and Graeme Berlyn for their guidance and support throughout the development of this study.

REFERENCES

Al Afas N, Marron N, and Ceulemans R. (2006) Clonal variation in stomatal characteristics related to biomass production of 12 poplar (Populus) clones in a short rotation coppice culture. Environ. Exp. Bot. 58:279-286.

Ashton PMS, and Berlyn GP. (1992) Leaf Adaptations of Some Shorea Species to Sun and Shade. New Phytol 121:587-596.

Barnes BVZ, Donald R.; Denton, Shirley R.; Spurr, and Stephen H. (1998) Forest ecology. 4th edition: John Wiley & Sons, Inc.

Bazzaz FA, Pickett STA. (1980) Physiological ecology of tropical succession - A Comparative Review Annu. Rev. Ecol. Syst. 11:287-310.

Branco Camargo MA, Marenco RA. (2011) Density, size and distribution of stomata in 35 rainforest tree species in Central Amazonia. Acta Amazonica 41:205-212.

Calvo-Alvarado JC, Arias D, Richter DD. (2007) Early growth performance of native and introduced fast growing tree species in wet to subhumid climates of the Southern region of Costa Rica. Forest Ecol Manag 242:227-235.

Camargo F, Lima TM, Merces EdA, Junca FA. (2010) Anurans of the Reserva Ecologica da Michelin, Municipality of Igrapiuna, State of Bahia, Brazil. Biota Neotropica 10:305-310.

Chazdon RL, Pearcy RW, Lee DW, Fetcher N. (1996) Photosynthetic responses of tropical forest plants to contrasting light environments. Chapman and Hall Ltd.; Chapman and Hall, Inc.

Craven D, Gulamhussein S, Berlyn GP. (2010) Physiological and anatomical responses of Acacia koa (Gray) seedlings to varying light and drought conditions. Environ. Exp. Bot. 69:205-213.

Davies SJ. (1998) Photosynthesis of nine pioneer Macaranga species from Borneo in relation to life history. Ecology 79:2292-2308.

de Souza FM, Batista JLF. (2004) Restoration of seasonal semideciduous forests in Brazil: influence of age and restoration design on forest structure. Forest Ecol Manag 191:185-200.

Gamage HK, Ashton MS. (2003) Leaf physiology and shade-tolerance of tropical rainforest tree seedlings. Plant Biology (Rockville) 2003:41.

Givnish TJ. (1998) Adaptation to sun and shade - A whole-plant perspective. Aust. J. Plant Physiol. 15:63-92.

Ishida A, Nakano T, Matsumoto Y, Sakoda M, Ang LH. (1999) Diurnal changes in leaf gas exchange and chlorophyll fluorescence in tropical tree species with contrasting light requirements. Ecol Res 14:77-88.

Kitajima K. (1994) Relative importance of photosynthetic traits and allocation patterns as correlates of seeedling shade tolreance of 13 tropical trees. Oecologia (1994) 98:419-428.

Kursar TA, Coley PD. (1999) Contrasting modes of light acclimation in two species of the rainforest understory. Oecologia 121:489-498.

Lamb D. Large-scale ecological restoration of degraded tropical forest lands: The potential role of timber plantations. Restoration Ecology (1998) 6:271-279.

Lichtenthaler HK, et al. (1981) Photosynthetic activity chloroplast ultrastructure and leaf characteristics of high light and low light plants and of sun and shade leaves. Photosynthesis Research (1981) 2:115-141.

Maxwell K, Johnson GN. (2000) Chlorophyll fluorescence - a practical guide. J. Exp. Bot. 51:659-668.

Montagnini F, Fanzeres A, DaVinha SG. (1995) The potentials of 20 indigenous tree species for soil rehabilitation in the Atlantic forest region of Bahia, Brazil. J. Appl. Ecol. 32:841-856.

Montgomery R. (2004) Relative importance of photosynthetic physiology and biomass allocation for tree seedling growth across a broad light gradient. Tree Physiol. 24:155-167.

Oberbauer SF, Strain BR. (1986) Effects of canopy position and irraadiance on the leaf physiology and morphology of pentaclethra-macroloba (mimosceae). Am J Bot 73:409-416.

Parrotta JA, Turnbull JW, Jones N. (1997) Introduction - Catalyzing native forest regeneration on degraded tropical lands. Forest Ecol Manag 99:1-7.

Ribeiro MC, Metzger JP, Martensen AC, Ponzoni FJ, Hirota MM. (2009) The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. Biological Conservation 142:1141-1153.

Sansevero JBB, Prieto PV, Moraes LFDd, Rodrigues PJP. (2009) Natural Regeneration in Plantations of Native Trees in Lowland Brazilian Atlantic Forest: Community Structure, Diversity, and Dispersal Syndromes. Restoration Ecology:no-no.

Schulze PC, Leighton M, Peart DR. (1994) Enrichment planting in selectively logged rain-forest - A combined ecological and economic analysis. Ecol. Appl. 4:581-592.

Silveira Paulilo MT, Duz SR, Siminski A, Santos M. (2007) Responses to light changes in tropical seedlings of the Brazilian Atlantic rainforest tree species Cecropia glazioui (Cecropiaceae) and Cedrela fissilis (Meliaceae). Aust J Bot 55:795-802.

Souza BD, Rodrigues BM, Endres L, Santos MG. (2010) Ecophysiology parameters of four Brazilian Atlantic Forest species under shade and drought stress. Acta Physiol. Plant. 32:729-737.

Souza GM, Ribeiro RV, Santos MG, Ribeiro HL, Oliveira RF. (2004) Functional groups of forest succession as dissipative structures: An applied study. Brazilian Journal of Biology 64:707-718.

Strauss-Debenedetti S, Bazzaz FA. (1991) Plasticity and Acclimation to Light in Tropical Moraceae of Different Sucessional Positions. Oecologia 87:377-387.

Strauss-Debenedetti S, Bazzaz FA. (1996) Photosynthetic characteristics of tropical trees along successional gradients. Chapman and Hall Ltd., 2-6 Boundary Row, London SE1 8HN, England 29 West 35th Street, New York, New York, USA.

Straussdebenedetti S, Bazzaz FA. (1991) Plasticity and acclimation to light in tropical moraceae of different successional positions. Oecologia 87:377-387.

Swaine MD, Whitmore TC. (1988) On the definition of ecological species groups in tropical rain forests. Vegetatio 75:81-86.

Tabarelli M, Pinto LP, Silva JMC, Hirota M, Bede L. (2005) Challenges and opportunities for Biodiversity conservation in the Brazilian Atlantic forest. Conserv. Biol. 19:695-700.

Teixeira AMG, Soares BS, Freitas SR, Metzger JP. (2009) Modeling landscape dynamics in an Atlantic Rainforest region: Implications for conservation. Forest Ecol Manag 257:1219-1230.

Valladares F, Skillman JB, Pearcy RW. (2002) Convergence in light capture efficiencies among tropical forest understory plants with contrasting crown architectures: A case of morphological compensation. Am J Bot 89:1275-1284.

Viani RAG, Durigan G, de Melo ACG. (2010) Natural regeneration under forest plantations: “Green deserts” or milieu for biodiversity? Cienc. Florest. 20:533-552.

Wishnie MH, et al. (2007) Initial performance and reforestation potential of 24 tropical tree species planted across a precipitation gradient in the Republic of Panama. Forest Ecol Manag 243:39-49.

Woodward FI, Kelly CK. (1995) The influence of CO_2 concentration on stomatal density. New Phytol. 131:311-327.

Assessing Rainforestation: The Social and Ecological Effects of Smallholder-based Native Species Reforestation in the Philippines

Tina Schneider, MF 2012 and Erica Pohnan, MESc 2012

ABSTRACT

Commercial logging and conversion of degraded forests to agriculture reduced forest cover in the Philippines from 70% to under 3% over the course of the 20th century. Many of these areas were planted with coconut palms and colonized by *Imperata cylindrica* grass, impeding natural regeneration to secondary forest. Consequently, large-scale reforestation efforts since the 1960s have primarily used fast-growing exotic trees to reclaim this forest cover. However, many of these efforts failed due to high tree mortality, low financial returns, and poor understanding of local socio-economic dynamics. In response, Visayas State University and GTZ developed the concept of Rainforestation Farming, a more holistic reforestation method that plants native tree species with crops to combine ecological restoration with improvement of livelihoods and food security. This method was piloted on 28 smallholder sites in the Visayas region between 1995 and 2000. However, no overall assessment has been conducted to date. Our study addresses this gap by assessing Rainforestation through two parameters: performance of planted species, and socio-economic benefits to local community members. Through tree growth measurements and interviews with landowners and project staff we gathered site history data that helped explain the performance of species across sites. Interviews were also conducted in two sites where establishment of Rainforestation demonstration farms was accompanied by formation of Farmers Association. Our study identified several high-performing native tree species, confirming that native tree species can be planted successfully in degraded lands. Long-term socio-economic benefits were realized through pathways different than the one envisioned, such as through formation of social networks rather than through seedling and food production. Community members also highly valued the environmental services provided by Rainforestation, such as watershed protection and disaster risk reduction.

Introduction

In the tropics, reforestation, agro-forestry and forest plantation projects are often dominated by the use of fast-growing exotics at the expense of using native species (Garen et al. 2009: 220). While exotic species can provide high-value timber, they have been found to support lower levels of biodiversity, contribute to

Erica Pohnan holds a B.A. in Environmental Studies from the University of Chicago. Prior to F&ES, she spent two years working in Bangkok, Thailand for an international NGO on community forestry and climate change issues in SE Asia. She is pursuing a Master of Environmental Science degree at F&ES, where she focuses on international forestry policy. She will continue to explore these issues while on a fellowship in Yogyakarta, Indonesia.

Tina Schneider grew up in Germany and graduated from Reed College with a B.A. in History. She spent 4 years working for GIZ, the Quito water fund FONAG, and Conservation International before Yale. Tina graduated from F&ES with a Master in Forestry, focusing on tropical forest management and restoration, and will spend the next year researching communal land tenure and community forestry in Laos on a Fulbright research grant.

soil erosion, and provide limited goods and services to landholders (Lamb et al. 2005: 1628). The use of exotic species can also alter ecosystem processes, which poses risks to long-term sustainability because they differ from native species in how they affect watershed systems and processes, fire regimes, and soil respiration (Lamb et al. 2005: 1629).

In the Philippines, the Rainforestation method for reforestation was developed specifically to use indigenous species for the rehabilitation of degraded landscapes while at the same time delivering socio-economic benefits (Milan and Margraf 1994: 10, Milan and Göltenboth 2005: 7). It was first developed in 1992 by Visayas State University (VSU) and the German Agency for Technical Cooperation (GTZ), based on the assumption that farming systems in the humid tropics can be made more sustainable, by approximating the structure and function of humid lowland and upland rainforest. In addition to providing environmental services such as increasing habitat for native plants and animals, restoring site productivity, and protecting watersheds, Rainforestation sought to provide timber, food products, spices, and medicinal plants in order to improve food security and local livelihoods (Milan and Göltenboth 2005: 26). In the pilot phase, native tree species produced in the VSU nursery were planted in 28 Rainforestation sites on the island of Leyte between 1995 and 2000.

Rainforestation addresses a recognized need for more holistic reforestation projects, incorporating plantations, agro-forestry, and native species components. Lamb et al. (2000) investigated the trade-offs between commercial timber production and species richness, and argued that what is needed in the future is a more diverse range of alternatives including plantation systems that yield financial returns plus a degree of biodiversity (Lamb 2000: 217).

Lessons from Rainforestation are relevant given recent developments in the forestry sector of the Philippines. In February 2011, Philippine

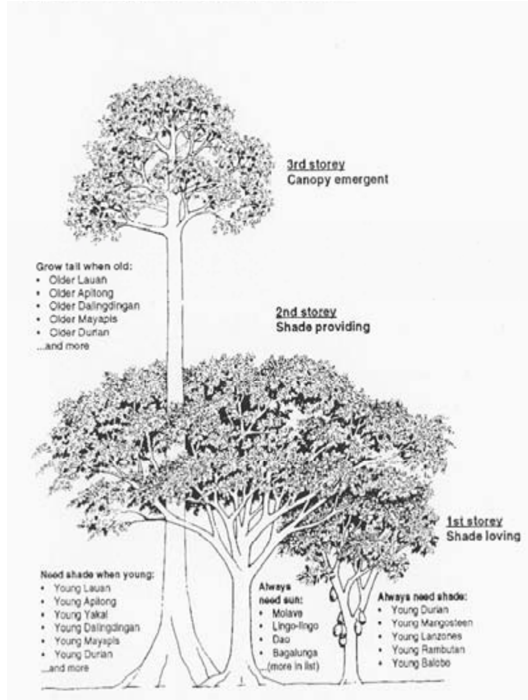


Figure 1. Rainforestation advises inter-planting shade intolerant pioneer tree species at high stocking rates (2 m x 2 m) with shade tolerant tall-growing species (mainly Dipterocarpaceae) as well as economically important fruit trees. Over time, a multi-story structure is created.

President Benigno Aquino III issued two new executive orders that banned all logging in natural forests in the Philippines, and mandated that 1.5 million hectares of the country's land area be reforested by 2016 via the establishment of a National Greening Program. Similar declarations have been made in the past in the wake of large natural disasters, yielding disappointing results and mistakes that would be disastrous to see repeated. Large-scale reforestation efforts in the Philippines began in the 1960s, initially through establishment of large-scale monoculture plantations of fast-growing exotic timber species such as *Gmelina arborea* and *Swietenia macrophylla* (Lasco and Pulhin 2006: 49). Between 1960 and 2002, about 1.7 million hectares of land were planted with trees. However, it has been estimated that only 30% of trees planted through these programs survived

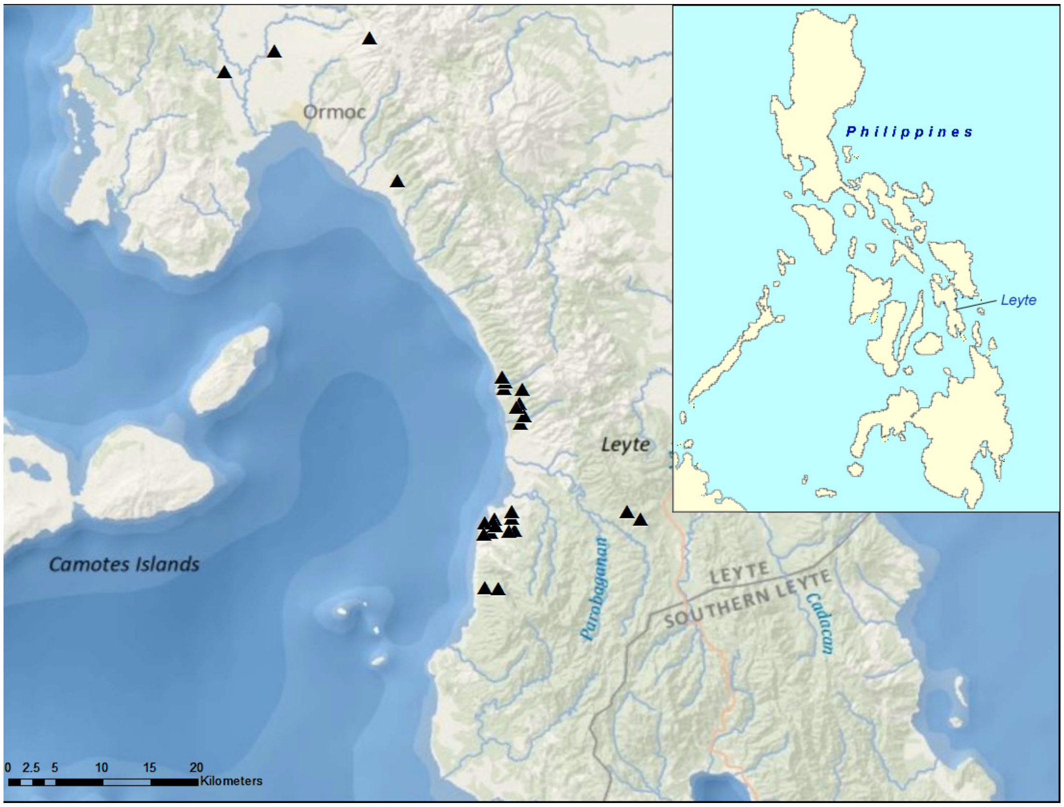


Figure 2. Map of Rainforestation sites, Leyte. The triangles represent study sites where height and diameter measurements were taken on planted trees.

(Lasco and Pulhin 2006: 50), even though more than USD 570 million has been spent on reforestation since the 1970s (Chokkalingam et al. 2006:6). Most efforts failed due to poor site adaptation of exotic species, low financial returns for landowners, failure to monitor or maintain sites over the long-term, and poor understanding of local socio-economic dynamics (Chokkalingam et al. 2006: 3, 43, 115).

Rainforestation can provide a model for alternative forms of reforestation to those employed by large-scale initiatives such as the National Greening Program. Although recent studies have examined various ecophysiological aspects of planted sites (Dierick and Hölscher 2009: 1317; Sales-Come and Hölscher 2010: 846; Navarrete et al. 2010: 289), none evaluating overall plantation success and growth performance have been conducted to date. This study assessed Rainforestation through two parameters: (1) performance of planted species; and (2) socio-economic benefits to local farmers. It fills several gaps in the literature, such as the need for data to address claims that native species grow too slowly or are prohibitively difficult to propagate in nurseries (Garen et al. 2009: 233). Furthermore, in SE Asia, the habitat ranges of native tree species in lowland dipterocarp forests are poorly understood in many locations, and more work is needed to determine species-site interactions and site requirements for long-term sustainability of reforestation efforts (Langenberger 2006: 155, Kettle 2010: 1144). This study endeavors to shed light on these issues and provide recommendations to aid the scaling up of Rainforestation in the future.

Background: Site description

Introduction to Leyte

The island of Leyte is the eighth largest island in the Philippine archipelago, with a population of approximately 1.72 million as of (NSO 2007). In 1972, 87% of the island was

Table 1. Comparison Between Two Case-Study Communities

	Community 1	Community 2
Forest Area	2,236 ha	582 ha
Tenure Status	Community-based Forest Management Agreement	Watershed Reserve Forest (Government Ownership)
Level of Organization	High. Active since 1997	Low. Re-organized in 2008
Total Members	113	63
Active Members	43	21
Threats motivating organization	Illegal logging, mining	Loss of water rights
Receiving outside funding for projects?	Yes	No
Alternative income sources	Seedling production and project activities	Employment outside community

covered by lowland dipterocarp forest. As of 1990, forest cover had declined to 12.1% due to industrial logging operations, illegal logging, and conversion of forest land to agriculture, and coconut and abaca (*Musa textilis*) plantations (Groetschel et al. 2001: 10). Most of the population are subsistence farmers, and the major crops grown are coconut, rice, abaca, sugarcane, banana, sweet potato, and maize, with coconut oil as the main commodity export.

Rainforestation site descriptions

Management regimes of the early Rainforestation sites fell into three categories easily typified according to the identity of the landowner: smallholders (n=22), experts with high education levels (n=2), and communities (n=2). The smallholder group included 11 sites with very low survival rates of planted trees, due to escaped fires, flooding, trampling by livestock, or neglect due to emigration or death of the landowner. Management intensity varied across all sites, with some sites weeded and monitored frequently. Two communities received technical assistance and financial support to develop native species nurseries and demonstration farms. Privately owned sites were leased to the community Farmers Association with divided revenues (owner-25%, association-75%).

These two communities have been involved with over two decades of forest rehabilitation activities, beginning in the late 1980s. The time that has passed has allowed ample opportunities to observe the relative success of the projects and their cumulative impacts on the individuals and communities involved (Table 1).

Methods

Performance of planted species

Planted trees and relevant site characteristics (elevation, slope, and aspect) were measured across 25 sites. Total height, and diameter at 1.4 m (diameter at breast height - DBH) of the trees were recorded, and height and straightness of the trunk were visually estimated.

Socio-economic benefits to local farmers

Sixty-two farmers were interviewed, as well as 12 individual landowners and 10 key informants from academia, national NGOs, and local government. The community interviews targeted members of the local farmers associations that were first established by the Rainforestation and the GTZ project. The sample consisted of men, women, youth, senior citizens, and both active and inactive members. Interviews focused on: (1) involvement with reforestation, (2) historical forest management, (3) livelihoods and property rights, and (4) household demographics.

Data was also gathered through active participant observation related to the two communities' efforts to get involved with the national government's National Greening Program. The local farmers engaged in activities every day, in the form of voluntary work known as *pintakasi*,

Table 2. Growth rates across the 25 rainforestation sites assessed.

Site	Size (ha)	Soil Type	Mean DBH (cm)	MAI DBH (cm/yr)	Mean Height (m)	MAI Height (m/yr)
1	0.25	Limestone	14.31	0.95	11.54	0.77
2	1	Volcanic	8.8	0.59	11.61	0.77
3	0.97	Volcanic	5.95	0.4	8.17	0.54
4	1	Volcanic	14.91	1.15	14.86	1.14
5	0.41	Limestone	22.93	1.53	17.77	1.18
6	0.38	Limestone	17.58	1.26	10.82	0.77
7	0.95	Limestone	11.81	0.79	11.71	0.78
8	0.43	Limestone	26.61	1.77	18.48	1.23
9	0.61	Volcanic	15.2	1	12.16	0.76
10	0.34	Volcanic	7.79	0.52	9.38	0.63
11	0.9	Limestone	11.11	0.74	11.6	0.77
12	0.87	Limestone	11.54	0.77	9.38	0.63
13	1.33	Volcanic	12.28	0.82	9.16	0.61
14	0.8	Volcanic	17.38	1.34	11.34	0.87
15	0.99	Limestone	22.61	1.51	16.45	1.1
16	3.37	Volcanic	7.49	0.47	9.53	0.6
17	0.59	Volcanic	16.37	1.09	14.32	0.95
18	0.7	Limestone	14.89	1.35	12.99	1.18
19	0.47	Limestone	20.41	1.36	15.58	1.04
20	0.48	Limestone	15.99	1.07	13.82	0.92
21	3.1	Limestone	5.83	0.73	10.56	1.32
22	1.8	Limestone	17.79	1.19	16.24	1.08
23	0.44	Volcanic	17	1.06	13.61	0.85
24	3.22	Volcanic	10.67	0.67	11.43	0.71
25	1	Volcanic	9.36	0.72	12.44	0.96

during which they constructed new nurseries, repaired structures, and collected and bagged seedlings. Data was also collected while observing regular stakeholder meetings, board meetings, and training events on dendrology and environmental advocacy.

Growth Rate Findings

We measured 2,858 live trees from 93 different species across 25 of the 28 sites established between 1995 and 2000. For each site, the mean annual increment (MAI) in DBH and height for all trees was calculated, with MAI for DBH ranging from 0.4 cm/year for site 3, to 1.77 cm/year for site 8, and MAI for height ranging from 0.54 m/year for site 3, to 1.32 m/year for site 21 (Table 2). For the 2,282 individuals of the 30 most frequently planted species (of which more than 20 individuals were measured across all 25 sites), MAI for DBH ranged from 1.89 cm/year for *Melia dubia*, to 0.27 cm/year for *Garcinia mangostana*. MAI for height ranged from 1.31 m/year for *Melia dubia*, to 0.33 m/year for *Garcinia mangostana*.

It should be noted that all trees were planted together in degraded areas after site preparation in the same year. Survival rates for the Rainforestation sites were high for both pioneer and dipterocarp species, which indicates that the widely held belief that dipterocarp seedlings cannot be planted in open areas should be reexamined.

The 25 sites visited showed a very high diversity in species composition, with only few sites overlapping in species composition, making robust statistical comparison of growth rates across sites difficult. However, the extensive ranges among sites and species suggest that factors such as soil quality and management through weeding and monitoring affected species performance across sites.

Socio-economic Findings

The second component of this study sought to explore the complex social context influencing the relationship between two local communities and Rainforestation by examining whether the advertised socio-economic benefits had materialized for community members. This is especially important in the Philippines, where an estimated 20 million people live in the uplands, half of whom are believed to be solely dependent on forest resources for their livelihood (FMB 2009). Many reforestation projects have failed due to improper alignment with local socio-economic conditions, and several scholars have argued that new opportunities and insights emerge when initial steps are taken to understand farmers' needs and interests when designing reforestation programs (Dove 1992: 13).

Our study found that the direct economic benefits of the Rainforestation site and nursery seedling revenues were minimal to farmers' association members. No revenues from timber in the demonstration farms have been realized; and after 16 years none of the fruit trees were producing fruit. Although one community averaged $2015/yr in seedling sales between 1998 and 2010 (CSVFA 2011), distribution of this income did not follow the benefit sharing arrangement dictated by the Rainforestation methodology. According to the Rainforestation manual, farmers association members would record the number of hours spent working on association activities, and receive a portion of seedling revenues directly proportional to their labor. However, farmers' association members in both communities could recall few instances in which income from seedling sales was directly distributed to association members.

However, the single most influential impact of Rainforestation was its catalytic role in organizing farmers associations that were able to receive official accreditation as Peoples' Organizations (PO). In the Philippines, POs can receive external funding from the government, NGOs, and other funders to implement local development projects. For example, the PO in one community was able to secure tenure over their 2,236 ha forest by applying for a Community-based Forest Management Agreement. With this official tenure, they have attracted a number of forest restoration, conservation, and agro-forestry projects over the past decade. These projects created several pathways to realize economic benefits; among them:

(1) Project budgets financed daily wage labor for nursery activities, which benefited both association members and relatives with certain skills (carpentry) or assets (vehicles).

(2) When projects included tree-planting components including funding for fruit trees and commercially valuable native timber species, association members were able to advocate for these project activities to be located on their own 'areas,' informally claimed individual parcels of land within the CBFMA area.

(3) Project implementation contributed to the cohesion of the farmers associations in both communities, maintaining a network that helped to distribute resources amongst farmers.

Analysis

Although Rainforestation has not yet significantly scaled-up throughout the Philippines, the method's ideology of native species-based reforestation has had a lasting legacy. After 16 years, Rainforestation had only been used to reforest a total area of 183 ha across the Philippines; on Leyte, the total area barely exceeds 20 ha (Milan 2010: 27). This is partially because Rainforestation was originally designed for smallholders, to rehabilitate swiddens only a few hectares in size. However, it has evolved beyond this original smallholder-based model to the point where it has been adopted by prominent Filipino environmental NGOs to restore habitat in large-scale biodiversity conservation projects. In 2004, the Department of Environment and Natural Resources (DENR) adopted it as one of the official reforestation strategies of the Philippines and issued guidelines for its use in an official memorandum (DENR MC 2004-06). Rainforestation has thus successfully challenged the entrenched government paradigm that it is impossible to raise native dipterocarp seedlings or reforest using native species. Our data support this, in providing evidence of long-term survival and growth rates of planted dipterocarps and other native species. It also falls in line with the observations of one community leader, who stated, "Any species will not survive if you don't plant it."

Conclusion

In response to increasing awareness of the importance of undertaking reforestation efforts using native species and involving local communities in planting and stewardship, Rainforestation aims to improve local livelihoods, as well as restore forest cover in the Philippines. Our research confirms that dipterocarps and other shade-tolerant species can successfully be used to restore degraded lands in the Philippines. Dipterocarp species showed high growth rates even when planted in open areas. While more analysis is needed to compare species of interest across different soil types, future reforestation efforts should not solely focus on fast-growing pioneer species, such as *Melia dubia*, which often are characterized by light wood that is less valuable in lumber markets. Also, trunk straightness in several of the fast-growing species was often poor, and trunk form could be improved through higher intensity silvicultural prescriptions, such as thinning and pruning. However, the additional permits required by the logging ban for harvesting timber may be a disincentive for smallholder reforestation projects.

Our assessment of this method shows that while economic motivation remains a strong driving force for smallholder reforestation and communities, timber and fruit harvests and seedling sales did not prove to be a significant source of earned income for farmers' association members. However, other forms of economic benefits were realized through paid labor for planting projects. Several smallholders have also begun extracting timber from their sites for house construction or have harvested pole-sized trees for their own use. In contrast, landowners and community members assigned high importance to the non-economic benefits, including environmental services (watershed protection and reducing the risk from natural disasters, e.g. landslides and floods). Rainforestation sites also symbolized the community's accomplishments, providing a sense of achievement and a rallying point for community cohesion and engagement in conservation activities.

ACKNOWLEDGMENTS

This research would not have been possible without support from Dr. Paciencia Milan at Visayas State University, VSU's Institute for Tropical Ecology, the Cienda-San Vicente Farmers Association, the Patag-Gabas-Guadalupe Farmers Association, and Dr. David Neidel and Ms. Hazel Consunji of the Environmental Leadership and Training Initiative (ELTI). We would like to thank our advisors, Dr. Florencia Montagnini, Dr. Mark Ashton, and Dr. Amity Doolittle, and our funding sources: the Tropical Resources Institute, the Council on Southeast Asia Studies, the Program on Agrarian Studies, and the Charles Kao Fund.

REFERENCES

Chokkalingam, U., Carandang, A. P., Pulhin, J. M., Lasco, R. D., Peras, R. J. J., and Takeshi, T. eds. (2006). One Century of Forest Rehabilitation in the Philippines: Approaches, Outcomes and Lessons. Bogor, Indonesia: Center for International Forestry Research. 146pp.

Cienda San-Vincente Farmers Association. (2011). Transformation of Sitios Cienda and San Vincente in Response to Rainforestation Approach (Presentation). Baybay, Leyte.

De Jong, W. (2010). Forest rehabilitation and its implication for forest transition theory. Biotropica 42(1): 3-9.Department of Environment and Natural Resources. Memorandum Circular 2004-06: Guidelines in the integration of Rainforestation farming strategy in the development of open and denuded areas within protected areas and other appropriate forest land. Republic of the Philippines. http://www.rainforestation.ph/resources/pdf/other/DENR_MC2004_06.pdf Accessed online 4-1-2012.

Dierick, D., and Hölscher, D. (2009). Species-specific tree water use characteristics in reforestation stands in the Philippines. Agricultural and Forest Meteorology 149: 1317-1326.

Dove, M. (1992). Foresters' Beliefs about Farmers: A Priority for Social Science Research in Social Forestry. Agroforestry Systems 17:13-41.

FMB. Philippine forestry outlook study. In *Asia Pacific Forestry Sector Outlook Studies II*. Ed. by Food and Agriculture Organisation of the United Nations, 97. Bangkok: Forest Management Bureau, Department of Environment and Natural Resources, 2009.

Garen, E. J., Saltonstall, K., Slusser, J. L., Mathias, S., Ashton, M. S., and Hall, J. S. (2009). An evaluation of farmers' experiences planting native trees in rural Panama: Implications for reforestation with native species in agricultural landscapes. Agroforestry Systems 76(1): 219-236.Groetschel, A., Aquino, R. R., Buchholz, I., Eufracio-Mazo, T. G., Ibkendanz, A., Sales, N.A., Seven, J. and Vicentuan, K. C. (2001). Natural Resources Management Strategies on Leyte Island, Philippines. Schriftenreihe des Seminars f. Ländl. Entwicklung 1. Aufl., Margraf Verlag, Berlin, Germany.

Kettle, C. J. (2010). Ecological considerations for using dipterocarps for restoration of lowland rainforest in Southeast Asia. Biodiversity Conservation 19:1137-1151.

Lamb, D. (2000). Rainforest restoration on a larger scale? Ecological Management and Restoration 1(3): 215-217.

Lamb, D., Erskine, P. D., and Parrotta, J. A. (2005). Restoration of degraded tropical forest landscapes. Science 310(5754): 1628-1632.

Langenberger, G. (2006). Habitat distribution of dipterocarp species in the Leyte Cordillera: an indicator for species-site suitability in local reforestation programs. Annals of Forest Science 63:149–156.

Lasco, R. D. and Pulhin, J. M. (2006). Environmental impacts of community-based forest management in the Philippines. International Journal of Environment and Sustainable Development 5:46-56

Milan, P. (2010). Rainforestation: A Paradigm Shift in Forest Restoration in the Philippines for Sustainability and Climate Change Mitigation. Mainstreaming Native-species Based Forest Restoration. Quezon City, Philippines, Visayas State University.

Milan, P. and Göltenboth, F. (2005). Abaca and Rainforestation Farming. A guide to sustainable farm management. Baybay, Leyte, Philippines: Visayas State University.

Milan, P. and Margraf, Jf (1994). Rainforestation Farming: An alternative to conventional concepts. Annals of Tropical Research 16:17–27.

Navarrete, I.A., Tsutsuki, K., and Navarrete, R.A. (2010). Humus composition and the structural characteristics of humic substances in soils under different land uses in Leyte, Philippines. Soil Science and Plant Nutrition 56:289-296.

National Statistics Office. (2007). Leyte: Results from the 2007 Census of Population. Retrieved 12-08-2011, from: http://www.census.gov.ph/data/pressrelease/2010/pr10118tx.html

Sales-Come. A.R., and Hölscherk D. (2010). Variability and grouping of leaf traits in multi-species reforestation (Leyte, Philippines). Forest Ecology and Management 260:846-855.

Announcing the 2012 Fellows

TRI Endowment Fellowships are designed to support Masters and Doctoral students who conduct independent research in tropical countries. This year 30 students received TRI Fellowships for summer research. The 2011 recipients and the countries where they conducted research are:

Ellen Arnstein	Bolivia
Lauren Baker	Peru
Jorge Barbosa	Ecuador/Brazil
Jeffrey Chow	El Salvador
Luisa Cortesi	India
Liliana Dávila Stern	Vanuatu/Nauru
Guilherme DePaula	Brazil
Julia Fogerite	Indonesia
Ankur Garg	Kenya
Jessica Gordon	China
Anobha Gurung	Nepal
Angel Hertslet	Haiti
Daniel Hoshizaki	Japan
Jasmine Hyman	Cambodia/Laos/Vietnam
Thomas James	Mongolia
Ambika Khadka	China
Bassem Khalifa	Kenya
Andrew Lerer	Argentina
Vrinda Manglik	Peru
Aparna Mani	India
Adina Matisoff	Peru
Kevin McLean	Panama
Jennifer Miller	India
Thomas Owens	Brazil
Pablo Peña	Costa Rica/Peru
Erin Raboin	Panama
Alark Saxena	India
Sumana Serchan	Nepal
Chris Shughrue	India
Jeffrey Stoike	Brazil
Angela Whitney	Philippines

The Andrew Sabin International Environmental Fellowships support the education and training of international students from less-developed countries, who intend to return to their home region or country to work in the field of conservation and development. This year's recipients and their home countries are:

	Home Country
Jorge Barbosa	Colombia
Bunyod Holmatov	Uzbekistan
Vijeta Jangra	India
Ambika Khadka	Nepal
Aparna Mani	India
José Medina Mora de León	Mexico
Pablo Peña	Peru
Lucia Ruíz Bustos	Mexico
Sumana Serchan	Nepal
Wen Wang	China

Tropical Resources Institute
Yale School of Forestry & Environmental Studies
301 Prospect Street
New Haven, CT 06511
United States of America

TROPICAL RESOURCES INSTITUTE

Tropical Resources, an annual publication of the Tropical Resources Institute, features the TRI-funded research of Masters and Doctoral students from the Yale School of Forestry & Environmental Studies.

Staff

Director: Dr. Carol Carpenter
Program Manager: Lisa Bassani
Research Assistants: Lakshmi Krishnan, Ryan Sarsfield, Theodore Varns
Cover Photos: Stephen Brooks
Graphic Design: Monte Kawahara

Yale School of Forestry & Environmental Studies
301 Prospect Street, New Haven, Connecticut, USA 06511
environment.yale.edu/tri
tri@yale.edu